The role of traditional aquaculture systems and fish in food security and livelihoods of fishing communities in two states in Nigeria.

A thesis submitted for the degree of Doctor of Philosophy

By

Ahmed Gomna

Institute of Aquaculture, University of Stirling, Stirling, Scotland

November 2006

Dedication

This thesis is dedicated to Almighty Allah

Declaration

I hereby declare that this thesis is my own original work and that to the best of my knowledge this work has not been submitted to any other university for a degree award.

Candidate :………………………..

Supervisor:……………………….

Date :………………………..

Acknowledgements

Many thanks are due to Federal Government of Nigeria for the award of scholarship to undergo the PhD programme. Many thanks also go to Federal College of Education, Kontagora for the study leave covering the period of the programme. Special thanks go to Dr K. J. Rana, my principal supervisor, without whose quality and friendly supervision this work would not have come to fruition. I would also like to thank Dr David Little, my second supervisor for his kindness and encouragement. Special thanks also go to my wife who endured the challenge of being a single parent to our little daughter Aziza Ahmed during my long absence in the UK.

Many thanks to Dr B.M.B Ladu, the Director of National Institute for Freshwater Fisheries Research (NIFFR), New Bussa for providing local supervision during fieldwork in Nigeria. I am also grateful to Mr Joshua Ayanda, H.O.D, Fisheries socio-economics and Mr S.O Alamu, NIFRR, New Bussa for their valuable suggestions during fieldwork.

I would also like to thank Dr O. A. Ayinla, Assistant Director of Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos for his kindness. I am grateful to Dr A. Oresegun, Dr B. B. Solarin and Mr A.B. Williams, staff members of NIOMR for their help. Many thanks to DSP A.I. Kuta for providing accommodation whilst in Lagos. I am grateful to extension agents of Agricultural Development Projects (ADP) for help during data collection.

Special thanks to Ms C.A Howie, for providing statistical advice. I would like to thank my parents, brothers, sisters and friends for their support, love and unceasingly prayers for my success.

Abstract

This study has examined the role of traditional aquaculture systems and fish in food security and livelihoods of fishing communities in two states in Nigeria. The research focused on the productivity, sustainability and profitability of the aquaculture systems including social and economic conditions of farmers. The study also compared the relative importance of fish as a high quality protein source with meats in fishing communities in two states in Nigeria.

Data were collected from 400 farmers with modern and traditional aquaculture systems in Niger and Lagos states using semi-structured questionnaires. Modern aquaculture consisted of small fish ponds with an average size of 0.1 ha. Liming was not widespread among farmers with fish ponds but fertilisation was done before stocking by applying fertilisers of both organic and inorganic origins. Farmers (90%) obtained their seeds from the hatcheries and the average stocking density was 5730 ha^{-1}. Polyculture was widely practised by farmers and local feeds were used in feeding fish.

Fish shelters and fish fences were the traditional aquaculture systems that were widely practised in two states in Nigeria and are poorly researched and recorded. Various materials were used in the construction of traditional aquaculture systems including branches, elephant grasses, worn out tyres, PVC pipes and clay pots and, were constructed in order to aggregate fish. There was no significant ($p > 0.05$) difference in yield of fish from fish parks and modern aquaculture systems. The study showed that fishermen prefer fishing in the vicinity of fish parks, tube shelters and fish fences because they make more catches around the installations. Cost–benefit analysis showed that traditional aquaculture systems are profitable because

the level of investment required to set and maintain them is quite low compared to returns obtained from them.

Fifty actively fishing and fifty non–fishing households in traditional fishing communities were randomly selected in Niger and Lagos states for fish consumption survey. A Simple scale was designed and given to each household to measure fish or meat entering the household for consumption. Intra household fish distribution and consumption was obtained by 24 hour recall method. A large number of fish species were consumed in the fishing communities confirming the relative abundance of the species in local rivers, floodplains and lagoons. Tilapia was the most consumed fish species contributing 19 and 32% by weight of the fish consumed in Niger and Lagos state, respectively. Beef was the most consumed meat followed by goat meat. The study reveals high preference for fresh fish and meat. Highest fish consumption occurred in March corresponding to period of lowest meat consumption.

Traditional aquaculture systems and capture fisheries were the main sources of fish in the fishing communities contributing 85% by weight to fish consumed. Male heads of households consumed higher amount of fish than other members of the household. Average weight of fish consumed per person per day was 24 g. Fish contributed 77% to total animal protein in diet of the people and was eaten daily by fishermen thus confirming the importance of fish in the food security of fishing communities.

Table of content

List of tables

List of figures

Chapter 1: Introduction, literature review and aims of study

1.1 Introduction

Global food fish supply from capture fisheries and aquaculture is currently the highest on record and remains significant for global food security, providing on average more than 15 percent of total animal protein supplies (FAO, 2003a). Fish which is rich in protein is an ideal and traditional supplement to a basic diet of starches in many developing countries. It compares favourably with eggs, milk, and meat in nutritional value of protein and amino acid composition (Jolly and Clonts, 1993).

The majority of fish consumed by humans comes from capture fisheries. However, the over- exploitation of fish resources and the ever increasing protein demand by the increasing human population has put great pressure on fish supply from natural waters. One realistic and practicable way of supplying more food protein is to increase fish production through the promotion, expansion and efficiency of aquaculture and inland fisheries (Meaden and Kapetsky, 1991) but this approach has at least until recently delivered little result in Africa.

In historical terms, two distinct categories of fish production system can be distinguished in Africa, the traditional and modern systems (ICLARM-GTZ, 1991). Systems which are believed to have originated in Africa, although sometimes with counterparts elsewhere in the world, and which are unique to the countries in which they are operated, are regarded as traditional (ICLARM-GTZ, 1991). These are extensive systems of fish production that fall outside the definition of aquaculture adopted by Food and Agriculture Organisation (FAO). The FAO definition states that aquaculture is:

> ‘the farming of aquatic organisms including crocodiles, amphibians, finfish, molluscs, crustaceans, and plants, where farming refers to their rearing up to their juvenile and / or adult phase under captive conditions. Aquaculture also encompasses individual, corporate or state ownership of the organism being reared and harvested in contrast to capture fisheries in which aquatic organisms are exploited as a common property source, irrespective of whether harvest is undertaken with or without exploitation rights’.

The definition encompasses three components:

- The cultured fish
- The practice and
- Ownership of cultured organism

All the components need to be fulfilled for an activity to be classified as aquaculture (Rana, 1997).

The concept of ownership deals with the degree to which the culturist is legally and socially entitled to the benefits from the investment made in the rearing system and to the fish reared to protect from appropriation by other people, to insurance of stock and facilities, and to compensation for damage to the fish by pollution and environmental degradation (Welcomme, 1996). However, many traditional forms of aquaculture are based on the exploitation of multipurpose water bodies in which the organisms themselves are ‘common property’, i.e. ‘owned’ neither by an individual nor corporate body or the state (Townsley, 1998; Beveridge and Little, 2002). Though fish caught from these systems is accepted as ‘owned’ by the people pursuing the activity. Fishing access and rights are also controlled by traditional authorities.

Traditional systems that employ simple methods to improve fish production from natural water bodies arose independently in different regions, particularly in flood plains along the lower courses of rivers characterised by seasonal cycles of flooding and drought (ICLARM-GTZ, 1991). During the wet season, fish thrive in the food-rich and sheltered habitats of inundated flood plains (Welcomme, 1983). Large numbers of fish become trapped as the floods recede, and those unable to return to permanent channels seek refuge in depressions, particularly those with perennial water (ICLARM-GTZ, 1991; Nzamujo, 1995). Such depressions are foci of dry season flood plain fisheries and can be envisaged as an initial stage in the evolution of aquaculture (Welcomme, 1983; ICLARM-GTZ, 1991). The simplest form of system is damming of natural flood plain depressions, excavation of drain–in ponds, creation of refuge traps and brush parks. Such systems may be regarded as being steps toward fish husbandry or extensive aquaculture (Welcomme, 1983), and in this thesis are described as 'traditional aquaculture.' In some of these systems such as brush parks, local feed such as pap, cassava wastes, rice and corn bran are added to enhance production. In some communities such as Niger state, the use of charms as a management technique to control poaching in brush parks and fish fences is also common.

Traditional aquaculture systems are common in West Africa and in the Nile Delta and production ranges from 0.1 to 38 t ha^{-1} yr^{-1} (ICLARM-GTZ, 1991). At these levels of production fish contribution to national supplies are likely to be low in comparison with production elsewhere and are unlikely to meet current and predicted demand.

1.2 Aquaculture in the World

Aquaculture has a long history, tracing its root back to thousands of years. Fish culture has been reported in all the ancient civilizations of Rome, Egypt, and particularly China. The origin of fish culture in China is generally attributed to

Wang Fang who founded the Chou dynasty. Between 1135 and 1122 BC, Wang Fang built ponds and filled them with water and fish, and also recorded the behaviours and growth of stocked fish (Fagbenro, 2002). This practice spread to India, Indonesia, Vietnam and Cambodia. Fish farming development from these early times has given the people of the region a head start in fish farming which they have maintained to the present day (Fagbenro, 2002).

Aquaculture production, excluding aquatic plants increased from 39.8 million tonnes (mt) by weight in 2002 to 41.9 mt in 2003. Aquaculture production reported by China - the largest producer – in 2002 showed a 6% increase by volume compared with 2001, reaching 27.8 mt. For world excluding China, aquaculture production was 12 mt by weight in 2002. Other major producing countries in 2002 were: India (2.2 mt), Indonesia (914 100 tonnes), Japan (828 400 tonnes) and Bangladesh (786 600 tonnes). In 2002, countries in Asia accounted for 91.2% of the production quantity and 82% of the value (FAO, 2004).

By region, over 91.3% of the total aquaculture production by weight was produced within the Asian region (41.72 mt) in 2000, followed by Europe (2.03 mt), Latin America and the Caribbean (0.87 mt), North America (0.55 mt), Africa (0.40 mt) and Oceania (0.14 mt) (FAO, 2003). The contribution of aquaculture to global supplies of fish, crustaceans and molluscs continue to grow, increasing from 3.9% of total production by weight in 1970 to 29.9% in 2002. Aquaculture sector has grown at an Annual Percent Rate (APR) of 8.9% per year since 1970, compared with 1.2% for capture fisheries and 2.8% for terrestrial farmed meat production systems over the same period (FAO, 2004).

1.3 Aquaculture in Africa

Aquaculture has been practised in parts of Africa for a very long time. A bas relief on the walls of the tomb of Thebaine traced the history of aquaculture in Africa to at least 2500 BC in ancient Egypt, showing tilapia being fished out of an artificial pond (Maar *et al,* 1966). This is the oldest presentation of a fish culture pond in the world. Modern fish culture was introduced into African countries in the early years of the last century, primarily for stocking waters for angling by expatriates (Fagbenro, 2002). Pond fish culture in sub–Saharan Africa first started in Kenya in 1924 and later spread to other parts of the continent (Huisman, 1986; Jackson, 1988).

In 1940s, fish farming was introduced in Zaire and in 1950s it was actively propagated in the country as a result of successful trials with tilapia species at Kipopo Fisheries Research Station (Table 1.1). By 1960, the number of fish ponds in Africa was estimated at 320 000 with a total surface area of 7324 ha (average pond surface area of 229 m^2). Total estimated production was 3714 t yr^{-1} (507 kg ha^{-1} yr^{-1}) (Fagbenro, 2002). Africa's history of traditional aquaculture includes brush parks, drain-in ponds, lagoon, flood plain and river bed farming, all dating over 200 years. Although these systems currently contribute 60% of all recorded farmed fish production in Africa, they are poorly researched and are even legislated against (Balarin *et al*, 1998).

Table 1.1: Early aquaculture history in West and Central Africa

Year	Activity	Country
1948	Kipopo Fisheries research station was set up	Zaire
1949	First Anglo – Belgian Fish Culture conference	Zaire
1952	First Symposium on Hydrobiology and African Inland Fisheries	Uganda
1956	Bouake Fisheries station was set up	Cote d'Ivoire

Fagbenro (2002)

Africa contributed less than 1% to world aquaculture production in 2000. The annual percent growth of reported aquaculture production in Africa increased from 9.8% per year (period 1970 – 1980) to 12.1% per year (period 1990 – 2000), with an over all growth of 13.0% per year for the period 1970 – 2000. Egypt and Nigeria contributed over 90% of the aquaculture production in 2000. The total number of cultured species increased from five in 1970 to 43 in 2000, with the main species groups cultivated in 2000 being finfish (96.2%), aquatic plants (1.8%), crustaceans (1.4%) and molluscs (0.6%) (FAO, 2003).

Until recently, African aquaculture practice has been at subsistence level to meet animal protein demand at individual and family levels and has been dominated by small scale subsistence farming of tilapia species. The active participation of African governments and donor agencies, such as FAO, has brought the benefits of modern aquaculture and aquacultural technology to expand the scope of African aquaculture. Additional cultivable species now include clariid cat fishes and exotic carps (FAO, 1991).

1.4 Aquaculture in Nigeria

Artisanal fishermen and fishing communities in Nigeria have for generations practised traditional methods of fish nurturing in tidal pools and floodplains (Dada, 1975). Modern aquaculture in Nigeria is of recent practice. The first organised attempt at aquaculture development in Nigeria was made in 1940 at Onikan in

Lagos and later in Buguma, Rivers State (Shimang, 1999). In 1951, the government of Northern Nigeria started the construction of pilot fish farm at Panyam. At about the same time, the governments of Western and Eastern Nigeria encouraged the construction of homestead fish ponds. FAO responded to Federal government requests to initiate the development of brackish water fish culture in the Niger Delta area in 1965 and another project in Lagos in 1968 (Dada, 1975). Cage culture was also initiated by FAO in Kainji Lake due to a sharp decline in commercial catches from the lake from 28 638 tonnes in 1971 to 10 905 tonnes in 1973 (Ita, 1975).

Tilapias, clariid catfishes and the common / mirror carps are the most widely cultured fish in Nigeria (Vanden Bossche and Bernacsek, 1990) and are suited to low technology farming systems in many developing countries. This is because of their fast growth rate, efficient use of natural aquatic foods, propensity to consume a variety of supplementary feeds, omnivorous food habits, resistance to disease and handling, ease of reproduction in captivity, and tolerance to wide ranges of environmental conditions (Fagbenro, 1987). Initially, seeds and fingerlings were obtained from the wild. Artificial breeding of carp was introduced in 1954 at Panyam fish farm (Ezenwa, 1975).

Nigeria contributed 6.4% to aquaculture production in Africa in 2000 (FAO, 2003). Domestic fish production from aquaculture in Nigeria increased from 4.5% in 1999 to 5.5% in 2000 (Table 1.2). Although there is considerable potential for aquaculture in Nigeria the present contribution to domestic fish production from this sector is rather low. Out of the estimated annual production of 467 098 tonnes in 2000 less than 10 percent comes from aquaculture (Federal Department of Fisheries, 2003).

Table 1.2: Domestic fish production in Nigeria (1990 – 2000) in tonnes

Year	Artisanal	Aquaculture	Industrial	Grand Total
1990	283 534 (89.6)	7 297 (2.3)	25 529 (8.1)	316 360 (100)
1991	291 286 (84.8)	15 840 (4.6)	36 226 (10.6)	343 352 (100)
1992	283 943 (82.8)	19 770 (5.8)	39 365 (11.4)	343 078 (100)
1993	201 176 (78.8)	18 703 (7.3)	35 644 (13.9)	255 523 (100)
1994	234 601 (82.8)	18 104 (6.4)	30 488 (10.8)	283 193 (100)
1995	320 955 (86.5)	16 619 (4.5)	33 479 (9)	371 053 (100)
1996	309 200 (86.9)	19 490 (5.5)	27 244 (7.6)	355 934 (100)
1997	360 219 (87.2)	25 265 (6.1)	27 703 (6.7)	413 188 (100)
1998	433 070 (89.6)	20 458 (4.2)	29 955 (6.2)	483 482 (100)
1999	426 786 (89)	21 738 (4.5)	31 139 (6.5)	479 663 (100)
2000	418 069 (89.5)	25 720 (5.5)	23 308 (5.0)	467 098 (100)

Source: Federal Department of Fisheries (FDF), 2003. Figures in brackets indicate percentages.

According to Shimang (1999), three categories of pond-based fish farmers exist in Nigeria. They include commercial, peasant and homestead fish farmers. Commercial fish farmers are economically well–to–do individuals, successful traders, politicians, retired Military and Senior Civil Servants. They build fish ponds of 1 – 5 ha with an average yield of 1.5 – 2 t ha^{-1} yr^{-1}. Peasant fish farmers have smaller fish ponds typically around 0.2 ha. These types of fish ponds are more numerous and have a wider spread all over the country. Yields from these ponds are modest at about 0.5 – 0.8 t ha^{-1} yr^{-1}. The third system of fish farming in Nigeria is homestead ponds. These are of very small size compared with peasant or commercial ones, and range in size from 0.01 to 0.08 ha. Average productivity in these ponds is about 0.03 t ha^{-1} yr^{-1}.

The major obstacles to rapid aquaculture development in Nigeria have been identified by Shimang (1999) as follows:

- Inadequate database on the biology and ecological requirements of endemic fish species which possess high aquaculture production potentials
- Inadequacy of practical research and trials to solve basic problems of the industry

- Insufficient extension institutions and extension officers at all levels of development as well as research information dissemination to end – users
- Low rating and therefore low priority given by government to the sector in its planned budget and resources allocation at all levels
- Lack of knowledge on the profitability of aquaculture as a commercial enterprise and lack of fish farm management technology
- Unavailable access to institutionalised credit for aquaculture development
- Unwillingness on the part of insurance institutions to grant security cover to would be fish farmers, both small, medium and large scale
- Difficulty in accessing land for aquaculture development
- Lack of rational aquaculture development policy
- Non implementation of government policies on fisheries development
- High cost of labour
- Lack of effectively organised and well run fishermen's Cooperative Association
- Lack of accurate statistics on all aspects of fisheries development and
- Legislation. Before 1982, the legal aspects of fishery management and exploitation covered the Marine environment only. These were: 1) The Sea Fisheries act of 1971, 2) The Sea Fisheries (fishing) Regulations of 1978 and 3) The Exclusive Economic Zone (EEZ) Act of 1978.

1.5 Traditional aquaculture

1.5.1 Types of traditional aquaculture systems in West Africa

Traditional aquaculture systems have been used in several West African countries. They include the damming of the natural depressions, fish parks / *acadjas* and drain–in ponds (Welcomme, 1972; ICLARM-GTZ, 1991; Nzamujo, 1995; Prein and Ofori, 1996).

1.5.1.1 Damming of natural depressions

Damming is a simple modification of naturally occurring flood plain habitats to block small seasonal stream beds, channels, or associated flooded depressions to confine fish for later capture during the dry season, as flood waters recede (ICLARM-GTZ, 1991). The dam walls are typically constructed from earth and stone and strengthened with wood (Welcomme, 1983; Beveridge and Little, 2002).

Experiments with simple but more permanent dams made of wooden posts, earth and clay-filled sacks have been carried out in the Niger River and in the Senegal (Reed, 1967; ICLARM-GTZ, 1991). Harvests from such dams are quite respectable - about 185 kg ha^{-1} yr^{-1} in the otherwise unmanaged state, but management by stocking with fry and feeding with agricultural wastes such as rice husks can improve production up to 500 kg ha^{-1} yr^{-1} (Welcomme, 1983). Damming the natural depressions is an initial stage toward extensive aquaculture (ICLARM-GTZ, 1991).

1.5.1.2 Fish parks (*Acadjas*)

The term *acadja* describes a family of installations of the fish-park type that are currently found in several of the West African coastal lagoons and in the South East Asia, Bangladesh and Ecuador (Welcomme, 1972). Generally, branches are placed in water to form aggregations, which are removed after a short lapse of time, together with any fish that may have sought shelter amongst them. Installations of this type must be considered simply as refuge traps that exploit the fish stock in the open waters in which they are placed, or which draw fish from the cover of adjacent reed-beds. In some coastal lagoons, however, the use of larger semi-permanent parks has been developed to a point where they give high yields, but at the same time may serve as sites for seed production for the surrounding waters (Welcomme, 1972).

Acadjas consist of branches, bushes or other soft vegetation stuck into muddy bottoms of lagoons, lakes or rivers at a depth of 1 - 1.5 metres (Welcomme, 1972). Generally, *acadja* systems consist of an outer ring of hard wood or bamboo poles, inside which soft, brush wood branches 2 - 2.5 m in length are either implanted upright in 50 cm of mud or placed in a variety of patterns on the muddy bottoms in waters up to 1.5 m deep (ICLARM-GTZ, 1991).

1.5.1.2.1 Types of fish parks

Fish parks are of two main types, those constructed of dead tree branches and shrubs (brush parks), and those constructed of living, soft, floating vegetation (vegetation parks). Both forms are installed in fresh (rivers and shallow lakes) and brackish (estuaries and coastal lagoons) waters. They may be free standing in open water, attached to the bank or constructed in pond–like depressions excavated into the bank (Welcomme, 2002).

1.5.1.2.2 Construction of fish parks

Construction of fish parks ranges from simple circles of branches that retain a mass of floating vegetation to complex constructions using different types of wood. Apart from floating vegetation the basic elements of brush park fisheries are branches

1 – 3 m in length. These are stuck more or less vertically into the bottom or are laid horizontally on the substrate to form a mosaic of different habitats suited to different life stages of the fish (Welcomme, 2002). Often several types of branches are used, harder ones to surround and shape the structure and softer elements to fill it. In some cases, such as the Lagos lagoon (Solarin and Udolisa, 1993) other materials such as old tyres and plastic pipes may be used to supplement the fill. Hem (1998) experimented with bamboo pipes filled with a variety of fertilizing materials such as chicken manure in the Ebrie Lagoon, Cote d'Ivoire. In the Benin lagoons many of the larger parks are structured with open circles distributed within the brush fill, which are left open as breeding areas for the fish or are filled with horizontal soft wood branches or woody debris. A bamboo framework often surrounds the core structure of the brush park to define its limits (Welcomme, 2002).

1.5.1.2.3 Quantities of wood used in fish parks

The branches used are relatively fine, weighing about 250 g dry or 500 g wet. They are usually dried after cutting and then soaked for some weeks before they are finally used to reduce their buoyancy (Welcomme, 2002). The author noted that densities of placement vary between individual brush parks depending on the means of the fishermen. In Lake Nokoue, 12 – 16 branches are usually staked per m^2, equivalent to 40 t ha^{-1} dry weight of wood. In Sri Lankan lagoons Amarasinghe *et al* (2002) recorded 12 – 30 kg of wood m^{-2} equivalent to 9 – 19 branches m^{-2} with a distinct preference for 10 branches m^{-2}.

1.5.1.2.4 Harvesting of fish parks

The smaller types of *acadjas* used to be harvested with a special cast net known as *acadjado*, which was thrown over the installation in such a manner as to enclose it completely (Welcomme, 1972). More recently, this technique has been abandoned, and now the fish are harvested in one of two ways: a single harvest after 12 months, or selective fishing throughout the year using nets with holes large enough to allow small fish to escape (Hem, 1998). In a single attempt, the *acadja* to be harvested is simply surrounded by a wall of netting held in a place with stakes. All the branches are removed from the enclosure, and when the area is completely free of wood, the net is drawn in together. The fish are thus trapped in the resulting netting, which is hauled aboard the fisherman's canoe, where the catch can be removed at leisure (Welcomme, 1972).

In some areas a closely woven fence made of split palm stems is used to encircle the *acadja* and in this case a heart- shaped chamber is constructed in one corner of the enclosure into which the fish are driven for removal (Welcomme, 1972). The author remarked that harvesting of a large *acadjas* can take several days and requires considerable labour force; a minimum of 180 man / days being estimated for the exploitation and reconstruction of one hectare. The actual fishing procedure requires considerable skill, and a specialised team of about ten fishermen carries out the final preparation stages. The mesh chosen for the encircling netting varies between 10 – 15 mm.

Research by Hem (1998) suggests that the preferable method is selective fishing, without moving the bamboo. The size of a park regulates the frequency with which it can be fished. Larger installations are exploited less frequently and the bigger *acadjas* of Lake Nokoue and the Port Novo Lagoon may be fished once per year to once in 18 months (Welcomme, 2002).

1.5.1.2.5 Species caught from fish parks

In the fresh water zone, a variety of species are attracted to the fish parks of Oueme River, Benin Republic from which up to thirty-two species have been recorded (Welcomme, 1983). The author noted that in the brackish water, *Sarotherodon melanotheron* and *Chrysichthys nigrodigitatus* made up 95% of the individuals present. According to Amarasinghe *et al* (2002) one cichlid species, *Etroplus suratensis* (Bloch), makes up 70% of the catch in Sri Lankan brush parks but 24 other fish, two crustacean and one mollusc species were also caught. The fish composition in Bangladeshi brush parks consisted of 17% Indian major carps, 24% cat fish, 13% clupeids, 9% feather backs, 6% tilapia and 31% others (Ahmed and Hambrey, 1999). Solarin and Udolisa (1993) recorded 21 fish species belonging to 17 families in the brush parks of Lagos Lagoon, Nigeria of which S*arotherodon melanotheron* was predominant contributing about 54% by weight. Jamu and Brummett (2002) reported that S*arotherodon melanotheron* constitutes about 60% of the species caught from *acadjas*.

Improvements on the management of *acadjas* have been attempted in Benin through the stocking of *Oreochromis niloticus* and the use of conventional feed instead of using branches to promote and attract food. However, high costs associated with building the enclosures and feed has made it difficult for local communities to adopt the technology (Nzamujo, 1995).

1.5.1.2.6 Yield from fish parks

The main controllable variables influencing the yield and the economy of fish parks are the type of installation used, the density of brush used per unit area of *acadja*, and the frequency of exploitation. Other factors include the species of fish present, the type of wood available, and its cost, the general productivity of the waters in which the *acadjas* are installed (Welcomme, 1972). The greater the number of branches per unit area, the greater the catch (Welcomme, 1983). According to the author, yields rose from about 20 kg ha^{-1} at a planting density of 1 branch per m^2 to 20 t ha^{-1} at a density of 20 branches per m^2.

Vegetation parks seem somewhat less efficient. The fish yield from Indian vegetation parks in Loktak Lake was only about 15% that of brush parks operated in a similar environment (Suresh, 2000). The difference in yields between vegetation parks and brush parks is also confirmed by the experiments conducted by Hem (1988) in Ebrie Lagoon, Cote d' Ivoire. In these studies brush parks stocked with 10 fish m^{-2} yielded up to 8.05 t ha^{-1}, vegetation parks 1.8 t ha^{-1} and controls 1.17 t ha^{-1}.

1.5.1.3 Drain–in ponds.

Drain–in ponds are traditional ponds or fish holes that are usually flooded with water during the wet seasons. There are three major types of drain–in ponds: *Ouedos*, *ahlos* and *hatsis* of West and Central Africa, which are currently used to produce tilapia (ICLARM-GTZ, 1991; Nzamujo, 1995; Prein and Ofori, 1996).

The *ouedos* are used by people living in the Oueme valley of Benin to catch fish when flood waters recede in the flood plain (Welcomme, 1983; Nzamujo, 1995). They are also found in coastal lagoons in Ghana and Cameroon (Balarin, 1985; Prein and Ofori, 1996). The fish holes, which are 50 to 1500 m long and 4 metres wide, are constructed from natural water channels and are deepened to about 1.5 metres below the dry season water table. Fish, predominantly tilapia, enter naturally into the fish holes during the wet season and are trapped as floodwaters recede. The fish are then harvested using nets or mobile reed barriers (ICLARM-GTZ, 1991). Yields of 1.5 - 2.1 t ha^{-1} yr^{-1} have been recorded from the Oueme valley in Benin (Welcomme, 1983; ICLARM-GTZ, 1991). The authors noted that species composition varies with *Ouedo* size as excessive vegetation growth in the smaller holes causes deoxygenation, which favours the hardier species such as tilapia, as well as predominance of air-breathing species. In *Ouedos* of less than 500 m^2, *Clarias gariepinus* and *Ophicephalus* spp. are common, *Heteroitis niloticus* occurs in intermediate size *Ouedos*; and those larger than 5000 m^2 are characterised by *Mormyrids* and *Lates* spp. Other species include *Channa*, *Anabas* and *Protopterus* (Welcomme, 1983). During the dry season, animals graze in the fish holes and their manure fertilises the fish holes (Nzamujo, 1995). In Benin, the *Ouedos* are integrated with agriculture where maize is cultivated in the draw down areas between ponds and crops such as vegetables, tomatoes and peppers are cultivated on the banks around the draw down areas (Welcomme, 1983). In Asia, the ponds are usually associated with rice-fields as a retreat for fish as the water is drained prior to harvesting (Welcomme, 1983).

The *ahlos* are drain–in ponds or fish holes with branches inside which are used to provide refuge and food to the fish (ICLARM-GTZ, 1991). The *ahlos* are a hybrid of *acadjas* and *ouedos* (Welcomme, 1971). In the *ahlos* system the artificially deepened trenches, some 30 m long, once flooded are filled with branches to increase production. As in the *acadjas*, the basis of this is increased feed for the fish from epiphytic algal growth and aufwuchs, as well as larval insects boring into the wood. The branches also provide refuge from predation and act as a fish nursery (ICLARM-GTZ, 1991). The problems being faced by these systems according to Welcomme and Kapetsky (1981) and Nzamujo (1995) include population growth, deforestation due to cutting of trees to provide branches for the *ahlos*, accumulation of undecomposed branches which reduce water flow and the indiscriminate harvesting of smaller fish which reduces recruitment into the rivers and lakes.

Hatsis are described as earthen dams located along the shores of coastal lagoons in zones normally dry for part of the year (ICLARM-GTZ, 1991). These dams fill with either rain or flood water and fish that enter during the wet season are entrapped as waters recede with the onset of dry season (ICLARM-GTZ, 1991). *Hatsis* are found in coastal lagoons in Ghana (Prein and Ofori, 1996).

Afani is another form of traditional aquaculture system practised in Ghana in the lower Volta where young clams are collected and “planted” in “owned” areas of the river (Prein and Ofori, 1996). A harvest of over 4000 t yr^{-1} was estimated at one time from this system along a 50-km stretch of river below Akuse in Ghana.

Barachois is another system that is found mainly in Mauritius, where the fringing barrier reef encloses a relatively sheltered and shallow lagoon (ICLARM-GTZ, 1991). Inlets are converted to *barachois* by blocking them with stone walls fitted with screen gates to permit water exchange. Fingerlings of mullet (*Mugilidae*), *Siganus* sp., and other fish caught by chance in the lagoon are stocked in the *barachois* at variable rates, but generally at about 1000 ha^{-1}. The yields are double the natural productivity of the lagoon. A similar technique is also found in Ghana (ICLARM-GTZ, 1991). Summary of the characteristics, inputs and expected yields of selected traditional extensive African aquaculture systems is given in Table 1.3.

Table 1.3: Summary of the characteristics, inputs and expected yields of selected traditional extensive African aquaculture systems

System (Dimensions)	Essential inputs	Accessory equipment	Time to harvest	Seed stock	Extrapolated yield (t/ha/yr.)
Damming of depressions (up to 1 ha)	Excavation, supplemental feed	Nets	Various often unregulated	Adventitious entry of wild stock	0.2-0.5
Drain-in ponds					
Howash (1-20 ha)	Earthen dike, Pumping, Manure, feeds	Pump, boat, nets	1-10 years.	“	0.5-4.5
Ouedos (20->1500m trench)	Excavation	Nets/Traps	4 months	“	1.0-2.1
Ahlos (30 m trench)	Excavation, Branches	Nets	1 year	“	1.0
Acadjas / Brush parks					
Amedjerotin (250-1250 m^2)	Palm fronds	Canoe, Nets	2 years	“	5.0-6.0
Adokpo (250-4000 m^2)	Branches	Canoe, Nets	4-8 months (2years)	“	8.0-10.0
Ava (0.2-7.0 ha)	Branches	Canoe, Nets	1-2 years	“	4.0-21.0
Hanou (20-150 m^2)	Branches	Canoe, Nets	2 months (6 years)	“	to 17.0
Godokpono (20-150 m^2)	Branches	Canoe, Nets	4-5 years	“	6.0-25.0
Aula (various)	Branches vegetation	Canoe, Nets	10 years	“	28.0
Hanoumecadja (20-150 m^2)	Branches	Canoe, Nets	2-3 years	“	3.6-38.0
Barachois (0.5-50 ha)	Stone wall	Seine net	1 year	“	0.1

ICLARM–GTZ (1991).

1.6 Environmental impacts of traditional aquaculture systems.

Aquaculture, like many other farming activities, is dependent on the use of natural resources such as water, land, seed and feed. It is the use of these resources by aquaculturists as well as their access to appropriate quantity and quality of these resources that determines the nature and scale of environmental interactions (Beveridge and Muir, 1991). The effects of traditional aquaculture on the environment can either be positive or negative although these may not necessary be permanent.

Environmental effects associated with extensive culture systems are considered minimal (Choo, 2001). Drain–in ponds can play a positive role in soil and water conservation programmes, by slowing down the force of erosion of run–off water and reducing down stream flooding (Harrison, 1994). Water storage in ponds can also help to irrigate vegetable farms with nutrient rich water and is considered a good way to utilise marginal land (Edwards, 1993). Recycling of nutrients and organic matter through integrated farming systems is long recognised as environmentally sound. Traditional aquaculture in rice fields can help farmers reduce use of environmentally damaging pesticides. The decomposition of the wood in *acadja* systems can lead to nutrient loading resulting in high productivity of the lagoon or lake (Welcomme, 1972; ICLARM-GTZ, 1991; Nzamujo, 1995). *Acadjas* may also act as reserve for the stocking of the waters of any lake in which they are constructed.

Negative impacts of aquaculture in general arise from the consumption of resources, the process itself and the production of wastes which are generally related to the intensity of culture (Beveridge and Muir, 1991). *Acadjas* compete with adjacent capture fisheries through the attraction of fish from the open water and competition for space. The conflict between *acadjas* and capture fisheries is exacerbated when the *acadja* is used as a fish aggregation device. This occurs when short harvest intervals (3 months) that do not allow breeding to occur inside the *acadja*. The prolific spread of *acadjas* in Benin has also been shown to result in serious social conflicts between *acadja* owners and navigators (ICLARM-GTZ, 1991). Welcomme (2002) remarked that large masses of floating vegetation and branches installed in the water together with the remains of old parks obstruct other types of fishing gear. *Acadjas* also contribute to local deforestation and environmental degradation (Welcomme and Kapetsky, 1981; Van Dam *et al*, 2001).

Acadjas can increase the productivity of the body of water in which they are used, but they may also shorten its life through accelerated silting and sedimentation (ICLARM-GTZ, 1991). High silt loads tend first to choke the existing vegetation, but later build internal deltas and braided channels, filling channels, lakes and reservoirs, and finally, by raising the river bed far above the surrounding plains, provoke extensive and catastrophic flooding (Welcomme and Henderson, 1976).

Wastes from aquaculture not only include uneaten food, faecal and urinary wastes but also chemicals, micro organisms and disease agents and feral (escaped) aquaculture fish (Beveridge and Muir, 1991). In aquaculture systems, uneaten food, faecal and urinary wastes can result in hypernutrification and eutrophification in the water column and an increase in organic matter inputs to sediments (Beveridge, 1984). Santiago (1995) reports that in the 104 ha Sampaloc Lake, place where 6000 tonnes of feed are used each year, anoxia and high ammonia concentrations are apparent throughout the water column and that there has been corresponding changes in phytoplankton community composition.

Common–user conflict and introduction of exotics, which may alter the diversity of the natural flora and fauna, and feral organisms from culture systems, are also contentious issues (Choo, 2001). Impacts of feral organisms include habitat destruction, competition and predation (Beveridge, 1984). Most parasites are disseminated and introduced into new localities through movements of infected hosts (Kennedy, 1976). In Malaysia, for example, the importation of pathogenic bacteria and parasites with grass carp, *Ctenopharyngodon idella* and big head carp, *Aristichthys nobilis* has been recorded (Shamsudin, 1986). The recent outbreaks and spread of the Ulcerative Disease Syndrome (UDS) in Southeast Asia have been linked by some to unregulated movements of fish (ADB-NACA, 1991).

1.7 Potential methods of enhancing natural productivity in traditional aquaculture systems

Natural productivity from traditional aquaculture systems could be increased by adding branches in ponds and through liming and fertilisation. Natural productivity refers to production volume attained under conditions where no supplementary feeds are added; the only food source consists of the botanical or zoological microbes in the pond produced outside or within the pond (Hirasawa and Chen, 1994).

1.7.1 Branches

The placing of branches in water to form aggregations has been shown to increase natural productivity in ponds (Welcomme, 1972; ICLARM-GTZ, 1991; Keshavanath *et al*, 2001; Van Dam *et al*, 2001; Wahab and Azim, 2001). Branches act as growth substrates for periphyton and epiphytic algae and also attract insects providing additional natural food quantities for the fish thus reducing the need to feed them. The decomposition of the branches and leaves could lead to high nutrient loading resulting in high productivity. The branches also offer shelter from predators and provide suitable places for breeding (Welcomme, 1972; ICLARM-GTZ, 1991).

According to Van Dam *et al* (2001) periphyton has the same functions of oxygen and feed production as phytoplankton, but may be more stable and can be utilised more efficiently by fish. They defined periphyton as "total assemblage of sessile or attached organisms on any substrate". According to them, other terms are aufwuchs ("all organisms that are attached to, or move upon a submerged substrate, but which do not penetrate into it," the difference with periphyton being the non-attached organisms), epiphyton (on plants), epipelon (on sediment), epixylon (on wood) and epilithon (on rocks). Periphyton may contain protozoan, bacteria, fungi, algae, rotifers, annelids, insect larvae and crustaceans (Van Dam *et al*, 2001). Functions performed by the periphyton community in ponds include:

- Support for primary production
- Capture of particulate organic matter from the water column
- Decomposition of organic matter
- NH_4^+ removal, NO_3^- production
- Denitrification in the anoxic layer of the periphytic community
- Support for microbial communities, some of which might have a probiotic effect
- Support for grazer communities, which include protozoan, zooplankton and fish /shrimp (Verdegem *et al*, 2001).

Substrates that have been used for growth and production of periphyton include bamboo poles, *Hizol* branches, *Kanchi* branches, mango tree branches, *Saora* tree branches, Gab tree, Gum tree, *Pani kachu* (*Colocasia esculenta*), sugar cane bagasse, PVC pipes and paddy straw (Faruk-ul-Islam, 2001; Gangadhar *et al*, 2001;

Keshavanath *et al*, 2001; Van Dam *et al*, 2001; Wahab and Azim, 2001). Of these substrates, bamboo may provide a better surface structure for epiphytic species to attach to or may leach nutrients beneficial for the growth of periphyton (Keshavanath *et al*, 2001; Gangadhar *et al*, 2001).

There are a few natural and culture systems where periphyton plays an important role in productivity. Van Dam *et al* (2001) cite an example of the Caribbean and Indo-pacific coral reef systems, where parrot fish (*Scaridae*) spend 90% of their time foraging on low quality periphyton (0.4 - 2.5% protein, high ash content). Other examples according to them, are the traditional milk fish (*Chanos chanos*) systems in the Philippines, Taiwan and Indonesia, where a thick layer of benthic algae ("*Lab-lab*") is grown in shallow ponds, and the *katha* fisheries in rivers and canals in Bangladesh, where branches of trees are used to attract fish, leading to yields of 100 - 1000 kg per 10 - 60 m^2 of *katha* area. They cite another example of a study in which no significant difference was found between yields of fish raised with microbial mats, fish fed with commercial feeds at 3% body weight per day or fish grown on a combination of mats and feed.

Studies conducted employing substrates such as sugar cane bagasse and paddy straw supplemented with low dose of manure have shown a 50% increase in growth of common carp, rohu and Mozambique tilapia compared to ponds without substrates (Shankar and Mohan, 2001). Manissery *et al* (2001) and Shankar and Mohan (2001) remarked that bagasse and paddy straw could support the growth of microbial biofilm which has several roles in aquaculture such as increasing production, improving water quality and health. Periphyton alone can sustain an estimated tilapia production of 5000 kg ha^{-1} yr^{-1} through the addition of substrate area equivalent to 100% of the pond surface area (Wahab and Azim, 2001). Karim *et al* (2001) showed that fish yield increased significantly from 1411 to 1876 kg ha^{-1} with addition of substrate. Different substrates available in rural areas could be used to increase fish production without adding much to input cost. Rahman *et al* (2001) recommended the use of bamboo trimmings in ponds where they are available on-farm at no cash cost to both deter theft and to promote growth of periphyton grazing fish.

In contrast to existing practices, it may be beneficial to introduce branches to ponds several weeks prior to stocking, permitting periphyton to colonise the substrate and enable recently stocked fish to exploit the food source immediately. Arranging branches so that maximum surface area is available for periphyton colonisation, ensuring that established periphyton cultures are not desiccated during harvest or low water level periods, and returning branches in roughly the same position and orientation, may also contribute significantly to potential benefits. Though this system can lead to deforestation and environmental degradation (Welcomme and Kapetsky, 1981; Van Dam *et al,* 2001), to minimise deforestation and accumulation of organic matter in the system, Hem and Avit (1996) recommended the use of bamboo which can last up to 4 - 6 years compared to soft wood branches which are replaced annually.

1.7.2 Liming.

Liming involves the application of lime to fishponds. Principal liming materials used in the culture of most species are agricultural lime, slaked lime and quick lime (Hickling, 1971). Agricultural lime is the best liming material to use in ponds (Boyd and Lichtkoppler, 1979). Liming stimulates Base Exchange action and brings about liberation of absorbed nutrients such as phosphates in bottom mud leading to an increase in benthic production and also raises the total alkalinity level and consequently the reserve carbon dioxide increases the availability of carbon for photosynthesis by raising the bicarbonate concentration in water and also prevents biological decalcification (Hey, 1952; Huet, 1972; Kutty, 1981; Erondu 1991). Boyd and Lichtkoppler (1979) reported that the presence of calcium in water neutralises the harmful effects of magnesium, sodium and potassium salts and is used in the formation of shells by molluscs and other crustaceans. Lime is to be applied when the pH and alkalinity of fish pond are too low and when the pond is too muddy (Ita, 1980). Recommended rates and system of lime application to ponds are given in Table 1.4.

Table 1.4: Recommended rates and system of lime application to ponds

Soil type	New pond	Old pond
Clay soil	1680 – 2240 kg / ha /year	1120 – 1680 kg / ha / year
Sandy soil	1120 kg /ha / year	560 – 1120 kg / ha / year

(Ita, 1980).

1.7.3 Fertilisation

Fertilisation is the practice of applying nutrients in the water in the form of organic (manure) and inorganic (chemical) fertilisers (Rafael, 1987). Organic manures are available in a variety of forms such as dung of cattle, sheep, pig, goat and poultry droppings, de-oiled cakes of Mahua, mustard, castor, linseed and neem. They also come in the form of farmyard manure, compost, green manure and sewage. Success has been achieved by using chicken manure in the fertilisation of brush parks (Hem, 1998). Organic manures are composite in nature and provide practically all the nutrients, including organic carbon, required for biological production (Kumar, 1992). Commercially produced inorganic compounds containing major nutrients, nitrogen, phosphorus and potassium are known as inorganic or chemical fertilisers. They contain high and fixed percentage of one or more major nutrients depending on the class (nitrogenous, phosphatic or mixed) of fertilisers. Due to their high solubility in water, the nutrients become readily available soon after their application (Kumar, 1992).

Fertilisation schedule involving both organic and inorganic fertilisers start 10 – 15 days prior to stocking and is prepared on the basis of the nutrient status and chemical environment of the pond soil and water (Kumar, 1992). Pond fertilisation may be appropriate if the following indicators are observed: Measurement indicates low levels of nitrates and phosphate, water is transparent and may contain abundant growth of submerged plants and water is turbid with suspended particles or stained with humic substances. Fertilisation may not be appropriate in soils containing high levels of nutrients sufficient to support plankton bloom (Rosario, 1984).

The productivity of the pond can be enhanced by the use of fertilisers which make up or provide essentially needed nutrients that is, minerals required for the production of aquatic biota (Huet, 1972). Jensen (1987) reports that fish pond fertilisation can increase fish yields three to four times. Fertilisation of water is a means of increasing the natural food for fish, which may even be sufficient, and no supplementary feeding is required. This situation could be advantageous to fish farmers since feed cost can account for as much as 60% of the production of fish (Jensen, 1987). Feed cost can markedly be reduced if advantage is taken of naturally available foods. Protein content of natural foods is very high with respect to the nutritive value (Hickling, 1971). Rate of manure application is given in Table 1.5.

Table 1.5: Rate of manure application as reviewed by Ita, (1980).

Type	Rate of application	Comment
Dry cow dung	500 kg / ha / month	3000 kg / ha to be applied to bottom of new ponds before filling.
Dry poultry droppings	112 – 224 kg / ha / week	
Dry pig manure	560 – 1680 kg / ha / week	

1.8 Feeding practices in traditional aquaculture systems

Technical literature related to feeding fish is scant. The majority of diets for fish grown in extensive aquaculture systems are natural, principally plankton and benthic invertebrates. Natural productivity alone is able to sustain production of several hundreds of kilograms per hectare from monoculture. Polyculture, where synergistic feeding relationships are exploited, is likely to be higher, although probably no more than 600 – 700 kg ha^{-1} yr^{-1}, depending on the nature of water body, proximity to human habitation and how nutrients drain into water bodies (Beveridge and Little, 2002).

Various studies (Welcomme, 1972; ICLARM-GTZ, 1991; Nzamujo, 1995; Prein and Ofori 1996; Hem, 1998) have shown that traditional aquaculture systems principally depend on natural productivity. The authors pointed out that, the wood or branches in *acadjas* and *ahlos* act as a growth substrate for periphyton and epiphytic algae, and also attract insects which serve as natural food for the fish and artificial food does not need to be introduced. The decomposition of the wood also results in high nutrient loading leading to high productivity.

Manuring has been widely used for centuries in Asia. In England too, Chambers and Gray (1988) cite evidence of human effluent deliberately channelled into monastery fishponds during the later medieval period. Nzamujo (1995) recommended the use of traditional feeds in feeding fish in traditional aquaculture systems to increase yield. He reported that fly larvae and maggots were used to feed fish in a study conducted in Benin. To obtain the same larvae and maggots one can make use of *tchaya* (protein-rich plant) or maize cobs, mixed with the droppings of the reared animals. In the open air, they represent a rich substrate for the multiplication of micro-organisms.

After slaughtering animals, the bowels are collected and mixed with blood which gives a high nutritive compound. In order to facilitate the consumption, the mixture is kneaded with cassava starch and cooked. After cooling, one obtains a paste, which is cut in small pieces and rolled into pellets of 5 cm diameter. The pellets are dried and fed at the right time (Nzamujo, 1995). Earthworm, termites and snails can also be cultured in wooden, bamboo or cement tanks and use to feed fish. Feeds generally used in Nigeria include groundnut cake, spoilt groundnut, palm kernel cake, rice bran, guinea corn / sorghum and maize (Dada, 1975).

1.9 Fishing gears in Nigeria

In small scale fisheries, Nigerian fisher folk use gear types made up of both natural and synthetic fibres. Natural fibres are easily and cheaply obtained from the abundant plant resources. However, most of the gear types are made with synthetic twines and nettings. Approximately 60% of these nettings are sourced locally, while the rest are imported (Udolisa *et al*, 1994). Types of fishing gears in Nigeria are given in Table 1.6.

Table 1.6: Types of fishing gears in Nigeria

Gear	Class of gear	Period used	Fish caught	Water body
Purse seine	Surrounding net	October – April	Pelagic clupeids	Coastal waters
Beach seine with bag	Seine net	Year round	*Pseudotolithus, Caranx spp*	,,
Beach seine without bag	,,	,,	*Ethmalosa, Chrysichthys, Alestes spp* & freshwater clupeids	Lagoons, rivers, lakes, creeks
Circular lift net	Lift net	,,	Crabs	Brackish water lagoons & rivers
Rectangular lift net	,,	October - January	*Alestes* & *physailia spp*	Lakes & rivers
Set gillnets	Gillnets	October – April	*Pseudotolithus, Arius, Gymnarchus, Lates spp* & fresh water catfish,	Estuary, coastal waters & lakes
Sawa driftnet	,,	October – April	*Sardinella spp.*	Coastal waters
Shark driftnet	,,	October – March	Sharks	,,
Bonga driftnet	,,	October – April	*Ethmalosa sp*	,,
Encircling gillnet	,,	,,	Pelagic fish	Coastal waters & rivers
Cast net	Falling gear	Year round	Tilapia, catfish, *Ethmalosa* & *Caranx spp*	Rivers & lagoons
Cover basket pot	,,	,,	Mud catfish	Shallow waters
Earthen pot	Trap	June – August	*Chrysicthys sp*	Shallow lagoons
Gura trap	,,	Year round	*Alestis, Gymnarchus, Lates spp*	Freshwater rivers & lakes
Bamboo trap	,,	,,	*Chrysicthys sp*	Lagoons
Set long line	Hooks & lines	Year round	Catfish & *Gymnarchus*	Coastal waters, rivers &lakes
Drifting long lines	,,	,,	Predatory fish	Rivers and lagoons

Sources: Reed *et al*, 1967; Udolisa *et al*, 1994

(a) Fisherman setting gill net in Lagos.

Fishermen mending gill net in Niger state

Figure 1.1: Examples of gill nets.

Figure 1.2: Cast net hung on a tree to dry

(a) Shrimp basket traps

(b) Fisherman setting trap

(c) Fisherman removing rectangular trap from creek

(d) The fisherman setting the trap back in water after removing fish

(e) Fisherman setting spring–loaded pole–and–line in Ojo creek

(f) The fisherman demonstrating how it operates

Figure 1.3: Gears and their operations in Lagos state

1.10 Traditional fish processing, preservation and marketing

Traditional methods of fish processing and preservation include drying, salting, smoking, boiling and fermentation (UNIFEM, 1993). The most practised methods in Africa particularly Nigeria include drying, roasting and smoking (Reed *et al*, 1967).

Indigenous processing techniques evolved because of local environmental conditions, availability of raw materials (fish, fuel, salt, building materials), preferences for taste, texture, colour and smell, social behaviour, and economics of production. Each community will most certainly have improved their technique in the first instance by trial and error and perfected a particular process by long experience (FAO, 1970).

Sun–drying is used with lower quality fish. Several methods are employed: lying larger fish individually on permanent racks constructed from timber supporting reeds or split bamboo; spreading small fish on rocks, directly on the soil, or on mats; and threading and hanging fish on split palm fronds (ICLARM-GTZ, 1991). The fish are periodically turned to expose the whole surface for drying. Sun-drying in this manner does not allow control over drying times, exposes the fish to attack by insects and animal pests, and allows contamination by sand and dirt (UNIFEM, 1993). FAO (1981) reported that a typical sun–dried product has, in general, a drying time of three to ten days. Examples of Sun–drying in Niger state are given in Figure 1.4.

(a) Fish being sun–dried on sacks

(b) Clupeids being sun-dried on *atalla* net

Figure 1.4: Examples of Sun–drying in Niger state.

If the fish are small and are to be kept for only a day or two, the usual method is to spread a layer of dry grass or an old grass mat on the ground and cover it with a single layer of fish. The grass is then fired and the fish become lightly roasted (Figure 1.5). During the peak of the season when smoking kilns are being used to capacity, fish are sometimes burnt in this manner while awaiting their turn to be taken to the kilns (Reed *et al*, 1967).

(a) Fish being sun–dried on grasses before roasting

(b) Roasting of fish

Figure 1.5: Sun drying and roasting of fish in Niger state

Smoking is a simple and fairly efficient way of preserving fish. All fish, excluding fingerlings, first have the gut removed before being smoked, but the gills and other organs are left intact (Reed *et al*, 1967). Three main methods of smoking are practised: using a metal grill placed over a pit fire; placing the fish on bamboo spits and then grilling them; and spreading the larger fish on a bamboo frame for partial cooking and slow drying beside the fire (ICLARM-GTZ, 1991). The most commonly used traditional smoking kilns are the rectangular kiln moulded from mud measuring about 4 m x 2 m x 1 m and the oil–drum kilns (halved or whole) (Figure 1.6).

(a) Halved oil drum smoking kiln

(b) Smoking kiln made of mud

Figure 1.6: Types of smoking kilns

Traditionally, fish is not filleted before smoking, but large fish are normally cut into portions (Figure 1.7). Hot smoked process takes about 35 – 45% moisture content, but with a limited shelf–life of 1 – 3 days at ambient temperatures. The smoke–dry process takes about 10 – 18 hours and sometimes 3 – 4 days and yields fish of 10 – 15% moisture content, sometimes even below 10% with shelf – life of 3 – 9 months when stored properly (Jallow, 1995). Bernaseck (1991) reported that the shelf–life of the smoked fish depends more on the cooking and the state of dryness of the fish than the smoke itself. The longer the fish is smoked, the drier it becomes and the more suitable it is for longer– term storage (UNIFEM, 1993).

Figure 1.7: Fish being cut into portions before smoking in Niger state.

(a) Fire wood for smoking fish (b) Smoked fish in a kiln

Figure 1.8: Fire wood and smoked fish

Fish smoking is relevant in the artisanal fisheries in that it prolongs the shelf–life of the fish, enhances flavour and increases utilisation of the fish, reduces waste when catches are good and increases protein availability to people (Jallow, 1995). An advantage of traditional ovens is their low capital cost (UNIFEM, 1993). Many disadvantages have been reported, however (Clucas, 1982). They include:

- Constant attention is required to control the fire and turn the fish. This may involve working through the night.
- The operation is both a health and fire hazard. The absence of smoke barriers creates dangerous levels of smoke, which is inhaled by the labourers who rotate the fish.
- Many ovens are inefficient in their use of fuel and ventilation systems.
- There is little or no control over the temperature of the fire and the density of smoke produced.
- The construction materials used limit the durability of the ovens.
- The open construction of the ovens leaves the fish susceptible to climatic conditions and animal attack.
- The fish product is of poor quality due to insufficient cooking of flesh inside and burning and charring outside.

Traditional ovens and kilns, with low–batch capacities and long smoke–drying times, are no match for the heavy landings of fish that occur during the peak season. With these long–standing problems serving as a backdrop, in 1989 the African Regional Centre for Technology (ARCT), in collaboration with the Nigerian Institute for Oceanography and Marine Research (NIOMR), launched its first kiln project. The following are some of the technical highlights of the project:

- Use of reflectors as an integral part of the design has helped to distribute the heat generated within the kiln more evenly. As a result, drying and smoking now take place without the danger and drudgery associated with constantly rotating the fish – a necessary practice in traditional kilns.
- The heat distribution mechanism created by the reflectors can be adapted to other kilns to improve their performance.
- The kilns are designed to be built in segments. This allows processors to fit the size of the oven to the size of the catch, thus saving labour, time and money.
- Construction of chimneys not only minimizes smoke inhalation but conserves energy by ensuring a more intense fire. Most importantly, the redesigned kiln has shortened drying times from 30 to three hours (NIOMR / ARCT, 1989).

Such improvements have been achieved through the use of appropriate technologies that rely on the existing resources readily available to fishing communities. Rapid distribution of the kilns, among both firms and families, has not only increased worker safety but curbed the adverse environmental impacts associated with fish processing. In particular, the industry's impact on deforestation, a major problem along the west coast of Africa, has been reduced. Advances in the design and operation of fish kilns have had a lasting impact on the communities' harvests and marketing of fish. The industry, which is dominated by women, has become more efficient, especially during the peak season when, historically, many fish are spoiled before they could be consumed or processed (NIOMR / ARCT, 1989).

In Malawi, traditional methods have been supplemented with the locally developed use of the rapidly degradable insecticide, Actellic (*Pirimiphos metyl*), which reduces post harvest losses to insects, particularly during the wet season. Having succeeded first with such small species as *Haplochromis* spp. and *Lethrinops* spp., the use of Actellic has now been extended to the preservation of larger fish like tilapia and catfish. The active ingredient is applied at levels less than 0.15% when applied by spray and 0.68% when done by dipping (ICLARM-GTZ, 1991). Another traditional method of preventing beetle infestation is in Mali where the local processors scatter pepper in a ring around fish placed in bundles or, alternatively, the powdered leaves of *Bosia senegalensis* may be used (UNIFEM, 1993).

In Nigeria, fish marketing is almost entirely in the hands of women. Though these traders are often the wives or family members of the fishermen, this does not prevent them from driving a hard bargain with their supplier and an even tougher one with their consumers. Even when fish are to be smoked before taken to the market, fishermen usually first sell their catch to their women folk, who take charge of the smoking and marketing. They frequently take the fish to the market and sell what they can as fresh; then smoke what is left at the end of the day. They often accumulate stocks until there is enough to warrant transporting it to the market (Reed *et al*, 1967).

Fresh or processed fish are packed into containers made of bamboo or sorghum stalk baskets, wooden or plastic boxes, paper cartons (Figure 1.10) and sacks made of coconut stalk, jute or synthetic fibre. Leaves from plantain or banana plants are used to line the bigger containers and pack the fish to reduce breakage and losses that may occur during transportation. Transportation is carried out either by foot, bicycles or motorcycles or motor vehicles especially to urban centres (Azengi, 1995).

(a) Smoked fish being packed in carton

(b) The carton is being tied with a twine.

Figure 1.9: Smoked fish in Niger state

Figure 1.10: Smoked fish packed in cartons ready for transportation to market.

1.11 Fisheries socio-economics

The study of socio-economic in fisheries and aquaculture represents one attempt to implement interdisciplinary fishery research, in particular through linking the “economic” and “human” aspects of the fishery. It can be seen as integrating social and institutional studies into conventional economic analysis, or alternatively as bringing the concepts and analytical methods of economics into social science research. Socio-economics can be viewed as including political, institutional, and legal, as well as social and economic aspects (Charles, 1994). The socio-economic contexts against which the introduction of aquaculture must be seen are those of the labour demand and supply to existing agricultural systems, and the economies of the households and other rural, small groups (ICLARM-GTZ, 1991).

Aquaculture projects have many sociological impacts, either in a beneficial way, such as the stimulation of development, improvement in the standard of living and nutrition, employment opportunities, or as negative social impacts, such as modification of traditional social values, privatisation of common property, use of natural resources, activity conflicts and unsuccessful technologies. Employment opportunities generated through aquaculture development, including processing, transport and marketing, can be expected to affect, to some extent, the drift of rural people to urban areas. Large–scale development of aquaculture can also lead to better communications into rural areas, as they are needed also for proper management of aquaculture production and distribution (Ruddle, 1993). Knowledge of the level of human, economic and social infrastructure development, and the cultural and political context in which the aquaculture programme has to be implemented, is necessary for appropriate project design (Pillay, 1990). As

Ruddle (1993) puts it, "aquaculture must be adapted to society; the converse is not worthy of consideration".

Traditional aquaculture systems and capture fisheries have socio–economic impacts on fishing communities in Nigeria. According to Federal Department of Fisheries (2000) traditional aquaculture systems and capture fisheries provide employment for over 1 000 000 people in Nigeria. These systems account for 70 – 90% of the annual income of fishing communities in Nigeria (DFID–FAO, 2002). The authors, however, pointed out that the income is rather low and can hardly sustain them and their families.

Fishing communities in Nigeria are socially disadvantaged and lack basic amenities like housing, good drinking water, sanitary facilities and education thus compromising their nutritional security. According to Williams (2000) individuals in the fishing communities live in shacks and houses with leaky roofs. The houses are temporary or semi–permanent structures – walls and roof of huts made of bamboo and thatch (DFID–FAO, 2002). According to the authors majority of fishermen live in appalling conditions in remote and isolated areas, with only one fifth of rural housing physically sound. Illiteracy is an all prevailing phenomenon in rural fishing villages and has negative impact on the flow of information. Lack of formal education makes it difficult for them to understand new technologies made available to them by the research – extension system (DFID–FAO, 2002). Ali *et al* (1982) reported that education and farm efficiency are closely related. The authors noted that high rate of illiteracy results in low farm efficiency.

Almost all the fishing settlements in the coastal areas are not accessible by roads. The only viable means of transportation include canoes and boats. The terrain (creeks and estuaries) are difficult to reach by research providers, thus alienating the fishing villages from capacity building and identification of felt needs (DFID–FAO, 2002). Lack of good roads also makes transportation of fish to urban markets where they could earn more income difficult. Lack of electrification is another problem faced by fishing communities. This affects processing of fish by refrigeration.

1.12 Contribution of aquaculture to livelihoods

Aquaculture contributes to the livelihoods of the poor through improved food supply, employment and income. Edwards (2000) enumerated the following as direct and indirect benefits of aquaculture to the livelihoods of the poor:

Direct benefits

- Food of high nutritional value, especially for vulnerable groups such as pregnant and lactating women, infants and pre-school children.
- ‘Own enterprise’ employment, including for women and children and
- Income through sale of relatively high value products.

Indirect benefits

- Increased availability of fish in local rural and urban markets, which may bring prices down.
- Employment on larger farms, in seed supply networks, market chains and manufacture / repair functions.
- Benefit from common pool resources, particularly the landless, through cage culture, culture of molluscs and seaweed, and enhance fisheries in communal water bodies.

- Increased farm sustainability through construction of ponds, which also serve as small-scale, on-farm reservoirs; and rice fish culture as a component of integrated pest management.

Although fish provides far less animal protein for global nutrition than livestock, people in major areas of Africa and Asia are highly dependent on fish as part of their diet: in 18 countries in Africa and Asia, nine on each continent, fish provide at least 40% of dietary animal protein including digestible energy and are rich source of fat and water soluble vitamins, minerals and fatty acids (Edwards, 2000). Aquaculture has contributed in the past towards poverty reduction in poor societies in the few areas of the world, in which it is traditional practice, for example China, Indonesia and Vietnam, and it continues to do so today. Few projects have specifically targeted the poor and the impact of aquaculture on poverty has scarcely been assessed (Edwards, 2000).

The role of aquatic resources in rural livelihoods is characterised by diversity: diversity in the resource, diversity of habitat and environment and diversity of resource users and the ways in which they exploit these resources and incorporate them into their livelihood strategies (Townsley, 1998).

Rural households exploit a wide range of aquatic resources, many of which are unrecorded and the importance of which is rarely measured. Low value species of fish, molluscs and shellfish, aquatic weeds and amphibians can all play important roles in the food supply and income generation strategies of rural households.

The nature of the aquatic habitat in which resources are found has a determining effect on the ways in which these resources are used and, in many cases, on who uses them. The characteristics of fisheries in deeper, open water areas, whether marine or fresh water, are very different from those of fisheries in shallow, closed waters. Swamps, rivers and estuaries, tidal areas and seasonal water bodies all have distinct characteristics which make particular demands on those exploiting the living resources in them – demands in terms of technology, level of investment, organisation of work, mobility, support mechanisms and market links .The different aquatic resources within these habitats can have very different behavioural patterns and require radically different strategies for their exploitation depending on whether they are migratory or sedentary, where in the water column they live, breed and feed and whether they obey seasonal or other cyclical patterns (Townsley, 1998).

Culture technologies of a wide range of relative sophistication can either make use of existing aquatic environments or create new or artificial ones. The levels of investment, and so the user groups for which they are appropriate, can shift considerably as a result. The diversity in aquatic resource use is reflected in the diversity of aquatic resource user groups. 'Fishers' (i.e. people who depend on fishing for most of their livelihoods) are usually only a proportion of the overall population who make use of aquatic resources (Townsley, 1998).

1.13 Fish consumption

In 2002, of the estimated 88.7 million tonnes (mt) of fish produced in the world, excluding China, nearly 74% (65.5 mt) was used for human consumption. The remainder (about 26%) was utilized for various non–food products, mostly for reduction to meal and oil. For China, out of 44 mt total production, nearly 35 mt (80%) was used for human consumption and the remainder was used for the manufacture of fish meal and other non–food uses, including direct feed to aquaculture (FAO, 2004).

The share of the animal protein intake of the whole human population derived from fish, crustaceans and molluscs increased from 13.7% in 1961 to 16.1% in 1996 and then showed a slight decline to 15.8% in 1999 (FAO, 2003a). The role of fish in nutrition shows marked continental, regional and national differences. For example, of the worldwide 100 mt available for consumption in 2001, only 6.3 mt were consumed in Africa (7.8 kg per capita); two – thirds of the total was consumed in Asia – 34.8 mt outside China (14.1 kg per capita) and a similar amount in China alone (giving an apparent consumption of 25.6 kg per capita). Of 16.3 kg of fish per capita available for consumption in 2001, the vast majority (74%) was finfish. Shellfish supplied 25% (about 4 kg per capita), sub divided into 1.5 kg of crustaceans, 2.0 kg of molluscs and 0.5 kg of cephalopods (FAO, 2004).

The total amount of fish consumed and the species composition of the food supply vary according to region and country, reflecting the different levels of natural availability of aquatic resources in adjacent waters as well as diverse food traditions, tastes, demand and income levels. Demersal fish are much preferred in northern Europe and North America, and cephalopods are consumed extensively in several Mediterranean and Asian countries, but to a much lesser extent in other regions. Despite the contribution of aquaculture to total fish production, crustaceans are still high–priced commodities and their consumption is concentrated in affluent economies (FAO, 2003a).

Fish provides a good source of readily digested high–quality animal protein together with a high concentration of vitamins A and D, a significant source of phosphorus, copper, zinc, magnesium and iron, as well as high concentrations of calcium in the bones (Roos, 2001). It is also a good source of selenium, co–enzyme Q_{10} and taurine (Anon, 2004). Shellfish and salt - water fish are rich in iodine and fluorine, in addition to traces of cobalt, and for that reason make a valuable contribution to diet.

Fish proteins are essential and critical in the diets of some densely populated countries, where the total protein intake level may be low, and it is very important in the diets of many other countries. For example, fish contributes more than, or close to, 50% of total animal proteins in countries like Gambia, Ghana, Equatorial Guinea, Indonesia, Sierra Leon, Togo, Guinea, Bangladesh, the Republic of Congo and Cambodia. About 56% of the world's population derives at least 20% of its animal protein from fish, and some small Island states depend on the fish almost exclusively. Dependence on fish is usually higher in coastal than in inland areas (FAO, 2003a).

Consumption of fish and fish oils has many health benefits. A high intake of fish has been linked to a significant decrease in age–related memory loss and cognitive function impairment and a lower risk of developing Alzheimer's disease (Kalmijn *et al*, 1997; Levine, 1997). Studies (Hibbeln and Salem, 1995; Hibbeln, 1998) have shown that countries with high levels of fish consumption have fewer cases of depression. Fish and shellfish have high values of poly–unsaturated fatty acids (PUFA), especially Omega–3 fatty acids which tend to lower blood cholesterol by depressing low density lipoprotein (LDL) concentration. Omega–3 fatty acids appear to also reduce levels of plasma triglyceride, in particular very low density lipoprotein (VLDL). Larsson *et al* (2004) has also shown that Omega–3 PUFAs are protective against cancer progression. Premature birth and an abnormally low birth weight and hyperactivity in children have been linked to insufficient intake of omega–3 fatty acids (Simopoulos, 1991; Cunnane *et al*, 2000; Makrides and Gibson, 2000; Olsen and Secher, 2002). Broughton *et al* (1997) reported that children who regularly eat fresh, oily fish have a four times lower risk of developing asthma than do children who rarely eat such fish.

The importance of fish in the diet can be estimated by the extent to which it accounts for the animal protein intake (Kent, 1997). Fish plays an important role in the diet of rural people in Nigeria by providing an average of 24 – 30% of total daily protein intake (Dreschl *et al*, 1995). According to DFID–FAO (2002) fish supplies 75% of the total animal protein intake of fishing communities in Nigeria. In Nigeria, per caput fish consumption increased from 7.3 kg in 2002 to 10 kg in 2003 (FAO, 2002; Nzeka, 2003). Fish represents an essential and often irreplaceable animal food for the poor in developing countries with access to water resources. The dependency on fish in developing countries is high; as substitutes by other animal foods are inaccessible to the poor (Kent, 1997). This is particularly the case in Nigeria, which has large areas of highly productive inland waters (Ita, 1993).

1.14 Justification of this study

Nigeria is blessed with a vast expanse of inland fresh water and brackish ecosystems. These water resources are spread all over the country from the coastal region to the arid zone of the Lake Chad basin (Ita, 1993). Nigeria has a coast line of 853 km and a maritime area of 46 000 km^2 (Udolisa *et al*, 1994) with an estimated total area of inland water bodies of 12 487 818 ha (Ita *et al*, 1985). Various forms of traditional aquaculture systems exist in these water bodies.

Information on traditional aquaculture systems and fish consumption in Nigeria is scant. The specific problems are:

- Lack of information on the production and research status of traditional aquaculture systems in Nigeria

- Lack of information on the profitability and environmental impacts of the systems in Nigeria and
- Lack of information on intra household fish consumption and distribution in fishing communities in Nigeria.

The only studies found were those carried out by Reed (1967), Solarin and Udolisa (1993). They observed fish shelters in fresh water environments of Northern Nigeria and Lagos Lagoon, respectively. These studies did not, however, report on the profitability and environmental impacts of the fish shelters. Dreschl *et al* (1995) conducted a nutrition survey of fishing communities in Kainji lake area of Nigeria for Nigerian–German Kainji Lake Fisheries Promotion Project (KLFPP) using a 24 hour recall protocol to assess the **quantitative** food intake including fish but did not include intra household consumption and distribution of fish. It was in the light of the above that this study was carried out.

1.15 Hypotheses and aims of the study

The hypotheses of this study were that:

1) Traditional aquaculture systems continue to be important in Nigeria, they are not uniform across the country, and in particular are likely to show differences across the environmental (coastal / inland), social and cultural contexts

2) Application of local knowledge can improve productivity from traditional aquaculture systems

3) Traditional aquaculture systems are potentially sustainable if appropriately managed and are competitive in terms of use of resources, and have the potential to play an important role in the livelihoods of fishing communities

4) Traditional aquaculture systems are economically viable

5) Fish supply associated with these systems play an important role in food security of fishing communities

In order to address these hypotheses the present study aimed at assessing the role of traditional aquaculture systems and fish consumption in food security and livelihoods of fishing communities in two states in Nigeria, where environmental, religious and cultural differences are marked. The following specific activities were proposed, carried out in two states in Nigeria, in order to achieve the above objective and to formulate policy recommendations:

i) To assess the key characteristics and productivity of traditional aquaculture systems.

ii) To assess the environmental needs and impacts of traditional aquaculture systems to determine their resource sustainability.

iii) To study the comparative economics of traditional aquaculture systems within and between the two states, to determine their profitability.

iv) To examine the comparative importance of fish and meat consumption in fishing communities and to determine the contribution of fish to total animal protein intake, and role of aquaculture systems in doing so.

v) To examine and compare intra household fish consumption and distribution in fishing communities to determine the quantity and parts of fish eaten by members of households.

Chapter 2: Methodology

2.1 Introduction

This chapter describes the research methods followed to achieve the objectives of the study. The choice for selecting study areas and research tools is explained including data collection process.

2.2 Selection of the study areas

Study sites were selected in two states in Nigeria; Niger and Lagos (Figure 2.1). The two states were selected in order to compare traditional aquaculture systems and fish consumption patterns in inland and coastal areas of Nigeria.

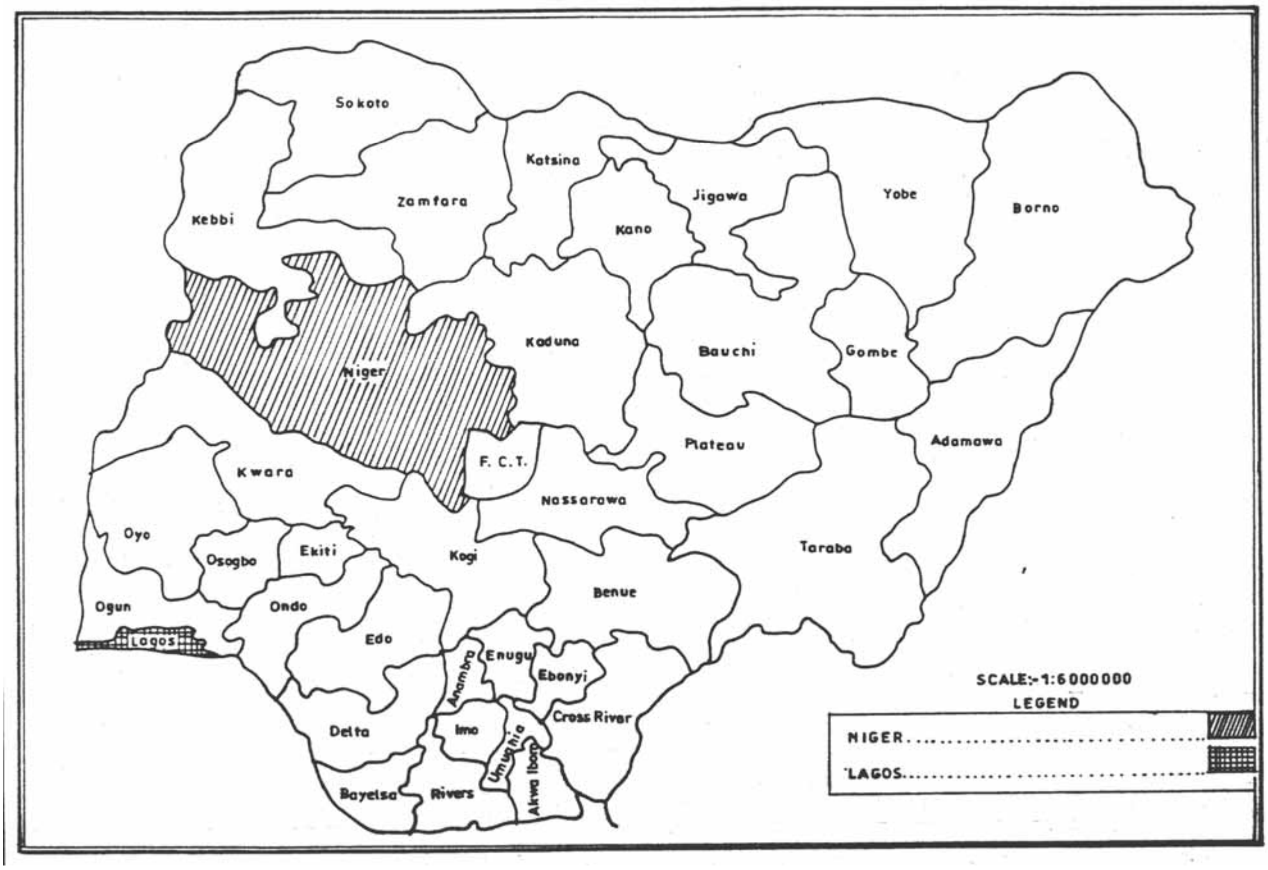


Figure 2.1: Map of Nigeria showing the study areas: Niger and Lagos states

Niger state is located between Latitudes 8^{o} 20’ N and 11^{o} 30’ N and Longitudes 3^{o} 30’ E and 7^{o} 20’ E. The state covers a total land area of 76,000 km^2 representing about 9% of Nigeria's total land area. This makes the state the largest in the country. According to 1991 census, Niger state has a population of 2 482 367 with a population density of 33 persons per sq km; the lowest in the country (NSMOI, 2003). There are three major ethnic groupings in the state. These include Nupes, Gwaris and Hausas.

Niger state is an inland region that has abundant fresh water resources. The state has numerous, large, perennial water bodies which include major rivers like Niger, Kaduna and Gurara (Figure 2.2) and three giant man–made lakes–Kainji, Jebba and Shiroro with an estimated water surface area of 436,196 ha (Azengi, 1995). Various forms of traditional aquaculture systems are practised in these fresh water bodies.

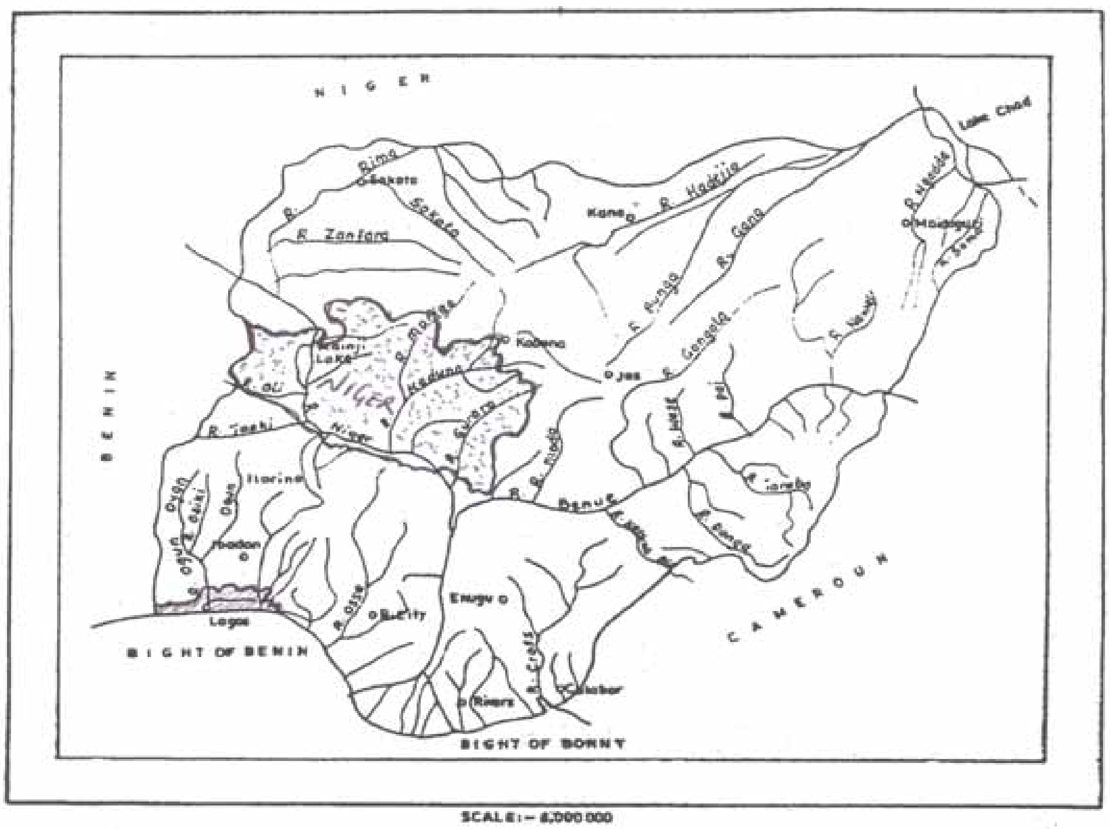


Figure 2.2: Map of Nigeria showing water resources in Niger and Lagos states

Lagos state is the smallest state in Nigeria and lies within Latitudes 6° 24' and 6° 31' N and Longitudes 3° 16' and 3° 27' E. Lagos state covers an area of 3577 km^2

representing 0.4% of Nigeria's land mass. According to 1991 census, the state has a total population of 5 725 116 out of national estimate of 88 992 220. Out of this population, Lagos metropolitan area is occupied by over 85% of the state population. It has the highest population density in Nigeria; being cosmopolitan and comprising of people from all parts of the world. The rate of population growth is about 300 000 persons per annum with a population density of about 1,308 persons per sq km (LSMOI, 1999). It is the commercial nerve centre of Nigeria accounting for over 50% of Nigeria industrial and commercial establishments.

Lagos state is endowed with enormous fresh water resources as well as coastline. The coastline is about 180 km bordering the Atlantic Ocean. There is also a network of Lagoon systems beginning with Badagry from the western end bordering Benin Republic through the Lagos and Epe Lagoon and finally to Lekki Lagoon at the eastern end (Figure 2.4). There are also numerous rivers; together with the flood plains, creeks and lagoons encompass an area of about 790 km^2 which is approximately 22% of the total area of Lagos state (Ajayi *et al*, 1990). Diverse traditional aquaculture systems also exist in these water bodies.

Within each state, five local government areas were selected on the basis of their proximity to main river system or lagoon, number of fish ponds, number of fish farmers and the importance of traditional aquaculture. In Niger state, the following local government areas were selected: Borgu, Katcha, Lavun, Magama and Mokwa (See Figure 2.3). The following were selected in Lagos state: Amuwo–Odofin, Badagry, Epe, Ibeju / Lekki and Lagos Mainland (See Figure 2.4).

The two states vary in size, population density and aquaculture systems and were selected to carry out a comparative study of traditional aquaculture in terms of (i) fish production (ii) cost and returns of fish production (iii) environmental impacts of the systems and (iv) socio–economic conditions of the farmers. In addition, a fish consumption survey was also carried out in order to compare fish consumption patterns in the fishing communities in the two states.

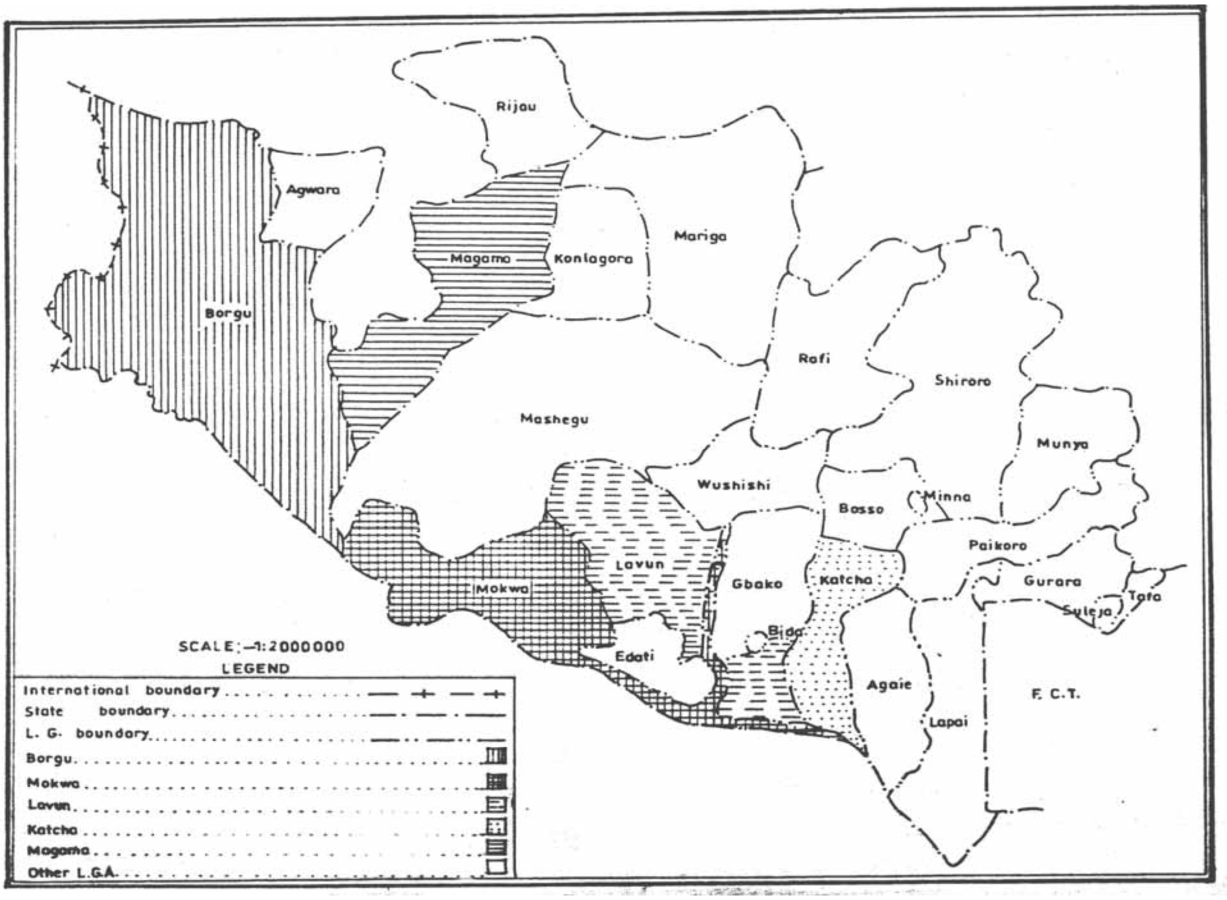


Figure 2.3: Map of Niger state showing the study areas.

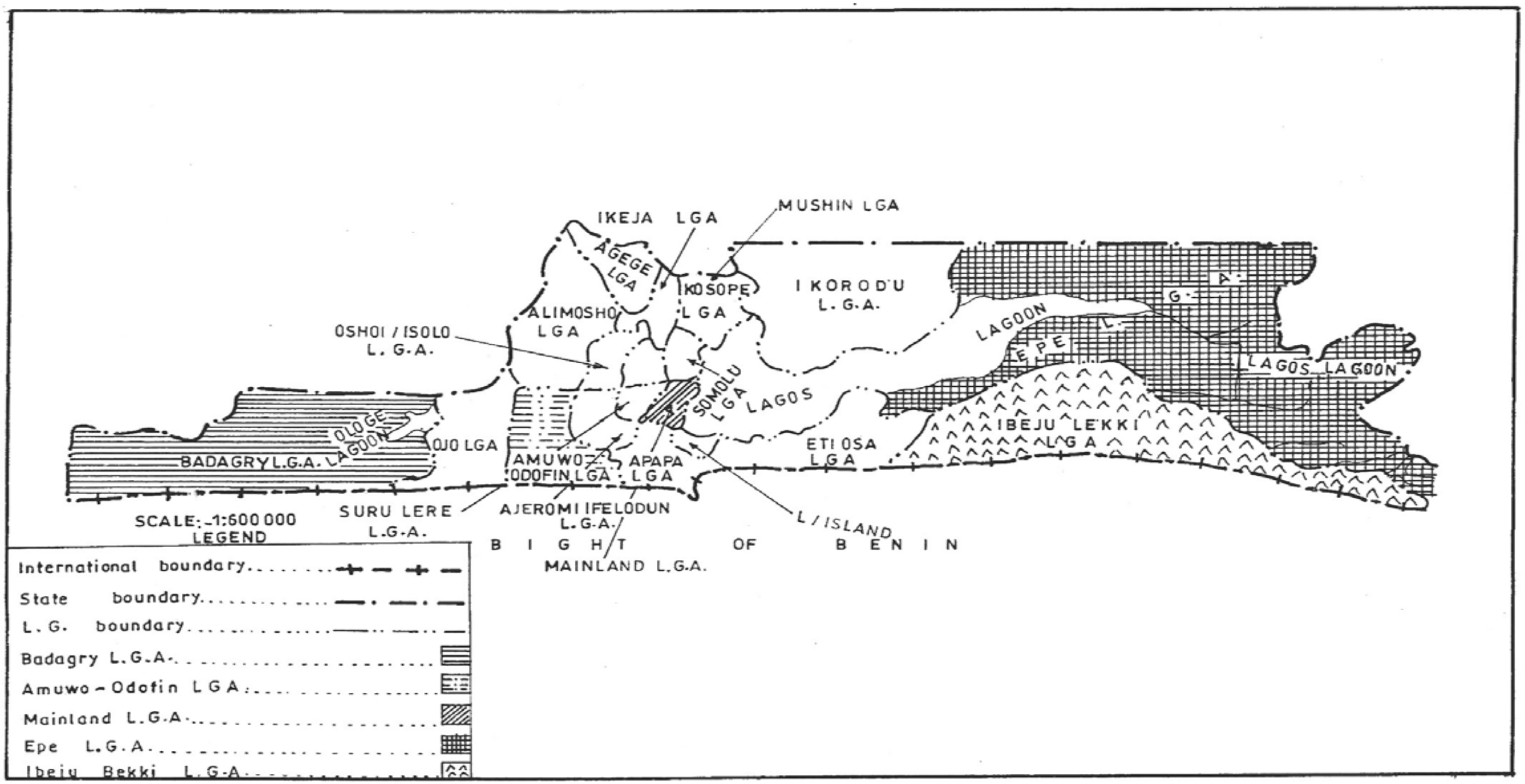


Figure 2.4 : Map of Lagos state showing study areas and lagoons.

2.3 Data collection process

Questionnaire interviews and Participatory Rural Appraisal (PRA) methodologies were used in collecting data from fish farmers.

2.3.1 Questionnaire interviews

Questionnaire survey research is the most popular social research method commonly used by universities and research institutions as well as government and non-governmental organisations (Haynes, 1982; Theis and Grady, 1991). According to these authors, it derives its popularity from its formal and standardised techniques, which produce quantifiable, representative, verifiable and comparable data, which can be statistically analysed.

Questionnaire interviews may either be structured or unstructured depending on the degree of standardisation imposed on the interview schedule. A highly structured interview is one where the questions asked and the responses permitted are pre–determined i.e. “closed”, while in a highly unstructured interview, the questions to be asked are only loosely pre–determined, and respondents are free to respond in their own words. In practice, the choice is not between these two extremes, but between many degrees of formality. Some researchers have advocated the semi–structured or focus interview, where questions are mainly open–ended, but in which closed questions can also be included (Maccoby and Maccoby, 1976).

For this study personal interview using semi–structured interview schedules were employed as the primary method of collecting data from fish farmers. The technique was preferred to others for the following reasons:

- It has higher response rates and permits the use of long and complex questionnaires.
- It enables the interviewer to explain, persuade, prompt and even probe.
- It enables the interviewer to spot insincere or careless responses, reduce the problem of semi-literate or foreign speaking respondents and use ancillary items such as photographs, sketches and prompt cards (Haynes, 1982).
- The personal face-to-face interview is deemed appropriate for studying in developing countries, where the level of education attained by most of the population is basic and clarifications of questions are necessary to obtain a complete response (Kholo, 1991).

Disadvantages of questionnaire interviews include:

- Higher cost. Interviews can be expensive to set up especially when respondents are widely dispersed geographically.
- Interview bias. Innate characteristics of interviews and differences in interview techniques may affect respondents' answers.
- Lack of anonymity. The presence of the interviewer may make the respondent feel threatened or intimidated.

2.3.2 Participatory Rural Appraisal

Participatory Rural Appraisal (PRA) is a specific form of Rapid Rural Appraisal (RRA), a research technique developed in the late 1970s and early 1980s by researchers in international development as a complementary alternative to conventional sample surveys (Theis and Grady, 1991).

Rapid Rural Appraisal (RRA) consists of a set of guidelines which help people to work in a structured but flexible way in rural communities and a set of tools to aid communication and interaction with those communities (Townsley, 1996). RRA according to the author consists of the following:

- It usually involves collecting information by talking to people "on the ground"
- It uses a set of guide lines on how to approach the collection of information, learning from that information and the involvement of local people in its interpretation and presentation
- It uses a set of tools- these consist of exercises and techniques for collecting information and means of organising that information so that it is easily understood by a wide range of people and provides methods for quickly analysing and reporting findings and suggesting appropriate action.

Participatory Rural Appraisal is an intensive, systematic but semi–structured learning experience carried in a community, and has a range of potential applications in aquaculture (Muir *et al*, 1999). Chambers (1992) stated that PRA is a group of methods used to collect information from rural communities in a participatory fashion. The advantage of the method is that it allows wider participation of the local people and enables them to present their own priorities and needs. Participatory Rural Appraisal technique was adopted because of the increasing recognition of the importance of local participation in development projects and the emphasis on learning from the people themselves.

Participatory Rural Appraisal methods usually rely upon the commitment and analysis of local people, enable the expression and sharing of their diverse and complex realities, give insights into their values, needs and priorities, and can also lead to participatory action (Guijit and Pretty, 1992). Townsley (1996) noted that PRA allows local people to present their priorities for development and get them incorporated into development plans. Where aquaculture is identified as a priority during the course of PRA, planners can be more certain that this respond to real need among local people, whether that is for increased income, better fish supply or intensive water use and management.

Participatory Rural Appraisal tools like transect walk and Focus Group Discussion (FGD) were used to get an overview of particular issues from the target groups. Transect walk is a data collection method which allows one to know about a village by walking through the village as far as practicable in a straight transect line, talking with villagers and through observation (Chambers, 1992). This enables the researcher to get a quick picture of farming areas and their systems. This method enables researchers to familiarise themselves with the research environment and also helps in establishing a rapport with farmers. Transect walks were carried out in two villages in each local government area in the two states. During the transect walk, various problems concerning the farming practices were discussed with the farmers.

In FGD, small groups of people who are knowledgeable or who are interested in the topics are invited to participate in a discussion. This allows the community to discuss the issues that they feel are important rather than responding to a questionnaire (Theis and Grady, 1991). Focus Group Discussions were held six times in each local government area. The FGD consisted of a minimum of six farmers and duration was approximately one hour. Theis and Grady (1991) noted that small groups of people of 6 to 12 are most suitable for focus group discussions.

In the present study, focus group interviews were used to get an overview of the aquaculture practices including social and economic conditions of the farmers. Focus Group Discussion was also used to assess consumption frequencies of fish species among the fish farmers. During each focus interview, respondents were asked to name the species they eat most, stating reasons. Where information was contradictory or required further assessment, interviews were crosschecked with key informants (fisheries experts).

2.4 Questionnaire design

Harmonised questionnaires were developed and implemented in all study sites. The questionnaires for fish farmers were divided into four sections which addressed:

- The issues of personal information
- Types of aquaculture systems
- Environmental impacts of aquaculture systems and
- Socio–economic conditions of the fish farmers.

Another questionnaire for research institutions and fisheries departments was related to the research status of traditional aquaculture systems in Nigeria (See Appendix for both).

Some questions in the questionnaires were open–ended while others were close questions with a number of alternative choices.

2.5 Pre–testing of questionnaire

Questionnaires were pilot tested with 40 fish farmers. The aim of the pilot test was to ensure that questions and issues regarding the subject of the study were included in the questionnaire and clear from ambiguities and that the respondents could answer the questions without significant constraint.

Some of the respondents, in the first instance, did not show any interest in taking part in the interview. They suspected me to be an employee or agent of tax office, police department or other government agency even though the interview was conducted in the presence of fisheries extension agent in charge of the area. They were suspicious about the identity of the researcher and were reluctant to talk unless with the intervention of the village head. This happened mainly with those who had no formal education. Co–operation from the village head was therefore sought, whenever possible, for interviewing these respondents and thereafter response was good.

Although, the reactions and responses of the farmers were generally positive, this was not always so when they were asked questions on costs, returns or incomes, with data supplied mainly from guess–work. Most of the farmers did not have any proper record of accounts and therefore great care had to be taken in compiling financial information.

It was also observed during the pre–testing that a few questions were not clearly understood by the respondents. Hence, some questions were dropped and a number of additional questions added. The sequence, phrasing and language of some questions were also changed.

2.6 Sampling

Cluster and stratified random sampling methods were adopted in this study. Cluster sampling is a simple random sampling in which each unit is a collection or cluster of elements. Cluster sampling is employed primarily:

- When no sampling frame is available for all units of the target population;
- When economic considerations are significant; and
- When cluster criteria are significant for the study (Sarantakos, 1998).

Characteristic of this sampling method is that first group of elements (clusters) are selected (schools, classes, local governments, etc.) and then individual elements are selected from these clusters. To choose the clusters and the respondents from the clusters a simple random sample method can be employed (Sarantakos, 1998). Cluster sampling was used in this study because no sampling frame was available for all units of the target population and also due to financial constraint.

In stratified random sampling, the population to be surveyed is divided into groups with similar attributes. Within these defined strata, random selection takes place, and provided this is done correctly, stratified random sampling tends to be more accurate than simple random sampling (Chisnall, 1997). A stratified sample is employed when there is a need to represent all groups of the target population in the sample, and when the researcher has a special interest in certain strata (Sarantakos, 1998). This method was used because there was need to represent the different aquaculture systems in the study.

There are two methods used to stratify samples: with uniform sampling fraction (proportionate) or with variable sampling fraction (optimal or disproportionate). Uniform sampling fraction (proportionate) occurs when equal proportions are sampled from each stratum and variable sampling fraction (disproportionate or optimal) occurs when larger proportions are taken from one stratum than from another according to the variability existing within the strata (Chisnall, 1997). According to the author, the method is useful where considerable variation occurs between strata or when some strata contain only a small number of sampling units. In the current study, disproportionate stratified random sampling was adopted.

A list of fish farmers in each local government area of the two states was prepared and 40 fish farmers selected in a random, stratified manner to cover farmers with fish ponds, fish shelters and fish fences. This type of sampling gives all units of the target population an equal chance of being selected (Sarantakos, 1998). In each local government area, questionnaires were administered to one farmer with fish pond, 30 to people with fish shelters and nine to people with fish fences making a total of 40. Questionnaire was administered to one fish farmer because in some local government areas only one fish pond was present and 30 to people with fish shelters because of variations in the fish shelters. Fish shelters in this study consisted of fish parks, pot traps and tube shelters (bamboo poles / PVC pipes).

The total study sample size (n) used for this study was 400. The sample size (n) was derived as follows:

$n = pqZ^2 / E^2$

Where:

p = Population estimate

q = Derived by subtracting p from 100 (p+q= 100)

Z = Confidence level (95%) (Z is given in the probabilities table of the standard normal distribution, 1.96) and

E = Denotes maximum deviation from true proportions that can be tolerated in the study (Sarantakos, 1998).

$p = 50$, $q = 50$ (100-50), $Z = 1.96$, $E = 4.9$

$n = 50 \times 50 \times (1.96)^2 / (4.9)^2 = 2500 \times 3.8416 / 24.01 = 9604 / 24.01 = 400$

2.7 Household fish and meat consumption

2.7.1 Household selection

Households were selected in local government areas that were used for questionnaire survey to compare fish and meat consumption patterns in fishing communities in Niger and Lagos states (Figure 2.1). Cluster and stratified random sampling methods were used.

Households were grouped by primary occupation of heads of households and those stating fishing as being their primary occupation were classified fishing households. A total of fifty fishing and fifty non–fishing households in fishing communities in Niger and Lagos states were selected in a random, stratified manner. These households were randomly selected from five fishing villages in Niger and Lagos states. In each village, five fishing and five non–fishing households were randomly selected for the study. The sampling strategy is outlined in Figure 2.5. In each household, age of members of household, family size, income and religion of head of household were recorded.

Sample size (n) = 100. Sample size was calculated as follows:

$n = pqZ^2 / E^2$

Where:

$p = 50$, $q = 50(100-50)$, $Z = 1.96$, $E = 9.8$

$n = 50 \times 50 \times (1.96)^2 / (9.8)^2 = 2500 \times 3.8416 / 96.04 = 9604 / 96.04 = 100$

The 100 households comprised of 50 fishing and 50 non–fishing households.

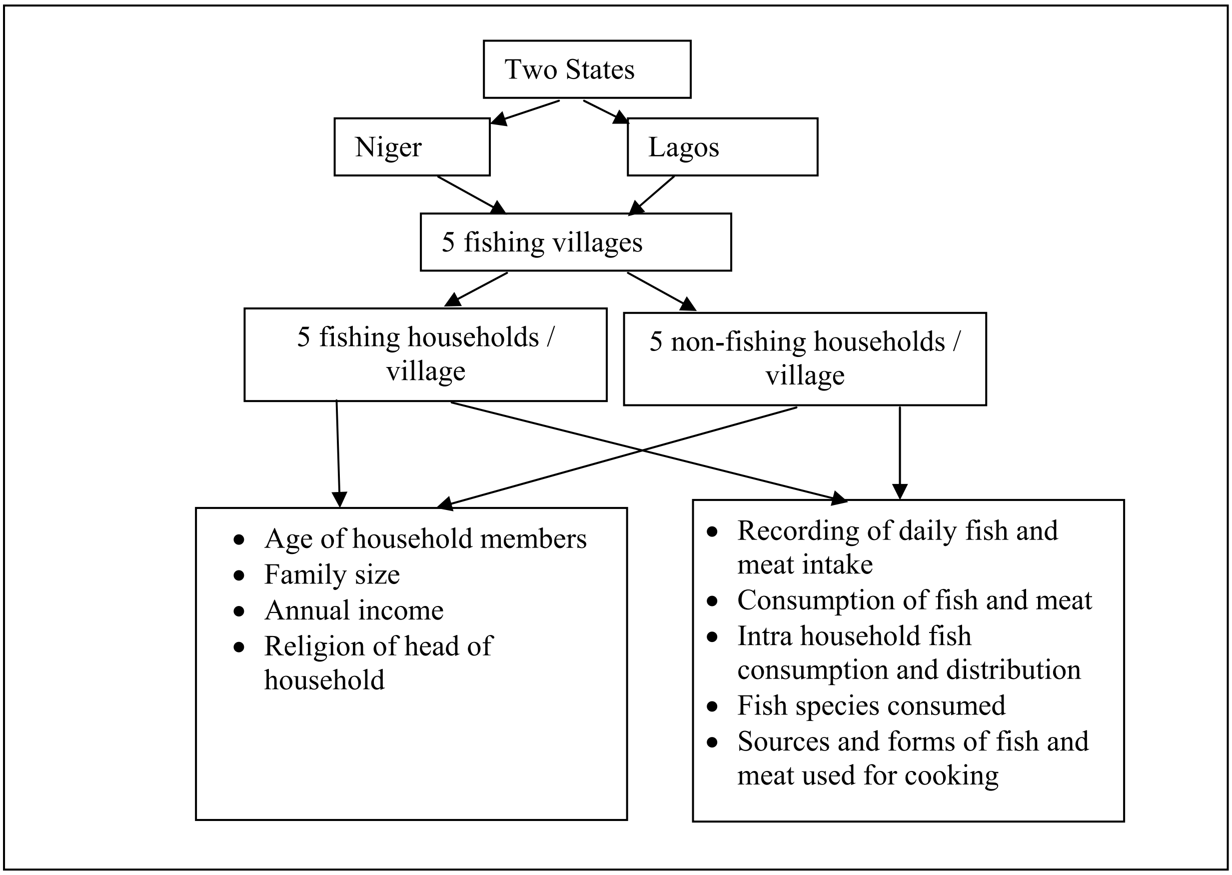


Figure 2.5: Sampling strategy employed in fish and meat consumption study

2.7.2 Recording of daily household fish and meat intake

In order to obtain quantifiable information on consumption, a simple field balance utilising dry sand and stones for weights was designed (Figure 2.6a). Each household was given the balance to measure the weights of fish or meat entering the house for consumption. The procedure for weighing and measuring fish and meat is illustrated in Figure 2.6. The fish to be weighed was kept on one side of the scale (Figure 2.6b) and then balanced with locally sourced stones and dry sand (Figure 2.6c). After balancing items with the stones and the dry sand (Figure 2.6d), the sand and stones were transferred and stored in labelled polythene bag (Figure 2.6e). If two or more species of fish were eaten, the species were weighed separately. The stones and sand that balanced the weights of the different species of fish together with species names were kept in different labelled polythene bags.

The polythene bags were then tied and kept in a larger polythene bag. The consumption of meat was estimated in a similar manner. The stones and the dry sand were measured during visits by extension agent using actual calibrated kitchen scale (Figure 2.6f). The weight of the stones and sand gave the weight of the fish eaten by the household the previous day and the fish species recorded. Fish or meat intake was recorded daily for seven months beginning from January to July, 03.

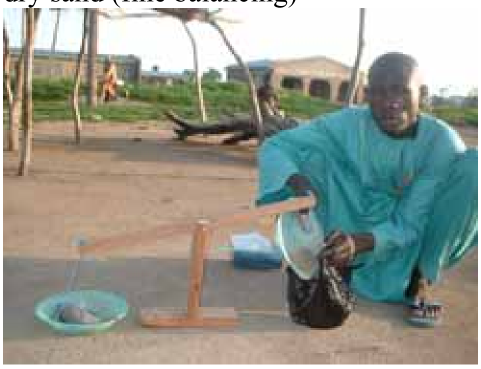
Although this method is tedious and demanding on the part of household and extension agents, it provides more meaningful results than the commonly used recall method. Recall method is mainly based on guess work. This method was developed to obtain more accurate data from members of households that do not have formal education to use actual scale and to reduce cost of operation. However, the success of this method does depend on the co–operation of the households and extension agents.

(a) Simple scale (Design concept = K.Rana)

(b) Fish on one side of scale

(c) Member of household balancing fish with locally sourced stones (coarse balancing) and dry sand (fine balancing)

(d) Balanced scale with stones and dry sand



(e) Stones and dry sand being put in labelled polythene bag

(f) Extension agent measuring stones and dry sand with actual scale at the time of visit

Figure 2.6: Procedure for measuring fish and meat using simple balance.

2.7.3 Intra household fish consumption and distribution

Twenty-four hour recall method was used to obtain the size of fish eaten by individual members within each household. Fish samples were shown to the members of the household and asked to pick the fish similar in size to the one he / she ate the previous day. The fish was then weighed and recorded as that eaten by him / her, and if recorded, used to verify with data collected the previous day. In some cases, the wife who cooked and distributed the fish was asked to pick the fish similar in size to the one she gave to the head of household, women and children. The fish was then weighed and recorded as that eaten by them. They were also asked to recall the parts of fish eaten and the parts thrown away. Information on the form the fish was used for cooking (fresh, smoked or dried), source of the fish (River, lagoon, sea or market) and the price of fish, if bought, was also obtained by 24 hr recall method. The data was obtained daily for seven months beginning from 2nd January to 1st August, 03.

2.8 Survey of fish and meat market prices

Retail price of fish per kg in two markets in Niger and Lagos states was surveyed for one year from January to December, 03. The prices were collected twice a month. Retail prices of meats were also collected in two local markets in the two states.

2.9 Data analysis

2.9.1 Questionnaire data

Questionnaire data was edited, coded, entered into Microsoft Excel spreadsheet and analysed using Computer software package SPSS 11.5 for Windows (Statistical Package for Social Scientists). Descriptive statistics used were frequency, percentages, mean and standard deviation. Tables and bar charts were also used. Independent samples t–test was used to compare the means of two independent samples and one way analysis of variance (ANOVA) for more than two independent samples for test of significance. These tests assume normality, when this was not the case non-parametric tests like Mann–Whitney U and Kruskal–Wallis H were used for two independent and more than two independent samples, respectively. Chi square (χ^2) was used to investigate the significant relationships between pairs of categorical variables. Relationships between pairs of quantitative variables were tested using correlation.

2.9.2 Fish and meat consumption

General Linear Model (GLM) was used to analyse fish consumption to establish significant ($p < 0.05$) differences in monthly fish consumption in fishing and non-fishing households in fishing communities in Niger and Lagos states. GLM was used because the data was quantitative and because the effect of many factors was examined. Analysis was performed using Minitab software (version 14.12) because it allows the use of multiple comparisons to identify where significant differences exist. This analysis assumes that the data is normally distributed; when this was not the case the data was transformed to ensure that the analysis was valid. Natural log and square root transformations were tried. Square root transformation gave better results and was therefore used for the analysis.

Consumption of meats, amount of money spent on buying fish and meats were analysed using the same model. Intra household fish consumption was analysed by replacing occupation in the model by member. The model used in the analysis is explained below.

Time + Time* State + Time* lga + Time* Occup + Time* State* Occup + Time* lga* Occup + State + lga(State) + Occup + State* Occup + lga*Occup + Household(State lga Occup).

Where:

Time = months (Jan - July), state = Niger and Lagos, Occup = Fishing and non-fishing, lga = Local government area (L.G.A), * represents the interaction between the factors, lga(state) = L.G.A nested within state, Household(state lga Occup) = Household nested within state, L.G.A and occupation. Months, state, occupation and L.G.A were fixed factors while household was random.

Tables, bar charts, line graphs and Pearson correlation were also used in the analysis of fish and meat consumption.

Chapter 3: Current practices of aquaculture systems in two states in Nigeria

3.1 Introduction

A number of aquaculture practices are employed world–wide in three types of environment (freshwater, brackish water and marine) for a great variety of culture organisms. Freshwater aquaculture is carried out either in fish ponds, fish pens, fish cages or, on a limited scale, in rice paddies. Brackish water aquaculture is done mainly in fish ponds located in coastal areas. Marine culture employs either on shore pumped system fish cages or substrates for molluscs and seaweeds such as stakes, ropes, and rafts (Baluyut, 1989). Aquaculture covers a wide range of species and methods. Culture systems range from extensive to intensive depending on the stocking density of the culture organisms, the level of inputs and the degree of management.

The type and intensity of farming depends on the species and on the final consumer preferences (Weber, 2003). For instance, the feeding behaviour of a species greatly influences the method of farming. Mussels and Oysters, which feed on plankton and organic particles in the surrounding water, are grown on the bottom or on suspended ropes or racks (Naylor *et al*, 2000). Carps which feed principally on plants or plants and invertebrates, are grown in ponds, whose waters are fertilised, sometimes with wastes from other activities such as agriculture, to increase the production of plants in the ponds. Most marine fish, including salmon, are raised in net pens in coastal waters and are fed on pellets manufactured from forage fish, such as anchovies and herring (Weber, 2003). The type of final consumer also determines the species and often the type and intensity of farming method. For instance, most aquaculture in developing countries aims at the production of food for household consumption and local markets in the rural economies (Naylor *et al*, 2000). According to these authors, aquaculture in developed countries aims at generating profits from producing moderate – to high – value species for urban or foreign markets, and relies on intensive, high – production forms of aquaculture that require high levels of chemical, energy, and other inputs.

Most global production is based predominantly on semi – intensive and extensive systems, and on culture based fisheries, producing affordable finfish for domestic rural markets and subsistence (Tacon *et al*, 1995; Barg and Phillips, 1997). Traditional aquaculture systems that are extensive systems of fish production utilise simple technologies and minimal inputs, and have been used for centuries in Africa. The net contribution of these traditional aquaculture systems can be high as they offer many benefits, including food security in developing nations (White *et al*, 2004). These systems benefit local communities and at minimal cost to the environment. Aquaculture and capture fisheries provide food, fish oil, and other products used in manufacturing, food processing, pharmaceuticals, and other products (Weber, 2003).

The objectives of this study were to:

1) Examine the different types of aquaculture systems in two states in Nigeria, Niger and Lagos

2) Assess the environmental impacts of fish ponds, fish shelters and fish fences in Niger and Lagos states

3) Identify the problems in fishing / fish farming in the two states

4) Assess fish and meat preferences among farmers in Niger and Lagos states.

3.2 Materials and methods

Materials and methods used in this chapter are given in the general materials and methods section (2.3 to 2.6).

3.3 Results

3.3.1 Types of aquaculture systems

Aquaculture systems currently practised in two states in Nigeria include fish ponds, fish shelters and fish fences. About 75% of the farmers had fish shelters, 23% had fish fences and only 3% had fish ponds (Table 3.1).

Table 3.1: Types of aquaculture systems in Niger and Lagos states

Aquaculture system	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Fish pond	5 (3)	5 (3)	10 (3)
Fish shelter	150 (75)	150 (75)	300 (75)
Fish fence	45 (23)	45 (23)	90 (23)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

3.3.1.1 Fish pond

3.3.1.1.1 Pond size

Average size of pond in the study area was 0.1 ha. Average pond size was the same in Niger and Lagos state (Table 3.2). Average pond size ranged from 0.01 to 0.40 ha. No statistical analysis was done for all the data on fish pond because the sample size was small as a result of few number of fish ponds in the study area.

Table 3.2: Pond size (hectare) in Niger and Lagos states

Pond size (ha)	State		Average total
	Niger n = 5	Lagos n = 5	n = 10
	0.1 ±0.3	0.1 ±0.1	0.1 ±0.2

Data is presented as mean ± standard deviation. n indicates sample size

3.3.1.1.2 Pond preparation

About 80% of the farmers in Niger and 60% in Lagos state applied fertiliser to ponds before stocking (Table 3.3). All the farmers with large sized ponds (> 0.08 ha) applied fertiliser before stocking (Table 3.4).

Table 3.3: Pond preparation by state

Pond preparation	State		Total
	Niger n = 5	Lagos n = 5	n = 10
No pond Preparation	0 (0)	1 (20)	1 (10)
Allowing the pond to dry	1 (20)	1 (20)	2 (20)
Applying fertiliser	4 (80)	3 (60)	7 (70)

n = sample size. Figures in brackets indicate percentages.

Of 10 farmers with fish ponds, six (60%) cultured tilapia sp and *Clarias gariepinus*, two (20%) cultured tilapia sp. and *Chrysichthys nigrodigitatus*, one (10%) cultured tilapia sp, *C. gariepinus* and *Heteroitis niloticus* and one farmer (10%) cultured only *C. gariepinus*. Nine of the farmers (90%) practised polyculture and only one farmer (10%) practised monoculture.

Table 3.4: Pond preparation by pond size category

Pond preparation	Size category			Total
	Small (< 0.04 ha) n = 3	Medium (0.04 – 0.08 ha) n = 5	Large (> 0.08 ha) n = 2	n = 10
No pond preparation	0 (0)	1 (20)	0 (0)	1 (10)
Allowing the pond to dry	1 (33)	1 (20)	0 (0)	2 (20)
Applying fertiliser	2 (67)	3 (60)	2 (100)	7 (70)

n = sample size. Figures in brackets indicate percentages.

3.3.1.1.3 Stocking density

Stocking density was higher in Niger than Lagos state (Table 3.5).

Table 3.5: Stocking density per ha by state

Stocking density	State		Average total
	Niger n = 5	Lagos n = 5	n = 10
	6271 ±10659	5189 ±4154	5730 ±7648

Data is presented as mean ± standard deviation. n indicates sample size.

Stocking density was found to increase with pond size (Table 3.6). Overall average stocking density was 5730 ha^{-1}.

Table 3.6: Stocking density per ha by pond size category

Stocking density	Size category			Average total
	Small (< 0.04) n = 3	Medium (0.04 – 0.08) n = 5	Large (> 0.08) n = 2	n = 10
	451 ±491	3789 ±1793	18500 ±9192	5730 ±7648

Data is presented as mean ± standard deviation. n indicates sample size.

3.3.1.1.4 Frequency of changing water from pond

About 80% of the farmers in Niger and 60% in Lagos state did not change water from ponds (Table 3.7).

Table 3.7: Frequency of changing water from pond per crop by state

Frequency	State		Total
	Niger n = 5	Lagos n = 5	n = 10
Did not change water	4 (80)	3 (60)	7 (70)
Twice	1 (20)	1 (20)	2 (20)
Thrice	0 (0)	1 (20)	1 (10)

n = sample size. Figures in brackets indicate percentages.

All the farmers with large sized ponds changed water from ponds two or three times per crop. Those with small sized ponds did not change water from ponds (Table 3.8). Of the three farmers who changed water from ponds (Table 3.7), one farmer discharged the water to lagoon and two to irrigation farms. The farmers reported that they changed the water when they considered it to be polluted.

Table 3.8: Frequency of changing water from pond per crop by pond size category

Frequency	Size category			Total
	Small (< 0.04 ha)	Medium (0.04 – 0.08 ha)	Large (> 0.08 ha)	
	n = 3	n = 5	n = 2	n = 10
Did not change water	3 (100)	4 (80)	0 (0)	7 (70)
Twice	0 (0)	1 (20)	1 (50)	2 (20)
Thrice	0 (0)	0 (0)	1 (50)	1 (10)

n = sample size. Figures in brackets indicate percentages.

3.3.1.1.5 Integrated fish farming

About 80% of the farmers in Lagos and 60% in Niger state did not grow fish with other crops (Table 3.9).

Table 3.9: Integrated fish farming by state

Integration	State		Total
	Niger	Lagos	
	n = 5	n = 5	n = 10
Yes	2 (40)	1 (20)	3 (30)
No	3 (60)	4 (80)	7 (70)

n = sample size. Figures in brackets indicate percentages.

All the farmers with large sized ponds did not grow fish with other crops (Table 3.10). Banana was the only crop farmers planted around their ponds.

Table 3.10: Integrated fish farming by pond size category

Integration	Size category			Total
	Small (< 0.04 ha)	Medium (0.04 – 0.08 ha)	Large (> 0.08 ha)	
	n = 3	n = 5	n = 2	n = 10
Yes	1 (33)	2 (40)	0 (0)	3 (30)
No	2 (67)	3 (60)	2 (100)	7 (70)

n = sample size. Figures in brackets indicate percentages.

Higher yield of banana (105 kg ha^{-1}) was recorded in Lagos state. Yields of 50 and 70 kg ha^{-1} were recorded in Niger state (Table 3.11).

Table 3.11: Yield of banana (kg ha $^{-1}$ yr $^{-1}$) by state

Yield (kg)	State		Total
	Niger	Lagos	
	n = 2	n = 1	n = 3
50	1 (50)	0 (0)	1 (33)
70	1 (50)	0 (0)	1 (33)
105	0 (0)	1 (100)	1 (33)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Yield of banana by pond size category is given in Table 3.12. Yield of banana was found to increase with pond size.

Table 3.12: Yield of banana (kg ha $^{-1}$ yr $^{-1}$) by pond size category

Yield (kg)	Size category		Total
	Small (< 0.04 ha)	Medium (0.04 – 0.08 ha)	
	n = 1	n = 2	n = 3
50	1 (100)	0 (0)	1 (33)
70	0 (0)	1 (50)	1 (33)
105	0 (0)	1 (50)	1 (33)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Of 10 farmers with fish ponds, seven (70%) produced fish only once in a year with a culture duration of twelve months and three (30%) produced twice a year with a culture duration of six months. All the farmers with fish ponds in Niger and 80% in Lagos state obtained their seeds from government hatcheries. Only one fish farmer (20%) in Lagos state obtained seeds from the wild.

3.3.1.1.6 Frequency of buying fish seeds

All the farmers in Niger and 40% in Lagos state bought fingerlings only once in a year. About 60% of the farmers in Lagos state bought seeds twice in a year (Table 3.13).

Table 3.13: Frequency of buying fish seeds per year by state

Frequency	State		Total
	Niger	Lagos	
	n = 5	n = 5	n = 10
Once	5 (100)	2 (40)	7 (70)
Twice	0 (0)	3 (60)	3 (30)

n = sample size. Figures in brackets indicate percentages.

Frequency of buying seeds by pond size category is presented in Table 3.14. All the farmers with small sized ponds bought seeds only once in a year.

Table 3.14: Frequency of buying fish seeds per year by pond size category

Frequency	Size category			Total
	Small (< 0.04 ha)	Medium (0.04 – 0.08 ha)	Large (> 0.08 ha)	
	n = 3	n = 5	n = 2	n = 10
Once	3 (100)	3 (60)	1 (50)	7 (70)
Twice	0 (0)	2 (40)	1 (50)	3 (30)

n = sample size. Figures in brackets indicate percentages.

3.3.1.1.7 Fish production from fish ponds

Mean production of fish from ponds in Niger and Lagos states is given in Table 3.15. Mean production of fish in Niger and Lagos state were 585 and 510 kg ha^{-1} yr^{-1}, respectively.

Table 3.15: Mean production of fish from fish ponds by state

Fish production	State		Average total
(kg ha^{-1} yr^{-1})	Niger n = 5	Lagos n = 5	n = 10
	585±812	510±55	548±544

Data is presented as mean ± standard deviation. n indicates sample size

Mean production of fish from ponds ranged from 0.14 to 1.25 t ha^{-1} $yr^{-1}$with an overall mean of 0.55 t ha^{-1} yr^{-1} (55 kg / pond / year) (Table 3.16).

Table 3.16: Mean production of fish from ponds by pond size category

Fish production (kg ha^{-1} yr^{-1})	Size category			Average total
	Small (< 0.04) n = 3	Medium (0.04 – 0.08) n = 5	Large (> 0.08) n = 2	n = 10
	142±142	510±55	1250±1060	548±544

Data is presented as mean ± standard deviation. n indicates sample size

(a) Earthen fish pond in Lagos state

(b) Concrete fish pond in Niger state

Figure 3.1: Fish ponds

3.3.1.2 Fish shelters

Fish shelters are aquaculture systems that provide habitats for fish. Fish enters them in search of shelter or hiding place. Results showed that only Nigerian Institute for Oceanography and Marine Research (NIOMR) has conducted a research on brush parks in Nigeria. Lack of funds was identified as the problem hindering research in the area of traditional aquaculture systems in Nigeria.

Types of fish shelters currently practised in two states in Nigeria are presented in Table 3.17. All the farmers in Niger and 67% in Lagos state had fish parks. There was a significant ($\chi^2 = 60$, d.f. = 2, $p < 0.001$) relationship between types of fish shelters and state, with farmers only in Lagos state using clay pots (17%) and hollow bamboo / PVC pipes (17%).

Table 3.17: Types of fish shelters in Niger and Lagos states

Type	State		Total
	Niger n = 150	Lagos n = 150	n = 300
Fish parks (*acadjas*)	150 (100)	100 (67)	250 (83)
Clay pot (*ikoko*)	0 (0)	25 (17)	25 (8)
Hollow bamboo / PVC pipes (*iho*)	0 (0)	25 (17)	25 (8)

n = sample size. Figures in brackets indicate percentage. Percentages have been rounded up.

Farmers provided different reasons for constructing fish shelters and these reasons differed significantly (χ^2 = 63, d.f. =1, p < 0.001) between states (Table 3.18). About 89% of the farmers in Niger constructed fish shelters in order to aggregate fish as compared with 47% for Lagos state. Only farmers (33%) in Lagos state constructed fish shelters in order to trap fish (Table 3.18).

Table 3.18: Reasons for constructing fish shelters in Niger and Lagos states

Reason	State		Total
	Niger n = 150	Lagos n = 150	n = 300
To aggregate fish	134 (89)	70 (47)	204 (68)
To provide shelters for fish	15 (10)	26 (17)	41 (14)
To provide breeding grounds for fish	1 (1)	4 (3)	5 (2)
To trap fish	0 (0)	50 (33)	50 (17)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. The last three rows were combined for the purpose of statistical analysis.

3.3.1.2.1 Fish parks

3.3.1.2.1.1 Types of fish parks

There were two main types of fish parks: brush and vegetation parks (Table 3.19). Fish parks differed significantly (p < 0.001) between states. All the farmers in Niger had brush parks as compared with 90% for Lagos state. Only farmers (10%) in Lagos state had vegetation parks (Table 3.19).

Table 3.19: Types of fish parks by state

Type of fish park	State		Total
	Niger n = 150	Lagos n = 100	n = 250
Brush park	150 (100)	90 (90)	240 (96)
Vegetation park	0 (0)	10 (10)	10 (4)

n = sample size. Figures in brackets indicate percentages.

About 99% of the farmers with small sized fish parks had brush parks and only one percent had vegetation parks (Table 3.20).

Table 3.20: Types of fish parks by size category

Type of fish park	Size category			Total
	Small (< 0.04 ha) n = 102	Medium (0.04 – 0.08 ha) n = 81	Large (> 0.08 ha) n = 67	n = 250
Brush park	101 (99)	78 (96)	61 (91)	240 (96)
Vegetation park	1 (1)	3 (4)	6 (9)	10 (4)

n = sample size. Figures in brackets indicate percentages.

(a) Vegetation park in Lekki Lagoon, Lagos.

(b) Brush park made of palm fronds in Badagry creek, Lagos

(c) Brush park made of tree (*Kate*) branches in Lagos

(d) Brush park made of tree branches (*Mitragyna inermis*) in Niger state

Figure 3.2: Types of fish parks in Niger and Lagos states

3.3.1.2.1.2 Size of fish parks

There was a significant ($p < 0.001$) difference in fish park size between Niger and Lagos state. The size of fish parks was higher in Lagos than Niger state (Table 3.21).

Table 3.21: Average size of fish parks (hectare) by state

Size (ha)	State		Average total
	Niger n = 150	Lagos n = 100	n = 250
	0.1 ±0.1[a]	0.2 ±0.3[b]	0.1 ±0.3

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

Average size of fish parks ranged from 0.02 to 0.4 ha (Table 3.22).

Table 3.22: Average size of fish parks (hectare) by size category

Size (ha)	Size category			Average total
	Small (< 0.04) n = 102	Medium (0.04 – 0.08) n = 81	Large (> 0.08) n = 67	n = 250
	0.02 ±0.01[a]	0.05 ±0.01[a]	0.40 ±0.37[b]	0.13 ±0.25

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

3.3.1.2.1.3 Shape of fish parks

About 57% of the farmers in Lagos and 54% in Niger state had circular fish parks (Table 3.23). Shape of fish parks was not significantly ($\chi^2 = 0.2$, d.f. = 1, $p = 0.640$) related to state.

Table 3.23: Shape of fish parks by state

Shape of fish park	State		Total
	Niger n = 150	Lagos n = 100	n = 250
Rectangular	69 (46)	43 (43)	112 (45)
Circular	81 (54)	57 (57)	138 (55)

n = sample size. Figures in brackets indicate percentage.

About 96% of the small sized fish parks were circular in shape and only 4% were rectangular (Table 3.24). About 91% of the large sized fish parks were rectangular and only 9% were circular. Shape of fish parks was significantly ($\chi^2 = 133$, d.f. = 2, $p < 0.001$) related to size, with large sized fish parks being rectangular in shape.

Table 3.24: Shape of fish parks by size category

Shape of fish park	Size category			Total
	Small (< 0.04 ha) n = 102	Medium (0.04 – 0.08 ha) n = 81	Large (> 0.08 ha) n = 67	n = 250
Rectangular	4 (4)	47 (58)	61 (91)	112 (45)
Circular	98 (96)	34 (42)	6 (9)	138 (55)

n = sample size. Figures in brackets indicate percentages.

3.3.1.2.1.4 Fish park construction materials

Types of materials used for constructing fish parks differed significantly ($\chi^2 = 250$, d.f. = 2, $p < 0.001$) between states (Table 3.25). All the farmers in Niger only used *Mitragyna inermis* to construct fish parks while 79% of the farmers in Lagos state used palm fronds.

Table 3.25: Types of materials used for constructing fish parks by state

Material	State		Total
	Niger n = 150	Lagos n = 100	n = 250
Palm fronds	0 (0)	79 (79)	79 (32)
Mitragyna inermis	150 (100)	0 (0)	150 (60)
Mangroves	0 (0)	11 (11)	11 (4)
Elephant grasses	0 (0)	10 (10)	10 (4)

n = sample size. Figures in brackets indicate percentages. The last two rows were combined for the purpose of statistical analysis.

(a) *Mitragyna inermis*

(b) *Gardenia* sp

Figure 3.3: Types of trees used in brush park construction in Niger state

About 69% of the farmers with small sized fish parks used *Mitragyna inermis*, 29% used palm fronds and only 2% used mangroves and elephant grasses (Table 3.26). There was a significant ($\chi^2 = 18$, d.f. = 4, p = 0.001) relationship between materials used for constructing fish parks and size of fish parks, with greater number of farmers with small sized fish parks using *Mitragyna inermis*.

Table 3.26: Types of materials used for constructing fish parks by size category

Material	Size category			Total
	Small (< 0.04 ha) n = 102	Medium (0.04 – 0.08 ha) n = 81	Large (> 0.08 ha) n = 67	n = 250
Palm fronds	30 (29)	27 (33)	22 (33)	79 (32)
Mitragyna inermis	70 (69)	48 (59)	32 (48)	150 (60)
Mangroves	1 (1)	3 (4)	7 (10)	11 (4)
Elephant grasses	1 (1)	3 (4)	6 (9)	10 (4)

n = sample size. Figures in brackets indicate percentages. The last two rows were combined for the purpose of statistical analysis.

3.3.1.2.1.5 Production cycle of fish parks

There were significant ($\chi^2 = 17$, d.f. = 2, p < 0.001) differences in production cycles of fish parks between Niger and Lagos state. About 69% of the farmers in Niger state constructed fish parks three times in a year as compared with 60% for Lagos state (Table 3.27).

Table 3.27: Fish park production cycles per year by state

Production cycle	State		Total
	Niger n = 150	Lagos n = 100	n = 250
Once	17 (11)	31 (31)	48 (19)
Twice	26 (17)	8 (8)	34 (14)
Thrice	104 (69)	60 (60)	164 (66)
Four times	3(2)	1 (1)	4 (2)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. Second and fourth rows were combined for the purpose of statistical analysis.

Production cycle of fish parks was significantly (χ^2 = 155, d.f. = 4, p < 0.001) related to size of fish parks, with greater number of farmers (96%) with small sized parks constructing fish parks three times in a year (Table 3.28). About 64% of the farmers with large sized parks constructed fish parks once in a year as compared with 5% for medium and 1% for small sized fish parks.

Table 3.28: Fish park production cycles per year by size category

Production cycle	Size category			Total
	Small (< 0.04 ha) n = 102	Medium (0.04 – 0.08 ha) n = 81	Large (> 0.08 ha) n = 67	n = 250
Once	1 (1)	4 (5)	43 (64)	48 (19)
Twice	0 (0)	21 (26)	13 (19)	34 (14)
Thrice	98 (96)	56 (69)	10 (15)	164 (66)
Four times	3 (3)	0 (0)	1 (1)	4 (2)

n = sample size. Figures in brackets indicate percentages. Second and fourth rows were combined for the purpose of statistical analysis.

3.3.1.2.1.6 Fish park installation period before harvest

Installation period of fish parks before harvest was significantly (p = 0.039) higher in Lagos than Niger state (Table 3.29) but in practice an average difference of one month is unlikely to be important.

Table 3.29: Fish park installation period before harvest by state

Installation period (Months)	State		Average total
	Niger n = 150	Lagos n = 100	n = 250
	5 ±3[a]	6 ±3[b]	6 ±3

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

Installation period of fish parks before harvest differed significantly ($p < 0.001$) among the size categories. Installation period was found to increase with size of fish parks (Table 3.30).

Table 3.30: Fish park installation period before harvest by size category

Installation period (Months)	Size category			Average total
	Small (< 0.04) n = 102	Medium (0.04 – 0.08) n = 81	Large (> 0.08) n = 67	n = 250
	4 ±1[a]	5 ±2[a]	9 ±3[b]	6 ±3

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

3.3.1.2.1.7 Number of branches used per unit area in brush park construction

Number of branches used per unit area in Niger and Lagos states is given in Table 3.31. There was no significant ($t = 0.427$, d.f. = 238, $p = 0.670$) difference in number of branches used per m^2 in the construction of brush parks between the two states.

Table 3.31: Number of branches used per m^2 in the construction of brush parks by state

Number (m^{-2})	State		Average total
	Niger n = 150	Lagos n = 90	n = 240
	4 ±1[a]	4 ±1[a]	4 ±1

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

There was no significant ($F = 2$, d.f. = 2, 237, $p = 0.132$) difference in number of branches used per m^2 in the construction of brush parks among the size categories (Table 3.32).

Table 3.32: Number of branches used per m^2 in the construction of brush parks by size category

Number (m^{-2})	Size category			Average total
	Small (< 0.04) n = 102	Medium (0.04 – 0.08) n = 81	Large (> 0.08) n = 67	n = 240
	4 ± 1^a	4 ± 1^a	4 ± 1^a	4 ± 1

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

3.3.1.2.1.8 Use of tyres and PVC pipes in the fish park construction

All the farmers in Niger state did not put worn out tyres and pipes in the fish parks while 90% of the farmers in Lagos state who had brush parks filled the brush parks with tyres and pipes (Table 3.33). There was a significant ($\chi^2 = 211$, d.f. = 1, $p < 0.001$) relationship between the use of tyres and PVC pipes in the fish park construction and state, with only farmers in Lagos using tyres and PVC pipes.

Table 3.33: Use of tyres and pipes in fish parks construction by state

Tyres and pipes	State		Total
	Niger n = 150	Lagos n = 100	n = 250
Use tyres and pipes	0 (0)	90 (90)	90 (36)
Did not use tyres and pipes	150 (100)	10 (10)	160 (64)

n = sample size. Figures in brackets indicate percentages.

Use of tyres and pipes in fish parks construction by size category is given in Table 3.34. There was no significant ($\chi^2 = 3$, d.f. = 2, $p = 0.226$) relationship between the use of tyres and pipes in the construction of brush parks and size of fish parks. All the farmers reported that they put worn out tyres and pipes in the brush parks in order to provide hiding and breeding grounds for fish. Of 250 farmers with fish parks, 227 (91%) stated that tilapia was the dominant species caught from fish parks and only 23 (9%) mentioned other species including *Chrysichthys*, *Clarias*, *Gymnarchus* and *Lates*.

Table 3.34: Use of tyres and pipes in fish parks construction by size category

Tyres and pipes	Size category			Total
	Small (< 0.04 ha) n = 102	Medium (0.04 – 0.08 ha) n = 81	Large (> 0.08 ha) n = 67	n = 250
Use tyres and pipes	31 (30)	30 (37)	29 (43)	90 (36)
Did not use tyres and pipes	71 (70)	51 (63)	38 (57)	160 (64)

n = sample size. Figures in brackets indicate percentages.

3.3.1.2.1.9 Yield of fish from fish parks

Mean production of fish from fish parks differed significantly ($p = 0.001$) between states. Mean production of fish was higher in Lagos (756 kg ha^{-1} yr^{-1}) than Niger state (404 kg ha^{-1} yr^{-1}) (Table 3.35).

Table 3.35: Mean production of fish from fish parks by state

Fish production (kg ha^{-1} yr^{-1})	State		Average total
	Niger n = 150	Lagos n = 100	n = 250
	404 ± 470^{a}	756 ± 854^{b}	545 ± 672

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

Mean production of fish from fish parks ranged from 0.13 to 1.35 t ha^{-1} yr^{-1} (Table 3.36). There was a significant ($p < 0.001$) difference in mean production of fish among the size categories, with production being higher in large sized category.

Table 3.36: Mean production of fish from fish parks by size category

Fish production (kg ha^{-1} yr^{-1})	Size category			Average total
	Small (< 0.04) n = 102	Medium (0.04 – 0.08) n = 81	Large (> 0.08) n = 67	n = 250
	130 ±89[a]	399 ±187[b]	1353 ±835[c]	545 ±673

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different (p > 0.05) share common superscript.

Effect of density of branches on yield

Yield of fish from brush parks increases with number of branches used per unit area (Figure 3.4). There was a statistically significant ($r = 0.242$, $p < 0.001$) linear correlation between number of branches used per m^2 and yield.

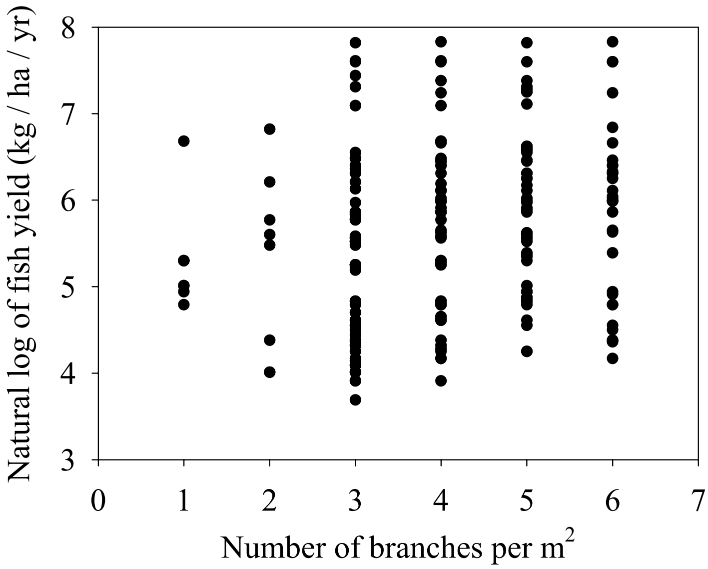


Figure 3.4: The relationship between fish yield from brush parks and number of branches used per unit area

Effect of fish park installation period on yield

Fish yield also increases with the period of installation of the fish parks (Figure 3.5). There was a statistically significant ($r = 0.770$, $p < 0.001$) linear correlation between period of installation of fish parks and yield.

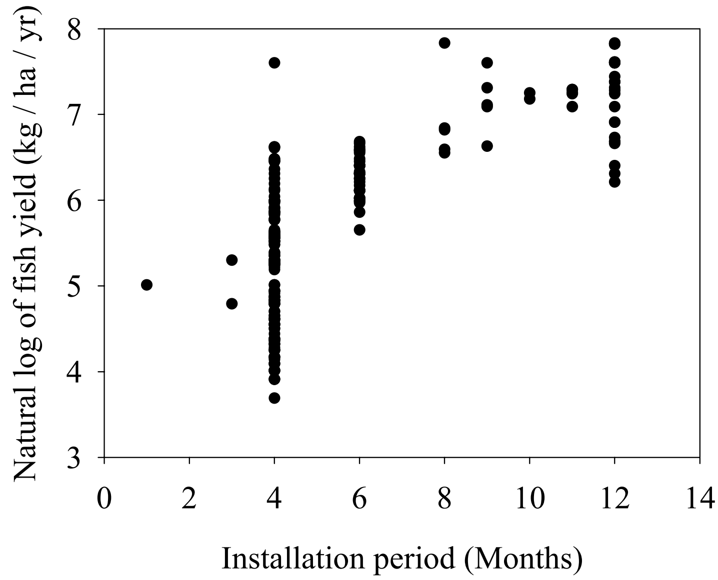


Figure 3.5: The relationship between fish yield from fish parks and period of installation

3.3.1.2.2 Pot shelters (*Ikoko, Isha*)

Pots are traps that are fitted with non return valves to make escape of fish difficult. Pot shelters were only found in Lagos state. Average diameters of mouth of pots are presented in Table 3.37. There were significant (p = 0.026) differences in the diameter of pots in the local government area (L.G.A). Highest average diameter (16 cm) was found in Badagry L.G.A. Average height of pots was 47 cm. The average diameter of the pots at the widest circumference was 38 cm.

Table 3.37: Average diameter of mouth of pots by local government area (L.G.A) in Lagos state

Diameter (cm)	L.G.A					Average total
	Amuwo-odofin	Badagry	Epe	Ibeju / lekki	Lagos mainland	
	n = 5	n = 5	n = 5	n = 5	n = 5	n = 25
	15 ± 2^{a}	16 ± 6^{a}	13 ± 2^{b}	12 ± 1^{b}	13 ± 1^{b}	14 ± 3

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different (p > 0.05) share common superscript.

Figure 3.6: Clay pot in Lagos.

Production period of pot shelters

Production periods of pot shelters are given in Table 3.38. Pots are installed from May to October in Amuwo–odofin, Badagry and Lagos mainland. They are installed year round in Epe and Ibeju / lekki. Pots were set for a maximum of three days and then harvested in all the L.G.A.

Table 3.38: Production periods of pot shelters by local government area (L.G.A) in Lagos state

Production period	L.G.A					Total
	Amuwo-odofin n = 5	Badagry n = 5	Epe n = 5	Ibeju / lekki n = 5	Lagos mainland n = 5	n = 25
May - October	5 (100)	5 (100)	0 (0)	0 (0)	5 (100)	15 (60)
Year round	0 (0)	0 (0)	5 (100)	5 (100)	0 (0)	10 (40)

n = sample size. Figures in brackets indicate percentages.

Materials used for making valves of pots

About 60% of the farmers in Amuwo–odofin, Epe, Ibeju / lekki and Lagos mainland used cane strips to make one way conical valves for fitting into the mouth of pots (Table 3.39). Average distance between pots in water was found to be four metres. Number of pots per production cycle ranged from 20 to 30 with an overall average of 25. All the farmers interviewed installed pots horizontally in water.

Table 3.39: Materials used for making valves of pots by local government area (L.G.A) in Lagos state

Material	L.G.A					Total
	Amuwo-odofin n = 5	Badagry n = 5	Epe n = 5	Ibeju / lekki n = 5	Lagos mainland n = 5	n = 25
Raffia mat	2 (40)	3 (60)	2 (40)	2 (40)	2 (40)	11 (44)
Cane strip	3 (60)	2 (40)	3 (60)	3 (60)	3 (60)	14 (56)

n = sample size. Figures in brackets indicate percentages.

Use of gravid females in pot shelters as bait

All the farmers in Epe and Ibeju / lekki put gravid females in pots to attract male fish of the same species (Table 3.40). The farmers mentioned female *Chrysichthys* as the fish they put in pots to attract male fish of the same species.

Table 3.40: The use of gravid females in pots by local government area (L.G.A) in Lagos state

Gravid female	L.G.A					Total
	Amuwo-odofin n = 5	Badagry n = 5	Epe n = 5	Ibeju / lekki n = 5	Lagos mainland n = 5	n = 25
Yes	3 (60)	2 (40)	5 (100)	5 (100)	4 (80)	19 (76)
No	2 (40)	3 (60)	0 (0)	0 (0)	1 (20)	6 (24)

n = sample size. Figures in brackets indicate percentages.

Mean total production of fish from pot shelters was 0.064 t yr^{-1}. Mean production per pot per year was 3 kg[1]. There was no significant ($t = -0.244$, d.f. = 23, $p < 0.810$) difference in fish production from pots with gravid females and those without the gravid females.

3.3.1.2.3 Bamboo poles / PVC pipes' shelters (*Ihos*)

Ihos are tube shelters that stop fish from getting out backwards. *Iho* shelters were only found in Lagos state. About 60% of the farmers in the L.G.A of Lagos state used hollow bamboo poles in constructing *iho* fish shelters and only 40% used PVC pipes (Table 3.41).

Table 3.41: Types of materials used in the construction of *iho* shelters by local government area (L.G.A) in Lagos state

Material	L.G.A					Total
	Amuwo-odofin	Badagry	Epe	Ibeju / lekki	Lagos mainland	
	n = 5	n = 5	n = 5	n = 5	n = 5	n = 25
Bamboo pole	3 (60)	3 (60)	3 (60)	3 (60)	3 (60)	15 (60)
PVC pipe	2 (40)	2 (40)	2 (40)	2 (40)	2 (40)	10 (40)

n = sample size. Figures in brackets indicate percentages.

[1] Average number of pots was 25

(a) Hollow bamboo poles

(b) Hard wood for blocking one end of PVC pipe

(c) Fisherman harvesting fish from hollow bamboo pole

Figure 3.7: Hollow bamboo poles and PVC pipes in Lagos

Diameter of pole / PVC pipe

Average diameter of poles / PVC pipes was 9 cm (Table 3.42). There were no significant ($F = 0.204$, d.f. = 4, 20, $p = 0.933$) differences in diameter of poles / PVC pipes in the L.G.A. Average length of poles / PVC pipes was 75 cm.

Table 3.42: Average diameters of pole / PVC pipe by local government area (L.G.A) in Lagos state

Diameter of pole (cm)	L.G.A					Average total
	Amuwo-odofin n = 5	Badagry n = 5	Epe n = 5	Ibeju / lekki n = 5	Lagos mainland n = 5	n = 25
	9 ± 1^{a}	9 ± 2^{a}	9 ± 1^{a}	9 ± 2^{a}	9 ± 1^{a}	9 ± 1

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

Materials used for covering one side of pole / PVC pipe

About 60% of the farmers who used hollow bamboo poles for constructing *iho* shelters covered one side of the poles with coconut husks while those who used PVC pipes covered one side of the pipe with any hard wood (Table 3.43). *Iho* fish shelters were constructed year round in the L.G.A.

Table 3.43: Materials used for covering one side of pole / PVC pipe by local government area (L.G.A) in Lagos state

Material	L.G.A					Total
	Amuwo-odofin	Badagry	Epe	Ibeju / lekki	Lagos mainland	
	n = 5	n = 5	n = 5	n = 5	n = 5	n = 25
Coco nut husks	3 (60)	3 (60)	3 (60)	3 (60)	3 (60)	15 (60)
Any hard wood	2 (40)	2 (40)	2 (40)	2 (40)	2 (40)	10 (40)

n = sample size. Figures in brackets indicate percentages.

Average number of poles used for constructing *iho* shelters was highest in Ibeju / lekki (980) and lowest in Badagry (760) (Table 3.44). There were, however, no significant ($p = 0.329$) differences in number of poles / PVC pipes used in the L.G.A. *Iho* installation duration was 14 days in all the L.G.A.

Table 3.44: Average number of poles per production cycle by local government area (L.G.A) in Lagos state

Number of poles	L.G.A					Average total
	Amuwo-odofin	Badagry	Epe	Ibeju / lekki	Lagos mainland	
	n = 5	n = 5	n = 5	n = 5	n = 5	n = 25
	820 ± 205^a	760 ± 251^a	840 ± 207^a	980 ± 45^a	960 ± 55^a	872 ± 182

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

Distance between poles / PVC pipes in water

Average distance between poles / PVC pipes in water was higher in Amuwo–odofin and Badagry (40 cm) and lowest in Ibeju / lekki L.G.A (36 cm) but there were no significant ($p = 0.158$) differences in the average distance between poles / PVC pipes in the L.G.A (Table 3.45).

Table 3.45: Average distance between poles / PVC pipes in water by local government area (L.G.A) in Lagos state

Distance (cm)	L.G.A					Average total
	Amuwo-odofin	Badagry	Epe	Ibeju / lekki	Lagos mainland	
	n = 5	n = 5	n = 5	n = 5	n = 5	n = 25
	40 ± 4^a	40 ± 0^a	39 ± 2^a	36 ± 4^a	37 ± 3^a	38 ± 3

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

All the farmers interviewed stated that bamboo poles / PVC pipes are installed vertically in water. The upper ends of the poles / PVC pipes are left open but lower ends are covered with coconut husks or any hard wood (Table 3.43) to prevent fish from getting out when it enters through the upper end. *Chrysichthys* was the dominant species caught from *iho* fish shelters.

Mean production of fish from *iho* shelters was 0.15 t yr^{-1}. Average production per pipe per year was 0.2 kg[2]. There was no significant ($t = -1.602$, d.f. = 23, $p = 0.123$) difference in fish production from hollow bamboo poles and PVC pipes.

3.3.1.3 Fish fences

Fish fences are barriers that are used either alone, or in combination with a variety of traps and nets, especially in swampy areas and where there is a wide floodplain.

3.3.1.3.1 Materials used in the construction of fish fences

Materials used in the construction of fish fences differed significantly ($\chi^2 = 90$, d.f. = 4, $p < 0.001$) between states (Table 3.46). About 80% of the farmers in Niger used

[2] Average number of poles / PVC pipes was 872

Alchornea sp for fish fence construction while 51% in Lagos state used bamboo strips.

Table 3.46: Materials used for constructing fish fence in Niger and Lagos states

Material	State		Total
	Niger n = 45	Lagos n = 45	n = 90
Bamboo strips	0 (0)	23 (51)	23 (26)
Cane strips	0 (0)	12 (27)	12 (13)
Palm fronds	0 (0)	10 (22)	10 (11)
Alchornea sp	36 (80)	0 (0)	36 (40)
Gill net	9 (20)	0 (0)	9 (10)

n = sample size. Figures in brackets indicate percentages.

3.3.1.3.2 Reasons for constructing fish fence

Reasons for constructing fish fences also differed significantly ($\chi^2 = 49$, d.f. = 1, $p < 0.001$) between Niger and Lagos state. About 80% of the farmers in Niger constructed fish fence in order to trap fish while 93% in Lagos state constructed fish fence in order to aggregate fish (Table 3.47).

Table 3.47: Reasons for constructing fish fence in Niger and Lagos states

Reason	State		Total
	Niger n = 45	Lagos n = 45	n = 90
To trap fish	36 (80)	3 (7)	39 (43)
To aggregate fish	9 (20)	42 (93)	51 (57)

n = sample size. Figures in brackets indicate percentages.

3.3.1.3.3 Production periods of fish fences

There was a significant ($\chi^2 = 90$, d.f. = 3, $p < 0.001$) relationship between production period of fish fence and state. About 60% of the farmers in Niger state constructed fish fence in November until April while November to May was the production period for 67% of the farmers in Lagos state (Table 3.48).

Table 3.48: Fish fence production periods in Niger and Lagos states

Period	State		Total
	Niger n = 45	Lagos n = 45	n = 90
November – May	0 (0)	30 (67)	30 (33)
November – April	27 (60)	0 (0)	27 (30)
March – May	18 (40)	0 (0)	18 (20)
March – October	0 (0)	15 (33)	15 (17)

n = sample size. Figures in brackets indicate percentages.

3.3.1.3.4 Construction of fish fences in combination with fishing gears

There was a significant ($\chi^2 = 15$, d.f. = 1, $p < 0.001$) relationship between the use of fishing gears in combination with fish fences and state, with greater number of farmers in Niger state (80%) constructing fish fences in combination with fishing gears. Only 40% of the farmers in Lagos state constructed fish fences in combination with fishing gears (Table 3.49).

Table 3.49: Distribution of farmers according to whether or not they constructed fish fence in combination with fishing gears in Niger and Lagos states

Fish fence and fishing gear	State		Total
	Niger n = 45	Lagos n = 45	n = 90
Yes	36 (80)	18 (40)	54 (60)
No	9 (20)	27 (60)	36 (40)

n = sample size. Figures in brackets indicate percentages.

Types of fishing gears used in combination with fish fences differed significantly ($\chi^2 = 54$, d.f. = 2, $p < 0.001$) between states. About 61% of the farmers in Niger state constructed fish fences in combination with *gura* traps (Figure 3.8), gill net and hooks. All the farmers who combined fish fences with fishing gears in Lagos state used *egun* traps (Table 3.50) (Figure 3.9).

Table 3.50: Types of fishing gears combined with fish fences in Niger and Lagos states

Fishing gear	State		Total
	Niger n = 36	Lagos n = 18	n = 54
Gura traps only	14 (39)	0 (0)	14 (26)
Gura, gill net and hooks	22 (61)	0 (0)	22 (41)
Egun traps	0 (0)	18 (100)	18 (33)

n = sample size. Figures in brackets indicate percentages.

Figure 3.8: *Gura* traps in Niger state.

(a) Big sized *egun* trap

(b)Medium sized *egun* traps

Figure 3.9: *Egun* traps in Lagos

3.3.1.3.5 Fish fence installation period

There was a significant ($p < 0.001$) difference in fish fence installation periods between Niger and Lagos state. Fish fences had higher installation period in Lagos than Niger state (Table 3.51).

Table 3.51: Average installation period of fish fence in Niger and Lagos states

Duration (Months)	State		Average total
	Niger n = 45	Lagos n = 45	n = 90
	5 ±2[a]	7 ±1[b]	6 ±2

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

3.3.1.3.6 Dominant species caught from fish fences

Fish species caught from fish parks differed significantly ($\chi^2 = 39$, d.f. = 1, $p < 0.001$) between Niger and Lagos state. Tilapia and Clarias were the dominant species caught from fish fences by all the farmers in Niger as compared with 40% for farmers in Lagos state (Table 3.52).

Table 3.52: Dominant species caught from fish fences in Niger and Lagos states

Species	State		Total
	Niger n = 45	Lagos n = 45	n = 90
Tilapia and *Clarias*	45 (100)	18 (40)	63 (70)
Chrysichthys and shrimps	0 (0)	6 (13)	6 (7)
Chrysichthys and tilapia	0 (0)	12 (27)	12 (13)
Chrysichthys, tilapia and shrimps	0 (0)	9 (20)	9 (10)

n = sample size. Figures in brackets indicate percentages. The last three rows were combined for the purpose of statistical analysis.

Frequency of harvesting fish from fish fence is given in Table 3.53. Farmers who installed fish fences for three months harvested fish once daily, those who installed for six months harvested twice daily and those who installed for seven and eight months harvested once daily after three and six months of installations, respectively.

Table 3.53: Frequency of harvesting fish from fish fences

Duration following installation of fish fence (Months)	Frequency of harvest				Total
	Once daily	Twice daily	Once daily after 6 months of installation	Once daily after 3 months of installation	
	n =18	n =27	n =15	n =30	n =90
3	18 (100)	0 (0)	0 (0)	0 (0)	18 (20)
6	0 (0)	27 (100)	0 (0)	0 (0)	27 (30)
7	0 (0)	0 (0)	0 (0)	30 (100)	30 (33)
8	0 (0)	0 (0)	15 (100)	0 (0)	15 (17)

n = sample size. Figures in brackets indicate percentages.

(a) Fish fence in Lagos

(b) Fish fence with “charm” hung to deter thieves in Niger state.

(c) Fish fence with scoop net hung for harvesting fish in Lagos

(d) Fish fence constructed of gill net in Niger state

Figure 3.10: Fish fences in Niger and Lagos states

Figure 3.11: Bamboo strips used for constructing fish fence in Lagos.

3.3.2 Culture / installation environments for aquaculture systems

Culture environments differed significantly (χ^2 = 171, d.f. = 1, p < 0.001) between states. All the farmers in Niger had the aquaculture systems in fresh water environments while 60% of the farmers in Lagos state had theirs in brackish water environments (Table 3.54).

Table 3.54: Culture environments for aquaculture by state

Environment	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Fresh water	200 (100)	80 (40)	280 (70)
Brackish water	0 (0)	120 (60)	120 (30)

n = sample size. Figures in brackets indicate percentages.

About 70% of the farmers had their fish ponds, fish shelters and fish fences in the fresh water environments and only 30% had theirs in brackish waters (Table 3.55).

There was no significant ($\chi^2 = 0$, d.f. = 2, p = 1) relationship between culture environments and aquaculture systems.

Table 3.55: Culture environments for aquaculture by aquaculture system

Environment	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Fresh water	7 (70)	210 (70)	63 (70)	280 (70)
Brackish water	3 (30)	90 (30)	27 (30)	120 (30)

n = sample size. Figures in brackets indicate percentages.

3.3.3 Sources of water used for aquaculture

Sources of water for aquaculture systems are presented in Table 3.56. About 99% of the farmers in Niger had river as their source of water for aquaculture systems while 98% in Lagos state had lagoon as source of water.

Table 3.56: Sources of water used for aquaculture by state

Source of water	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
River	197 (99)	0 (0)	197 (49)
Lagoon	0 (0)	195 (98)	195 (49)
Ground water	1 (1)	5 (3)	6 (2)
Tap water and rain fed	1 (1)	0 (0)	1 (0)
Spring	1 (1)	0 (0)	1 (0)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

About 60% of the farmers with fish ponds depended on ground water as source of water for fish ponds (Table 3.57).

Table 3.57: Sources of water used for aquaculture by aquaculture system

Source of water	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
River	2 (20)	150 (50)	45 (50)	197 (49)
Lagoon	0 (0)	150 (50)	45 (50)	195 (49)
Ground water	6 (60)	0 (0)	0 (0)	6 (2)
Tap water and rain fed	1 (10)	0 (0)	0 (0)	1 (0)
Spring	1 (10)	0 (0)	0 (0)	1 (0)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

3.3.4 Ownership of land / water

About 61% of the farmers in Niger state owned land / ox bow lake where the aquaculture was practised. Only 2% of the farmers owned land in Lagos state and 1% was a leased farmer. About 98% of the farmers in Lagos depended on the lagoon which was open access as compared with 39% for Niger state depending on river as open access (Table 3.58).

Table 3.58: Ownership of land / river / lagoon by state

Ownership status	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Owner	122 (61)	4 (2)	126 (32)
Leased	0 (0)	1 (1)	1 (0)
Open access	78 (39)	195 (98)	273 (68)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Ninety percent of the farmers who had fish ponds owned the lands where the ponds were constructed and only one person (10%) was a leased farmer. Seventy percent of those with fish shelters and fish fences depended on lagoons and rivers that were open access (Table 3.59). According to lease farmer, leases are usually for 15 years.

Table 3.59: Ownership of land / river / lagoon by aquaculture system

Ownership status	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Owner	9 (90)	90 (30)	27 (30)	126 (31.5)
Leased	1 (10)	0 (0)	0 (0)	1 (0.25)
Open access	0 (0)	210 (70)	63 (70)	273 (68.25)

n = sample size. Figures in brackets indicate percentages.

All the farmers owning land / ox bow lake acquired them through inheritance. Ox bow lakes were only owned by farmers in Niger state. Average size of ox bow lake was 3 ha.

3.3.5 Experience and training for fishing / fish farming

Of 400 farmers interviewed, 390 (98%) started fishing since childhoods and only 10 (2%) had an average of 11 years in fish farming. Source of training for fishing / fish farming in Niger and Lagos states is given in Table 3.60. About 98% of the fishermen learnt how to fish from their parents. Two percent of the farmers learnt how to culture fish from Fisheries Extension Agents (E.A) and 1% from agricultural institutions in both states.

Table 3.60: Source of training for fishing / fish farming by state

Source	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Parents	196 (98)	195 (98)	391 (98)
E.A	3 (2)	4 (2)	7 (2)
Agricultural institution	1 (1)	1 (1)	2 (1)

n = sample size. Figures in brackets indicate percentages. E.A = Extension agents. Percentages have been rounded up.

All the farmers with fish shelters and fish fences learnt how to fish from their parents. About 70% of the farmers with fish ponds acquired the knowledge of fish farming from E.A, 20% from agricultural institutions and 10% from parents (Table 3.61).

Table 3.61: Source of training for fishing / fish farming by aquaculture system

Source	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Parents	1 (10)	300 (100)	90 (100)	391 (98)
E.A	7 (70)	0 (0)	0 (0)	7 (2)
Agricultural institution	2 (20)	0 (0)	0 (0)	2 (1)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

3.3.6 Management of aquaculture systems

3.3.6.1 Liming

All the farmers in Niger and 99% in Lagos state did not apply lime. Only 2% of the farmers in Lagos state applied lime to fish ponds (Table 3.62).

Table 3.62: Distribution of farmers according to whether or not they applied lime by state

Liming	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Yes	0 (0)	3 (2)	3 (1)
No	200 (100)	197 (99)	397 (99)

n = sample size. Figures in brackets indicate percentage. Percentages have been rounded up.

All the farmers with fish shelters and fish fences did not apply lime to aquaculture systems. Only 30% of the farmers with fish ponds applied lime to fish ponds (Table 3.63). All the farmers who applied lime reported that they applied agricultural lime in order to kill germs in the pond. They all applied the lime before stocking at the rate of 143 kg ha^{-1} yr^{-1}. All the farmers that did not apply lime reported that they did not know of lime.

Table 3.63: Distribution of farmers according to whether or not they applied lime by aquaculture system

Liming	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Yes	3 (30)	0 (0)	0 (0)	3 (1)
No	7 (70)	300 (100)	90 (100)	397 (99)

n = sample size. Figures in brackets indicate percentages.

3.3.6.2 Fertilization

About 98% of the farmers in Niger and Lagos states did not apply fertilizer. Only 2% of the farmers in Niger state applied fertilizers to ponds as compared with 3% for Lagos (Table 3.64).

Table 3.64: Distribution of farmers according to whether or not they applied fertilizers by state

Fertilization	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Yes	4 (2)	5 (3)	9 (2)
No	196 (98)	195 (98)	391 (98)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

All the farmers with fish shelters and fish fences did not apply fertilizer to their production systems. About 90% of the farmers with fish ponds applied fertilizers to ponds (Table 3.65). Of the nine farmers who applied fertilisers, seven (78%) applied organic manure only while two (22%) applied both organic and inorganic fertilisers. Organic manures applied were cow dung and poultry droppings. The two farmers who used inorganic fertilisers applied only NPK. All the farmers bought the NPK fertiliser from local markets. About 78% of the farmers applied the fertilisers before and after stocking while 22% applied after stocking only. The farmers reported that they applied the fertilisers in order to promote the growth of natural food in the ponds.

Table 3.65: Distribution of farmers according to whether or not they applied fertilizers by aquaculture system

Fertilization	Aquaculture system			total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Yes	9 (90)	0 (0)	0 (0)	9 (2)
No	1 (10)	300 (100)	90 (100)	391 (98)

n = sample size. Figures in brackets indicate percentages.

3.3.6.3 Feeds / feeding

Feeding of fish in the different aquaculture systems in Niger and Lagos states is given in Table 3.66. About 9% of the farmers in Niger fed their fish as compared with 4% for Lagos state. There was a significant (χ^2 = 5, d.f. = 1, p = 0.023) relationship between feeding and state, with greater number of farmers in Niger state feeding fish.

Table 3.66: Distribution of farmers according to whether or not they fed their fish by state

Feeding	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Yes	18 (9)	7 (4)	25 (6)
No	182 (91)	193 (97)	375 (94)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

All the farmers with fish ponds fed their fish. Only 2% and 10% of the farmers with fish shelters and fish fences, respectively, fed their fish (Table 3.67). There was a significant (χ^2 = 161, d.f. = 2, p < 0.001) relationship between feeding and aquaculture system, with feeding more pronounced among farmers with fish ponds. Of 25 farmers feeding fish, 21 (84%) used local feeds only, one (4%) used pelleted feeds only and three (12%) used local feeds, fish meal and pelleted feeds.

Table 3.67: Distribution of farmers according to whether or not they fed their fish by aquaculture system

Feeding	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Yes	10 (100)	6 (2)	9 (10)	25 (6)
No	0 (0)	294 (98)	81 (90)	375 (94)

n = sample size. Figures in brackets indicate percentages.

Types of local feeds used by farmers in Niger and Lagos states are presented in Table 3.68. About 78% of the farmers in Niger used corn bran only as compared with 17% for Lagos state. Thirty three percent of the farmers in Lagos state used corn bran and brewery wastes as compared with 6% for Niger state.

Table 3.68: Types of locals feed used by fish farmers by state

Type of local feed	State		Total
	Niger	Lagos	
	n = 18	n = 6	n = 24
Corn bran only	14 (78)	1 (17)	15 (63)
Corn bran and brewery wastes	1 (6)	2 (33)	3 (13)
Corn and rice bran	3 (17)	0 (0)	3 (13)
Coco nut	0 (0)	1 (17)	1 (4)
Pap and cassava wastes	0 (0)	1 (17)	1 (4)
Fish trash and animal intestines	0 (0)	1 (17)	1 (4)

n = sample size. Figures in brackets indicate percentages.

All the farmers with fish fences used corn bran only to feed fish. About 83% of the farmers with fish shelters used corn bran only and 17% used pap and cassava wastes (Table 3.69).

Table 3.69: Types of local feeds by aquaculture system

Type of local feed	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 9	n = 6	n = 9	n = 24
Corn bran only	1 (11)	5 (83)	9 (100)	15 (63)
Corn bran and brewery waste	3 (33)	0 (0)	0 (0)	3 (13)
Corn and rice bran	3 (33)	0 (0)	0 (0)	3 (13)
Coco nut	1 (11)	0 (0)	0 (0)	1 (4)
Pap and cassava waste	0 (0)	1 (17)	0 (0)	1 (4)
Fish trash and animal intestines	1 (11)	0 (0)	0 (0)	1 (4)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Of 24 farmers using local feeds, 10 (42%) obtained their feeds from local markets, 11 (46%) obtained from feed mills only, three (12%) from breweries, feed mills, farm and home. All the farmers who used fish meal and pelleted feeds reported that they obtained the feeds from local markets and feed mills. Reasons for using local feeds in Niger and Lagos states are given in Table 3.70. About 72% and 33% of the farmers in Niger and Lagos state, respectively, used local feeds in order to attract fish.

Table 3.70: Reasons for using local feeds by state

Reasons	State		Total
	Niger	Lagos	
	n = 18	n = 6	n = 24
Cheaper and to promote growth	5 (28)	3 (50)	8 (33)
To attract fish	13 (72)	2 (33)	15 (63)
To promote growth only	0 (0)	1 (17)	1 (4)

n = sample size. Figures in brackets indicate percentages.

Reasons for using local feeds by aquaculture system are presented in Table 3.71. Farmers with fish shelters and fish fences used local feeds in order to attract fish. Of 25 farmers feeding fish (Table 3.67), 19 (76%) fed their fish twice a day; morning and evening, five (20%) fed once a day either morning or evening and one (4%) fed the fish once a week.

Table 3.71: Reasons for using local feeds by aquaculture system

Reasons	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 9	n = 6	n = 9	n = 24
Cheaper and to promote growth	8 (89)	0 (0)	0 (0)	8 (33)
To attract fish	0 (0)	6 (100)	9 (100)	15 (63)
To promote growth only	1 (11)	0 (0)	0 (0)	1 (4)

n = sample size. Figures in brackets indicate percentages.

3.3.6.4 Harvest

About 78% of the farmers in Niger and Lagos states harvested fish once per crop (Table 3.72). Frequency of harvesting fish was significantly (χ^2 = 90, d.f. = 4, p < 0.001) related to state, with only farmers in Niger state harvesting fish twice a day.

Table 3.72: Frequency of harvesting fish per crop / installation duration by state

Frequency	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Once per crop	155 (78)	155 (78)	310 (78)
Once a day	18 (9)	2 (1)	20 (5)
Twice a day	27 (14)	0 (0)	27 (7)
Once a day after six months of installation	0 (0)	13 (7)	13 (3)
Once a day after three months of installation	0 (0)	30 (15)	30 (8)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Frequency of harvesting fish by aquaculture system is presented in Table 3.73. All the farmers with fish ponds and fish shelters harvested fish once per crop.

Table 3.73: Frequency of harvesting fish per crop / installation duration by aquaculture system

Frequency	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Once per crop	10 (100)	300 (100)	0 (0)	310 (78)
Once a day	0 (0)	0 (0)	20 (22)	20 (5)
Twice a day	0 (0)	0 (0)	27 (30)	27 (7)
Once a day after six months of installation	0 (0)	0 (0)	13 (14)	13 (3)
Once a day after three months of installation	0 (0)	0 (0)	30 (33)	30 (8)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Ninety nine percent of the farmers in Niger and Lagos states carried out total harvest of fish from fish ponds, fish shelters or fish fences while 1% employed partial / selective method of harvesting fish (Table 3.74).

Table 3.74: Fish harvesting methods by state

Method	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Total	198 (99)	198 (99)	396 (99)
Partial / selective	2 (1)	2 (1)	4 (1)

n = sample size. Figures in brackets indicate percentages.

All the farmers with fish shelters and fish fences carried out total harvest of fish as compared with 60% for those with fish ponds (Table 3.75).

Table 3.75: Fish harvesting methods by aquaculture system

Method	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Total	6 (60)	300 (100)	90 (100)	396 (99)
Partial / selective	4 (40)	0	0 (0)	4 (1)

n = sample size. Figures in brackets indicate percentages.

Of 400 farmers interviewed, 392 (98%) used fishing gears only to harvest fish without draining, seven (2%) drained the ponds and then used fishing gears to harvest fish and only one farmer drained the pond and then used hand and bowl to harvest fish. Of eight of the farmers draining their ponds, four (50%) used water pumps to drain the ponds while the remaining four (50%) drained the ponds through outlet.

3.3.6.5 Types of fishing gears used in harvesting fish

Fishing gears used by farmers in harvesting fish in Niger and Lagos states are given in Table 3.76. About 75% of the farmers in Niger and 46% in Lagos state used encircling gill nets only for harvesting fish.

Table 3.76: Types of fishing gears used in harvesting fish by state

Gear types	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Drag nets	4 (2)	5 (3)	9 (2)
Encircling gill nets only	150 (75)	92 (46)	242 (61)
Hand and bowl	1 (1)	0 (0)	1 (0)
Gura traps only	14 (7)	0 (0)	14 (4)
Gura traps, gill nets and hooks	22 (11)	0 (0)	22 (6)
Homa traps	9 (5)	0 (0)	9 (2)
Encircling gill nets and *egun* traps	0 (0)	8 (4)	8 (2)
Clay pots	0 (0)	25 (13)	25 (6)
Bamboo traps	0 (0)	15 (8)	15 (3)
PVC pipes	0 (0)	10 (5)	10 (3)
Scoop nets	0 (0)	27 (14)	27 (7)
Egun traps only	0 (0)	18 (9)	18 (5)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Ninety percent of the farmers with fish ponds used drag nets for harvesting fish and 10% used hand and bowl. About 81% of the farmers with fish shelters used encircling gill nets only to harvest fish while 30% of those with fish fences used scoop nets (Table 3.77).

Table 3.77: Types of fishing gears used in harvesting fish by aquaculture system

Gear types	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Drag nets	9 (90)	0 (0)	0 (0)	9 (2)
Encircling gill net only	0 (0)	242 (81)	0 (0)	242 (61)
Hand and bowl	1 (10)	0 (0)	0 (0)	1 (0)
Gura traps only	0 (0)	0 (0)	14 (16)	14 (4)
Gura, gill nets and hooks	0 (0)	0 (0)	22 (24)	22 (6)
Homa traps	0 (0)	0 (0)	9 (10)	9 (2)
Encircling gill nets and *egun* traps	0 (0)	8 (3)	0 (0)	8 (2)
Clay pots	0 (0)	25 (8)	0 (0)	25 (6)
Bamboo traps	0 (0)	15 (5)	0 (0)	15 (3)
PVC pipes	0 (0)	10 (3)	0 (0)	10 (3)
Scoop nets	0 (0)	0 (0)	27 (30)	27 (7)
Egun traps only	0 (0)	0 (0)	18 (20)	18 (5)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Of 399 farmers using fishing gears, 331 (83%) bought the fishing gears from local markets, 66 (17%) made the fishing gears themselves using local materials while two (1%) borrowed the fishing gears from Agricultural Development Projects (ADP). The farmers were satisfied with the use of the fishing gears. According to them, the fishing gears are effective in harvesting fish. Average mesh size of nets was 1.4 inches.

3.3.7 Fish production experience

3.3.7.1 Levels of production

Current levels of production of fish did not differ significantly ($\chi^2 = 5$, d.f. = 2, p = 086) between states. About 83 and 76% of the farmers in Lagos and Niger state, respectively, reported that their current production levels were not different from the previous year (Table 3.78).

Table 3.78: Current levels of fish production by state

Level of production	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Higher than last year	15 (8)	16 (8)	31 (8)
Lower than last year	34 (17)	19 (10)	53 (13)
About the same	151 (76)	165 (83)	316 (79)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Higher proportions of the farmers with fish fences (88%) and fish shelters (77%) reported that their current levels of production were not different from the previous year (Table 3.79).

Table 3.79: Current levels of fish production by aquaculture system

Level of production	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Higher than last year	2 (20)	29 (10)	0 (0)	31 (8)
Lower than last year	3 (30)	39 (13)	11 (12)	53 (13)
About the same	5 (50)	232 (77)	79 (88)	316 (79)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Reasons for increase in levels of production by state are presented in Table 3.80. About 88% of the farmers in Lagos and 86% in Niger state reported that the use of more branches per m^2 was the major reason for increase in production levels.

Table 3.80: Reasons for increase in production levels by state

Reasons	State		Total
	Niger	Lagos	
	n = 15	n = 16	n = 31
Improved management	1 (7)	1 (6)	2 (6)
More branches m^{-2}	13 (86)	14 (88)	27 (87)
Use of dry branches	1 (7)	1 (6)	2 (6)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

About 93% of the farmers with fish shelters who reported change in production mentioned the use of more branches per m^2 as reason for increase in production levels (Table 3.81). All the farmers with fish ponds who reported change in production mentioned improved management as reasons for increase in production.

Table 3.81: Reasons for increase in production levels by aquaculture system

Reasons	Aquaculture system			Total
	Fish pond n = 2	Fish shelter n = 29	Fish fence n = 0	n = 31
Improved management	2 (100)	0 (0)	0 (0)	2 (6)
More branches m^{-2}	0 (0)	27 (93)	0 (0)	27 (87)
Use of dry branches	0 (0)	2 (7)	0 (0)	2 (6)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Reasons for decrease in levels of production in Niger and Lagos states are given in Table 3.82. Sixty eight percent of the farmers in Lagos and 62% in Niger state reported poaching as reason for decrease in production levels.

Table 3.82: Reasons for decrease in production levels by state

Reasons	State		Total
	Niger n = 34	Lagos n = 19	n = 53
Poaching	21 (62)	13 (68)	34 (64)
Lack of funds	6 (18)	6 (32)	12 (23)
Lack of flood	6 (18)	0 (0)	6 (11)
Seepage	1 (3)	0 (0)	1 (2)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Poaching was also the major reason for decrease in production levels for 72% of the farmers with fish shelters (Table 3.83). Seepage was reported by farmers with fish ponds (33%) as reason for decrease in production levels.

Table 3.83: Reasons for a decrease in production levels by aquaculture system

Reasons	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 3	n = 39	n = 11	n = 53
Poaching	1 (33)	28 (72)	5 (46)	34 (64)
Lack of funds	1 (33)	10 (26)	1 (9)	12 (23)
Lack of flood	0 (0)	1 (2)	5 (46)	6 (11)
Seepage	1 (33)	0 (0)	0 (0)	1 (2)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

3.3.7.2 Production and utilization of fish catch / harvest

Mean production of fish from all the aquaculture systems and utilization of the catch / harvest in Niger and Lagos states are given in Figure 3.12. Production was higher in Lagos than Niger state. Volumes of fish sold fresh and processed were also higher in Lagos than Niger state.

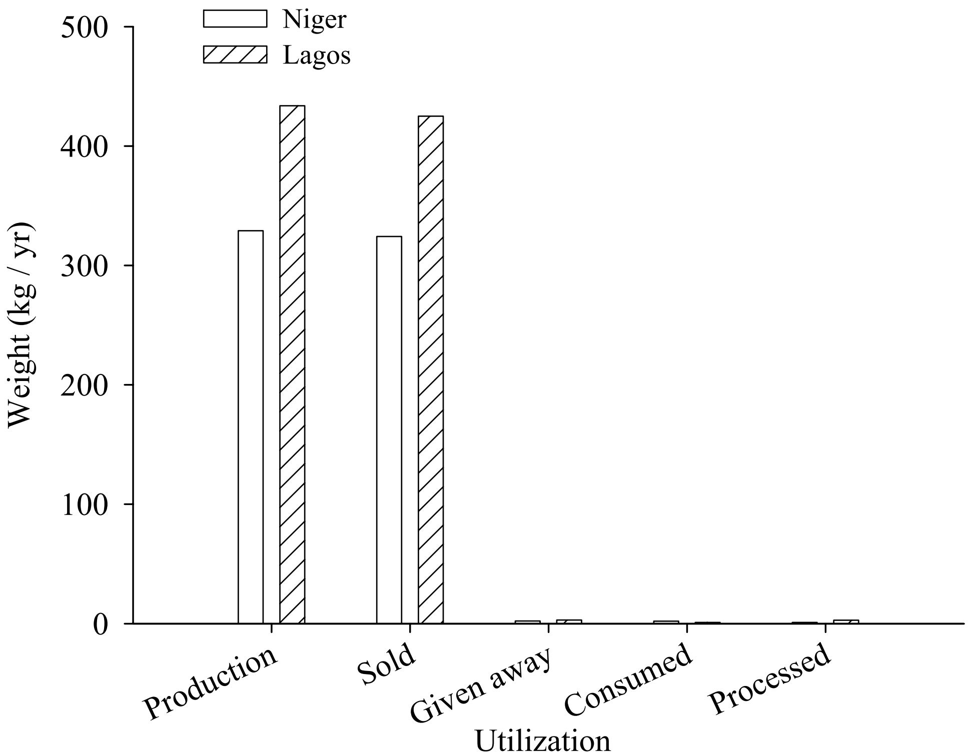


Figure 3.12: Mean production and utilization of fish catch / harvest in Niger and Lagos states. Data not shown are too small to appear on the scale.

3.3.7.3 Satisfaction with earnings from fish

All the farmers in Niger state were satisfied with the earnings from fish and would not want to change to other occupation. Only 1% of the farmers in Lagos state were not satisfied with the earnings from fish (Table 3.84).

Table 3.84: Satisfaction with earnings from fish by state

Satisfaction	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Yes	200 (100)	198 (99)	398 (100)
No	0 (0)	2 (1)	2 (1)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

All the farmers with fish fences were satisfied with the earnings from fish as compared with 90% for farmers with fish ponds (Table 3.85). Only 1% of the farmers with fish ponds and fish shelters were not satisfied with the earnings. One of the farmers mentioned that he would like to change to a civil service job to earn more money and the other farmer reported that he would like to change to pig farming because of the problem of poaching in fish farming. All the farmers interviewed reported that an increase in price of fish would make them produce more fish and indicated intentions to expand fish farms if there is means.

Table 3.85: Satisfaction with earnings from fish by aquaculture system

Satisfaction	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Yes	9 (90)	299 (100)	90 (100)	398 (100)
No	1 (10)	1 (0)	0 (0)	2 (1)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

3.3.8 Fish processing and preservation

Ninety two percent of the farmers in Niger and 87% in Lagos state did not process fish (Table 3.86).

Table 3.86: Fish processing methods by state

Method	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Smoking only	15 (8)	26 (13)	41 (10)
Salting, sundrying and smoking	1 (1)	0 (0)	1 (0)
Roasting and smoking	1 (1)	0 (0)	1 (0)
Did not process fish	183 (92)	174 (87)	357 (89)

n = sample size. Figures in brackets indicate percentage. Percentages have been rounded up.

Higher percentage of farmers with fish fences (90%) did not process fish as compared with 89 and 80% for farmers with fish shelters and fish ponds, respectively (Table 3.87). All the farmers who smoked fish used traditional smoking kilns.

Table 3.87: Fish processing methods by aquaculture system

Method	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Smoking only	2 (20)	31 (10)	8 (9)	41 (10)
Salting, sun drying and smoking	0 (0)	0 (0)	1 (1)	1 (0)
Roasting and smoking	0 (0)	1 (0)	0 (0)	1 (0)
Did not process fish	8 (80)	268 (89)	81 (90)	357 (89)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

All the farmers interviewed reported that their wives are actively involved in fish processing and preservation. All the farmers who preserved fish noted that they have experienced post harvest loss due to insects' infestation.

3.3.9 Fish marketing

Ninety six percent of the farmers in Niger and 97% in Lagos state sold their fish at the landing sites only (Table 3.88). Place for selling fish did not differ significantly ($\chi^2 = 0.3$, d.f. = 1, p = 0.586) between the two states.

Table 3.88: Place for selling fish by state

Place	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Landing site only	192 (96)	194 (97)	386 (97)
Both landing site and market	8 (4)	6 (3)	13 (4)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Higher percentage of farmers with fish fence (99%) sold their fish at landing sites only as compared with farmers with fish shelters (96%) and fish ponds (80%) (Table 3.89). All the farmers interviewed sold their fish fresh. Farmers, who processed fish, only did so for home consumption and not for sale. According to them, processing and marketing was entirely in the hands of their wives.

Table 3.89: Place for selling fish by aquaculture system

Place	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Landing site only	8 (80)	289 (96)	89 (99)	386 (97)
Both landing site and market	2 (20)	11 (4)	1 (1)	14 (4)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Prices of fresh tilapia in Niger and Lagos states are given in Table 3.90. Average price of fresh tilapia was significantly ($p < 0.001$) higher in Lagos than Niger state.

Table 3.90: Landing prices of fresh tilapia per kg by state

Price (Naira)	State		Average total
	Niger	Lagos	
	n = 200	n = 200	n = 400
	126 ± 3^{a}	149 ± 2^{b}	138 ± 12

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1 US$ = N 128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

Average prices of fresh tilapia by aquaculture system are presented in Table 3.91. There were no significant ($p = 0.578$) differences in price of fresh tilapia from different aquaculture systems.

Table 3.91: Landing prices of fresh tilapia per kg by aquaculture system

Price (Naira)	Aquaculture system			Average total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
	138±13[a]	137±12[a]	138±11[a]	138±12

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1 US$ = N 128 in 2003). Values that are not significantly different (p > 0.05) share common superscript.

Average price of fresh *Clarias* was also significantly (p < 0.001) higher in Lagos than Niger state (Table 3.92).

Table 3.92: Landing prices of fresh *Clarias* per kg by state

Price (Naira)	State		Average total
	Niger n = 200	Lagos n = 200	n = 400
	157±5[a]	251 ±3[b]	204±47

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1 US$ = N 128 in 2003). Values that are not significantly different (p > 0.05) share common superscript.

Prices of fresh *clarias* from fish ponds were higher than those from fish shelters and fish fences (Table 3.93) but there were no significant (p = 0.822) differences in the price of fresh *clarias* from different aquaculture systems.

Table 3.93: Landing prices of fresh *Clarias* per kg by aquaculture system

Price (Naira)	Aquaculture system			Average total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
	206±49[a]	204±47[a]	204±47[a]	204±47

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1 US$ = N 128 in 2003). Values that are not significantly different (p > 0.05) share common superscript.

Prices of fresh *Chrysichthys* differed significantly (p < 0.001) between Lagos and Niger state (Table 3.94).

Table 3.94: Landing prices of fresh *Chrysichthys* per kg by state

Price (Naira)	State		Average total
	Niger n = 200	Lagos n = 200	n = 400
	157±5[a]	251±4[b]	204±47

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1 US$ = N 128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

Average price of fresh *chrysichthys* from different aquaculture systems did not differ significantly ($p = 0.820$) (Table 3.95).

Table 3.95: Landing prices of fresh *Chrysichthys* per kg by aquaculture system

Price (Naira)	Aquaculture system			Average total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
	207±50[a]	204±48[a]	204±47[a]	204±47

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1 US$ = N 128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

Ninety nine percent of the farmers in Lagos and 55% in Niger state sold their fish by cash only (Table 3.96). There was a significant ($\chi^2 = 111$, d.f. = 1, $p < 0.001$) relationship between mode of payment and state, with greater number of farmers in Lagos state selling by cash only.

Table 3.96: Mode of payment by state

Payment	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Cash	109 (55)	198 (99)	307 (77)
Credit	91 (46)	2 (1)	93 (23)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

All the farmers with fish ponds sold their fish by cash only as compared with 80 and 63% for farmers with fish shelters and fish fences, respectively (Table 3.97). Mode of payment was significantly ($\chi^2 = 14$, d.f. = 2, $p = 0.001$) related to aquaculture system, with payment by cash only more pronounced among farmers with fish ponds. Retailers who buy fish on credit repay debt after selling fish in the market. The retailers were mostly wives of the fish farmers.

Table 3.97: Mode of payment by aquaculture system

Payment	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Cash	10 (100)	240 (80)	57 (63)	307 (77)
Credit	0 (0)	60 (20)	33 (37)	93 (23)

n = sample size. Figures in brackets indicate percentages.

3.3.10 Labour

Seventy percent of the farmers in Niger and 26% in Lagos state did not employ labourers (Table 3.98). There was a significant (χ^2 = 78, d.f. = 1, $p < 0.001$) relationship between employment of labour and state, with greater number of farmers in Lagos state employing labourers.

Table 3.98: Distribution of farmers according to employment of labour by state

Labour	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Yes	61 (31)	149 (75)	210 (53)
No	139 (70)	51 (26)	190 (48)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

About 70% of the farmers with fish ponds employed labourers as compared with 61% for farmers with fish fences and 49% with fish shelters (Table 3.99). Employment of labour was not significantly (χ^2 = 5, d.f. = 2, p = 0.078) related to aquaculture system.

Table 3.99: Distribution of farmers according to employment of labour by aquaculture system

Labour	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Yes	7 (70)	148 (49)	55 (61)	210 (53)
No	3 (30)	152 (51)	35 (39)	190 (48)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Average number of labourers employed per crop did not differ significantly ($p = 0.895$) between Niger and Lagos state (Table 3.100).

Table 3.100: Average number of labourers employed by farmers per crop by state

Average number	State		Average total
	Niger	Lagos	
	n = 61	n = 149	n = 210
	$6±5^a$	$6±5^a$	6±5

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

Farmers with fish shelters employed significantly ($p < 0.001$) higher number of labourers than those with fish ponds and fish fences (Table 3.101).

Table 3.101: Average number of labourers employed by farmers per crop by aquaculture system

Average number	Aquaculture system			Average total
	Fish pond	Fish shelter	Fish fence	
	n = 7	n = 148	n = 55	n = 210
	$4±3^a$	$7±6^b$	$3±1^a$	6±5

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

Areas of farming activities labourers are employed by farmers in Niger and Lagos states are given in Table 3.102. About 64% of the farmers in Niger employed labourers in the areas of pond construction / installation and harvesting as compared with 24% for Lagos state.

Table 3.102: Areas of farming activities labourers are employed by farmers by state

Activity	State		Total
	Niger	Lagos	
	n = 61	n = 149	n = 210
Pond construction / installation only	8 (13)	44 (30)	52 (25)
Harvesting only	2 (3)	2 (1)	4 (2)
Pond construction / installation and harvesting	39 (64)	36 (24)	75 (36)
Cutting of grasses and installation	2 (3)	0 (0)	2 (1)
Cutting branches, installation and harvesting	10 (16)	41 (28)	51 (24)
Pond repairs only	0 (0)	1 (1)	1 (1)
Cutting branches and installation	0 (0)	25 (17)	25 (12)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Farmers with fish ponds (57%) employed labourers in the area of harvesting only while those with fish shelters (47%) employed labourers in the area of installation and harvesting. About 62% of the farmers with fish fences employed labourers in the area of fish fence installation (Table 3.103).

Table 3.103: Areas of farming activities labourers are employed by farmers by aquaculture system

Activity	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 7	n = 148	n = 55	n = 210
Pond construction / installation	0 (0)	18 (12)	34 (62)	52 (25)
Harvesting only	4 (57)	0 (0)	0 (0)	4 (2)
Pond construction / installation and harvesting	2 (29)	70 (47)	3 (6)	75 (36)
Cutting of grasses and installation	0 (0)	0 (0)	2 (4)	2 (1)
Cutting branches, installation and harvesting	0 (0)	51 (35)	0 (0)	51 (24)
Pond repairs only	1 (14)	0 (0)	0 (0)	1 (1)
Cutting branches and installation	0 (0)	9 (6)	16 (29)	25 (12)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

3.3.11 Loan

About 88% of the farmers in Niger and 87% in Lagos state did not acquire loans for fish farming / fishing (Table 3.104). There was no significant ($\chi^2 = 0.2$, d.f. = 1, p = 0.653) relationship between loan and state.

Table 3.104: Respondent response to loan for fishing / fish farming by state

Loan	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Yes	24 (12)	27 (14)	51 (13)
No	176 (88)	173 (87)	349 (87)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Irrespective of systems, the majority of fish farmers did not acquire loans (Table 3.105). Only 30% of the farmers with fish ponds acquired loans as compared with 13 and 12% of the farmers with fish fences and fish shelters, respectively. There was no significant ($\chi^2 = 3$, d.f. = 2, p = 0.240) relationship between loan and aquaculture system.

Table 3.105: Respondent response to loan for fishing / fish farming by aquaculture system

Loan	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Yes	3 (30)	36 (12)	12 (13)	51 (13)
No	7 (70)	264 (88)	78 (87)	349 (87)

n = sample size. Figures in brackets indicate percentages.

Of 51 farmers who took loans (Table 3.105), 37 (73%) acquired the loans from government at an interest rate of 8% per annum, 13 (25%) took the loans from co–operative societies and one (2%) from NGO both at interest rate of 10% per annum. Loan from the government was higher (N20270)[3] than that from NGO (N20000)

[3] Nigerian currency is Naira (N). (1US$ = N128 in 2003)

and co-operative (N10385). Majority of the farmers in Niger (96%) acquired the loans from the government as compared to 52% for Lagos state.

Amount of loan received by farmers was significantly ($p < 0.001$) higher in Niger than Lagos state (Table 3.106).

Table 3.106: Amount of loan received by farmers by state

Amount (Naira)	State		Average total
	Niger n = 24	Lagos n = 27	n = 51
	20208±1793[a]	15556±5064[b]	17745±4507

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1 US$ = N 128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

Farmers with fish fences received higher amount of loans (N20000) than those with fish ponds (N18333) and fish shelters (N16944) (Table 3.107). There were, however, no significant ($p = 0.182$) differences in amount of loans received by farmers with different aquaculture systems.

Table 3.107: Amount of loan received by farmers by aquaculture system

Amount (Naira)	Aquaculture system			Average total
	Fish pond n = 3	Fish shelter n = 36	Fish fence n = 12	n = 51
	18333±2887[a]	16944±5110[a]	20000±0[a]	17745±4507

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1 US$ = N 128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

3.3.12 Problems in fishing / fish farming

All the farmers interviewed stated that they have not experienced disease outbreaks in fish ponds or aquaculture systems but they reported poaching as a major problem. About 99% of the farmers in Niger and 61% in Lagos state had experienced poaching (Table 3.108). There was a significant ($\chi^2 = 92$, d.f. = 1, $p < 0.001$)

relationship between poaching and state, with poaching more pronounced in Niger state.

Table 3.108: Distribution of farmers according to poaching by state

Poaching	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Yes	198 (99)	121 (61)	319 (80)
No	2 (1)	79 (40)	81 (20)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

About 80% of the farmers with fish ponds and 83% with fish shelters had experienced poaching as compared with 70% for those with fish fences (Table 3.109). There was a significant (χ^2 = 7, d.f. = 2, p < 0.032) relationship between poaching and aquaculture systems, with poaching more experienced by farmers with fish shelters and fish ponds.

Table 3.109: Distribution of farmers according to poaching by aquaculture system

Poaching	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Yes	8 (80)	248 (83)	63 (70)	319 (80)
No	2 (20)	52 (17)	27 (30)	81 (20)

n = sample size. Figures in brackets indicate percentages.

Farmers employed several measures to check poaching. About 73% of the farmers in Niger and 96% in Lagos state paid regular visits to fish farms in order to check poaching. About 25% of the farmers in Niger state combined regular visits with the use of charms in order to check poaching (Table 3.110). No farmer used charms in Lagos state.

Table 3.110: Measures employed by farmers to check poaching by state

Measures	State		Total
	Niger n = 198	Lagos n = 121	n = 319
Fencing	3 (2)	2 (2)	5 (2)
Employing security guard	0 (0)	2 (2)	2 (1)
Regular visits only	146 (73)	117 (96)	263 (82)
Regular visits and charms	49 (25)	0 (0)	49 (15)

n = sample size. Figures in brackets indicate percentages.

Farmers with fish shelters (85%) and fish fences (81%) paid regular visits to aquaculture systems in order to check poaching as compared with only 13% with fish ponds (Table 3.111). Fifteen percent of the farmers with fish shelters and 19% with fish fences combined regular visits with the use of charms to check poaching (see Figure 3.10b). No farmer with fish pond used charms to check poaching.

Table 3.111: Measures employed by farmers to check poaching by aquaculture system

Measures	Aquaculture system			Total
	Fish pond n = 8	Fish shelter n = 248	Fish fence n = 63	n = 319
Fencing	5 (63)	0 (0)	0 (0)	5 (2)
Employing security guard	2 (25)	0 (0)	0 (0)	2 (2)
Regular visits only	1 (13)	211 (85)	51 (81)	263 (82)
Regular visits and charms	0 (0)	37 (15)	12 (19)	49 (15)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Apart from poaching, a number of other constraints were reported including predation, flooding, net destruction by reptiles and lack of funds. Farmers were found to set traps to capture reptiles that are destroying their nets. Of 400 farmers interviewed, 355 (89%) stated that they use to contact fisheries extension agents when they have problems in fishing / fish farming, 44 (11%) mentioned village heads and one farmer mentioned National Institute for Freshwater Fisheries Research (NIFFR). Farmers who contact extension agents and NIFFR remarked that they received technical advice from them while those contacting village heads contact them in order to deter thieves. Whenever there is poaching, village head warns the community to desist from such act either through town crier or in a meeting with members of the community.

3.3.13 Environmental impacts of aquaculture systems

3.3.13.1 Environmental impacts of fish parks, *ihos* and fish fences

Fifty nine percent of the farmers in Niger and 57% in Lagos state who had fish parks, *ihos* and fish fences stated that these aquaculture systems can lead to deforestation. There was no significant (χ^2 = 0.14, d.f. = 1, p = 0.711) relationship between deforestation and state.

Table 3.112: Distribution of farmers according to whether or not brush parks, *ihos* and fish fences can cause deforestation by state

Deforestation	State		Total
	Niger n = 195	Lagos n = 170	n = 365
Yes	115 (59)	97 (57)	212 (58)
No	80 (41)	73 (43)	153 (42)

n = sample size. Figures in brackets indicate percentages.

About 54% of the farmers with fish parks and 80% with fish fences stated that fish parks, *iho*s and fish fences can cause deforestation (Table 3.113). There was a significant (χ^2 = 37, d.f. = 2, p < 0.001) relationship between deforestation and aquaculture system, with greater number of farmers with fish fences stating that fish parks, *iho*s and fish fences can cause deforestation.

Table 3.113: Distribution of farmers according to whether or not brush parks, *ihos* and fish fences can cause deforestation by aquaculture systems

Deforestation	Aquaculture system			Total
	Fish park	*Iho*	Fish fence	
	n = 250	n = 25	n = 90	n = 365
Yes	136 (54)	4 (16)	72 (80)	212 (58)
No	114 (46)	21 (84)	18 (20)	153 (42)

n = sample size. Figures in brackets indicate percentages.

Of 212 farmers who mentioned that deforestation could be caused by brush parks, *ihos* and fish fences, 183 (86%) proposed planting more trees, four (2%) and 25 (12%) stated that the use of PVC pipes and worn out tyres, respectively, could minimise the deforestation.

About 94% of the farmers in Niger and 93% in Lagos state reported that brush parks, *ihos* and fish fences can also cause siltation (Table 3.114). There was no significant ($\chi^2 = 0.31$, d.f. = 1, p = 0.578) relationship between siltation and state.

Table 3.114: Distribution of farmers according to whether or not brush parks, *ihos* and fish fences can cause siltation by state

Siltation	State		Total
	Niger	Lagos	
	n = 195	n = 170	n = 365
Yes	184 (94)	158 (93)	342 (94)
No	11 (6)	12(7)	23 (6)

n = sample size. Figures in brackets indicate percentages.

There was a significant ($\chi^2 = 11$, d.f. = 2, p = 0.004) relationship between siltation and aquaculture systems, with all the farmers with fish fences and *ihos* stating that fish parks, *ihos* and fish fences can cause siltation. Only 91% of the farmers with fish parks reported that fish parks, *ihos* and fish fences can cause siltation (Table 3.115).

Table 3.115: Distribution of farmers according to whether or not brush parks, *ihos* and fish fences can cause siltation by aquaculture system

Siltation	Aquaculture system			Total
	Fish park	*Iho*	Fish fence	
	n = 250	n = 25	n = 90	n = 365
Yes	227 (91)	25 (100)	90 (100)	342 (94)
No	23 (9)	0 (0)	0 (0)	23 (6)

n = sample size. Figures in brackets indicate percentages.

About 86% of the farmers in Niger and 70% in Lagos state mentioned that they do not have problems with other fishermen as a result of the installation of fish parks, *ihos* and fish fences (Table 3.116). There was a significant (χ^2 = 14, d.f. = 1, p < 0.001) relationship between problems with other fishermen and state, with greater number of farmers in Niger stating that they do not have problems with other fishermen as a result of the installation of fish parks, *ihos* and fish fences.

Table 3.116: Distribution of farmers according to whether or not they have problems with other fishermen due to installation of fish parks, *ihos* and fish fences by state

Problems	State		Total
	Niger	Lagos	
	n = 195	n = 170	n = 365
Yes	27 (14)	51 (30)	78 (21)
No	168 (86)	119 (70)	287 (79)

n = sample size. Figures in brackets indicate percentages.

There was a significant (χ^2 = 33, d.f. = 1, p < 0.001) relationship between problems with other fishermen and aquaculture systems, with only farmers with fish parks (31%) stating that they do have problems with other fishermen as a result of the installation of fish fences, *ihos* and fish parks (Table 3.117).

Table 3.117: Distribution of farmers according to whether or not they have problems with other fishermen due to installation of fish parks, *ihos* and fish fences by aquaculture system

Problems	Aquaculture system			Total
	Fish park	*Iho*	Fish fence	
	n = 250	n = 25	n = 90	n = 365
Yes	78 (31)	0 (0)	0 (0)	78 (21)
No	172 (69)	25 (100)	90 (100)	287 (79)

n = sample size. Figures in brackets indicate percentages.

All the farmers with fish parks, *ihos* and fish fences stated that the aquaculture systems could cause problem to navigation but reported that the systems could increase the productivity of water bodies. According to them, other fishermen prefer fishing around the aquaculture systems because they make more catches of fish around the areas.

3.3.13.2 Environmental impacts of fish pond

All the farmers with fish ponds stated that pond water could be used to irrigate vegetable farms.

3.3.14 Extension Agents (E.A)

Frequency of visiting contact farmers by E.A differed significantly ($\chi^2 = 400$, d.f. = 1, $p < 0.001$) between states (Table 3.118). Extension agents visit their contact farmers weekly in Niger and fortnightly in Lagos state.

Table 3.118: Distribution of farmers according to frequency of visits of E.A by state

Frequency	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Fortnightly	0 (0)	200 (100)	200 (50)
Weekly	200 (100)	0 (0)	200 (50)

n = sample size. Figures in brackets indicate percentages.

Frequency of visiting contact farmers with different aquaculture systems by E.A is given in Table 3.119. There was no significant (χ^2 = 0.0, d.f = 2, p = 1) relationship between frequency of visits by E.A and aquaculture systems.

Table 3.119: Distribution of farmers according to frequency of visits of E.A by aquaculture system

Frequency	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Fortnightly	5 (50)	150 (50)	45 (50)	200 (50)
Weekly	5 (50)	150 (50)	45 (50)	200 (50)

n = sample size. Figures in brackets indicate percentages.

3.3.15 Co – operative society

There was no significant (χ^2 = 2, d.f. = 1, p = 0.169) relationship between membership of co–operative society and state. About 97% of the farmers in Niger and 94% in Lagos state were members of co–operative societies (Table 3.120).

Table 3.120: Distribution of farmers according to whether or not they belonged to co – operative societies by state

Co – operative society	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Yes	193 (97)	187 (94)	380 (95)
No	7 (4)	13 (7)	20 (5)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Ninety nine percent of the farmers with fish fences were members of co–operative societies as compared with 95 and 50% for farmers with fish shelters and fish ponds, respectively (Table 3.121).

Table 3.121: Distribution of farmers according to whether or not they belonged to co – operative societies by aquaculture system

Co – operative society	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Yes	5 (50)	286 (95)	89 (99)	380 (95)
No	5 (50)	14 (5)	1 (1)	20 (5)

n = sample size. Figures in brackets indicate percentages.

Of 380 farmers belonging to co–operative societies (Table 3.121), 377 (99%) were members of fishermen co–operative societies and only three farmers (1%) were members of multipurpose co–operative societies. Eighteen farmers (5%) held the positions of chairmen, two (1%) were secretaries, 10 (3%) were public relations officers, 14 (4%) held the positions of treasurers, 18 (5%) were vice chairmen and 318 (84%) were ordinary members. Thirteen of the farmers (3%) reported that they got loans from the co–operative societies, 366 (96%) stated that they use to get financial assistance from the co–operative societies when they are in problems or during wedding or naming ceremonies and one farmer remarked that he has not yet benefited from the co–operative society. Average length of membership in co–operative society was 11 years.

3.3.16 Fish and meat consumption

About 99% of the farmers in Lagos and 98% in Niger state reported that they eat fish daily (Table 3.122).

Table 3.122: Distribution of farmers according to daily fish consumption by state

Daily fish consumption	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Yes	196 (98)	198 (99)	394 (99)
No	4 (2)	2 (1)	6 (2)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up

All the farmers with fish shelters and fish fences (fishermen) stated that they eat fish daily (Table 3.123). In contrast, only 40% of the farmers with fish ponds stated that they do eat fish daily.

Table 3.123: Distribution of farmers according to daily fish consumption by aquaculture system

Daily fish consumption	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Yes	4 (40)	300 (100)	90 (100)	394 (99)
No	6 (60)	0 (0)	0 (0)	6 (2)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

3.3.16.1 Consumption of fish species

Consumption frequencies of fish species among farmers are given in Figure 3.13. About 53% of the farmers reported that tilapia is the fish they eat frequently followed by *Synodontis* species (32%). All the farmers stated that they prefer eating fresh fish. According to them fresh fish is more delicious.

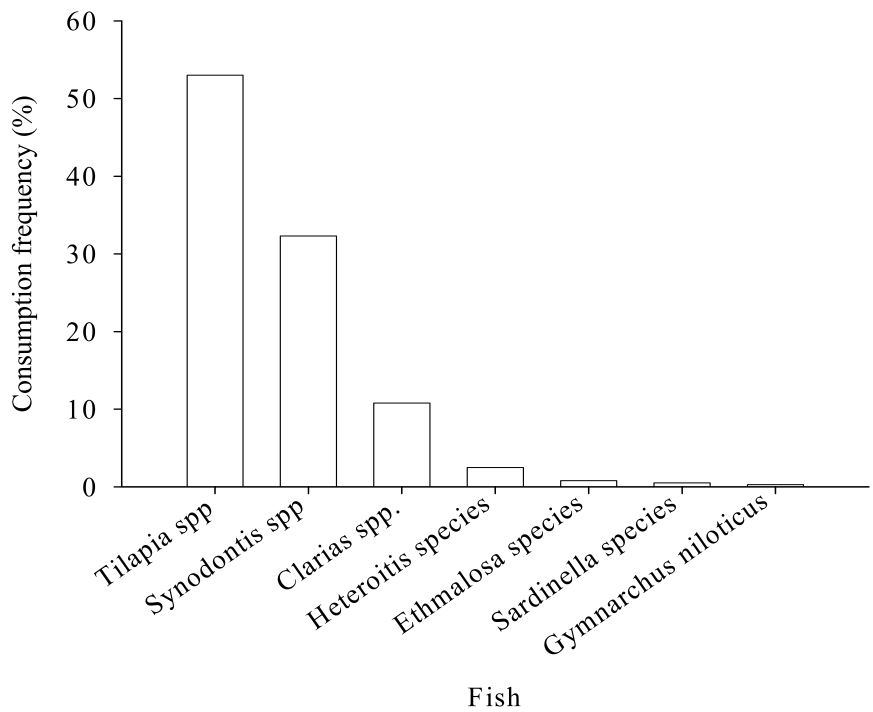


Figure 3.13: Consumption frequencies of fish among farmers in two states in Nigeria

3.3.16.2 Reasons for the frequently consumed fish species

About 95, 81 and 67% of the farmers who ate *Synodontis*, tilapia and *Ethmalosa*, respectively, reported that they eat the species frequently because of their availability. All the farmers who ate *Heteroitis*, *Sardinella*, *Gymnarchus* and about 98% of those who ate *Clarias* eat the species because they are more palatable (Table 3.124).

Table 3.124: Distribution of farmers according to species frequently consumed and reasons for its consumption

Reasons	Fish species							Total
	Tilapia spp	*Synodontis* spp	*Clarias* spp	*Heteroitis* spp	*Ethmalosa* spp	*Sardinella* spp	*Gymnarchus* sp	
	n = 212	n = 129	n = 43	n = 10	n = 3	n = 2	n = 1	n = 400
More palatable	39 (18)	6 (5)	42 (98)	10 (100)	1 (33)	2 (100)	1 (100)	101 (25)
Most available	171 (81)	123 (95)	0 (0)	0 (0)	2 (67)	0 (0)	0 (0)	296 (74)
Few bones	0 (0)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)
Lacks odour	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)

n = sample size. Figures in brackets indicate percentages.

3.3.16.3 Meat preference

Meat preference among farmers is given in Figure 3.14. About 97% of the farmers preferred eating fish to other animal protein foods.

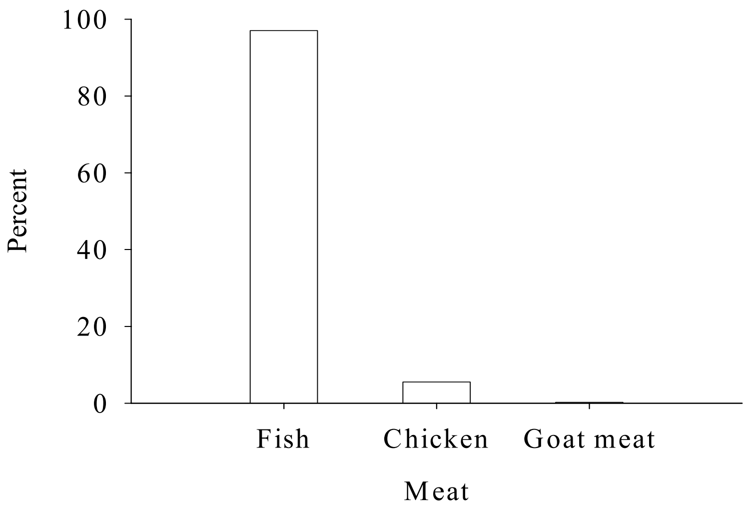


Figure 3.14: Meat preference among farmers. Data for goat meat is too small to appear on the scale

3.3.17 Discussion

The aquaculture systems currently practised in two states in Nigeria include fish ponds, fish shelters and fish fences. Fish shelters and fish fences in this study are regarded as traditional aquaculture systems. These are extensive systems of fish production that provide refuge for fish in rivers, floodplains and lagoons. This study reveals that traditional aquaculture systems are poorly researched in Nigeria. This agrees with the findings of Balarin *et al* (1998). They reported that traditional aquaculture contributes 60% to fish production in Africa but are poorly researched and recorded, and even legislated.

3.3.17.1 Fish ponds

Fish culture activities although established long ago have not yet developed despite the abundant water resources in Nigeria. Ajana (1995) attributed the reason in Lagos state to high cost of land which is out of reach of rural farmers. Another reason according to the author is high preference for construction of residential quarters which has higher revenue than fish ponds, and rural communities that are engaged in capture fisheries prefer fishing from the wild than establishing fish ponds which require management. The numbers of fish ponds found at the time of study in Lagos and Niger states were 155 and 64, respectively. Ajana (1995) found 158 fish farms in Lagos state of which 65% were functional.

The current study showed that farmers operated small fish ponds which were less than one hectare in size. Average size of the ponds ranged from 0.01 to 0.40 ha with an overall average of 0.1 ha. Oresegun *et al* (1996) also obtained an average size of less than one hectare (0.35 ha) in Lagos state. In the present study, farmers (70%) prepared their ponds by applying fertiliser before stocking, 20% allowed the ponds to dry and 10% did not prepare their ponds before stocking. This compares with the findings of Ajana (1995). His study showed that fertilisation of fish ponds was prevalent among farmers in Lagos state, Nigeria.

The most common fish cultured were tilapia sp and *Clarias gariepinus* usually in polycutural practice. Other species cultured were *Chrysichthys nigrodigitatus* and *Heteroitis niloticus*. This confirms the findings of Ajana (1995) and Oresegun *et al* (1996). Most of the farmers (90%) obtained their seeds from hatcheries. Average stocking density was 5730 ha^{-1} which was lower than 3 fish m^{-2} recommended by fisheries extension agents (Ajana, 1995). An important principle of aquaculture production is that a suitable density of fish should be stocked in a pond. Understocking may result in under utilization of feed and space while overstocking may result in competition for food and space and in a decline in the survival and growth rates (Shang, 1981). The stocking density increased with pond size. Ahmed (2001) also reported an increase in stocking density with pond size in Bangladesh. Most of the farmers (70%) produced fish once in a year with culture duration of one year. This agrees with the findings of Oresegun *et al* (1996).

In the current study farmers were found to change water from ponds only when they thought it was polluted. Few farmers (30%) grew banana around their fish ponds to provide shade for fish and to obtain banana fruit in addition to fish. Mean production of fish from ponds ranged from 0.14 to 1.25 t ha^{-1} yr^{-1} with an overall mean of 0.55 t ha^{-1} yr^{-1} which is similar to that obtained by Oresegun *et al* (1996). They obtained mean yield of fish ranging from 0.2 to 1.0 t ha^{-1} yr^{-1} in Lagos state, Nigeria.

3.3.17.2 Fish shelters

Fish shelters are traditional aquaculture systems that provide habitat or hiding place for fish. Many species of fish regularly use woody and vegetated structures in their environment for refuge, food and reproduction. Fish shelters in this study include fish parks, clay pots and tube shelters (*ihos*). Farmers installed fish shelters in rivers and lagoons in order to aggregate fish.

Fish parks identified in this study include brush parks and vegetation parks. Brush parks are constructed of dead branches of trees and shrubs. Vegetation parks are constructed of living, soft, floating vegetation (Welcomme, 2002). Both forms could be installed in fresh and brackish waters. In the present study, brush parks were constructed of palm fronds (*Elaies guineensis*), branches of *mitragyna inermis* and mangroves (*Rhizophora spp* and *Avicennia africana*). Vegetation parks were constructed of elephant grasses (*Pennisetum purpureum*) and were only found in Lagos state. Fish parks are known as *acadjas* in Lagos and as *gidan kifi* in Niger state. Average size of the fish parks ranged from 0.02 to 0.40 ha with an overall average of 0.13 ha. The sizes were similar to those constructed by Solarin and Udolisa (1993) in Lagos Lagoon. Fish parks of greater than 0.08 ha in size were mostly rectangular (91%) while those that were less than 0.04ha (96%) were circular in shape. Welcomme (1972) also identified fish parks of similar shapes in Lake Nokoue system in Dahomey.

Production cycle of smaller fish parks (< 0.04 ha) was thrice a year and those greater than 0.08 ha was once a year. The small size, ease of fishing and low capital cost might have made farmers to construct and harvest smaller fish parks three times in a year. Installation period before harvest was found to increase with size of fish park. Average installation period before harvest ranged from 4 to 9 months.

This agrees with the findings of Welcomme (1972). Brush parks were constructed at an average density of 4 branches m^{-2}. Farmers in Lagos state filled the brush parks with worn out tyres and plastic pipes similar to those constructed by Solarin and Udolisa (1993) in order to provide hiding and breeding places for fish.

The dominant fish species caught from the fish parks was tilapia. This agrees with the findings of Welcomme (1983), Solarin and Udolisa (1993). Mean yield of fish from the fish parks ranged from 0.13 to 1.35 t ha^{-1} yr^{-1} which is lower than those obtained by Welcomme (1972), Solarin and Udolisa (1993). They obtained 1.26 to 12.6 t ha^{-1} and 0.75 to 4.35 t ha^{-1} in coastal lagoons of Benin Republic and Lagos, respectively. Lower yield in the present study may be due to lower unit density of branches used. Fish yield was found to increase with density of implantation of the brush parks. The correlation was significant ($r = 0.242$, $p < 0.001$). There was also a significant ($r = 0.770$, $p < 0.001$) correlation between yield and period of installation of the fish parks. This confirms the results of Solarin and Udolisa (1993).

Clay pots are traps that are provided with non return valves through which the fish enters. Clay pot shelters were only found in Lagos state. They are known as *ikoko* or *isha*. The pots used in this study had single openings at the top with an average diameter of 14 cm and were fitted with conical valves made of either cane strips or raffia mat. The average diameter of the pots at the widest circumference was 38 cm. The pots were set at the bottom horizontally while attached to poles and arranged in rows. Average distance between pots in water was 4 metres. Most of the farmers (76%) kept live gravid female C*hrysichthys sp* in order to attract male C*hrysichthys sp.* The peak season was May to October during the rains for those who installed in brackish water and was year round for those who installed in fresh water lagoon. Number of pots per production cycle ranged from 20 to 30 pots with an overall mean of 25. Pots were set for three days and then harvested in all the local government areas. *Chrysichthys* was the dominant species caught. This account of pot shelters is similar to that given by Udolisa *et al* (1994).

Mean total production of fish from the pot shelters was 0.064 t yr^{-1}. Mean production per pot per harvest was 3 kg[4]. There was no significant ($t = -0.244$, d.f. $= 23$, $p = 0.810$) difference in fish production from pots with gravid females and those without the gravid females.

Bamboo / PVC pipe shelters (*Ihos*) are tubular traps that stop fish from getting out backwards. *Ihos* were only found in Lagos state. *Ihos* consisted of either hollow bamboo poles or PVC pipes of average lengths of 75 cm, with an average diameter of 9 cm. One end of *iho* was covered with either coco nut husks or any hard wood and set vertically in shallow waters through out the year. They were set in rows attached to sticks which served as markers, with an average distance of 38 cm between poles / pipes. Total number of poles / pipes per production cycle ranged from 500 to 1000 with an overall average of 872 poles. Installation period of *ihos* before harvest was found to be 14 days in all the local government areas. The dominant species caught was *Chrysichthys* which entered the pipes in search of shelter. Udolisa *et al* (1994) also observed similar hollow bamboo poles in Lagos state. They also observed another variation in Cross River state, Nigeria in which hollow bamboo poles lie horizontally at the bottom of the river and the target fish; *Chrysichthys* and *Synodontis spp* move into the holes of the bamboo trunks in pairs, one male and one female through the opening made on the upper part of each bamboo trunk. *Ihos* in the current study are similar to hollow logs or iron pipes used in European waters (Von Brandt, 1984).

[4] Average number of pots was 25

Mean total production of fish from *iho* shelters was 0.15 t yr^{-1}. Average production per pipe per harvest was 0.2 kg[5]. There was no significant (t = -2, d.f. = 23, p = 0.123) difference in fish production from hollow bamboo poles and PVC pipes.

3.3.17.3 Fish fences

Fish fences are barriers that are used either alone, or in combination with a variety of traps and nets, especially in swampy areas and where there is a wide floodplain. They were made of various materials such as bamboo strips, cane strips, palm fronds, *Alchornea cordifolia* and gill nets. Farmers constructed fish fences in order to aggregate or trap fish. Fish fences can reach a considerable length and can be arranged in complex forms, giving a labyrinth – like effect (Welcomme, 1979). Capture is either in trap – shaped chambers, or in *gura* and *egun* traps or nets which are used in combination with the fence. They were used as aggregation devices when left undisturbed for three to six months. They are called *awa* in Lagos state and *saba*, *chaba* or *chamba* in Niger state.

Fish fences were constructed mostly from November to May when the currents were not very strong. Dominant species caught from fish fences were tilapia, *clarias*, *chrysichthys* and shrimps. Reed *et al* (1967) and Udolisa *et al* (1994) observed similar fish fences in river Niger and Lagos lagoon, respectively. Mean total production of fish from fish fence was 0.06 t yr^{-1}.

3.3.17.4 Culture / installation environments for aquaculture systems

This study reveals that aquaculture systems (fish ponds, fish shelters and fish fences) were practised in fresh and brackish waters with rivers and lagoons as major sources of water. Most of the farmers with fish ponds (90%) owned land while 70%

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[5] Average number of poles / PVC pipes was 872

of those with fish shelters and fish fences had the aquaculture systems in rivers and lagoons which were open access. All the farmers with fish shelters and fish fences started fishing since childhoods. They all learnt how to fish from their parents. Farmers with fish ponds had an average of 11 years in fish farming with majority of them (70%) acquiring the knowledge of fish farming from extension agents.

3.3.17.5 Management of aquaculture systems

In this study, only few farmers with fish ponds (1%) applied lime to fish ponds in order to kill pathogens. Ajana (1995) also found that application of lime in Lagos state was not wide spread as the chemical was costly and scarce. The current study, however, reveals that farmers (99%) not applying lime did not understand the value of lime in increasing productivity. It was also found that only farmers with fish ponds (2%) applied both organic and inorganic fertilisers to ponds to promote growth of natural food. Organic manures used were cow dung and poultry droppings while NPK was the only inorganic fertiliser used. This confirms the findings of Ajana (1995) and Ayinla (1999). As with land crops, the fertility of the water determines the productivity of the pond. Fertilization can double or triple fish production by stimulating the growth of microscopic plants (phytoplankton) and animals (zooplankton), which comprise the base of the food chain. These organisms are fed upon by insects and small fish which serve as food for larger fish.

All farmers with fish ponds fed their fish with local feeds including fish trash, animal intestines, coconut, cassava waste, corn and rice bran. This compares with the findings of Ajana (1995) and Oresegun *et al* (1996). Fish meal and pelleted feeds were not widely used by farmers. This could be due to high cost in Lagos (Ajana, 1995) and scarcity in Niger state. Few farmers with fish shelters and fish fences were found to feed fish. Reed *et al* (1967) also observed that few days before fish shelter is raided, scraps of food, sometimes in baskets are placed amongst the branches. In the Indian vegetation parks feed consisting mainly of rice and rice bran is placed in bags hung below the vegetation mass. In Bangladesh, brush parks are fed with attractants such as rice bran, wheat bran, mustard oil cake and fermented rice (Welcomme, 2002). According to the author, natural power of attraction of a brush park could be supplemented by feeding or by other attractants that draw more fish into the park, stop existing populations leaving and fatten the fish that are resident in the park.

Proper fish harvesting is one of the more important factors in pond management. In this study, fish was harvested from fish ponds and fish shelters once per crop. Fish harvesting from fish fence was once or twice daily and once daily after three or six months of installation. All farmers with fish shelters and fish fences carried out total harvest of fish. Total harvest of fish from fish parks has been described by Welcomme (1972). Only few farmers with fish ponds (40%) carried out partial / selective harvest of fish from ponds. Fish was harvested from fish shelters and fish fences using fishing gears only without draining. Most of the farmers with fish ponds (70%) drained the ponds either through outlet or with water pump to irrigation farms or lagoons and then used fishing gear to harvest fish. Ajana (1995), however, reported that pond draining was not commonly adopted by farmers in Lagos state and only few farmers (30%) utilized water pumps for draining.

Various fishing gears were used in harvesting fish including drag nets, encircling gill nets, scoop nets, traps such as clay pots and hollow bamboo poles / PVC pipes. Most of the farmers with fish ponds (90%) used drag nets while 81% of those with fish shelters used encircling gill net. Farmers with fish fences (30%) used scoop nets to harvest fish from fish fences. Average mesh size of nets was found to be 1.4 inches.

3.3.17.6 Fish processing, preservation and marketing

In this study, majority of the farmers (89%) did not process fish. Only 11% of the farmers processed fish by smoking, salting, sundrying and roasting. All the male farmers interviewed (99.75%) reported that they sell fresh fish to their wives who take charge of processing, preservation and marketing. Fish marketing is almost entirely in the hands of women. This compares with the findings of Reed *et al* (1967).

Most of the farmers (97%) sold their fish at the landing sites to retailers and only 4% sold both at landing sites and market. Prices of fresh tilapia, *clarias* and *chrysichthys* were higher in Lagos than Niger state. Higher price in Lagos could be due to better markets as Lagos is a commercial state. Fish wholesalers in Niger state often transport smoked fish to Lagos as a result of better markets. Seventy seven percent of the farmers sold their fish by cash only and 23% sold by credit to retailers who are mostly their wives. The retailers repaid debts after selling fish in the local markets.

3.3.17.7 Fish production experience

The current study showed that fish production for 79% of the farmers was the same with previous year, 13% reported smaller production than previous year and 8% reported larger production. Reasons for a decrease in production included lack of funds, poaching, seepage and lack of flood. Farmers with brush parks stated that the use of more branches m^{-2} and dry branches were the reasons for increase in production. Fish production from the aquaculture systems (fish ponds, fish shelters and fish fences) was higher in Lagos than Niger state. Higher production in Lagos could be due to more water volume in lagoons. Large volume of total harvest was sold by farmers for income. Volume of fresh fish sold was also higher in Lagos than Niger state probably due to ready markets in Lagos. Most of the farmers (99.5%) were satisfied with earnings from fish and would not want to change to other occupations. This supports the findings of Wara (2002).

3.3.17.8 Problems in fishing / fish farming

All the farmers interviewed stated that they have not experienced disease out break in fish ponds or aquaculture systems but poaching was reported by 80% of the farmers. This confirms the findings of Ajana (1995). Farmers employed several methods to check poaching including fencing the farm, regular visits, employing security guard and the use of charms. The use of charms was common in Niger state among farmers with fish fences. Apart from poaching, other constraints were reported by farmers which included predation, over flooding, net destruction by reptiles and lack of funds.

Farmers (89%) were found to contact extension agents (E.A) when they have problems in fishing / fish farming. Other farmers (11%) were found to report cases of poaching to village heads who help in deterring thieves. One farmer mentioned NIFFR as an organisation she contacts when she has problem in her fish pond. Extension agents were found to visit farmers fortnightly in Lagos and weekly in Niger state. The difference in frequency of visits may be due to ease of movement in Niger state. An organized extension service is provided by Agricultural Development Authority (ADP) in both states. Unified extension service system was in place in which one E.A delivers messages in all components of agriculture i.e. crop, livestock, agro forestry, fisheries, processing and marketing. E.A visits his contact farmer to extend the services or technology to him after identifying his problem.

3.3.17.9 Environmental impacts of aquaculture systems

Most of the farmers (58%) reported that brush parks, *ihos* and fish fences encourage deforestation since branches are used in their construction. In order to minimise deforestation, farmers proposed the planting of more trees, use of PVC pipes and worn out tyres in the construction of fish parks and *ihos*. Farmers (94%) also stated that brush parks, *ihos* and fish fences could bring siltation. To minimise deforestation and accumulation of organic matter in the system, Hem and Avit (1996) used bamboo, which last up to 4 to 6 years compared to soft wood branches that are replaced annually. According to these authors yields using bamboo are almost double those realised using branches (8 - 10 tonnes per hectare compared with 5 - 6 tonnes when using the traditional enclosure). This is because algae and other organisms easily cling to bamboo, providing natural food in sufficient quantities for the fish and eliminating the need to feed them. All the farmers interviewed stated that brush parks, *ihos* and fish fences could cause problem to navigation.

Seventy nine percent of the farmers reported that they do not have problem with other fishermen as a result of the installation of brush parks, *ihos* and fish fences in water. All the farmers interviewed mentioned that other fishermen prefer fishing around brush parks, *ihos* and fish fences because they catch more fish around the areas. This confirms the findings of Welcomme (1972). According to the farmers, the aquaculture systems could increase the productivity of the water bodies because they provide shelters and breeding grounds for fish. All the farmers with fish ponds stated that pond water could be used to irrigate vegetable farms.

3.3.17.10 Labour

About 52% of the farmers employed labourers while 48% used household labour. Farmers with fish shelters employed higher number of labourers per crop in the areas of installations and harvesting than farmers with fish ponds and fish fences probably due to large sizes of fish parks.

This study reveals that majority of the farmers (87%) did not get loan for fishing / fish farming. This agrees with the findings of Oresegun *et al* (1996) and Ahmed (2001). Thirteen percent of the farmers got loans from the government, Co operative societies and NGOs at interest rates of 8% and 10%, respectively. Loan from the government was through Nigerian Agricultural, Co–operative and Rural Development Bank (NACRDB). Majority of the farmers (95%) were members of fishermen and multipurpose co-operative societies. The co-operatives provided loans and financial assistance to members.

3.3.17.11 Fish consumption

The current study reveals that fishermen eat fish daily (Table 3.123) confirming its importance in the diet of rural people. Farmers were found to prefer fresh fish. According to them, fresh fish is more delicious. A study in Los Rios province by Holguin (2005) also showed high preference for fresh fish. Tilapia and *Synodontis* species were eaten frequently by farmers because of their availability. Fish was preferred by farmers to other animal protein foods. This confirms the results of Abobarin (2003) and Holguin (2005).

Chapter 4: Economic analysis of fish production and socio–economic conditions of fish farmers

4.1 Introduction

One way of assessing suitability of species or methods for aquaculture production is to apply cost–benefit analysis. This analysis can be used to estimate the rate of return on the resources invested both from a private and from a social point of view (Shang, 1990; Tisdell, 1994). Both aspects are important. The former is important because private producers have no incentive to adopt new forms of aquaculture unless they yield sufficient monetary return. The social rate of return takes into accounts not only private returns but often unaccounted social benefits of aquaculture such as food supply, employment and infrastructure development.

Economic analysis of fish production is essential to evaluate the viability of investment in aquaculture, determine the efficiency of resource allocation and evaluate new culture technology (Shang, 1990). Total cost of production is often divided into explicit and implicit costs (Jolly and Clonts, 1993). The money payments for fertilizer, fingerlings and feed are explicit costs. Explicit costs also include payments for fixed assets and depreciation. Implicit costs are opportunity costs that are not often reflected in the farmer's accounting statement. The opportunity cost of resources used (such as land, labour and capital) should be included as cost items in the cost–return calculation especially in developing countries where labour use can be intensive (Shang, 1990; Jolly and Clonts, 1993).

In the present study, opportunity costs[6] of own land, capital and family labour were included as cost items. Opportunity cost of own land was estimated from cost of

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[6] Opportunity cost of wood was not included in the cost-return calculation of fish parks but the implications of this were discussed later.

lease per ha in the area. Interest on own capital was calculated from interest rate of commercial banks. Opportunity cost of family labour was estimated from cost of hired labour in the area. Depreciation rate was estimated using the straight line method assuming a salvage value of zero at the end of useful component life. Annual depreciation rate was therefore computed by dividing the cost of the asset by its expected years of economic life (useful life). Fishing nets, pots, PVC pipes and pond construction were the only items depreciated in this study.

Total cost is the amount of money that must be expended to obtain various levels of production and can be further categorised into fixed and variable costs. Fixed costs are those that must be paid by the farmer regardless of how much his farm produces. Fixed costs do not change in magnitude as the amount of output of the production process changes. These costs include land, property taxes, depreciation and interest on capital investments. Variable costs include payments for items such as feed, fingerlings, fertilizers and labour, which normally vary with the level of output. These may also fluctuate during the production period.

Successful development of aquaculture not only requires appropriate environmental conditions but also supportive socio-economic conditions. Socio-economic conditions influence the type of aquaculture which can be developed successfully on the species suitable for culture and appropriate methods of culture. On the economic side, demand for aquaculture products and markets are seen as important. Significant social influences include customs, tastes and social attitudes (Tisdell, 1994). The economic and social implications of different types of aquaculture vary greatly. Some farms are valuable even when used on a small scale, are labour intensive, require little capital, are ecologically benign, give worthwhile economic returns and may make for greater equality in the distribution of income. This appears to be so for seaweed farming in villages in Bali, Indonesia (Tisdell, 1994). On the other hand, some types of aquaculture are comparatively capital intensive, can be ecologically unsustainable and environmentally damaging if incorrectly managed and can increase inequality of income. This appears to be so for much of shrimp farming in Bangladesh. Many shrimp farms are controlled by rich members of the society (Tisdell, 1994). Aquaculture systems that require less input for production are likely to be preferred from a cost–benefit and social access point of view.

This chapter is aimed at determining costs and returns of fish production from fish ponds, fish parks, pot shelters, *ihos* and fish fences. Social and economic conditions of fish farmers are also examined.

4.2 Materials and methods

Materials and methods used in this chapter are detailed in the general materials and methods section (2.3 to 2.6).

4.3 Results

4.3.1 Costs and returns

4.3.1.1 Costs of production from fish ponds

Mean costs of production from fish ponds by state are presented in Table 4.1. Mean total costs of fish production in Niger and Lagos states were N 57656[7] (US$ 450) and N 63739 (US$ 478) ha^{-1} yr^{-1}, respectively, with an average of N 60698 (US$ 467) ha^{-1} yr^{-1}. Mean total variable cost in Niger state was N 39596 (US$ 309) as compared to N 51054 (US$ 399) ha^{-1} yr^{-1} for Lagos state accounting for 69 and 80% of the total costs, respectively. Fish seed accounted for 96% of the total

[7] Nigerian currency is Naira (N). (1US$ = N128 in 2003).

variable cost in Niger and 88% for Lagos state. Total fixed costs were 31 and 20% of the total costs in Niger and Lagos state, respectively, with cost of land dominating the fixed costs in both states.

Standard deviations for costs of seeds, depreciation and land were 169, 128 and 108%, of their mean values, respectively, in Niger while those of Lagos state were 76, 64 and 54% of their mean values, respectively, suggesting that the amount paid for seeds, land and items (nets and pond construction) depreciated by farmers in Niger differed greatly due to large differences in sizes of ponds in Niger as seen in the large standard deviation for pond size. Average pond size was 0.1 ha in both states but standard deviations were 0.3 and 0.1 in Niger and Lagos, respectively.

Overall standard deviation for cost of seeds was 17% higher than its mean value while those of security and land were 16 and 11% higher than their mean values, respectively, and those of other cost items were lower than their mean values. Higher standard deviation for cost of seeds suggests that there were large differences in the amount paid for seeds by farmers in Niger and Lagos states as a result of differences in sizes of ponds and prices of seeds between the two states. Standard deviation for cost of labour was 38% of its mean value in Niger as compared with 48% for Lagos. Larger standard deviation in Lagos may be due to high cost of labour in the state resulting in its use being reduced by farmers. Standard deviation for mean total cost of production per hectare per year was 125% of its mean value in Niger as compared with 54% for Lagos suggesting that there were wider variations in the cost of production in Niger state as a result of large differences in pond sizes, depreciation, costs of seeds and land in the state probably due to more variability in the availability of the inputs resulting in differences in prices of the items perhaps due to less development in the state.

Table 4.1: Costs of fish production from fish ponds by state

Cost item ($N\ ha^{-1}\ yr^{-1}$)	Niger		Lagos		Mean total	%
	Mean	%	Mean	%		
Fish seed	37834±63827 (5)	66	45090±34333 (5)	71	41462±48467 (10)	68
Lime	n.a		4967±2550 (3)	5	4967±2550 (3)	2
Inorganic fertilizer	n.a		135±21 (2)	0	135±21 (2)	0
Feed	752±761 (5)	1	630±667 (5)	1	691±677 (10)	1
Labour[8]	1010±387 (5)	2	2300±1095 (5)	4	1655±1030 (10)	3
Total variable Cost	39596±64311 (5)	69	51054±36805 (5)	80	45325±49766 (10)	75
Interest	1760±270 (5)	3	1960±568 (5)	3	1860±433 (10)	3
Security (Guard)	n.a		1100±1273 (2)	1	1100±1273 (2)	0
Land	14200±15369 (5)	25	6160±3333 (5)	10	10180±11308 (10)	17
Depreciation	5250±6718 (2)	4	4125±2637 (5)	7	4446±3529 (7)	5
Total Fixed Cost	18060±16069 (5)	31	12685±3496 (5)	20	15373±11323 (10)	25
Total cost	57656±71815 (5)	100	63739±34130 (5)	100	60698±53106 (10)	100

Data is presented as mean ± standard deviation. n.a = not applicable as the item was not used. Figures in brackets indicate the number of farmers that used the item. % indicates percentage cost. Percentages have been rounded up. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

Mean total annual costs of production per hectare from fish ponds by pond size category are given in Table 4.2. Mean total annual cost of production per hectare increased with pond size as a result of the high use of seed, labour and fertiliser by farmers with larger farms. Costs of fish seed and labour increased with pond size. Farmers with small sized fish ponds did not have items that could be depreciated.

Standard deviations for costs of seed and feed were 14 and 39%, respectively, greater than their mean values in small sized fish ponds than other size categories. Standard deviation for mean total cost of production per hectare per year was 46% of its mean value in small sized category while those of medium and large sized

[8] Labour cost covers costs of pond repairs and harvesting

categories were 40 and 31%, respectively. Higher standard deviation in small sized category may be due to more variability in quantities and prices of seed and feed used by small pond operators perhaps due to wider variety of knowledge and practice.

Table 4.2: Costs of fish production from fish ponds by size category

Cost item (N ha^{-1} yr^{-1})	Small (<0.04 ha)		Medium (0.04 – 0.08 ha)		Large (> 0.08 ha)		Mean total	%
	Mean	%	Mean	%	Mean	%		
Fish seed	3057±3487 (3)	24	31890±19234 (5)	57	123000±38184 (2)	85	41462±48468 (10)	68
Lime	n.a		4950±3606 (2)	9	5000±0 (1)	2	4967±2550 (3)	2
In organic fertilizer	n.a		150±0 (1)	0	120 ± 0 (1)	0	135±21 (2)	0
Feed	753±1046 (3)	6	690±631 (5)	1	600±566 (2)	0	691±677 (10)	1
Labour	833±58 (3)	7	1670±712 (5)	3	2850±1626 (2)	2	1655±1031 (10)	3
Total variable Cost	4644±3001 (3)	37	36260±21022 (5)	65	129010±33503 (2)	89	45325±49766 (10)	75
Interest	1567±57 (3)	12	1960±568 (5)	4	2050±71 (2)	1	1860±433 (10)	3
Security (Guard)	n.a		1100±1273 (2)	2	n.a		1100±1273 (2)	0
Land	6333±6658 (3)	50	13420±15166 (5)	24	7850±5869 (2)	5	10180±11309 (10)	17
Depreciation	n.a		3725±3062 (5)	7	6250±5303 (2)	4	4446±3530 (7)	5
Total Fixed Cost	7900±6684 (3)	63	19545±13061 (5)	35	16150±11243 (2)	11	15373±11323 (10)	25
Total cost	12544±5785 (3)	100	55805±22186 (5)	100	145160±44746 (2)	100	60698±53105 (10)	100

Data is presented as mean ± standard deviation. n.a = not applicable as the item was not used. Figures in brackets indicate the number of farmers that used the item. % indicates percentage cost. Percentages have been rounded up. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.1.2 Profitability of fish ponds

Profitability was defined by the following criteria:

- Net return, defined as gross revenue minus total cost. The gross or total revenue is the total product or output multiplied by the market price of output. A positive net return means the activity is profitable.

- Benefit–cost ratio, defined as net return divided by the total cost. The greater the amount above 1.0 the more profitable is the activity.
- Rate of farm income, defined as net return divided by gross revenue, times 100. The larger the rate of farm income, the greater the production efficiency.

Costs and returns of production from fish ponds by state are presented in Table 4.3. Mean production of fish from fish ponds in Niger and Lagos state were 585 (range = 25 - 2000) and 510 (range = 450 - 600) kg ha^{-1} yr^{-1}, respectively. Net return per hectare per year, rate of income and benefit–cost ratio were higher in Lagos than Niger state. Cost of fish production per kg was N 99 (US$ 0.8) in Niger state as compared to N 125 (US$ 1) for Lagos state. Net return per kg was also higher in Lagos than Niger state.

Standard deviations for net returns, fish production levels and total cost of production per hectare per year were 84, 39 and 25%, respectively, higher than their mean values in Niger while those of Lagos state were lower than their mean values. Standard deviations for rate of income, benefit-cost ratio and net return per kilogram in Niger state were also greater than their mean values. Higher standard deviations in Niger may be due to wider variations in sizes of ponds, depreciation, costs of seeds and land in Niger. Large differences in fish production and net returns per hectare in Niger may also be due to more variability in management practice and in wider ranges of market prices of fish. This suggests that Lagos state has much more uniform approach to fish production and less variation in input costs probably due to more development in the state.

Table 4.3: Costs and returns of fish ponds by state

State	Niger	Lagos
	n = 5	n = 5
Mean production (kg ha^{-1} yr^{-1})	585 ±812	510 ±55
Gross revenue (N ha^{-1} yr^{-1})	87848 ±123920	109700 ±12508
Total cost (N ha^{-1} yr^{-1})	57656 ±71815	63739 ±34130
Net return (N ha^{-1} yr^{-1})	30192 ±55443	45961 ±29615
Rate of income (%)	34 ±61	42 ±29
Benefit - cost ratio	0.5 ±0.7	0.7 ±0.9
Average cost (N kg^{-1})	99 ±80	125 ±64
Average price (N kg^{-1})	150 ±6	215 ±5
Net return (N kg^{-1})	51 ±60	90 ±62

Data is presented as mean ± standard deviation. n = sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

Mean production of fish per hectare per year from ponds increased with pond size (Table 4.4). Net returns per hectare per year also increased with increase in pond size. The highest income rate (46%) and benefit–cost ratio (0.8) were found in medium sized category. The lowest rate of income and benefit-cost ratio were found in large sized category at 30% and 0.4, respectively. Average cost of fish production per kg increased with increase in pond size. Net return per kg was highest in medium sized category due to higher average price, perhaps due to better market opportunities.

Standard deviations for net returns per hectare, benefit-cost ratio and net return per kilogram were 97, 50 and 7%, respectively, higher than their mean values in small sized category than other size categories probably due to more variability in management techniques such as feeding, control of predators and diseases.

Table 4.4: Costs and returns of fish ponds by size category

Size category	Small (<0.04 ha)	Medium (0.04 – 0.08 ha)	Large (>0.08 ha)
	n =3	n = 5	n =2
Mean production (kg ha $^{-1}$ yr $^{-1}$)	142 ±142	510±55	1250±1060
Gross revenue (N ha^{-1} yr^{-1})	20467 ±21058	102468±20311	207000±137179
Total cost (N ha^{-1} yr^{-1})	12544 ±5785	55805±22186	145160±44746
Net return (N ha^{-1} yr^{-1})	7923 ±15576	46663±28155	61840±92433
Rate of income (%)	39 ±40	46±28	30±32
Benefit - cost ratio	0.6 ±0.9	0.8±0.9	0.4±0.5
Average cost (N kg^{-1})	88 ±41	109±34	116±98
Average price (N kg^{-1})	144 ±5	201±30	166±48
Net return (N kg^{-1})	56 ±60	92±59	50±49

Data is presented as mean ± standard deviation. n = sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.1.3 Costs of production from fish parks

Mean costs of production from fish parks by state are presented in Table 4.5. Mean total costs of fish production in Niger and Lagos state were N 7579 (US$ 59) and N 15006 (US$ 117) ha^{-1} yr^{-1}, respectively. Mean total variable and fixed costs were also higher in Lagos than Niger state. Percentage total fixed cost was, however, higher in Niger than Lagos state. Depreciation and labour were the major cost items in Niger and Lagos state, respectively. Feed accounted for less than one percent of the total costs in the two states. There was a significant ($p < 0.001$) difference in total cost of fish production between Niger and Lagos state, with Lagos being higher than Niger.

Standard deviation for cost of feed was`141% of its mean value in Lagos as compared with 13% for Niger suggesting that there were large differences in quantities and prices of feed used by farmers in Lagos perhaps due to wider variety in methods and practice. Standard deviation for cost of labour was 119% higher than its mean value in Niger while that of Lagos was only 28% higher than its mean value suggesting that there were wider variations in the cost of labour in Niger perhaps due to less development in the state resulting in more variability in the availability of labour.

Table 4.5: Costs of production from fish parks by state

Cost item ($N\ ha^{-1}\ yr^{-1}$)	Niger		Lagos		Mean total	%
	Mean	%	Mean	%		
Feed	188 ±25 (4)	0	500±707 (2)	0	292±356 (6)	0
Labour[9]	1737±3807 (150)	23	7006±8936 (100)	47	3844±6864 (250)	36
Total Variable Costs	1742±3805 (150)	23	7016±8940 (100)	47	3851±6866 (250)	37
Interest	2209±252 (150)	29	2118±431 (100)	14	2172±337 (250)	21
Depreciation	3628±2435 (150)	48	5873±3532 (100)	39	4526±3118 (250)	43
Total Fixed Cost	5837±2471 (150)	77	7991±3546 (100)	53	6698±3126 (250)	63
Total Cost	7579±5868 (150)	100	15006±11673 (100)	100	10550±9384 (250)	100

Data is presented as mean ± standard deviation. Figures in brackets indicate the number of farmers that used the item. % indicates percentage cost. Percentages have been rounded up. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

Mean total costs of production from fish parks by park size category are presented in Table 4.6. Mean total costs of production per hectare per year increased with increase in fish park size. Mean total variable and total fixed costs per hectare per year also increased with size. Cost of labour per hectare per year also increased with size and was the major cost item in large sized fish parks. Large sized fish parks (> 0.08 ha) had a significant ($p < 0.001$) higher total cost per hectare per year than small and medium sized parks.

Standard deviation for cost of feed was 141% of its mean value in large sized category as compared with 16% for small sized category. Standard deviation for

[9] Labour cost covers costs of cutting branches, installation and harvesting

mean total cost of production per hectare per year was 55% of its mean value in larger fish parks while those of medium and small sized categories were 53 and 36%, respectively, suggesting that there were larger differences in quantities and prices of feed used by larger fish park operators probably due to wider variety in methods and practice.

Table 4.6: Costs of production from fish parks by size category

Cost item (N ha^{-1} yr^{-1})	Small (< 0.04 ha)		Medium (0.04 - 0.08 ha)		Large (> 0.08 ha)		Mean total	%
	Mean	%	Mean	%	Mean	%		
Feed	183±29 (3)	0	200±0 (1)	2	500±707 (2)	0	292±355 (6)	0
Labour	455±730 (102)	9	2371±3324 (81)	27	10785±9707 (67)	51	3844±6864 (250)	36
Total Variable Cost	460±730 (102)	9	2373±3322 (81)	27	10800±9706 (67)	51	3851±6866 (250)	37
Interest	2198±274 (102)	45	2196±312 (81)	25	2105±434 (67)	10	2172±337 (250)	21
Depreciation	2262±1238 (102)	46	4333±1801 (81)	49	8205±2950 (67)	39	4526±3118 (250)	43
Total Fixed Cost	4460±1276 (102)	91	6530±1836 (81)	73	10310±3045 (67)	49	6698±3126 (250)	63
Total Cost	4921±1772 (102)	100	8903±4712 (81)	100	21109±11621 (67)	100	10550±9384 (250)	100

Data is presented as mean ± standard deviation. n.a = not applicable as the item was not used. Figures in brackets indicate the number of farmers that used the item. % indicates percentage cost. Percentages have been rounded up. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.1.4 Profitability of fish parks

Mean production of fish from fish parks in Niger and Lagos state were 404 and 756 kg ha^{-1} yr^{-1}, respectively, (Table 4.7). There was a significant difference ($p = 0.001$) in fish production per hectare per year from fish parks between the two states, with production being higher in Lagos than Niger. Net return per hectare per year, rate of income and benefit-cost ratio from fish parks were also higher in Lagos than Niger state. There was a significant ($p < 0.001$) difference in net returns per hectare per year between the two states, with Lagos being higher than Niger. Average costs of fish production per kg from fish parks were N 19 (SD[10] = 18) and N 20 (SD = 17) in Niger and Lagos state, respectively. Net return per kg was higher in Lagos than Niger state.

Standard deviations for fish production levels and net returns per hectare per year were 16 and 41%, respectively, higher than their mean values in Niger than Lagos state probably due to wider differences in management techniques such as control of predators and diseases in Niger.

Table 4.7: Costs and returns of fish parks by state

State	Niger	Lagos
	n = 150	n = 100
Mean production (kg ha^{-1} yr^{-1})	404 ±470	756 ±854
Gross revenue (N ha^{-1} yr^{-1})	52826 ±68676	112430 ±121051
Total cost (N ha^{-1} yr^{-1})	7579 ±5868	15006 ±11673
Net return (N ha^{-1} yr^{-1})	45247 ±63833	97424 ±111638
Rate of income (%)	86 ±16	87 ±77
Benefit - cost ratio	6.0 ±4.1	6.5 ±3.5
Average cost (N kg^{-1})	19 ±18	20 ±17
Average price (N kg^{-1})	131 ±21	149 ±25
Net return (N kg^{-1})	112 ±94	129 ±34

Data is presented as mean ± standard deviation. n = indicates sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

Costs and returns of production from fish parks by size category are presented in Table 4.8. Mean production of fish per hectare per year from fish parks increased with size of fish park. Net returns per hectare per year, rate of incomes and benefit–cost ratios from fish parks also increased with size. Average cost of fish production per kg decreased with size of fish parks and net returns per kg increased with size. Mean production of fish and net returns per hectare per year from fish parks were significantly ($p < 0.001$) higher in large sized fish parks (> 0.08 ha) than small and medium sized parks.

[10] SD = Standard deviation

Standard deviation for net returns per hectare per year was about 100% of its mean value in small sized fish parks while those of medium and small sized parks were 60 and 64%, respectively, of their mean values. Higher standard deviation in small sized parks may be due to differences in management practice and in wide ranges of market prices of fish produced by small fish park operators and, perhaps also due to effects of poaching/theft as it is easier to get fish illegally from smaller parks.

Table 4.8: Costs and returns of fish parks by size category

Size category	Small (< 0.04 ha)	Medium (0.04 – 0.08 ha)	Large (> 0.08 ha)
	n = 102	n = 81	n = 67
Mean production (kg ha^{-1} yr^{-1})	130 ±89	399 ±187	1353 ±835
Gross revenue (N ha^{-1} yr^{-1})	16960 ±13305	54025 ±29329	194940±119184
Total cost (N ha^{-1} yr^{-1})	4921 ±1772	8903 ±4712	21109±11621
Net return (N ha^{-1} yr^{-1})	12039 ±12040	45122 ±27126	173831±111428
Rate of income (%)	71 ±14	84 ±18	89±8
Benefit - cost ratio	2.4 ±1.5	5.1 ±2.5	8.2±4.4
Average cost (N kg^{-1})	38 ±17	22 ±13	16±10
Average price (N kg^{-1})	130 ±18	135 ±29	144±32
Net return (N kg^{-1})	92 ±26	113 ±29	128±33

Data is presented as mean ± standard deviation. n = indicates sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.1.5 Profitability of pot shelters in Lagos state

Pot and *iho* (tube) shelters were only practised in Lagos state. Costs and returns of production from pot shelters in local government areas (L.G.A) in Lagos state are given in Table 4.9. Total cost of production per year was highest (N 6158) in Amuwo-odofin and lowest (N 5462) in Badagry L.G.A. Mean production of fish per year was highest (69 kg) in Ibeju / lekki and lowest (59 kg) in Amuwo-odofin. Net returns per year, rate of income and benefit–cost ratio were also higher in Ibeju / lekki than the remaining L.G.A. There was, however, no significant difference in mean production of fish ($p = 0.502$), total cost of production ($p = 0.663$) and net returns per year ($p = 0.078$) in the L.G.A.

Table 4.9: Costs and returns of pot shelters by L.G.A in Lagos state

Mean cost of item (N yr^{-1})	Amuwo-Odofin (5)	Badagry (5)	Epe (5)	Ibeju / lekki (5)	Lagos Mainland (5)
Labour	218±15	232±24	226±18	226±21	236±17
Total Variable Cost	218±15	232±24	226±18	226±21	236±17
Interest	2200±158	1980±567	2040±270	2300±158	2000±570
Depreciation	3740±622	3250±984	3625±599	3125±625	3375±559
Total Fixed Cost	5940±639	5230±1108	5665±638	5425±735	5375±541
Total Cost	6158±651	5462±1123	5891±651	5651±755	5611±548
Mean production (kg yr^{-1})	59±11	61±24	67±3	69±3	65±4
Gross revenue (N)	13195±1967	14530±5619	15700±891	16650±929	15500±1173
Net return (N yr^{-1})	7037±1439	9068±5081	9809±808	10999±449	9889±1162
Rate of income (%)	53±4	62±16	63±4	66±3	64±4
Benefit-cost ratio	1.1±0.2	1.7±0.8	1.7±0.3	1.9±0.3	1.8±0.3
Average cost (N kg^{-1})	104±10	89±38	88±9	82±8	87±9
Average price (N kg^{-1})	224±16	238±10	234±9	241±2	238±2
Net return (N kg^{-1})	120±13	149±37	146±10	159±6	151±8

Data is presented as mean ± standard deviation. Figures in brackets indicate sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

Costs and returns of production by number of pots are presented in Table 4.10. Mean total cost of production, mean production of fish and net returns per year increased with the increase in number of pots. Use of 30 pots had the highest net returns per year (N10994), rate of income (64%) and benefit–cost ratio (1.8). There was a significant difference in mean production of fish ($p = 0.001$), total cost of production ($p = 0.007$) and net returns per year ($p = 0.021$) among the numbers of pots, with the use of 30 pots being higher than 20 and 25.

Table 4.10: Costs and returns of pot shelters by number of pots

Mean cost of item (N yr^{-1})	Number of pots		
	20 (8)	25 (7)	30 (10)
Labour	206±7	226±5	246±8
Total Variable Cost	206±7	226±5	246±8
Interest	2125±255	2214±177	2010±542
Depreciation	2744±663	3554±414	3875±339
Total Fixed Cost	4869±644	5768±388	5885±675
Total Cost	5075±646	5994±385	6131±674
Mean production (kg yr^{-1})	56±13	61±9	73±5
Gross revenue (N)	13201±2974	14431±2448	17125±1390
Net return (N yr^{-1})	8126±2745	8437±2623	10994±1659
Rate of income (%)	62±8	59±11	64±6
Benefit cost ratio	1.6±0.5	1.4±0.5	1.8±0.4
Average cost (N kg^{-1})	91±21	98±24	84±11
Average price (N kg^{-1})	236±10	237±6	235±14
Net return (N kg^{-1})	145±20	139±29	151±19

Data is presented as mean ± standard deviation. Figures in brackets indicate sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.1.6 Profitability of *iho* (tube) shelters in Lagos state

Costs and returns of production from *ihos* by L.G.A in Lagos state are given in Table 4.11. Mean total cost of production per year was highest (N7220) in Amuwo-odofin and lowest (N5698) in Ibeju / lekki. Mean production of fish per year, net returns per year, rate of income and benefit–cost ratio were higher in Ibeju / lekki and lowest in Badagry L.G.A. There was no significant difference in mean production of fish (p = 0.475), cost of fish production (p = 0.978) and net returns per year (p = 0.073) in the L.G.A.

Table 4.11: Costs and returns of *ihos* by L.G.A in Lagos state

Mean cost of item (N yr^{-1})	Amuwo-Odofin	Badagry	Epe	Ibeju / lekki	Lagos Mainland
Labour	3200±2465 (5)	2100±1884 (5)	1900±894 (5)	2078±2030 (5)	1640±805 (25)
Total Variable Cost	3200±2465 (5)	2100±1884 (5)	1900±894 (5)	2078±2030 (5)	1640±805 (25)
Interest	1820±782 (5)	2100±158 (5)	2060±669 (5)	2120±497 (5)	2380±311 (25)
Depreciation	5500±2828 (2)	5500±2828 (2)	5375±3005 (2)	3750±0 (2)	6875±177 (10)
Total Fixed Cost	4020±3306 (5)	4300±3362 (5)	4210±2877 (5)	3620±1754 (5)	5130±3664 (25)
Total cost	7220±4398 (5)	6400±2855 (5)	6110±3161 (5)	5698±1384 (5)	6770±3288 (25)
Mean production (kg yr^{-1})	147±35	139±37	151±45	176±19	158±27
Gross revenue (N)	35150±9154	30950±7688	35850±10569	43200±4705	38900±6630
Net return (N yr^{-1})	27930±8324	24550±7729	29740±9774	37502±3779	32130±5093
Rate of income (%)	80±11	79±9	83±7	87±2	83±6
Benefit cost ratio	3.9±3.3	3.8±3.4	4.9±3.2	6.6±1.4	4.7±2.3
Average cost (N kg^{-1})	49±28	46±21	41±17	32±6	43±16
Average price (N kg^{-1})	239±9	223±17	237±6	245±1	246±1
Net return (N kg^{-1})	190±27	177±21	196±6	213±16	203±16

Data is presented as mean ± standard deviation. Figures in brackets indicate the number of farmers that used the item. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

Farmers who used PVC pipes in *iho* shelters had higher mean total costs (N 8589), mean production of fish (167 kg) and net returns per year (N 30961) (Table 4.12). Rate of income (86%), benefit–cost ratio (6.0) and net returns per kg (N 206) were, however, higher for those who used hollow bamboo poles. There was a significant (p = 0.003) difference in total cost of production between hollow bamboo poles and PVC pipes, with PVC pipes being higher than bamboo poles but there was no significant difference in mean production of fish (p = 0.156) and net returns per year (p = 0.868). Standard deviation for cost of labour (1589) for farmers who used PVC pipes was greater than its mean value suggesting that there were wide variations in number of labourers used by the farmers.

Table 4.12: Costs and returns of *ihos* by type of material used

Mean cost of item (N yr^{-1})	Hollow bamboo poles (15)	PVC pipes (10)
Labour	2767±1522	1309±1589
Total Variable Cost	2767±1522	1309±1589
Interest	2240±467	1880±545
Depreciation	n.a	5400±1969
Total Fixed Cost	2240±467	7280±2073
Total cost	5007±1532	8589±3297
Mean production (kg yr^{-1})	146±36	167±26
Gross revenue (N)	34983±9293	39550±6367
Net return (N yr^{-1})	29976±9535	30961±5284
Rate of income (%)	86±8	78±7
Benefit cost ratio	6.0±2.9	3.6±1.6
Average cost (N kg^{-1})	34±18	51±16
Average price (N kg^{-1})	240±12	237±11
Net return (N kg^{-1})	206±23	186±19

Data is presented as mean ± standard deviation. n.a = not applicable as the item was not used. Figures in brackets indicate sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.1.7 Profitability of fish fence

Mean total costs of production from fish fence in Niger and Lagos state were N 3871 (US$ 30) and N 5914 (US$ 46) per year, respectively (Table 4.13). Mean production of fish per year was higher in Lagos (69 Kg) than Niger state (51 Kg). Net returns per year, rate of income and benefit cost–ratio were also higher in Lagos than Niger state. There was a significant difference in mean production of fish ($p < 0.001$), total cost of production ($p < 0.001$) and net returns per year ($p < 0.001$) between Niger and Lagos state, with Lagos being higher than Niger.

Table 4.13: Costs and returns of fish fence by state

Mean cost of item (N yr^{-1})	Niger	Lagos
Feed	378 ±87 (9)	n.a
Labour	431 ± 418 (45)	2929 ± 1686 (45)
Total Variable Cost	507 ± 411 (45)	2929 ± 1686 (45)
Interest	2109 ± 302 (45)	2224 ± 287 (45)
Depreciation	1255 ± 1136 (45)	1269 ± 67 (27)
Total Fixed Cost	3364 ± 1119 (45)	2985 ± 677 (45)
Total cost	3871 ± 1063 (45)	5914 ± 1938 (45)
Mean production (kg yr^{-1})	51 ± 12	69 ± 12
Gross revenue (N)	6245 ± 1345	16044 ± 2770
Net return (N yr^{-1})	2375 ± 1657	10130 ± 2847
Rate of income (%)	38±23	63±11
Benefit cost ratio	0.6±0.5	1.7±1.1
Average cost (N kg^{-1})	76±29	86±26
Average price (N kg^{-1})	122±15	233±10
Net return per kg (N kg^{-1})	46±28	147±28

Data is presented as mean ± standard deviation. n.a = not applicable as the item was not used. Figures in brackets indicate the number of farmers that used the item. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

Costs and returns of production from fish fence by type of materials used are presented in Table 4.14. Farmers who used palm fronds to construct fish fences had higher total cost of production per year (N6615) than those who used bamboo strips (N5852), cane strips (N5449), gill nets (N5247) and *Alchornea* sp (N3527). Mean production of fish (77 Kg) and net returns per year (N11360) were also higher for fish fences constructed of palm fronds. Rate of income (64%), benefit–cost ratio (1.8) and net return per kg (N148) were, however, higher for fish fences constructed of bamboo strips. There was a significant difference in mean production of fish ($p < 0.001$), cost of fish production ($p < 0.001$) and net returns per year ($p < 0.001$) among the materials used for fish fence construction, with palm fronds being higher than other materials.

Table 4.14: Costs and returns of fish fence by type of material used

Mean cost of item (N yr^{-1})	Bamboo Strips	Cane strips	Palm fronds	*Alchornea* sp	Gill net
Feed	n.a	n.a	n.a	378±87 (9)	n.a
Labour	2839±1689 (23)	2608±1545 (12)	3520±1860 (10)	457±454 (36)	328±218 (9)
Total Variable Cost	2839±1689 (23)	2608±1545 (12)	3520±1860 (10)	552±437 (36)	328±217 (9)
Interest	2252±269 (23)	2216±349 (12)	2170±267 (10)	2167±264 (36)	1878±349 (9)
Depreciation	1250±0 (14)	1250±0 (6)	1321±122 (7)	808±581 (36)	3042±1064 (9)
Total Fixed Cost	3013±677 (23)	2841±785 (12)	3095±573 (10)	2975±650 (36)	4920±1276 (9)
Total cost	5852±1904 (23)	5449±2016 (12)	6615±1920 (10)	3527±687 (36)	5247±1217 (9)
Mean production (kg $yr^{-1)}$	70±11	60±12	77±7	52±13	47±8
Gross revenue (N)	16239±2442	14063±2949	17975±1689	6347±1451	5840±706
Net return (N yr^{-1})	10387±2894	8613±1957	11360±3093	2821±1407	593±1403
Rate of income (%)	64±12	61±10	63±12	44±16	10±26
Benefit cost ratio	1.8±1.1	1.6±0.9	1.7±1.3	0.8±0.5	0.1±0.4
Average cost (N kg^{-1})	84±27	91±23	86±28	68±19	112±37
Average price (N kg^{-1})	232±12	234±5	233±9	122±12	124±25
Net return (N kg^{-1})	148±30	143±22	147±33	54±21	12±29

Data is presented as mean ± standard deviation. Figures in brackets indicate the number of farmers that used the item. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.1.8 Comparison of profitability of aquaculture systems

Mean production of fish from fish ponds and fish parks were 548 and 545 kg ha^{-1} yr^{-1}, respectively (Table 4.15). Total cost of production per hectare per year from fish ponds (N60698) was considerably higher than that of fish parks (N10550). Net return (N66118) per hectare per year, rate of income (86%) and benefit-cost ratio (6.3) were, however, higher for fish parks (Table 4.15). Standard deviations for fish production levels and net returns per hectare per year were 123 and 136% of their mean values, respectively, for fish parks while those of fish ponds were 99 and 112%, respectively, of their values. Higher standard deviations for fish parks may be due to larger differences in fish park sizes and wider variety in methods and practice. Average size (0.1 ha) was the same for both fish parks and ponds but standard deviations were 0.3 and 0.1 for fish parks and ponds, respectively. Standard deviations for rate of income, benefit-cost ratio and net return per kilogram were, however, 28, 33 and 22% higher than their mean values for fish ponds while those of fish parks were lower than their mean values suggesting that there were wide variations in costs of land and seed used by pond operators **(**Table 4.2**)** perhaps due to differences in management practice and also in wider variations of market prices of fish.

There was no significant difference in mean production of fish ($p = 0.449$) and net returns ($p = 0.310$) per hectare per year from fish ponds and fish parks but total cost of fish production per hectare per year was significantly ($p < 0.001$) higher for fish ponds.

Table 4.15: Profitability of fish ponds and fish parks

Aquaculture system	Fish ponds	Fish parks
	n = 10	n = 250
Mean production (kg ha^{-1} yr^{-1})	548 ± 544	545 ± 673
Gross revenue (N ha^{-1} yr^{-1})	98774 ± 83829	76668 ± 97490
Total cost (N ha^{-1} yr^{-1})	60698 ± 53106	10550 ± 9384
Net return (N ha^{-1} yr^{-1})	38076 ± 42721	66118 ± 89719
Rate of income (%)	39 ± 50	86 ± 17
Benefit-cost ratio	0.6 ± 0.8	6.3 ± 3.9
Average cost (N kg^{-1})	111 ± 69	19 ± 18
Average price (N kg^{-1})	180 ± 38	141 ± 27
Net return (N kg^{-1})	69 ±84	122 ±34

Data is presented as mean ± standard deviation. n = sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.1.9 Costs and returns by farm profitability.

The relationship between state, aquaculture system and profitable farm groups is given in Table 4.16. The overall average net profit in this study was N 46166 per year[11]. Net profits were grouped into five units as follows:

1. Top group – well performing systems with net profits ≥ N 100 600. There were 47 systems which included 17 and 30 systems in Niger and Lagos, respectively, and these were fish pond (1) and fish parks (46). About 12% of the total sample was in this group.

2. Average group- moderately performing systems with net profits ranging from ≥ N 46340 to < N 100 600. There were 52 systems which included 30 in Niger and 22 in Lagos. These were fish parks (48) and fish ponds (4). About 13% of the total sample was in this group.

3. Below average – poor performing systems with net profits ranging from ≥ N10 000 to < N 46340.There were 155 systems of which 60 and 95 were in Niger and Lagos state, respectively. These systems included fish pond (1), fish parks (98), pot shelters (12), *ihos* (25) and fish fence (19). About 39% of the total sample was in this group.

4. Bottom group – poorest performing systems with net profits ranging from ≥ N 10 to < N 10 000. There were 139 systems which included 88 in Niger and 51 in Lagos. These systems included fish pond (1), fish parks (57), pot shelters (13) and fish fence (26). About 35% of the total sample was in this group.

[11] Nigerian currency is Naira (N). (1US$ = N128 in 2003)

5. Unprofitable group – with negative net profits. There were 5 and 2 systems in Niger and Lagos state, respectively. These systems included fish ponds (3), fish parks (1) and fish fence (3). About 2% of the total sample was in this group.

Table 4.16: Relationship between state, aquaculture system and profitable groups

State	Aquaculture System	Profitable group					Total
		Top (≥ N100600) n = 47	Average (≥ N46340 to < N100600) n = 52	Below average (≥N10000 to < N46340) n = 155	Bottom (≥ N 10 to < N 10000) n = 139	Unprofitable group n = 7	n =400
Niger	Fish pond	1 (2)	0 (0)	1 (1)	1 (1)	2 (29)	5 (1)
	Fish parks	16 (34)	30 (58)	59 (38)	45 (32)	0 (0)	150 (38)
	Fish fence	0 (0)	0 (0)	0 (0)	42 (30)	3 (43)	45 (11)
	Total	17 (36)	30 (58)	60 (39)	88 (63)	5 (71)	200 (50)
Lagos	Fish pond	0 (0)	4 (8)	0 (0)	0 (0)	1 (14)	5 (1)
	Fish parks	30 (64)	18 (35)	39 (25)	12 (9)	1 (14)	100 (25)
	Pots	0 (0)	0 (0)	12 (8)	13 (9)	0 (0)	25 (6)
	Ihos	0 (0)	0 (0)	25 (16)	0 (0)	0 (0)	25 (6)
	Fish fence	0 (0)	0 (0)	19 (12)	26 (19)	0 (0)	45 (11)
	Total	30 (64)	22 (42)	95 (61)	51 (37)	2 (29)	200 (50)

n = sample size of farmers. Figures in brackets indicate percentages of n. Percentages have been rounded up.

Costs and returns as classified by profitability is given in Table 4.17. About 12% of the total sample was in the top group, 13% in the average group, 39% were below average, 35% in the bottom group and 2% in the unprofitable group. Operating cost differed significantly ($p < 0.001$) among the farm groups as classified by profitability. Average total cost of profitable farms ranged from N 4840 to 28390 per year. Unprofitable farms had the highest total cost of production at N 31794 per year. Mean productivity of fish was significantly ($p < 0.001$) higher for the top group (1708 kg yr^{-1}). The top group accounted for 53% of the total production of fish followed by below average (21%), average (20%), bottom group (6%) and unprofitable group (1%). Average price of profitable groups ranged from N 139 to N 152. Unprofitable group had the lowest average price (N 130) suggesting that unprofitable farms produced small sized fish at harvest. Cost of production per kilogram was lowest (N 16 / kg) in the top group and highest (N 139 / kg) in the unprofitable group. The top group had the highest (N 132 / kg) net return per kilogram.

Standard deviations for mean total cost of production and mean productivity per year were 38 and 4%, respectively, higher than their mean values in unprofitable farms while those of profitable groups were lower than their mean values suggesting that there were large differences in quantities and prices of inputs used by unsuccessful farmers probably due to larger differences in sizes of the farms, skills, knowledge and management practice. Standard deviation for average price was 48% of its mean value in unprofitable farms as compared with 23% for both top and average groups, 35% for below average and 34% for bottom group, thus suggesting that there were larger differences in sizes of fish produced at harvest by unprofitable farms. Sizes of ponds and fish parks were higher in the top group than other groups. Quantities of manure (300 kg/ha/yr) and feed (60 kg/ha/yr) used by farmers were also higher in the top group suggesting more confidence to use inputs more intensively as they are capable of getting a return from them.

Table 4.17: Costs and returns by farm profitability

Profitability	Top (≥ N 100600) n = 47	Average (≥ N 46340 to < N 100600) n = 52	Below average (≥ N10000 to < N46340) n = 155	Bottom (≥ N 10 to < N 10000) n = 139	Unprofitable group n = 7
Total cost (N yr^{-1})	28390 ± 24520	14237 ± 13677	6578 ± 3488	4840 ± 1830	31794 ±43843
Mean production (kg yr^{-1})	1708 ± 791	574 ± 139	202 ± 107	69 ± 25	229 ± 239
Average price (N kg^{-1})	148 ± 34	139 ± 32	152 ± 53	149 ± 51	130 ± 62
Total revenue (N yr^{-1})	253048 ± 102557	79907 ± 19951	30779 ± 12744	10276 ± 3988	29764 ± 43737
Net returns (N yr^{-1})	224658 ± 97504	65670 ± 14595	24201 ± 11337	5436 ± 2855	-2030 ±1668
Average cost (N kg^{-1})	16 ± 12	25 ± 23	33 ± 22	70 ± 27	139 ±78
Net return (N kg^{-1})	132 ± 35	114 ± 24	119 ± 42	79 ± 38	-9 ± 46

Data is presented as mean ± standard deviation. n = sample size of farmers. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

4.3.2 Socio - economic conditions of farmers

4.3.2.1 Personal information

About 100% of the farmers in Niger and 27% in Lagos state were Muslims. Only 1% in Niger and 71% in Lagos state were Christians. Two percent of the farmers in Lagos state belonged to traditional religion (Table 4.18). There was a significant (χ^2 = 226, d.f. = 1, p < 0.001) relationship between religious status and state, with greater number of Muslims in Niger state.

Table 4.18: Religious status of farmers by state

Religion	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Islam	199 (100)	54 (27)	253 (63)
Christianity	1 (1)	142 (71)	143 (36)
Traditional	0 (0)	4 (2)	4 (1)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. The last two rows were combined for the purpose of statistical analysis.

Religious status of farmers by aquaculture system is presented in Table 4.19. About 64% of the farmers with fish shelters were Muslims as compared with 63% for those with fish fences and 50% with fish ponds. About 50% of the farmers with fish ponds and 36% with fish shelters were Christians as compared with 34% for those with fish fences. Only farmers with fish fences (2%) and fish shelters (1%) belonged to traditional religion. There was no significant (χ^2 = 1, d.f. = 2, p = 0.678) relationship between religion and aquaculture system.

Table 4.19: Religious status of farmers by aquaculture system

Religion	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Islam	5 (50)	191 (64)	57 (63)	253 (63)
Christianity	5 (50)	107 (36)	31 (34)	143 (35)
Traditional	0 (0)	2 (1)	2 (2)	4 (1)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. The last two rows were combined for the purpose of statistical analysis.

There was a significant (t = 15, d.f. = 398, p < 0.001) difference in mean family size of farmers between Niger and Lagos state. The family size was higher in Niger than Lagos state (Table 4.20).

Table 4.20: Mean family size of farmers by state

Family size	State		Average total
	Niger n = 200	Lagos n = 200	n = 400
	13 ± 4^{a}	8 ± 3^{b}	11 ± 4

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different (p > 0.05) share common superscript.

Family size differed significantly (F = 5, d.f. = 2, 397, p = 0.008) among farmers with different aquaculture systems. Farmers with fish ponds had smaller family size than those with fish shelters and fish fences (Table 4.21).

Table 4.21: Mean family size of farmers by aquaculture system

Family size	Aquaculture system			Average total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
	7 ± 4^{a}	11 ± 4^{b}	10 ± 4^{b}	11 ± 4

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different (p > 0.05) share common superscript.

Average age of farmers in Lagos was higher than those in Niger state (Table 4.22). There was a statistically significant (p = 0.01) difference in average age of farmers between Niger and Lagos state but in practice an average difference of two years is unlikely to be important.

Table 4.22: Average age of farmers by state

Age (years)	State		Average total
	Niger n = 200	Lagos n = 200	n = 400
	54 ± 8^{a}	56 ± 5^{b}	55 ± 7

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different (p > 0.05) share common superscript.

Farmers with fish ponds had higher average age than farmers with fish shelters and fish fences (Table 4.23). There was, however, no significant (p = 0.643) difference in average age of the farmers among the aquaculture systems.

Table 4.23: Average age of farmers by aquaculture system

Age (Years)	Aquaculture system			Average total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
	56 ± 9^{a}	55 ± 6^{a}	54 ± 8^{a}	55 ± 7

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

Only two percent of the farmers in Niger and 5% in Lagos state had formal education (Table 4.24). Of 15 farmers who had formal education, five (33%) had primary education, six (40%) had secondary education and four (27%) had tertiary education. There was no significant ($\chi^2 = 3$, d.f. = 1, $p = 0.065$) relationship between education level of farmers and state.

Table 4.24: Education level of farmers by state

Education	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
No formal education	196 (98)	189 (95)	385 (96)
Have formal education	4 (2)	11 (5)	15 (4)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Sixty percent of the farmers with fish ponds had formal education as compared with 2% for farmers with fish shelters and 3% with fish fences (Table 4.25). Of 400 farmers interviewed, 316 (79%) live where there are educational institutions. Educational institutions found were primary and secondary schools.

Table 4.25: Education level of farmers by aquaculture system

Education	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
No formal education	4 (40)	294 (98)	87 (97)	385 (96)
Have formal education	6 (60)	6 (2)	3 (3)	15 (4)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

4.3.2.2 Economic conditions

4.3.2.2.1 Source of income

Primary occupation of the farmers is presented in Table 4.26. About 98% of the farmers in both states had fishing as their primary occupation. Only 2% of the farmers in both states had crop farming as their primary occupation. Two farmers (1%) in Niger state were civil servants. There was no significant (p = 1.0) difference in the primary occupation of the farmers in the two states.

Table 4.26: Primary occupation of farmers by state

Primary occupation	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Crop farming	3 (2)	4 (2)	7 (2)
Fishing	195 (98)	196 (98)	391 (98)
Civil service	2 (1)	0 (0)	2 (1)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. First and third rows were combined for the purpose of statistical analysis.

Seventy percent of the farmers with fish ponds were crop farmers and 20% were civil servants. All the farmers with fish shelters and fish fences were fishermen (Table 4.27).

Table 4.27: Primary occupation of farmers by aquaculture system

Primary occupation	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Crop farming	7 (70)	0 (0)	0 (0)	7 (2)
Fishing	1 (10)	300 (100)	90 (100)	391 (98)
Civil service	2 (20)	0 (0)	0 (0)	2 (1)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. First and third rows were combined for the purpose of statistical analysis.

Secondary occupation of the farmers did not differ significantly (p = 1.0) between states. About 98% of the farmers in both states had crop farming as secondary occupation (Table 4.28).

Table 4.28: Secondary occupation of farmers by state

Secondary occupation	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Crop farming	195 (98)	196 (98)	391 (98)
Fishing	2 (1)	1 (1)	3 (1)
Fish farming	2 (1)	3 (2)	5 (1)
Trading	1 (1)	0 (0)	1 (0)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. The last three rows were combined for the purpose of statistical analysis.

All the farmers with fish shelters and fish fences had crop farming as their secondary occupation (Table 4.29).

Table 4.29: Secondary occupation of the farmers by aquaculture system

Secondary occupation	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Crop farming	1 (10)	300 (100)	90 (100)	391 (98)
Fishing	3 (30)	0 (0)	0 (0)	3 (1)
Fish farming	5 (50)	0 (0)	0 (0)	5 (1)
Trading	1 (10)	0 (0)	0 (0)	1 (0)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

4.3.2.2.2 Annual income and expenditure

Annual income of farmers in Lagos was higher than those in Niger state (Table 4.30). There was, however, no significant ($p = 0.087$) difference in the mean annual income of the farmers in the two states.

Table 4.30: Mean annual income of farmers by state

Income (Naira/year)	State		Average total
	Niger n = 200	Lagos n = 200	n = 400
	N 266092 ± 64563^{a}	N 278775 ± 64653^{a}	N 272434 ± 64839

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

Annual income of the farmers with fish ponds (N335800) was higher than those with fish shelters (N271822) and fish fences (N267433) but there was no significant (p = 0.065) difference in the mean annual income of the farmers with different aquaculture systems (Table 4.31). Standard deviation for annual income was 30% of its mean value for pond operators as compared with 24% for farmers with fish shelters and 19% for those with fish fences suggesting that there were wider variations in the annual incomes of pond operators probably due to differences in income generating activities of the pond operators between the two states (see Table 4.27 and Table 4.29).

Table 4.31: Mean annual income of farmers by aquaculture system

Income (Naira/year)	Aquaculture system			Average total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
	N 335800 ±100547[a]	N 271822 ±66418[a]	N 267433 ±50269[a]	N 272434 ±64839

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

Annual expenditure of the farmers by state is presented in Table 4.32. Annual expenditure was higher in Lagos than Niger state. Standard deviation for expenditure per year was 24% of its mean value in Niger as compared with 65% for Lagos state suggesting that there were wider variations in the amount spent on food, medication and inputs such as feed perhaps due to more development in the state and also perhaps due to greater variability in input prices in Lagos because of the greater range from urban to rural conditions. There was, however, no significant (p = 0.215) difference in the mean annual expenditure between the two states.

Table 4.32: Mean annual expenditure of farmers by state

Expenditure(Naira/year)	State		Average total
	Niger n = 200	Lagos n = 200	n = 400
	N212489±50219[a]	N229650±149072[a]	N221070±111423

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

Farmers with fish ponds had higher annual expenditure (N262000) than farmers with fish shelters (N222059) and fish fences (N213222) but there was no significant ($p = 0.139$) difference in the mean annual expenditure of the farmers with different aquaculture systems (Table 4.33).

Table 4.33: Mean annual expenditure of farmers by aquaculture system

Expenditure (Naira/year)	Aquaculture system			Average total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
	N 262000 ±95661[a]	N 222059 ±125254[a]	N 213222 ±42103[a]	N 221070 ±111423

Data is presented as mean ± standard deviation. n indicates sample size. Nigerian currency is Naira (N). (1US$ = N128 in 2003). Values that are not significantly different ($p > 0.05$) share common superscript.

4.3.2.3 Social conditions

4.3.2.3.1 Housing conditions

Housing condition was used as a wealth indicator. The house types found in the study area were mud thatched, mud zinc, plank zinc and bamboo huts - walls and roofs were made up of mud and thatch, mud and zinc, plank and zinc, bamboo poles and thatch, respectively (Figure 4.1). Round huts – walls and roof made up of thatch are common in temporary fishing settlements (Figure 4.1f). House types by state are presented in Table 4.34. There was a significant ($\chi^2 = 340$, d.f. = 3, $p < 0.001$) relationship between housing condition and state, with plank zinc and bamboo huts found only in Lagos state.

Table 4.34: Housing conditions of farmers by state

Housing condition	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Bamboo hut	0 (0)	117 (59)	117 (29)
Mud thatched	111 (56)	3 (2)	114 (29)
Mud zinc	89 (46)	14 (7)	103 (26)
Plank zinc	0 (0)	66 (33)	66 (17)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

All the farmers with fish ponds had mud zinc houses. Only 22% and 31% of the farmers with fish shelters and fish fences, respectively, had mud zinc houses (Table 4.35).

Table 4.35: Housing conditions of farmers by aquaculture system

Housing condition	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Bamboo hut	0 (0)	89 (30)	28 (31)	117 (29)
Mud thatched	0 (0)	94 (31)	20 (22)	114 (29)
Mud zinc	10 (100)	65 (22)	28 (31)	103 (26)
Plank zinc	0 (0)	52 (17)	14 (16)	66 (17)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.


(a) Mud zinc with white paint


(b) Mud zinc without paint


(c) Mud thatched


(d) Plank zinc


(e) Bamboo hut


(f) Round hut (in temporary settlements)

Figure 4.1: House types in fishing communities in two states in Nigeria

House size of farmers in Niger was 280 m^2 as compared with 278 m^2 for Lagos state (Table 4.36). There was a statistically significant ($p < 0.001$) difference in house size of the farmers between the two states, with the house size being higher in Niger than Lagos.

Table 4.36: Average house size of farmers by state

Size (m^2)	State		Average total
	Niger n = 200	Lagos n = 200	n = 400
	280±486[a]	278±421[b]	279±454

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript

House size differed significantly ($p = 0.042$) among farmers with different aquaculture systems. Farmers with fish ponds had larger house areas (1972 m^2) than those with fish shelters (242 m^2) and fish fences (215 m^2) (Table 4.37).

Table 4.37: Average house size of farmers by aquaculture system

Size (m^2)	Aquaculture system			Average total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
	1972±2167[a]	242±183[b]	215±72[b]	279±454

Data is presented as mean ± standard deviation. n indicates sample size. Values that are not significantly different ($p > 0.05$) share common superscript.

4.3.2.3.2 Electricity facilities

About 96% of the farmers in Niger and 56% in Lagos state had no access to electricity facilities (Table 4.38). There was a significant ($\chi^2 = 89$, d.f. = 1, $p < 0.001$) relationship between access to electricity facility and state, with farmers in Lagos having more access to electricity than those in Niger.

Table 4.38: Distribution of farmers according to accessibility of electricity facilities by state

Electricity	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Yes	8 (4)	89 (45)	97 (24)
No	192 (96)	111 (56)	303 (76)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

About 80% of the farmers with fish ponds had access to electricity facilities as compared with 24% for those with fish fences and 22% with fish shelters (Table

4.39). There was a significant (χ^2 = 18, d.f. = 2, p < 0.001) relationship between access to electricity facility and aquacultures system, with farmers with fish ponds having greater access to electricity than those with fish shelters and fish fences.

Table 4.39: Distribution of farmers according to accessibility of electricity facilities by aquaculture system

Electricity	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Yes	8 (80)	67 (22)	22 (24)	97 (24)
No	2 (20)	233 (78)	68 (76)	303 (76)

n = sample size. Figures in brackets indicate percentages.

About 71% of the farmers in Lagos and 63% in Niger state reported that there are health institutions in their villages (Table 4.40). Health institutions found in the villages were dispensaries, rural health centres and general hospitals. There was no significant (χ^2 = 3, d.f. = 1, p = 0.111) relationship between availability of health institutions and state.

Table 4.40: Distribution of farmers according to availability of health institutions by state

Health Institution	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
Yes	126 (63)	141 (71)	267 (67)
No	74 (37)	59 (30)	133 (33)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up

About 90% of the farmers with fish ponds reported that there are health institutions in their villages as compared with 72% for those with fish fences and 64% with fish shelters (Table 4.41). There was no significant (χ^2 = 4, d.f. = 2, p = 0.109) relationship between availability of health institution and aquaculture system.

Table 4.41: Distribution of farmers according to availability of health institutions by aquaculture system

Health Institution	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Yes	9 (90)	193 (64)	65 (72)	267 (67)
No	1 (10)	107 (36)	25 (28)	133 (33)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

About 100% of the farmers in Lagos and 66% in Niger had road and water as means of transport (Table 4.42). Means of transport was significantly (χ^2 = 80, d.f. = 1, p < 0.001) related to state, with more farmers in Lagos having greater access to road and water transport.

Table 4.42: Transport type by state

Transport type	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Road and water	131 (66)	199 (100)	330 (83)
Road, water and rail	40 (20)	0 (0)	40 (10)
Road only	29 (15)	1 (1)	30 (8)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. The last two rows were combined for the purpose of statistical analysis.

About 84% of the farmers with fish fences and 83% with fish shelters had road and water as means of transport as compared with 40% for those with fish ponds (Table 4.43). There was a significant (χ^2 = 13, d.f. = 2, p = 0.002) relationship between means of transport and aquaculture system, with more farmers with fish ponds having greater access to road transport only.

Table 4.43: Transport type by aquaculture system

Transport type	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Road and water	4 (40)	250 (83)	76 (84)	330 (83)
Road, water and rail	1 (10)	30 (10)	9 (10)	40 (10)
Road only	5 (50)	20 (7)	5 (6)	30 (8)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. The last two rows were combined for the purpose of statistical analysis.

About 60% of the farmers in Niger and 54% in Lagos state live in villages with rural markets (Table 4.44). There was no significant (χ^2 = 2, d.f. = 1, p = 0.226) relationship between availability of market and state.

Table 4.44: Distribution of farmers according to availability of market by state

Availability of market	State		Total
	Niger n = 200	Lagos n = 200	n = 400
No market	81 (41)	93 (47)	174 (44)
Rural market	119 (60)	107 (54)	226 (57)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up

About 90% of the farmers with fish ponds and 62% with fish fences live in villages with rural markets as compared with 54% for those with fish shelters (Table 4.45). There was a significant (χ^2 = 7, d.f. = 2, p = 0.034) relationship between availability of market and aquaculture system, with more farmers with fish ponds having greater access to rural markets.

Table 4.45: Distribution of farmers according to availability of market by aquaculture system

Availability of market	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
No market	1 (10)	139 (46)	34 (38)	174 (44)
Rural market	9 (90)	161 (54)	56 (62)	226 (57)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

Thirty three percent of the farmers in Niger state had river only as source of drinking water while 57% in Lagos state had well only as source of drinking water (Table 4.46). There was a significant (χ^2 = 78, d.f., 1, p < 0.001) relationship between source of drinking water and state, with farmers in Lagos having well only as source of water.

Table 4.46: Sources of drinking water by state

Water source	State		Total
	Niger	Lagos	
	n = 200	n = 200	n = 400
River only	65 (33)	0 (0)	65 (16)
Well only	0 (0)	114 (57)	114 (29)
Tap only	9 (5)	1 (1)	10 (3)
River, well and borehole	56 (28)	0 (0)	56 (14)
Well and borehole	14 (7)	66 (33)	80 (20)
River and borehole	53 (27)	0 (0)	53 (13)
Well, borehole and tap	3 (2)	19 (10)	22 (6)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up. The last six rows were combined for the purpose of statistical analysis.

About 30% of the farmers with fish ponds had tap water only as source of drinking water as compared with 1% for those with fish shelters and 4% with fish fences (Table 4.47). There was no significant (χ^2 = 2, d.f. = 2, p = 0.370) relationship between source of drinking water and aquaculture system.

Table 4.47: Sources of drinking water by aquaculture system

Water source	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
River only	0 (0)	50 (17)	15 (17)	65 (16)
Well only	2 (20)	86 (29)	26 (29)	114 (29)
Tap only	3 (30)	3 (1)	4 (4)	10 (3)
River, well and borehole	0 (0)	43 (14)	13 (14)	56 (14)
Well and borehole	2 (20)	60 (20)	18 (20)	80 (20)
River and borehole	0 (0)	44 (15)	9 (10)	53 (13)
Well, borehole and tap	3 (30)	14 (5)	5 (6)	22 (6)

n = sample size. Figures in brackets indicate percentage. Percentages have been rounded up. The last six rows were combined for the purpose of statistical analysis.

About 99% of the farmers in Niger and 96% in Lagos state had no sanitary facilities (Table 4.48). There was no significant (χ^2 = 2, d.f. = 1, p = 0.126) relationship between availability of sanitary facility and state.

Table 4.48: Distribution of farmers according to availability of sanitary facilities by state

Sanitary facility	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Yes	3 (2)	8 (4)	11 (3)
No	197 (99)	192 (96)	389 (97)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

All the farmers with fish fences and 98% with fish shelters had no sanitary facilities as compared with 50% for those with fish ponds (Table 4.49).

Table 4.49: Distribution of farmers according to availability of sanitary facilities by aquaculture system

Sanitary facility	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	n = 400
Yes	5 (50)	6 (2)	0 (0)	11 (3)
No	5 (50)	294 (98)	90 (100)	389 (97)

n = sample size. Figures in brackets indicate percentages. Percentages have been rounded up.

All the farmers in Niger used wood only as source of fuel for cooking while those in Lagos state used wood and coco nut husks as sources of fuel for cooking (Table 4.50). Source of fuel for cooking was significantly (χ^2 = 400, d.f. = 1, p < 0.001) related to state, with wood only as source of fuel in Niger.

Table 4.50: Sources of fuel for cooking by state

Fuel	State		Total
	Niger n = 200	Lagos n = 200	n = 400
Wood only	200 (100)	0 (0)	200 (100)
Wood and coconut husks	0 (0)	200 (100)	200 (100)

n = sample size. Figures in brackets indicate percentages.

There was no significant (χ^2 = 0, d.f. = 2, p = 1.0) relationship between source of fuel for cooking and aquaculture system (Table 4.51).

Table 4.51: Sources of fuel for cooking by aquaculture system

Fuel	Aquaculture system			Total
	Fish pond n = 10	Fish shelter n = 300	Fish fence n = 90	 n = 400
Wood	5 (50)	150 (50)	45 (50)	200 (100)
Wood and coconut husks	5 (50)	150 (50)	45 (50)	200 (100)

n = sample size. Figures in brackets indicate percentages.

4.3.2.3.3 Recreational facilities

All the farmers interviewed had radios. Of 400 farmers interviewed, 391 (98%) had cassette players. Only 14% of the farmers in Lagos and 2% in Niger state had televisions (Table 4.52). There was a significant (χ^2 = 20, d.f. = 1, p < 0.001) relationship between availability of television and state, with greater number of farmers in Lagos having T.V.

Table 4.52: Distribution of farmers according to availability of T.V by state

T.V	State		Total
	Niger n = 200	Lagos n = 200	 n = 400
Yes	4 (2)	28 (14)	32 (8)
No	196 (98)	172 (86)	368 (92)

n = sample size. Figures in brackets indicate percentages.

Sixty percent of the farmers with fish ponds had T.V as compared with 9% for those with fish fences and 6% with fish shelters (Table 4.53). T.V was significantly (χ^2 = 39, d.f. = 2, p < 0.001) related to aquaculture system, with greater number of farmers with fish ponds having T.V. Of 400 farmers interviewed, only 20 (5%) had videos. All the farmers interviewed had no telephone facilities.

Table 4.53: Distribution of farmers according to availability of T.V by aquaculture system

T.V	Aquaculture system			Total
	Fish pond	Fish shelter	Fish fence	
	n = 10	n = 300	n = 90	n = 400
Yes	6 (60)	18 (6)	8 (9)	32 (8)
No	4 (40)	282 (94)	82 (91)	368 (92)

n = sample size. Figures in brackets indicate percentages.

4.3.3 Discussions

4.3.3.1 Costs and returns of fish production

Cost–return analysis is the basic method usually used to evaluate the economic viability or performance of a commercial aquaculture operation. This method is used to compare the economics of culture systems, different sizes of operation and farms in different locations (Shang, 1990).

In the present study, costs and returns of fish ponds were found to vary with geographic location and size. The study showed that total cost of production per hectare per year from fish ponds was higher in Lagos than Niger state. This was due to high costs of inputs like seeds and labour in Lagos (Table 4.1). There are more fish farmers in Lagos than Niger state leading to high demand for seeds hence high cost. There are more fish farmers in Lagos probably due to higher market prices of fish per kilogram **(**Table 4.3**)** and also wealthier, having assets, prepared to commit inputs**.** As a result of few sources of fingerlings and high demand for seeds in Lagos, farmers also buy their fingerlings from neighbouring states (Ajana, 1995). Farmers in Lagos state also used inorganic fertilizers, lime and employed security men to check poaching. These contributed to high cost of production per hectare per year. Farmers in Niger state employed other methods such as regular visits and use of charms to check poaching. The use of charms helped to reduce loss of fish due to poaching in Niger because people believe in charms. Net returns, rate of income and benefit–cost ratio were also higher in Lagos despite high cost and low production of fish in the state (Table 4.3). This was primarily due to the higher average market price of fish per kg as there is high demand for fish in Lagos, being commercial state of Nigeria. Thus, fish wholesalers in Niger state often transport smoked fish to Lagos as a result of better markets, and the margins are in turn reflected in lower first-hand sale prices in Niger state.

Standard deviations for fish production levels, total cost of production and net returns per hectare per year were higher in Niger than Lagos state as a result of wider variations in pond sizes, costs of inputs, management practice and market prices of fish suggesting that there were more unprofitable fish ponds in Niger than Lagos state (Table 4.16). This also suggests that methods and skills are more diverse in Niger perhaps due to less development suggesting that there is more scope for more efficient producers to emerge in the state.

Total cost of production per hectare per year increased with size of fish ponds (Table 4.2). This agrees with the findings of Ahmed (2001). High cost of production in larger farms could be due to seeds and labour. Costs of seeds and labour increased with size of fish ponds as a result of high use of seeds and labour by farmers with larger farms. Farmers with larger farms also used lime and inorganic fertilisers (Table 4.2), thus contributing to the high cost. Cost of production per kilogram also increased with pond size (Table 4.4) perhaps because farmers with larger farms tend to have more assets and are prepared to commit more inputs even though return per hectare may not be so good, they may still make more per farm with these inputs. Seed accounted for 85% of the total cost of production in larger farms (> 0.08 ha). A study in Taiwan by Rabanal and Shang (1976) has also shown that 53% of the total cost of fish production was accounted for by fingerlings.

Net returns per hectare per year also increased with pond size despite the high cost of production. This could be due to higher production of fish from larger farms as mean production of fish increased with pond size. Rate of incomes and benefit-cost ratios were, however, higher in medium sized farms (0.04 – 0.08 ha) due to higher market price per kg (Table 4.4) suggesting that medium sized fish ponds produced larger fish at harvest. Standard deviations for fish production levels, total cost of production and net returns per hectare per year were higher in large pond sized category than small and medium sized categories as a result of wider variations in fish production and cost of production per hectare per year perhaps due to wider variety in methods and skills.

Profitability of a farm is dependent on level of yield, cost of production and farm price. The level of physical production is mainly dependent on stocking rate, survival rate and growth rate which are in turn affected by:

- bio – technical factors such as fertilisation and feeding, mono or polyculture, different stocking and harvesting strategies,
- environmental factors such as water quality, diseases and predators; and
- Physical facilities such as site selection, construction, soil condition and equipment used.

The cost of production relates to the level of input, the prices of inputs, the culture system, the size of operation, as well as the institutional factors such as costs of credit and marketing. The farm price of aquaculture products is usually affected by the size and quality of the product, the supply–demand situation for the product, the market structure and the existence of (if any) of governmental pricing policies (Shang, 1990). Increases in yield, reductions in costs and increases in price, therefore, are the major means of increasing profits. In the present study, as expected, unprofitable farms had the highest total cost of production per year and lowest average price (Table 4.17) suggesting that they produced small sized fish at harvest or had poor market opportunities.

Costs and returns of fish parks also varied with geographic location and size. Total cost of production from fish parks was higher in Lagos than Niger state (Table 4.5). This could be due to high cost of labour in Lagos as farmers had larger farms. Average fish park sizes were 0.1 and 0.2 ha in Niger and Lagos state, respectively. Net returns and benefit-cost ratios were also higher in Lagos probably due to higher production of fish from fish parks and market price per kg (Table 4.7). Standard deviations for fish production levels and total cost of production per hectare per year were higher in Lagos than Niger state as a result of wide variations in fish park sizes, fish production and cost of production per hectare per year suggesting that there were only unprofitable fish parks in Lagos state (Table 4.16). This also suggests that there are wider varieties of fish parks in Lagos perhaps due to more development in the state.

Total costs of production per hectare per year from fish parks increased with increase in size (Table 4.6). This could be due to cost of labour and depreciation as the use of the inputs increased with size. Farmers with large farms used more labourers and large nets to harvest fish from the fish parks leading to high cost. Net returns, rate of incomes and benefit–cost ratios also increased with size of fish parks (Table 4.8). This could be due to higher production of fish and market price per kg from larger farms perhaps because larger parks are not easily poached like small parks and probably due to better market opportunities.

There was no significant ($p > 0.05$) difference in cost of production from pot shelters in the local government areas (L.G.A) in Lagos state but net returns, rate of income and benefit–cost ratio were higher in Ibeju / lekki local government area. High yield of fish and market price per kg could be responsible for the profitability (Table 4.9). Cost of production from pot shelters increased with an increase in number of pots used. Total variable and fixed costs all increased with increase in number of pots. The use of more number of pots led to more use of labourers, hence high cost. Net returns, rate of income and benefit–cost ratio were higher in higher number of pots (30 pots) due to higher yield of fish (Table 4.10).

There was no significant ($p > 0.05$) difference in cost of production from *iho* shelters in the L.G.A in Lagos state. Net returns, rate of income and benefit–cost ratio were, however, higher in Ibeju / lekki due to higher production of fish in the L.G.A. (Table 4.11). Farmers who used PVC pipes in constructing *iho* shelters had higher cost of production as a result of depreciation (Table 4.12). Net return per year was also higher for PVC pipes due to higher yield of fish. Rate of income, benefit–cost ratio and net return per kg were, however, higher for hollow bamboo poles as a result of higher market price per kg and low total cost of production. Difference in market price per kg was as a result of the composition of the fish catch. Harvest containing fish that have high market value will usually give high net returns, rate of income and benefit cost ratio with low total cost of production.

Total cost of production from fish fence was higher in Lagos than Niger state due to high cost of labour and interest (Table 4.13). Lagos being the most prominent commercial state of Nigeria, one would expect high cost of inputs including labour as a result of high demand. Despite the high cost, net returns, rate of income and benefit–cost ratio were higher in Lagos state due to higher yield of fish and market price per kg. Market price is high in Lagos as a result of high demand for fish, being the most populous and commercial state of Nigeria, comprising of people from all parts of the world.

Fish fences constructed of palm fronds had higher total cost as a result of high cost of labour. This could be due to more use of labourers by farmers who had fish fences constructed of palm fronds. Net return per year was also higher for fish fences constructed of palm fronds due to higher yield of fish (Table 4.14). Rate of income and benefit-cost ratio were, however, higher for fish fences constructed of bamboo strips as a result of higher market price per kg.

4.3.3.2 Socio - economic conditions of farmers

Social and economic conditions of fish farmers are of significance in the planning of development activities. In keeping with wider population characteristics the study showed that for fish producing households there are more Muslims in Niger than Lagos state where Christians are the majority (Table 4.18). Niger state is in the Northern part of Nigeria where Muslims are concentrated (Falola, 1999). Farmers in Niger also had larger family size than farmers in Lagos state (Table 4.20). This could be due to religion and geographic location. The majority of the farmers in Niger state had Islam as their religion, which allows polygamy that could lead to more children as compared with majority of the farmers in Lagos who are Christian and are monogamous. The high cost of living in Lagos state could also make farmers in the state to have small family size. Average fish production from all the aquaculture systems in Niger was 329 kg / yr (25 kg / household member) as compared with 434 kg / yr (54 kg / household member) for Lagos suggesting that large family size may have made it difficult for farmers in Niger to invest in fish farming. Gill and Motahar (1982) also reported that large family size in Bangladesh made it difficult for farmers to invest in fish farming. Farmers with fish ponds had smaller family size than those with fish shelters and fish fences (Table 4.21). This study showed that farmers with fish ponds (60%) had formal education (Table 4.25). The educational background of the farmers may have made them to have smaller family size. In Nigeria, monogamy is common among the educated elite while Muslims and traditionalists continue to practice polygamy (Falola 1999).

There is a strong relationship between society and education (Malassis, 1976). Human resource development is largely a function of literacy and educational attainment. Amongst farmers, literacy and education attainments help develop conceptual skill and also facilitate the acquisition of technical skill, which can have direct bearing on income generation, expenditure and saving activities. Veerina *et al* (1999) noted that factors such as literacy have a role in influencing yields through production decisions. There is a general consensus that education has a positive effect on agricultural productivity (Phillips, 1987; 1994), a high rate of illiteracy resulting in low farm efficiency (Ali *et al*, 1982). Atapattu (1994) stated that fish farmers should be properly educated with respect to the importance of management.

There was no significant ($p > 0.05$) difference in average age of farmers with different aquaculture systems (Table 4.23). Knowledge of the age structure of farmers is important in estimating potential human resources. Planning of education, health and employment generation requires sufficient data on relevant age structures. The age structure of a population affects a nation's key socioeconomic issues. Countries with young populations (high percentage under age 15) need to invest more in schools, while countries with older populations (high percentage ages 65 and over) need to invest more in the health sector. The age structure can also be used to help predict potential political issues. For example, the rapid growth of a young adult population unable to find employment can lead to unrest.

Most of the farmers with fish ponds (70%) had crop farming as their source of income, 20% were civil servants and only 10% had fishing as source of income. All farmers with fish shelters and fish fences were fishermen (Table 4.27). Primary or main occupation is defined as that to which more than half the total working hours are devoted. Second occupation is that to which less than half of the total working time is devoted (Hartog and Van Staveren, 1983). Primary occupation may not provide full time employment and the income derived from it may be insufficient to provide adequate means of livelihood, hence secondary occupation. In this study, 98% of the farmers had crop farming as their secondary occupation. Others had fishing, fish farming and petty trading as secondary occupations (Table 4.28).

In the present study, average annual income of farmers was N272 434 which is lower than the average annual income (N323 856) obtained by Orebiyi (2005) in Kwara state, Nigeria. The average annual income (N278 775) was higher in Lagos than Niger state (N266 092) probably due to higher net returns from fish ponds (Table 4.3), fish parks (Table 4.7) and fish fences (Table 4.13). Average annual income (N335 800) of farmers with fish ponds was higher than those with fish shelters (N271 822) and fish fences (N267 433). Farmer’s income is a key measure reflecting economic security. A household is economically secure when it has the capacity to generate sufficient income to satisfy the basic needs of the family and to maintain or increase the goods necessary for the stability of the household economy (CARE, 1998).

Average annual expenditure was also higher in Lagos than Niger state (Table 4.32). This could be due to high cost of living in Lagos perhaps due to more development in the state. Expenditure in farmer's households was related to basic human needs including food, housing, clothing, education and medication. According to respondents, food was the single most important category of expenditure. Farmers also noted that expenditure is incurred on fishing and agricultural inputs.

In this study, four types of housing structures were identified to denote wealth ranking including bamboo hut, mud thatched, mud zinc and plank zinc. Farmers with mud zinc houses had higher annual income (N295 259) than those with plank zinc (N291 697), bamboo hut (N266 624) and mud thatched (N246 621). The study showed that all the farmers with fish ponds had mud zinc houses (Table 4.35) probably due to higher income (Table 4.31). Farmers with fish ponds owned land and also had larger house size (Table 4.37) which is an indication of wealth. The size of house space is an important feature of livelihood quality. The average house size including premises was 279 m^2. Land ownership is an important determinant of the incentive for investment, of the ability to obtain credit, and ultimately of household income. Securely owned land may be used as collateral for credit and, of course, the more land one owns the larger the amounts and easier the terms of loans one is able to secure.

Farmers in Lagos state had more access to electricity facilities than those in Niger (Table 4.38), most likely related again to the level of development in Lagos state and since the farmers had higher income they could afford the electricity facilities. Farmers with fish ponds had more access to electricity facilities than those with fish shelters and fish fences due to higher income. This study showed that 79% of the farmers had access to educational institutions including primary, secondary and tertiary institutions.

Health institutions found in the study area were dispensaries, rural health centres and general hospitals but drugs were generally in short supply. A family may be said to be well served in health facilities when all of its members have sustainable access to the medical care needed to be free of debilitating, preventable health problems and to have health problems addressed by a competent health care professional (Albrecht *et al*, 1998). Owing to escalating cost of drugs and the scarcity of modern health facilities, a large number of people continue to consult traditional healers or resort to Islamic and Christian preachers for solutions through prayer or charms (Falola, 1999).

Majority of the farmers (57%) had access to rural markets (Table 4.44). Some of these markets were fish markets in which fish (fresh and smoked) and fishing gears were sold along side other goods (Figure 4.2). Canoes are also manufactured in some of these markets. Farmers transport their goods to the market by road, water and occasionally by rail.

(a) Smoked fish

(b) Fishing nets

Figure 4.2: Fish market in Niger state

River, well, bore holes and tap were major sources of drinking water. The provision of clean and safe drinking water is considered to be the most valued element in the society (Tellegen *et al*, 1996). Farmers in Niger state (33%) depended on river as source of drinking water (Table 4.46). Rain water is also collected for drinking especially in households with roof made of zinc. Majority of the farmers in the study area (97%) did not have toilet facilities and usually pass faeces in the bush. Some farmers in Lagos state had toilets built over lagoon (Figure 4.3) and others had pit toilets. Farmers in Niger state used wood as source of fuel. Coco nut husks were used in addition to wood in Lagos state as coco nut trees are abundant in the state (Table 4.50).

Figure 4.3: Toilet built over lagoon in Lagos state.

All the farmers interviewed had radios, 98% had cassette players, 8% had T.V. (Table 4.52), 5% had videos and none with telephone facilities. Higher percentage of farmers in Lagos state (14%) and those with fish ponds (60%) had T.V probably due to higher income. This places traditional fish producing households in worse situation as their neighbours because possession of T.V, videos and telephones in Nigeria is seen as sign of wealth**.** The acquisition of these recreational facilities can be used as an indirect measure of wealth.

4.3.3.3 Overview of profitability of aquaculture systems and socio-economic conditions of farmers

This study suggests that, it is more profitable to produce fish in Lagos state despite high cost of production as a result of higher price of fish per kg. Currently, though many input costs are lower, the prospects for modern aquaculture in Niger state are limited by the lack of conducive local market for fish. Access to local markets and better marketing infrastructure could help in the development of modern aquaculture in the state. The easier or less costly it is to gain access to markets for aquaculture products, the greater the potential for aquaculture development. Improved transport, communication systems, storage and distribution systems can favour the development of aquaculture by reducing market transaction costs (Tisdell, 1994).

The current study also suggests that, it is more profitable to produce fish from fish parks as net returns, rate of incomes and benefit–cost ratios were higher from these systems than fish ponds (Table 4.15). About 98% of well performing systems were fish parks (Table 4.16) suggesting that these systems have the potential to expand in Nigeria as a result of their profitability. Fish parks were constructed from locally available materials such as wood, PVC pipes and worn out tyres at little or no cost suggesting that it is feasible to develop more fish parks in the study areas though there are concerns about the long term sustainability of the parks as a result of local deforestation and competing use of wood. However, net return was higher for fish ponds when the opportunity cost of wood was taken into account in the cost-return calculation of fish parks but rate of income and benefit-cost ratio were still higher for fish parks (Table 4.54). This also suggests that modern aquaculture too has the potential to develop in Nigeria despite the high cost of production as a result of the high net returns.

Table 4.54: Profitability of fish ponds and fish parks with an estimated opportunity cost of wood

	Fish ponds	Fish parks
	n = 10	N = 250
Mean production (kg ha^{-1} yr^{-1})	548	545
Mean gross revenue (N ha^{-1} yr^{-1})	98774	76668
Mean total operating cost (N ha^{-1} yr^{-1})	60698	42550[12]
Net return (N ha^{-1} yr^{-1})	38076	34118
Rate of income (%)	39	45
Benefit cost ratio	0.6	0.8

n = sample size of farmers. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

Low profitability (rate of income and benefit-cost ratio) of fish ponds could be due to high total mortalities resulting in low yield. Based on the average stocking density and mean production in this study, less than half of the fish (48%) could be accounted for (Table 4.55). Low profitability of the fish ponds could also be due to high cost of production. Fish seeds and land contributed to the high cost of production. Fish seeds and land accounted for 68% and 17% (85%) of the total cost of production, respectively (Table 4.1). In this study, traditional aquaculture systems were carried out in lagoons, rivers and floodplains which were open access and fish were drawn from the wild thus eliminating the costs of seed and land.

[12] 1000 kg of dry wood in the study area costs N 1600 and 50% of this (N 800) was used in calculating the opportunity cost of wood used by farmers that had brush parks because the wood used in the construction of brush parks are not of good quality as those sold in the market for fire wood. The calculation was based on the estimation that one dry weight of wood used in the construction of brush parks was 1 kg. Total cost without the opportunity cost was N 10550 / ha. Mean size of brush parks was 0.1 ha and 4 branches of wood were used per m^2.

Table 4.55: An estimated total survival rate of fish at harvest from fish ponds

Mean stocking rate / ha	Mean production (kg / ha)	Mean number of fish at harvest[13] / ha	Total survival rate (%)
5730	548	2740	48

Increasing yield, reducing costs and increasing market price could increase the profitability of fish ponds. Increasing stocking rate, survival rate and growth rate are the primary means of increasing production (Rabanal and Shang, 1976; Shang, 1981). In order to increase the yield of fish ponds, farmers should pay more attention to management techniques such as mortality reduction, liming, fertilisation, feeding, water quality monitoring, control of predators and poaching. Although the total cost of production is higher with fertilisation and supplementary feeding than without, the production cost per kg may be lower and the additional revenue generated may be higher than the additional cost involved. Using domestic and farm wastes for fish culture often reduces the cost of feed and fertilizer (Shang, 1981). This practice could help in recycling wastes, thereby protecting the environment and at the same time contributing to food production. Joint culture of ducks, poultry and pigs in combination with fish culture could facilitate this. Efforts should also be made to reduce the cost of seeds by increasing the supply of fry through breeding of species in captivity and by conducting surveys to locate new spawning grounds and by improvements in the capture, distribution and fry survival.

Farmers should also aim at producing large fish at harvest in order to obtain higher prices. Phased stocking so that harvesting occurs at desirable times with respect to demand and price of fish can increase the price of fish received (Rabanal and Shang, 1976). Low quality, spoilage, and waste reduce the average price that the

[13] Assuming individual fish at harvest was 200 g

farmers receive. However, the quality of fish can be improved through proper preservation during transport.

In this study, standard deviations were quite high as a result of wide variations in size of farms, production levels and total costs of production probably due to wider variety in methods and skills suggesting that some farms were profitable and others unprofitable (Table 4.16). This also suggests that there is scope for efficient producers to emerge in the study area. However, the standard deviations were lower than their mean values in profitable groups suggesting that production levels and total costs of production were similar when the systems were grouped into profitable units (Table 4.17).

This study suggests that traditional aquaculture systems play an important role in the economy of fishing communities in two states in Nigeria as evidenced from the profitability of the systems, although few farmers were not successful (Table 4.16). These systems and capture fisheries account for 70 – 90% of the annual income of the fishing households in Nigeria (DFID-FAO, 2002). In the present study, traditional aquaculture systems accounted for 20% of the annual income of fishing households suggesting that capture fisheries and other activities may have accounted for 80% of the annual income**.** Their financial requirements for investment, food consumption, education, health and other family needs depend on income from fish. However, fishermen also undertake other activities such as crop farming **(**Table 4.29**)** in order to reduce the risks and vulnerability issues associated with fish production from traditional aquaculture systems.

The current study showed that majority of the farmers (96%) had no formal education (Table 4.24) and they may therefore be unable to benefit from available literature even if they are widely disseminated, and this may limit the development of aquaculture in Nigeria. The development of aquaculture is limited by technological and biological knowledge, and the level of education and experience in a society (Tisdell, 1994). This study showed that fish pond operators are better off and better educated than traditional fish producers and are more likely to respond to technical improvements and also benefit from available literature. Fish producers in Lagos are also better off and better educated than fish producers in Niger state probably due to more development in Lagos.

In the present study, majority of the farmers (57%) had access to local markets (Table 4.44) but most of these markets lacked stalls, good network of roads, water and electricity. Poor infrastructure, especially roads may limit the distribution of fish. Poor infrastructure and marketing facilities decrease farm prices because they result in poor and over supply. These social and economic issues influence the development of aquaculture and need to be taken into account in planning it. Even if biological, technological and environmental conditions are favourable for the development of aquaculture, it may fail if the social and economic factors are unfavourable (Tisdell, 1994).

Chapter 5: Fish and meat consumption in fishing communities in two states in Nigeria

5.1 Introduction

Aquatic animals contain a high level of protein with an amino acid profile similar to that of the meat of land animals. Forty percent of the developed world population relies on fish as a source of protein, whereas 45% of the developing world depends on fish as a source of protein (FAO, 1980). Thus, consumption in the third world has accounted for much of the world fish demand. In the poorest societies of the world, fish provides a significant single source of the total dietary animal protein. In these regions, fish constitutes 20% of the total protein intake (Tall, 2002). Given that much of the consumption in rural areas is unrecorded, the actual consumption is likely to be much higher.

The consumption of fish, wherever available in sufficient quantities, can be expected to help considerably in correcting the state of malnutrition widely prevalent in the world today. Fish is a highly nutritious food. Both qualitatively and quantitatively, fish consumption could significantly supplement the low–protein; high cereal diet consumed in many countries of the world and provides trace nutrients such as copper, fluorine and iodine which are crucial for infant development. Cereal proteins unlike fish proteins are low in lysine and methionine (Guha, 1962). Fish is also a fairly good source of calcium and phosphorus, particularly small fish which are eaten with bones. Fish has also a fair proportion of the B–vitamins. Fish represents a valuable source of micronutrients, minerals, essential fatty acids such as omega-3 and omega-6 fatty acids, and proteins in the diet of many countries (Guha, 1962).

Increasing the per caput consumption of fish and shellfish in any country benefits health (Satia, 1989). Populations with the highest consumption of fatty fish appear to have the lowest incidence of cardiovascular diseases. Fish consumption has also been linked to reduced hypertension, reduced blood clotting tendencies, and more favourable plasma lipid and lipo–protein levels (Mori *et al*, 1999; Addis, 2004).

Average apparent per capita consumption of fish, crustaceans and molluscs worldwide in 2002 was estimated to be 16.2 kg, 21% higher than in 1992 (13.1 kg). This growth is largely attributable to China, whose estimated share of world fish production increased from 16% in 1992 to 33% in 2002. If China is excluded, the per capita fish consumption would be 13.2 kg, almost the same as in 1992 (FAO, 2004). It is estimated that fish contributes up to 180 kilocalories per capita per day, but reaches such high levels only in a few countries where there is a lack of alternative protein foods, and where a preference for fish has been developed and maintained. More commonly, fish provides 20 to 30 kilocalories per capita per day (FAO, 2004).

Meat and meat products can also make a valuable contribution to the diets in developing countries. The importance of meat in the diet is as a concentrated source of protein which is not only of high biological value but its amino acid composition complements that of cereal and other vegetable proteins by making good their relative deficiency of lysine. It is also a good source of minerals, such as iron, copper, zinc and manganese. Moreover, compared with plant foods the iron in meat is well absorbed and meat promotes the absorption of iron from other foods. Meat and meat products are important sources of all the B–complex vitamins including thiamin, riboflavin, niacin, biotin, vitamins B6 and B12, pantothenic acid and folacin. The last two are especially abundant in liver which, together with certain other organs is rich in vitamin A and supplies appreciable amounts of vitamins D, E and K (Bender, 1992).

In most communities meat has long occupied a special place in the diet, for a variety of reasons including taste preference, prestige, tradition and availability, with the nutritional aspects being included more recently (Rogowski, 1980). While it is true that meat is not essential in the diet and many people thrive on diets derived largely or even entirely from plant foods there are many diets that would be considerably improved by the inclusion of even small amounts of meat and meat products (Bender, 1992). As little as 25 g of meat will supply 45% of a child's daily need for protein and half the vitamin B12; the addition of 100 g of meat to the average Zambian diet would increase the protein by 50%, iron by 12%, niacin by 40% and energy by 25% (Jensen, 1981).

The amount of meat consumed in different countries varies enormously with social, economic and political influences, religious beliefs and geographical differences (Bender, 1992). The main determinant of per capita meat consumption appears to be wealth (Speedy, 2003). Consumption of meat in the United States in 2002 was 124 kg / capita / yr compared to the global average of 39 kg. The countries that consumed the least amount of meat were in Africa and South Asia. Consumption in these countries was between 3 and 5 kg / capita / yr (FAO, 2002).

Fishing communities are frequently identified as being among the poorest of the poor (Jazairy *et al*, 1992) and are often characterised by over crowded living conditions and inadequate services, low levels of education and a lack of skills and assets (particularly land) which would permit diversification of their livelihoods (Townsley, 1998).

The objectives of the present study were:

- To examine the relative importance of fish in diet by comparing consumption patterns of fish to meats in fishing communities in Niger and Lagos states.
- To examine the intra household fish consumption and distribution in the fishing communities in the two states.
- To identify the types of fish species consumed in fishing communities including sources and forms of fish used for cooking.
- To compare households' expenditure patterns on fish and meat in fishing communities in Niger and Lagos states.
- To compare retail market prices of fresh and smoked fish in the two states.

5.2 Materials and methods

Materials and methods used in this chapter are given in the general materials and methods section (2.7 & 2.8).

5.3 Results

5.3.1 Characteristics of households

5.3.1.1 Family size and income

The household structure consisted mainly of nuclear family, which includes the head of household, his wife or wives and their children. Family size and income within each state are given in Table 5.1. Family size was significantly ($p < 0.001$) higher in Niger than Lagos state but there was no significant ($p = 0.243$) difference in annual income of heads of households between the two states.

Table 5.1: Family size and income of households in Niger and Lagos states.

State	Family size	Annual income (Naira)
Niger	8 ±3^{a} (50)	50690 ±33949^{a} (50)
Lagos	6 ±2^{b} (50)	45932 ±34639^{a} (50)
Average total	7 ±3 (100)	48311 ±34206 (100)

Data is presented as mean ±Standard deviation. Figures in brackets indicate number of households. Nigerian currency is Naira (N). (1US$ = N128 in 2003). Values with the same superscript in a column do not differ significantly ($p > 0.05$) from each other.

The impact of primary occupation by household heads on family size and annual income is shown in Table 5.2. Occupation had no significant bearing on mean family size ($p = 0.569$) of fishing and non–fishing households and annual income ($p = 0.992$) of heads of households.

Table 5.2 : Family size and income of fishing and non-fishing households in fishing communities in two states.

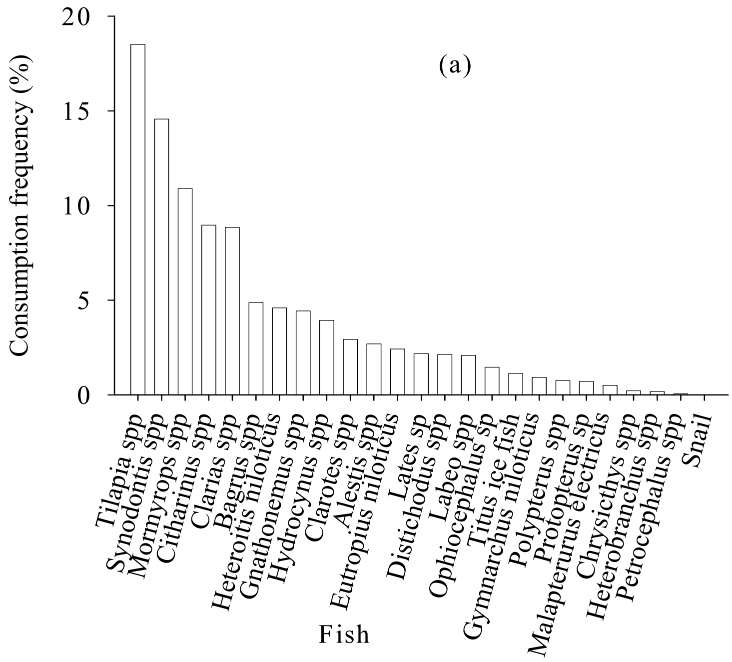
Households	Family size	Annual income (Naira)
Fishing	7 ±3^{a} (50)	47352 ±32478^{a} (50)
Non–fishing	7 ±3^{a} (50)	49270 ±36156^{a} (50)
Average total	7 ±3 (100)	48311 ±34206 (100)

Data is presented as mean ±Standard deviation. Figures in brackets indicate number of households. Nigerian currency is Naira (N). (1US$ = N128 in 2003). Values with the same superscript in a column do not differ significantly ($p > 0.05$) from each other.

5.3.2 Fish consumption in fishing communities

5.3.2.1 Consumption of fish species in fishing communities

Freshwater fish species consumed in the fishing communities in Niger state are given in Figure 5.1a. Tilapia species were consumed with highest frequency (19%) followed by *Synodontis* (14%) and *Mormyrops* species (11%). The least consumed species group was the snail. A total of 25 different fish species were recorded as being consumed in Niger state. Fish species consumed in the fishing communities in Lagos state are given in Figure 5.1b. Tilapia species were also consumed with highest frequency (31%) followed by *Caranx* (8%) and *Sphyraena* (Barracuda) species (7%). The least consumed fish species was titus ice fish (*Scomber* *japonicum*). A total of 22 different fish species were recorded as being consumed in Lagos state.



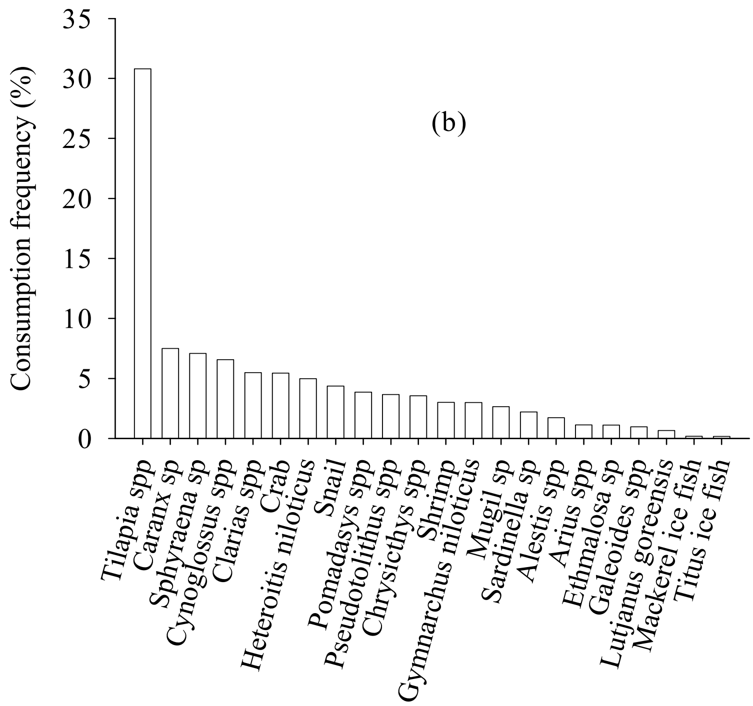


Figure 5.1: Overall consumption frequencies of fish species in fishing communities in (a) Niger and (b) Lagos state[14]. Data not shown are too small to appear on the scale.

[14] Species consumed in Niger were exclusively freshwater fish while those consumed in Lagos were both fresh and brackish water species. Two local government areas in Lagos had freshwater lagoon as their main source of fish.

5.3.2.2 Household consumption patterns of fish

Consumption patterns of fish in Niger and Lagos states are given in Figure 5.2a. Fish consumption was higher, almost twice in Niger than Lagos state. Average weights of fish consumed per household per day in Niger and Lagos states were 217 and 124 g, respectively. Consumption of fish was higher in fishing households than non–fishing households (Figure 5.2b). Overall fishing households consumed an average of 230 g of fish per day as compared to 111 g for non–fishing households. Highest fish consumption occurred in March in all the households in Niger and Lagos states.

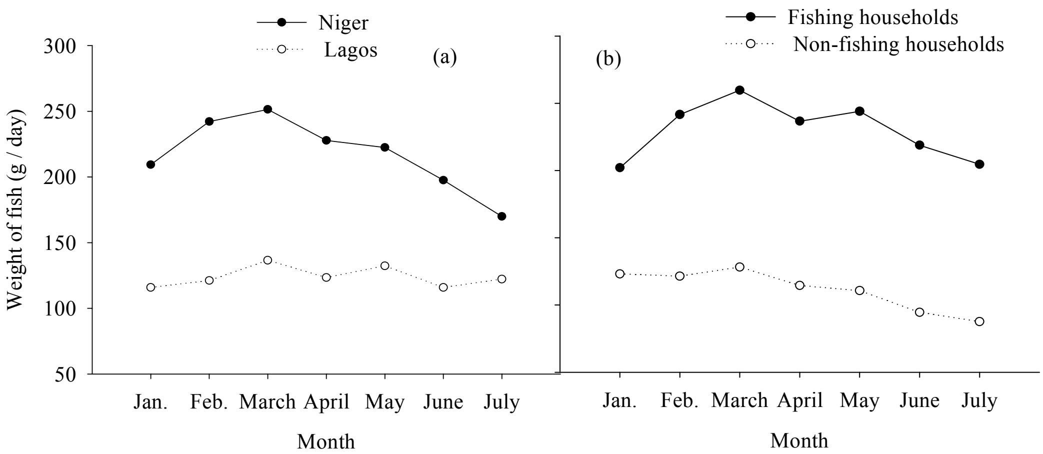


Figure 5.2: Temporal fish consumption patterns in fishing communities in (a) Niger and Lagos states, and (b) fishing and non–fishing households.

There were significant ($p < 0.001$) differences in the overall monthly fish consumption in fishing and non–fishing households in fishing communities in Niger and Lagos states. In both states, the average daily fish consumption in all the months (January-July) in fishing households was significantly ($p < 0.001$) higher than those of non-fishing households. The significant differences are summarized in Figure 5.3.

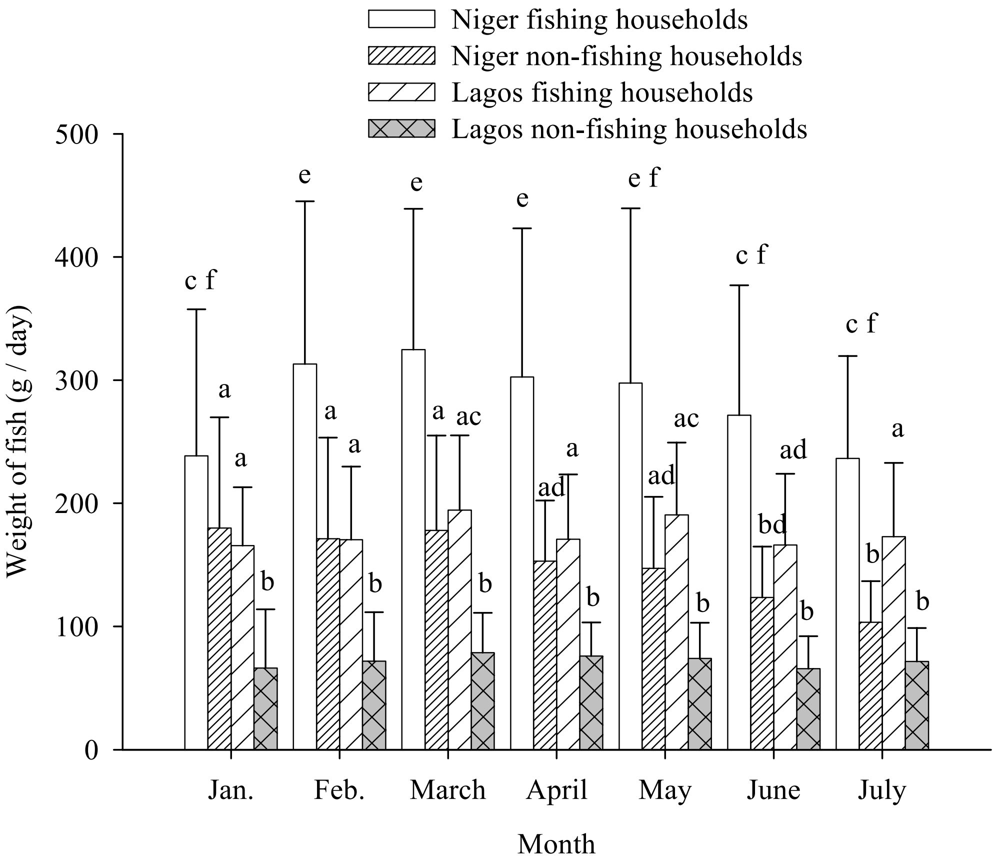


Figure 5.3: Average daily weights of fish consumed within each month in fishing and non–fishing households in fishing communities in Niger and Lagos states. Data are presented with the average values ± standard deviations. Values that are not significantly different ($p > 0.05$) share common superscript.

5.3.2.3 Average weights of fish consumed per person per day in fishing communities

In Niger, average weight of fish consumed per person per day was 28 g (10 kg per year) as compared with 22 g (8 kg per year) for Lagos state. In fishing households, however, average weight of fish consumed per person per day was higher at 33 g (12 kg per year) as compared with 17 g (6 kg per year) for non–fishing households. In all the households, highest fish consumption per person per day occurred in March (Figure 5.4).

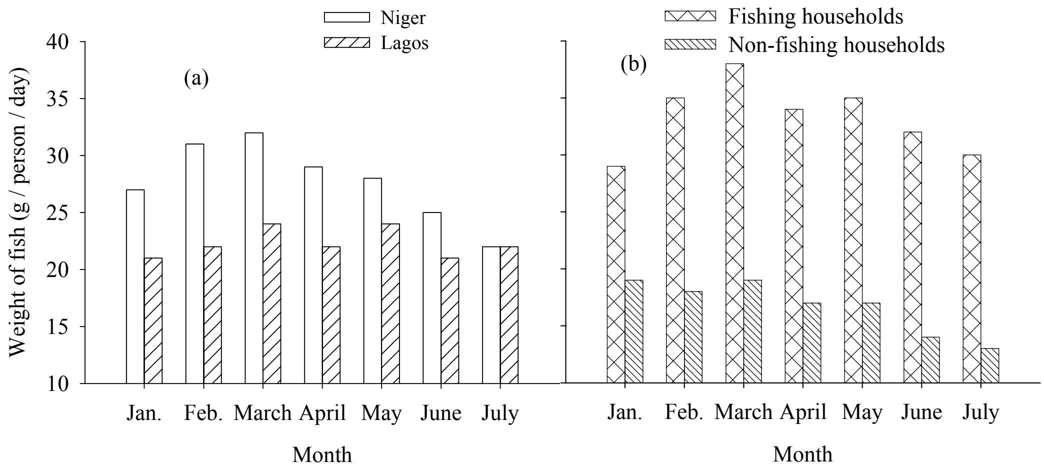


Figure 5.4: Overall average daily weights of fish consumed within each month per person in (a) Niger and Lagos states, and (b) fishing and non–fishing households in fishing communities.

5.3.2.4 Forms of fish used for cooking

Most of the fish (95%) consumed during the study was in the fresh form. Smoked, frozen and dried fish were occasionally used for cooking (Figure 5.5).

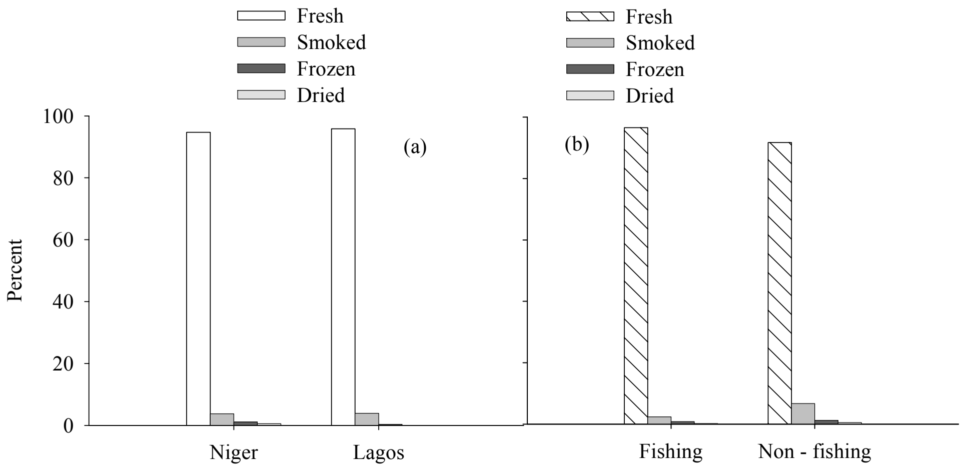


Figure 5.5: Forms of fish used for cooking in fishing communities in (a) Niger and Lagos states, and (b) fishing and non-fishing households. Data not shown are too small to appear on the scale. Data are expressed as percentages of frequencies. Fishing refers to fishing households and non–fishing to non–fishing households.

5.3.2.5 Sources of fish

The main sources of fish varied between states (Figure 5.6a). River was the most important (87%) source of fish in Niger state followed by the market (13%) whilst in Lagos state; lagoon was the main source (60%). Other sources of fish in Lagos state were market (15%), creek (15%), sea (9%) and pond (1%). Sources of fish for fishing and non–fishing households are given in Figure 5.6b. About 67% of the fish consumed in fishing households came from river. Other sources were Lagoon (22%), creek (6%), sea (4%) and pond (1%). River was also the major source (46%) of fish for non-fishing households. Market also contributed significantly (43%) followed by lagoon (9%).

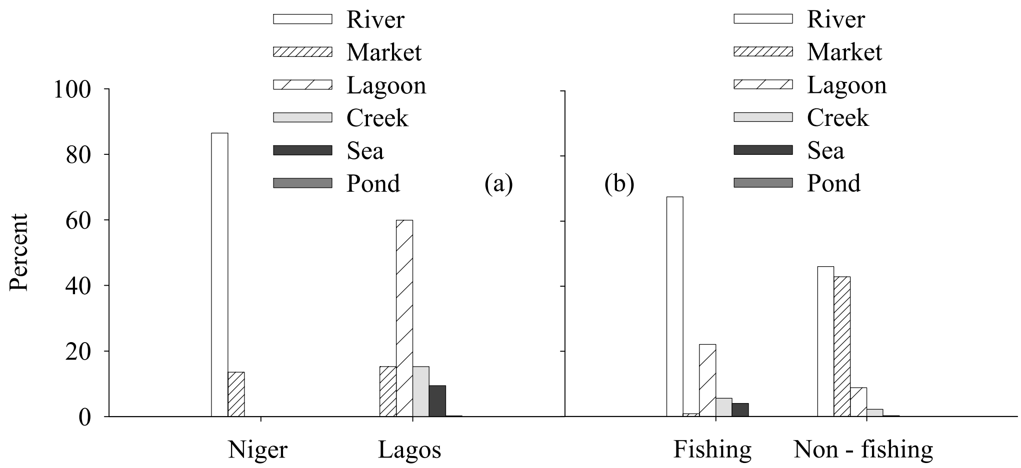


Figure 5.6: Sources of fish consumed in fishing communities in (a) Niger and Lagos states and (b) fishing and non-fishing households. Data are expressed as percentages of frequencies. Data not shown are too small to appear on the scale. Fishing refers to fishing households and non–fishing to non–fishing households.

5.3.2.6 Monthly amount spent on fish

Monthly amount spent on fish in Niger and Lagos states is shown in Figure 5.7a. Highest amount of money spent on buying fish occurred in January in both states. Average amount spent on fish per household per day in Niger and Lagos states was

N 4[15]. Amount of money spent on buying fish in non–fishing households also peaked in January (Figure 5.7b). No significant amount of money was spent on buying fish in fishing households.

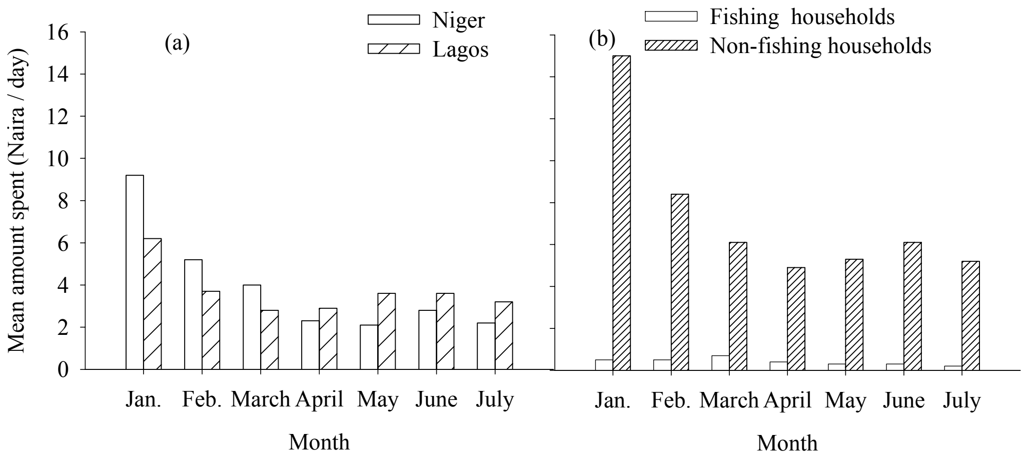


Figure 5.7: Average daily amount spent on fish within each month per household in fishing communities in (a) Niger and Lagos states, and (b) fishing and non-fishing households.

There were significant ($p = 0.027$) differences in the overall monthly amount spent on buying fish in fishing and non–fishing households in fishing communities in Niger and Lagos states. In Niger state, the average daily amount spent on fish in January, February and March in fishing households was significantly ($p < 0.05$) lower than those of non-fishing households. In Lagos state, fishing households did not spend any significant amount of money on fish throughout the study period. The significant differences are given in Figure 5.8.

[15] Nigerian currency is Naira (N). 1 US$ = N 128 in 2003.

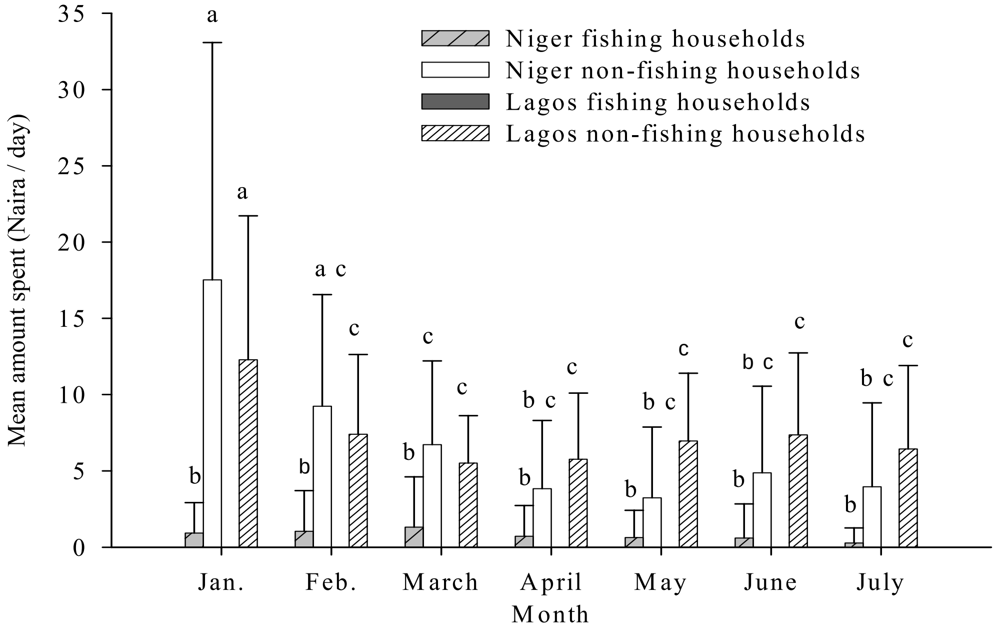


Figure 5.8: Average daily amount spent within each month on fish in fishing and non-fishing households in fishing communities in Niger and Lagos states. Data not shown are too small to appear on the scale. Data are presented with the average values ±standard deviations. Values that are not significantly different (p >0.05) share common superscript.

5.3.2.7 Intra household fish consumption and distribution

5.3.2.7.1 Intra household fish consumption

The pattern of intra–household consumption of fish was influenced by the social household structure. In the study area, heads of households consumed higher amount of fish than wives and children. Children consumed the lowest weight of fish. The average weight of fish consumed by the head of household was 66 g per day (24 kg per year) compared to 32 g (12 kg per year) for the wife and 13 g per day for the child (5 kg per year). Intra–household fish consumption varied during the year (Figure 5.9). Consumption of fish by all the members of households was highest in March.

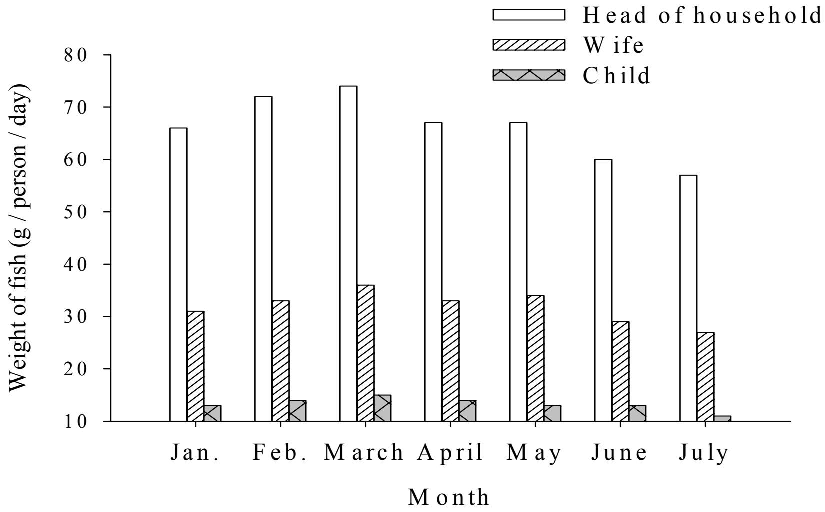


Figure 5.9: Overall average daily weights of fish consumed within each month by members of households in fishing communities in two states in Nigeria.

In each state, heads of households also consumed higher amount of fish than their wives and children (Figure 5.10). In Niger state, the average weight of fish consumed by the head of household was 73 g per day (27 kg per year) as compared to 34 g (12 kg per year) for the wife and 17 g per day (6 kg per year) for the child. In Lagos state, head of household consumed an average of 59 g per day (22 kg per year) as compared to 28 g (10 kg per year) for the wife and 8 g per day (3 kg per year) for the child.

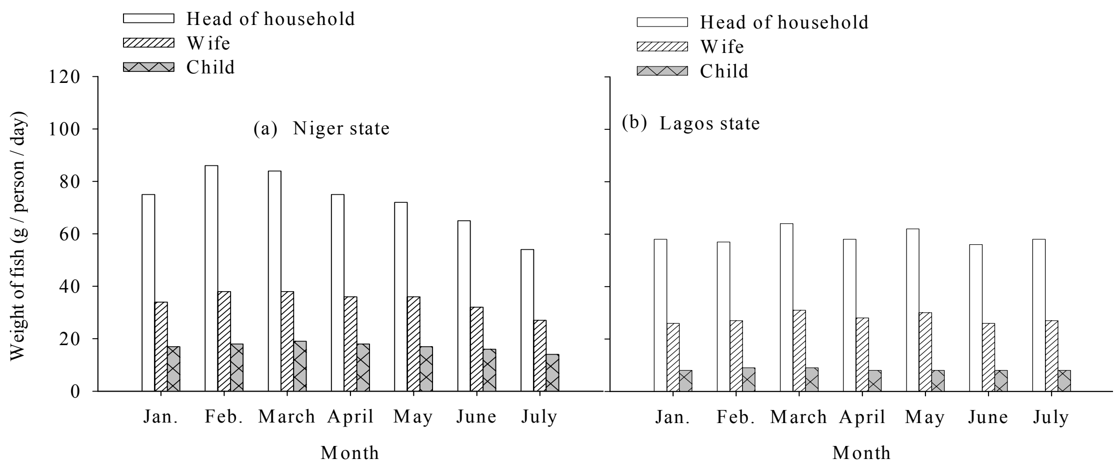


Figure 5.10: Average daily weights of fish consumed within each month by members of households in fishing communities in (a) Niger and (b) Lagos state.

Intra household fish consumption in fishing and non–fishing households is given in Figure 5.11. Heads of households consumed higher amount of fish than other members in fishing and non–fishing households. The average weight of fish consumed by the head of fishing households was 88 g per day (32 kg per year) as compared to 42 g (15 kg per year) for the wife and 18 g per day (7 kg per year) for the child. Head of non–fishing households consumed an average of 45 g of fish per day (16 kg per year) as compared to 21 g (8 kg per year) for the wife and 8 g per day (3 kg per year) for the child.

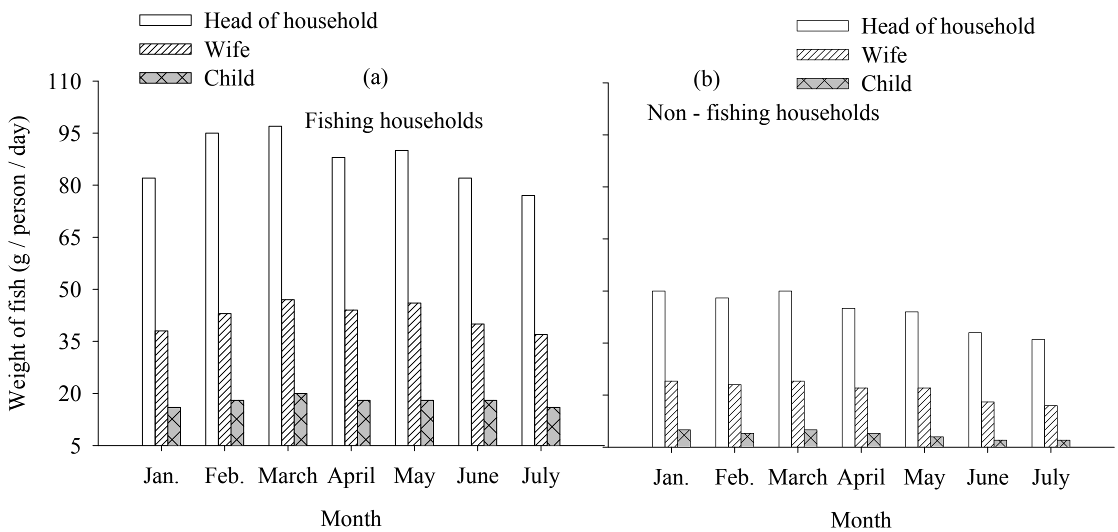


Figure 5.11: Average daily weights of fish consumed within each month by members of households in (a) fishing and (b) non–fishing households in fishing communities in two states.

There were significant ($p < 0.001$) differences in the overall monthly fish consumption among members of households in fishing communities in Niger and Lagos states. In both states, the average daily weight of fish consumed by heads of households in all the months (January-July) was significantly ($p < 0.001$) higher than those of wives and children. Children in Lagos state consumed significantly (p

< 0.001) lower amount of fish than other members throughout the study period. The significant differences are summarised in Figure 5.12.

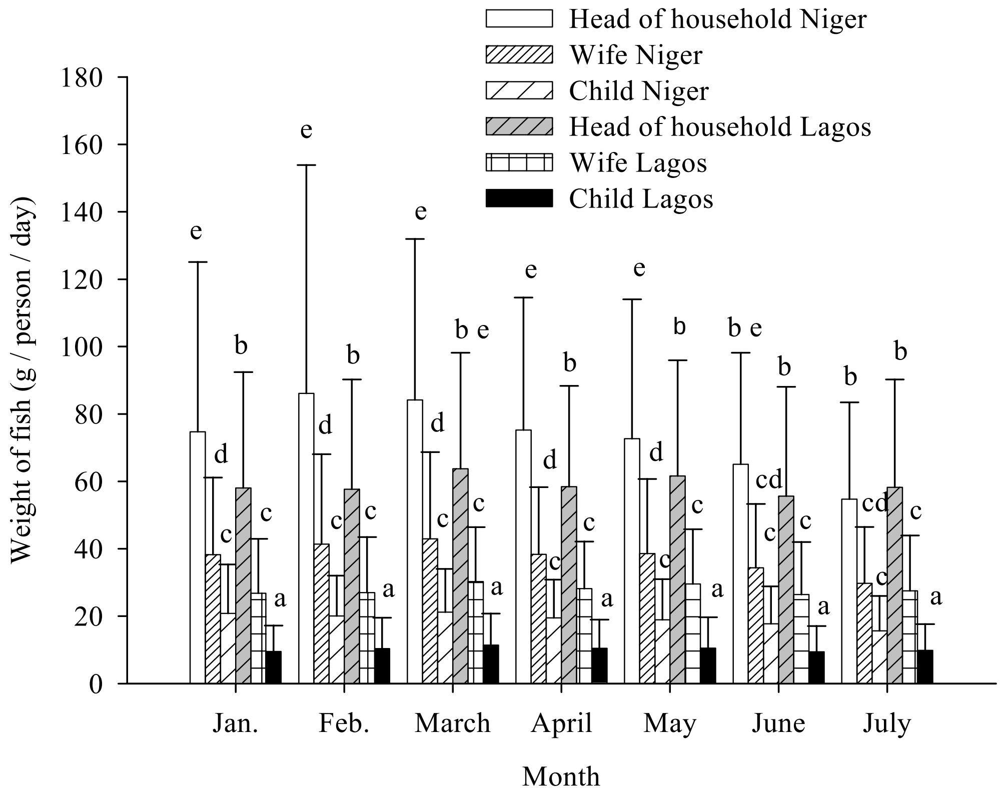


Figure 5.12: Average daily weights of fish consumed within each month by members of households in fishing communities in Niger and Lagos states. Data are presented with the average values ±standard deviations. Values that are not significantly different (p >0.05) share common superscript.

5.3.2.7.2 Intra household fish distribution

The allocation of different parts of fish for consumption was also influenced by household status. In the study area, when a single fish is shared within the household, the body of fish (79%) was often given to the head of household, the tail (71%) to wives and head (77%) to children (Figure 5.13).

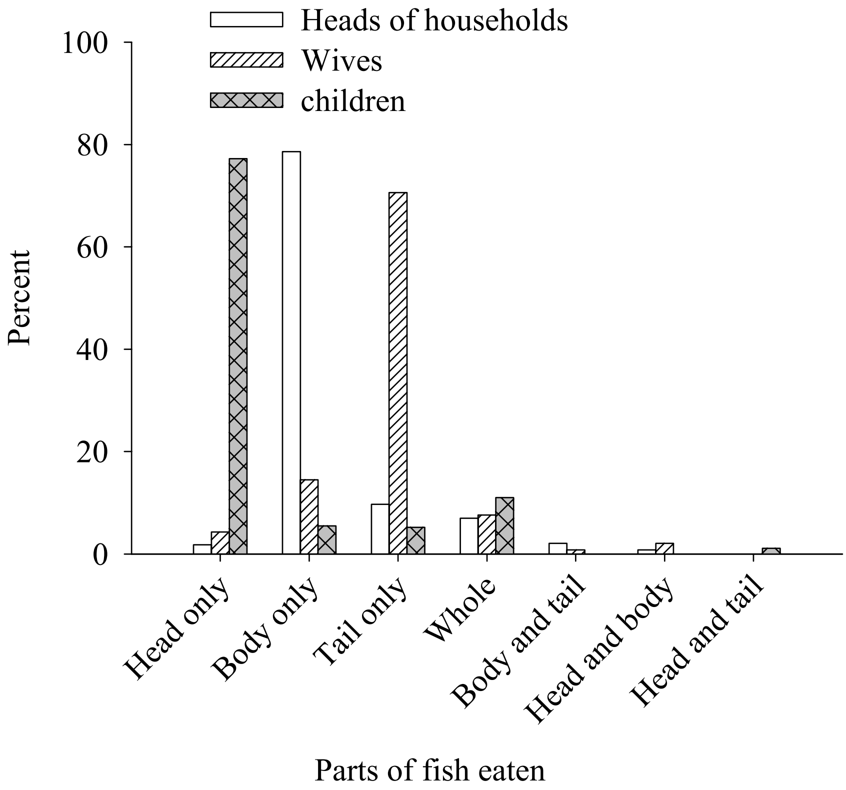


Figure 5.13: Overall frequencies of parts of fish eaten by members of households in fishing communities in two states in Nigeria. Data not shown are too small to appear on the scale.

In each state, body, tail and head of fish were parts of fish that were mostly eaten by heads of households, wives and children, respectively (Figure 5.14 a&b). The allocation of different parts of fish was the same in fishing and non–fishing households in fishing communities in the two states (Figure 5.14 c&d).

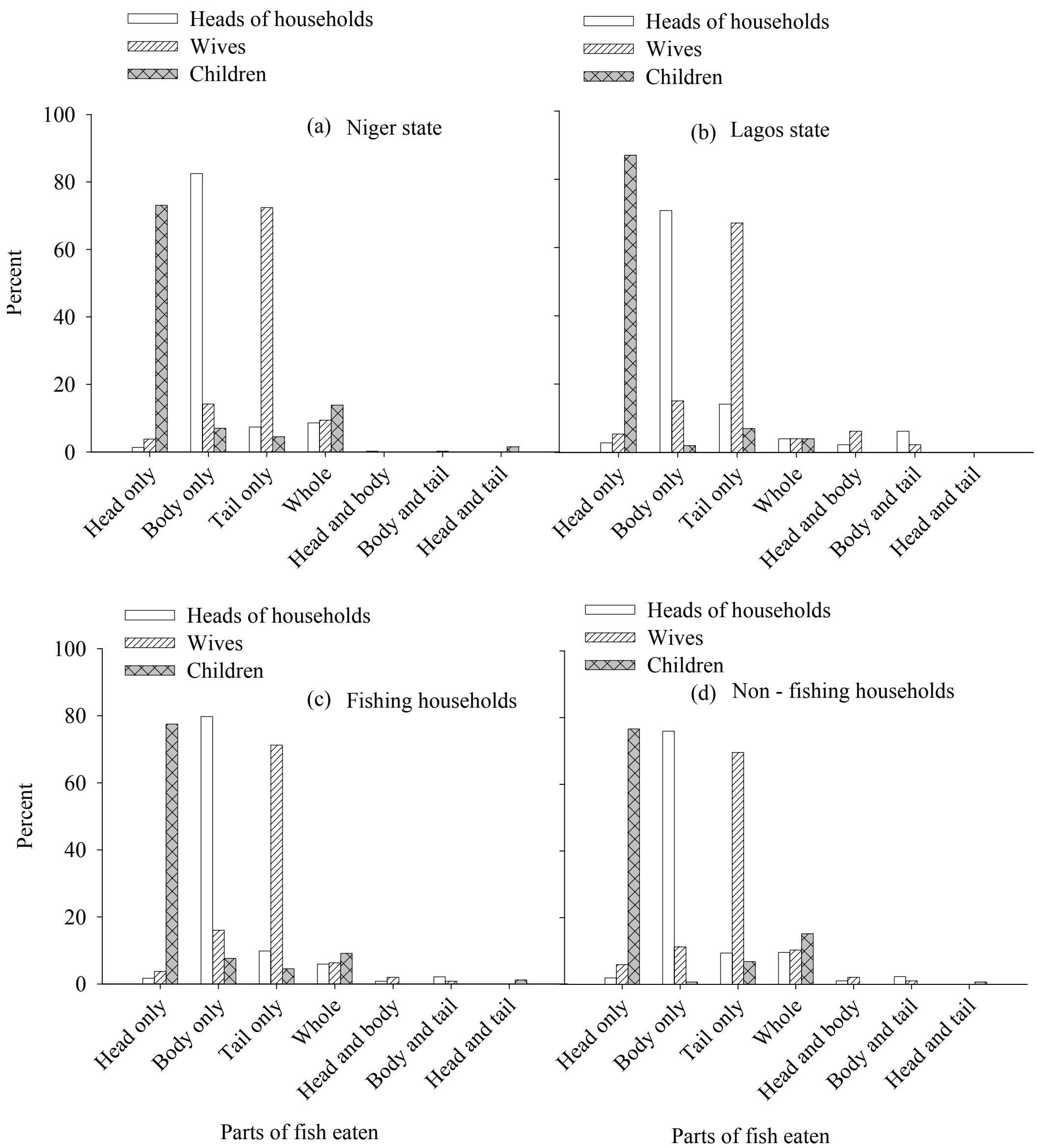


Figure 5.14: Frequencies of parts of fish eaten by members in (a) Niger (b) Lagos state (c) fishing and (d) non–fishing households in fishing communities. Data not shown are too small to appear on the scale.

5.3.2.7.3 Parts of fish thrown away

Fish was often eaten whole in fishing communities in two states in Nigeria. Bones even if thrown away, were often first chewed (Figure 5.15).

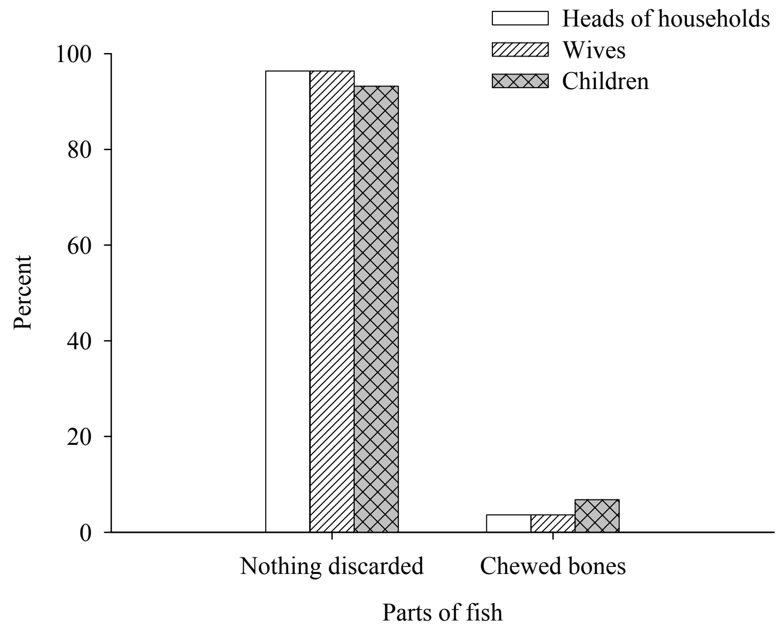


Figure 5.15: Overall frequencies of parts of fish thrown away by members of households in fishing communities in two states in Nigeria.

Every part of fish was eaten in fishing communities in Niger as well as Lagos state (Figure 5.16), and in fishing and non–fishing households in the two states (Figure 5.17). Chewed bones were discarded only when big fish were eaten.

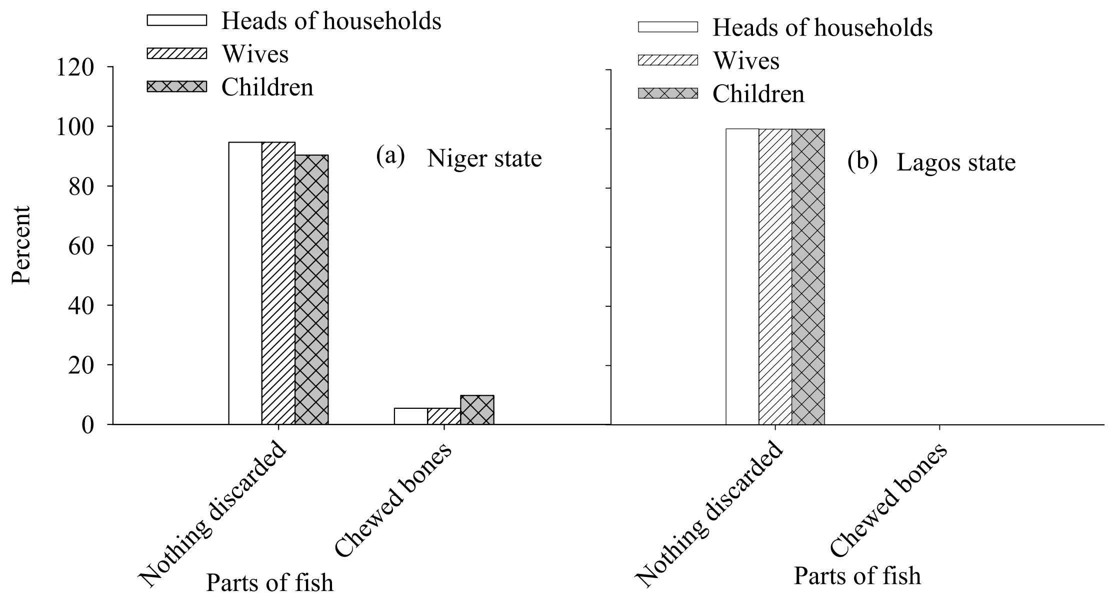


Figure 5.16: Frequencies of parts of fish thrown away by members of households in fishing communities in (a) Niger and (b) Lagos state. Data not shown are too small to appear on the scale.

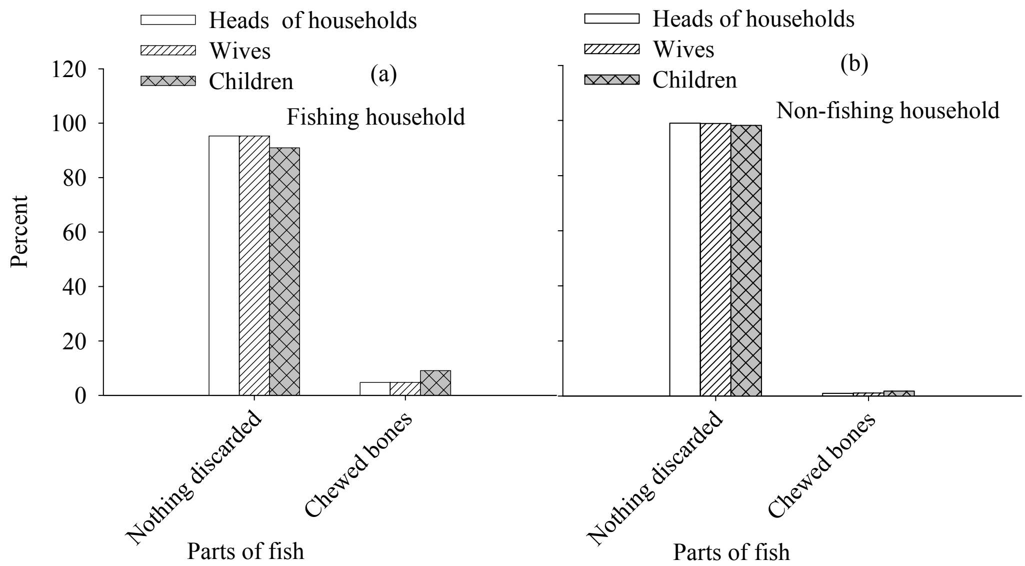


Figure 5.17: Frequencies of parts of fish thrown away by members in (a) fishing and (b) non–fishing households in fishing communities in two states. Data not shown are too small to appear on the scale.

5.3.2.8 Fish prices in two states in Nigeria

Trends of retail fish prices in local markets in two states in Nigeria are given in Figure 5.18. Prices of fish varied during the year. Price of both fresh and smoked fish was lowest in March.

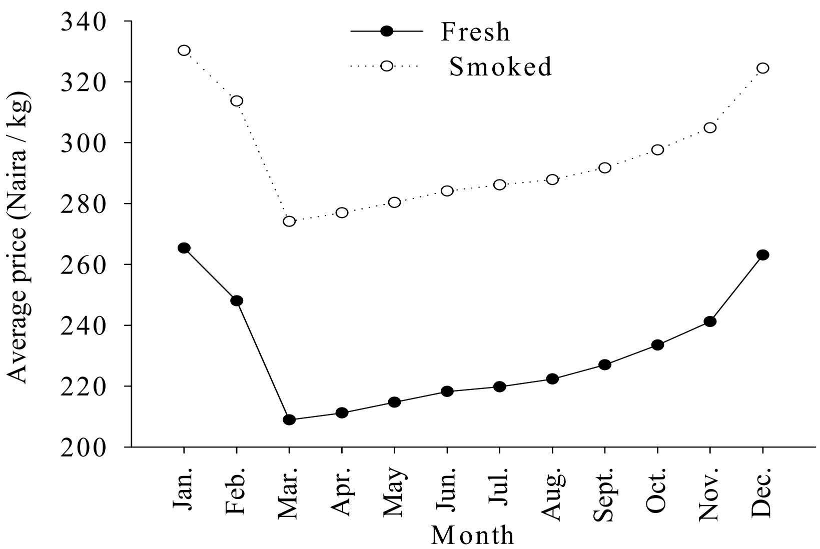


Figure 5.18: Overall monthly trend of retail fish prices in local markets in two states in Nigeria in 2003

In each state, price of both fresh and smoked fish was lowest in March (Figure 5.19). Prices of fresh and smoked fish were higher in Lagos than Niger state.

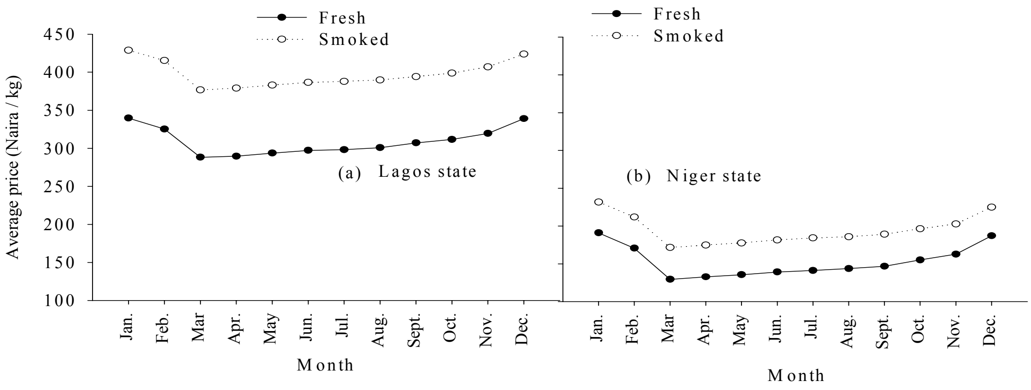
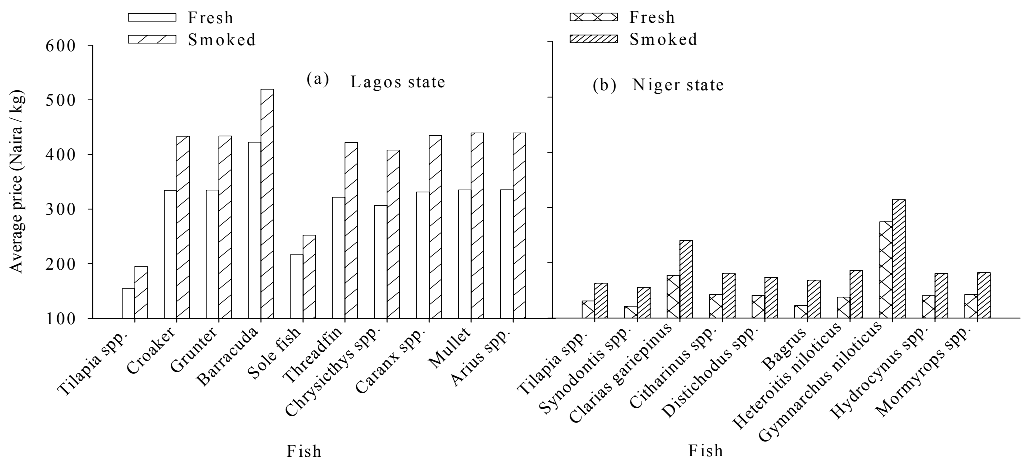


Figure 5.19: Trends of retail monthly fish prices in local markets in (a) Lagos and (b) Niger state.

Prices of fish species in Niger and Lagos states are given in Figure 5.20. *Gymnarchus niloticus* and Barracuda had the highest prices in Niger and Lagos state, respectively. Average price of fresh *Gymnarchus niloticus* in Niger was N 274 as compared to N 422 for Barracuda in Lagos state[16], while fresh tilapia; the most commonly eaten fish fetched N 131 and N 154 in Niger and Lagos state, respectively.



[16] Nigerian currency is Naira (N). 1 US$ = N 128 in 2003.

Figure 5.20: Average prices of fish species in (a) Lagos and (b) Niger state. Species in Niger are freshwater fish while those in Lagos state are brackish water.

5.3.3 Meat consumption in fishing communities

5.3.3.1 Consumption frequencies of meats in fishing communities

Consumption frequencies of meats in fishing communities in two states in Nigeria over the study period are given in Figure 5.21. Beef was the most frequently eaten meat (47%) followed by goat meat (20%) and chicken (14%). The least consumed meat was lamb. Grass cutter was the bush meat that was eaten with highest frequency (9%).

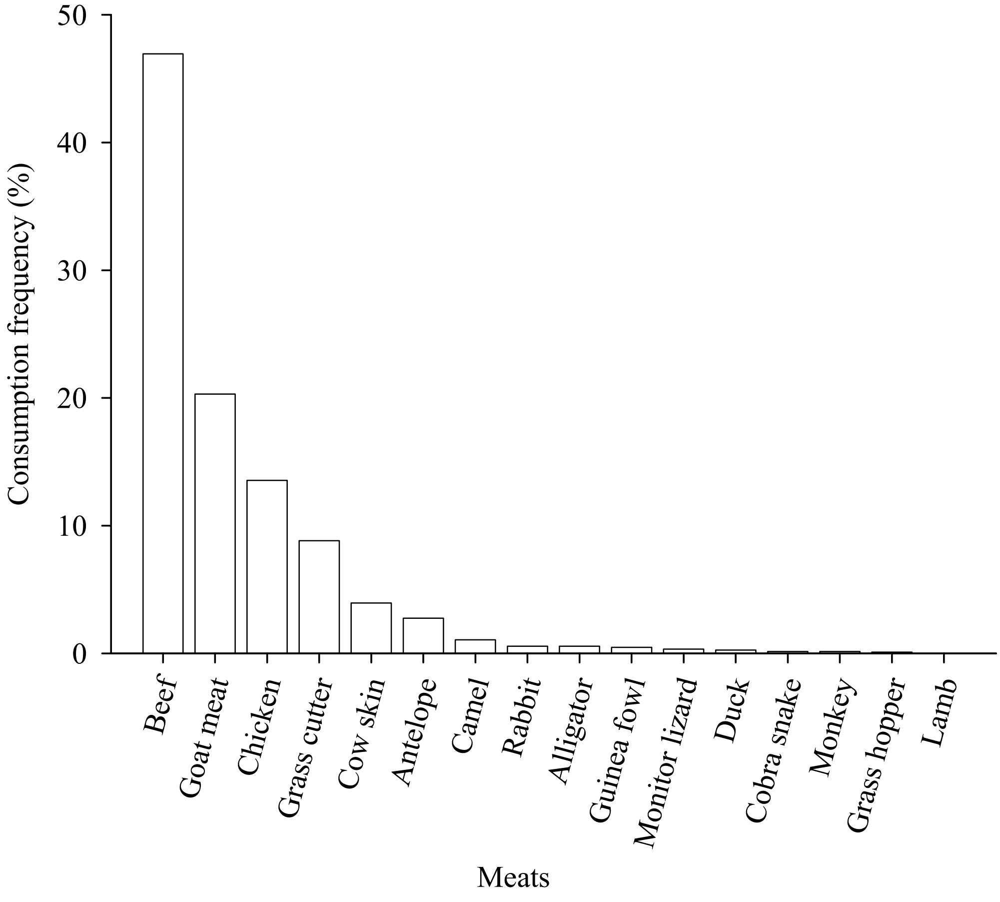


Figure 5.21: Overall consumption frequencies of meats in fishing communities in two states in Nigeria. Data not shown are too small to appear on the scale.

5.3.3.2 Household consumption patterns of meats

Meat consumption was higher in Niger than Lagos state (Figure 5.22a). Average weights of meats eaten per household per day in Niger and Lagos state were 61 and 38 g, respectively. Fishing households consumed an average of 48 g of meats per household per day as compared to 51 g for non–fishing households. Consumption of meat was lowest in March in all the households.

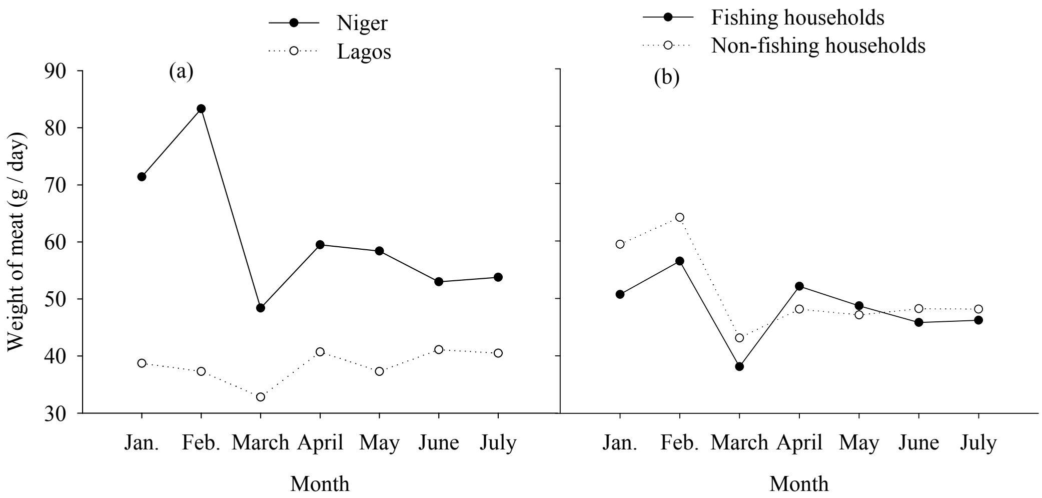


Figure 5.22: Temporal consumption patterns of meats in fishing communities in (a) Niger and Lagos states and (b) fishing and non–fishing households.

There were significant ($p = 0.013$) differences in the overall monthly meat consumption in fishing and non–fishing households in fishing communities in Niger and Lagos states. In Lagos state, the average daily weight of meat consumed in January and February in fishing households was significantly ($p < 0.05$) lower than those of non-fishing households in Lagos as well as Niger state. The significant differences are summarised in Figure 5.23.

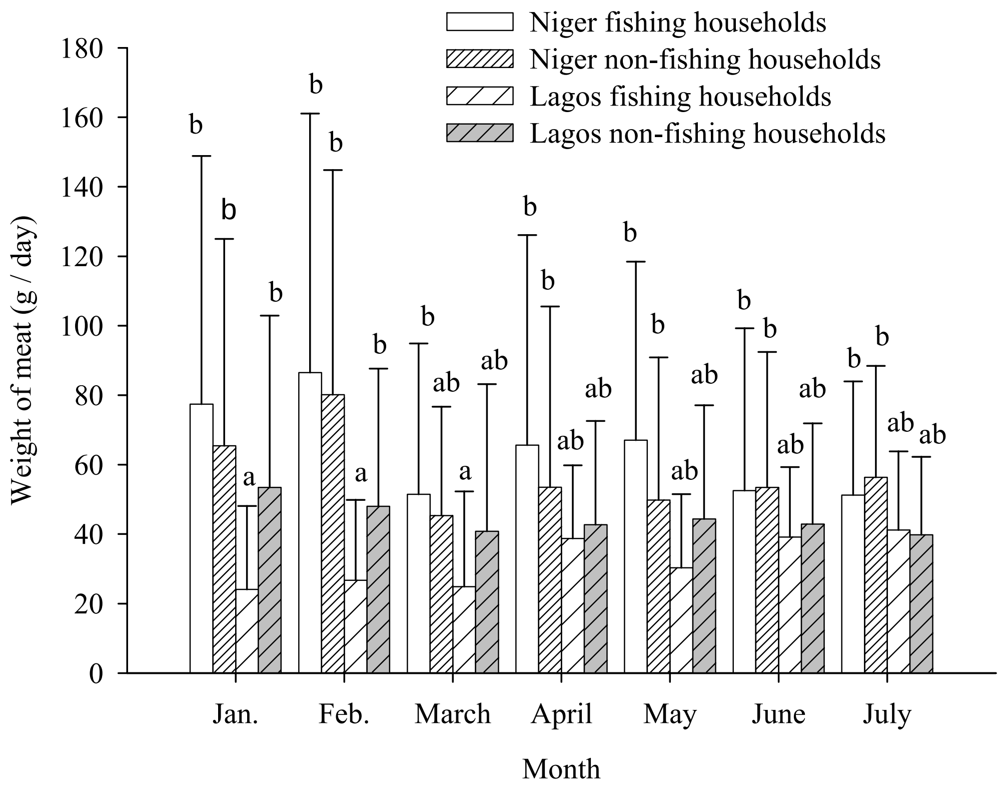


Figure 5.23: Average daily weights of meats consumed within each month in fishing and non–fishing households in Niger and Lagos states. Data are presented with the average values ±standard deviations. Values that are not significantly different ($p > 0.05$) share common superscript.

Overall consumption patterns of fish with meats in fishing communities in two states in Nigeria are given in Figure 5.24. Consumption of fish was significantly higher than meats. Average weight of fish consumed per household per day was 170 g as compared with 50 g for meats. Fish contributed 77% by weight to total animal protein diet of fishing communities in two states in Nigeria as compared with 23% for meats. Consumption of fish and meat varied during the year. Fish consumption was highest in March corresponding to period of lowest meat consumption. Meat consumption was highest in February (Figure 5.24).

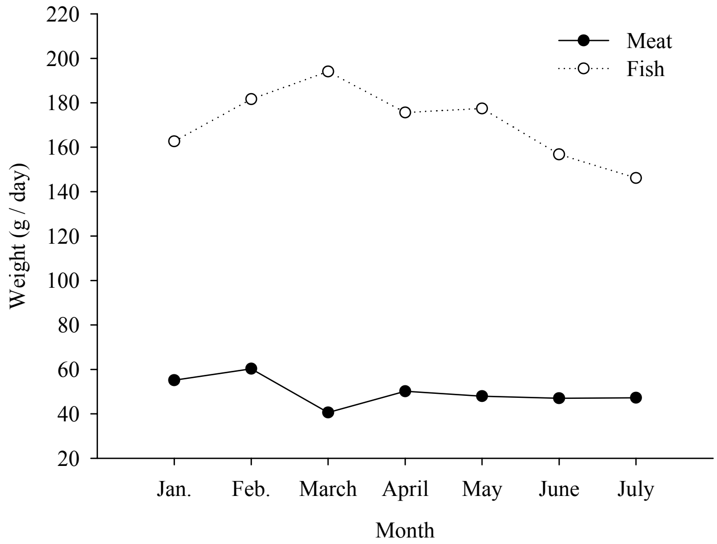


Figure 5.24: Overall temporal consumption patterns of fish and meats in fishing communities in two states in Nigeria.

5.3.3.3 Average weights of meats consumed per person per day in fishing communities

In Niger, average weight of meat consumed per person per day was 8 g (3 kg per year) as compared to 7 g (3 kg per year) for Lagos state (Figure 5.25a). Average meat consumption per person per day was 7 g (3 kg per year) and 8 g (3 kg per year) in fishing and non–fishing households, respectively (Figure 5.25b). In all the households, meat consumption per person per day was lowest in March.

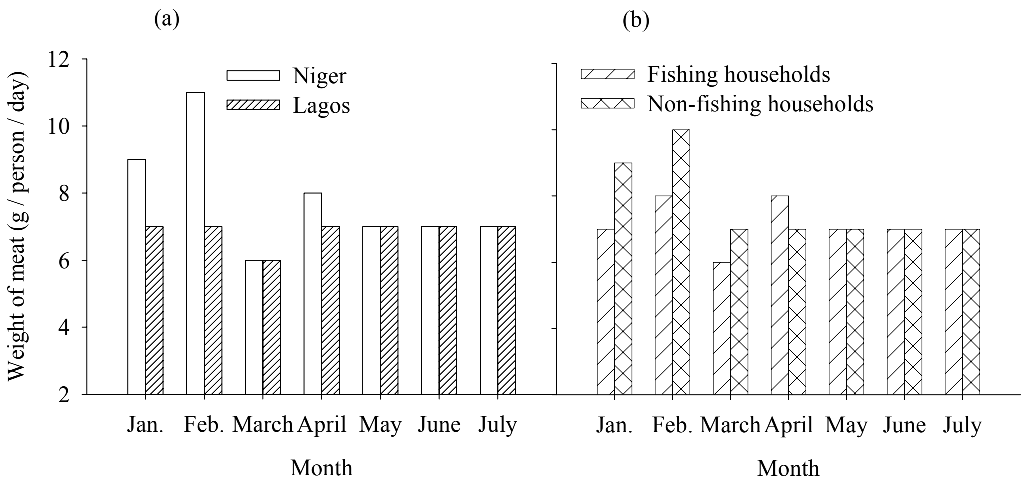


Figure 5.25: Average daily weights of meats consumed within each month per person in fishing communities in (a) Niger and Lagos states, and (b) fishing and non–fishing households.

In the study area, lowest meat consumption per person per day coincided with peak fish consumption which occurred in March (Figure 5.26). The average daily weight of fish consumed in fishing communities in the study area was 25 g per person (9 kg per year) as compared to 7 g (3 kg per year) for meats.

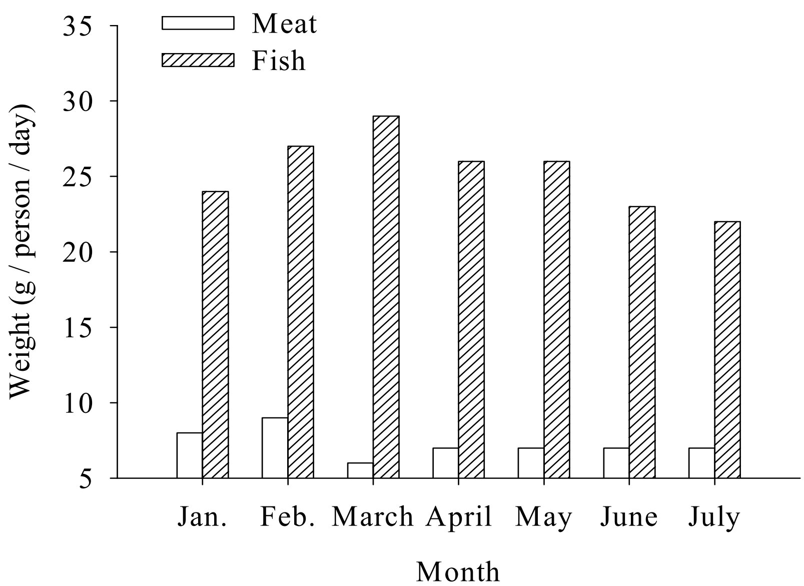


Figure 5.26: A comparison of average daily weights of fish and meats consumed within each month per person in fishing communities in two states in Nigeria.

5.3.3.4 Forms of meats used for cooking

Meats (83%) consumed during the study were mostly cooked in the fresh form (Figure 5.27). They were occasionally cooked in the dried or roasted form.

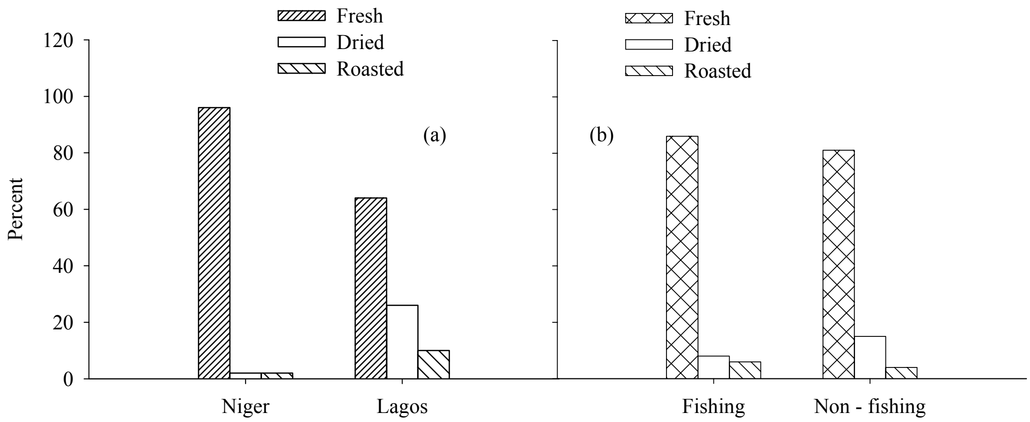


Figure 5.27: Forms of meats used for cooking in fishing communities in (a) Niger and Lagos states, and (b) fishing and non-fishing households. Data are expressed as percentages of frequencies. Fishing refers to fishing households and non–fishing to non–fishing households.

A comparison of forms of fish and meats used for cooking in fishing communities in two states in Nigeria is given in Figure 5.28. Higher percentage of fish (95%) and meats (83%) consumed during the study were cooked in the fresh form. Smoked, frozen, dried and roasted fish and meats were only cooked occasionally.

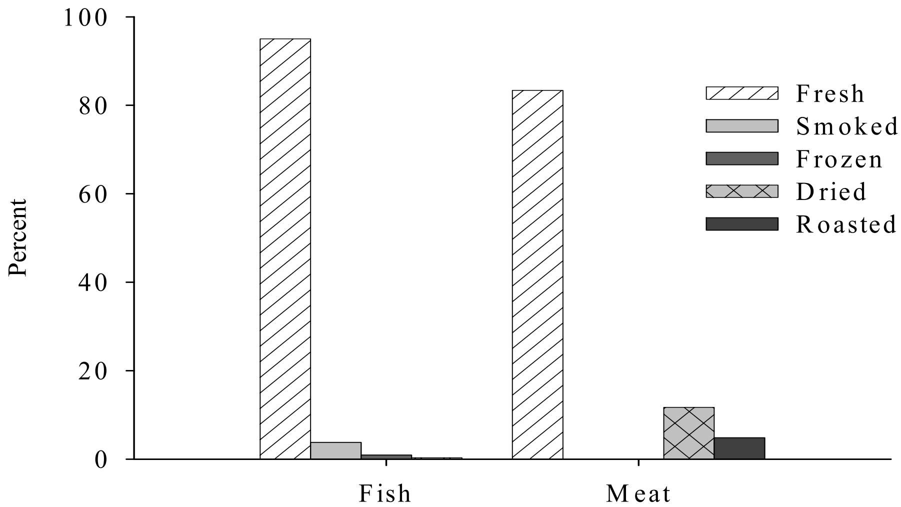


Figure 5.28: A comparison of forms of fish and meats used for cooking in fishing communities in two states in Nigeria. Data are expressed as percentages of frequencies. Data not shown are too small to appear on the scale.

5.3.3.5 Sources of meats

Markets were the main sources of meat for households in Niger (97%) as well as Lagos state (87%) (Figure 5.29a). Markets were also the main sources of meat in fishing (96%) and non–fishing (90%) households in the two states (Figure 5.29b). Meats were occasionally obtained from bush through hunting and at times owned animals were slaughtered for consumption.

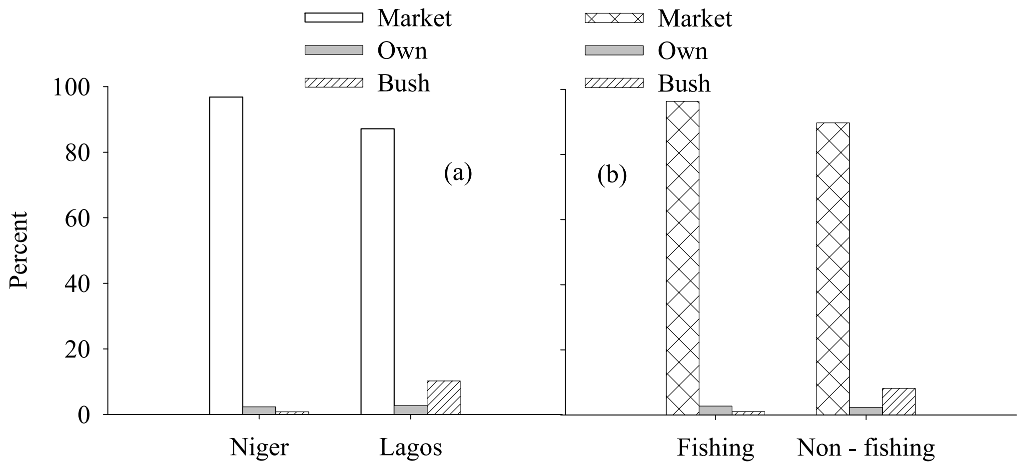


Figure 5.29: Sources of meats in fishing communities in (a) Niger and Lagos states, and (b) fishing and non-fishing households. Data are expressed as percentages of frequencies. Fishing refers to fishing households and non–fishing to non–fishing households.

A comparison of sources of fish and meats in fishing communities in the study area is given in Figure 5.30. River was the major source of fish consumed (61%) in all the households followed by lagoon (18%), market (14%), creek (5%) and sea (2%) whereas markets (93%) were the major sources of meat. About 5% of meats eaten were bush meats. Some households had animals (2%) that were occasionally slaughtered and eaten especially during festivals.

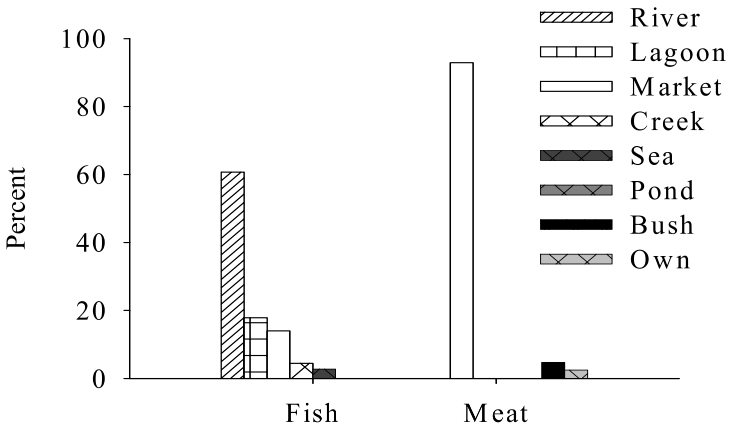


Figure 5.30: A comparison of sources of fish and meats in fishing communities in two states in Nigeria. Data are expressed as percentages of frequencies. Data not shown are too small to appear on the scale.

5.3.3.6 Monthly amount spent on meats

Average amount spent on meats per household per day in Niger and Lagos state were N 27 and N 21, respectively[17]. In Niger state, higher amount (N 37) spent on meats per household per day was recorded in February whilst in Lagos state highest amount (N 25) was spent in April (Figure 5.31a). An average of N 24 was spent on meats per day in fishing and non–fishing households in the two states. Fishing households spent higher amount (N 29) on meats in April whilst in non–fishing households highest amount (N 28) was spent in February (Figure 5.31b).

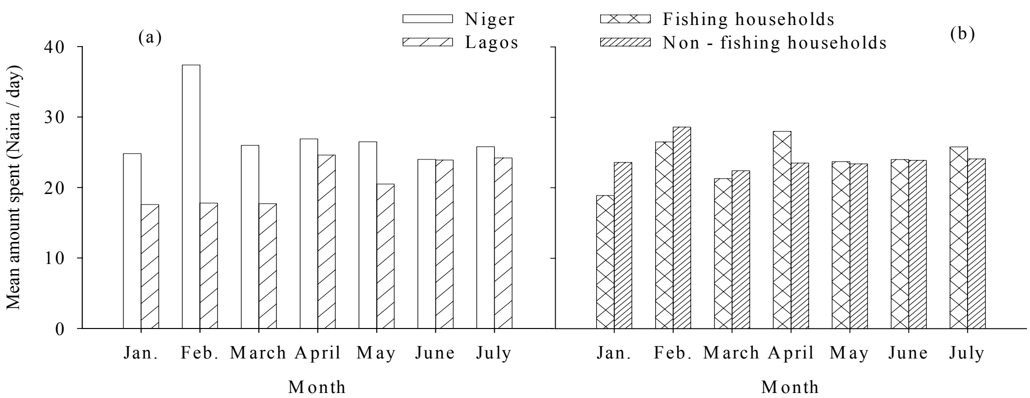


Figure 5.31: Average daily amount spent within each month on meats per household in fishing communities in (a) Niger and Lagos states and (b) fishing and non-fishing households.

[17] Nigerian currency is Naira (N). 1 US$ = N 128 in 2003

There were significant ($p < 0.001$) differences in the overall monthly amount spent on meat in fishing and non–fishing households in fishing communities in Niger and Lagos states. The average daily amount spent on meat in February and March in fishing households in Niger state was significantly ($p < 0.001$) higher than those of fishing and non-fishing households in Lagos state. The average daily amount spent on meat in May in fishing households in Lagos state was significantly ($p < 0.001$) lower than those of fishing households in Niger state. In Lagos state, the average daily amount spent on meat in July in fishing households was significantly ($p < 0.001$) higher than those of non-fishing households. The significant differences are given in Figure 5.32.

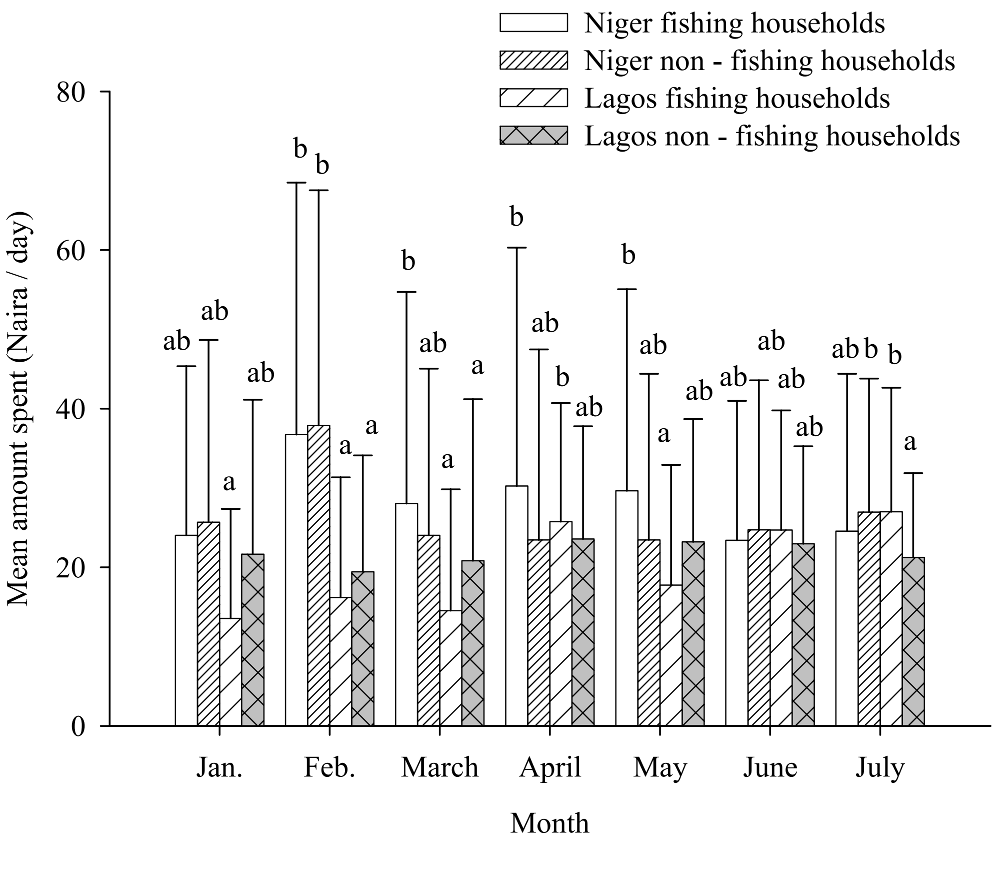


Figure 5.32: Average daily amount spent within each month on meats in fishing and non-fishing households in Niger and Lagos states. Data are presented with the average values ±standard deviations. Values that are not significantly different ($p > 0.05$) share common superscript.

Average daily amount spent within each month on fish and meats in fishing communities in two states in Nigeria is given in Figure 5.33. Highest amount of money (N 8) per household per day was spent on fish in January while February was the month of highest expenditure (N 28) on meat[18] per household per day.

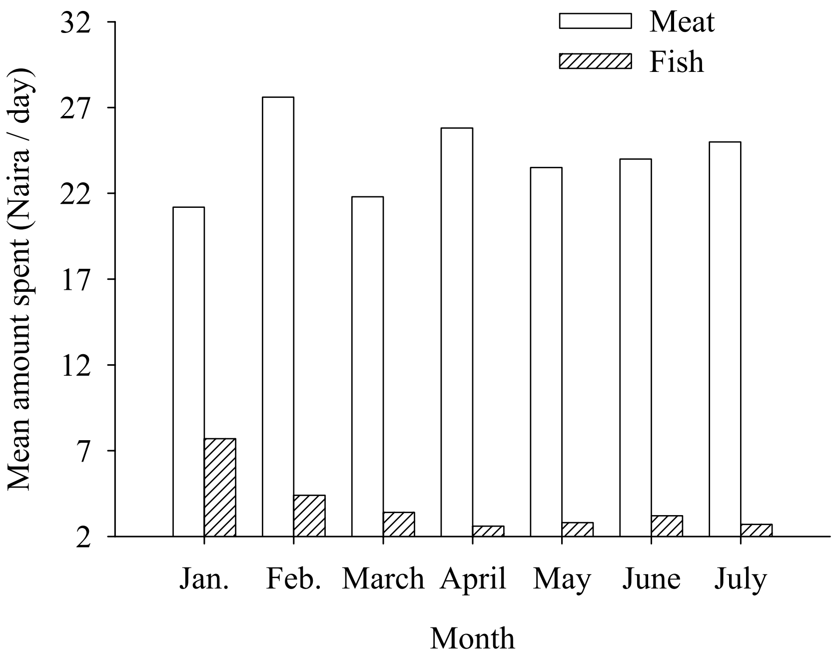


Figure 5.33: Average daily amount spent within each month on fish and meats per household in fishing communities in two states in Nigeria.

5.3.3.7 Prices of meats in two states in Nigeria

Prices of fresh meats were higher in Lagos than Niger state (Table 5.3). Chicken had the highest average price (N 765) in two states in Nigeria followed by lamb (N 570), goat meat (N 507) and beef (N 462).

Table 5.3: Average prices of fresh meats in Niger and Lagos states (N / kg)

State	Beef	Goat meat	Lamb	Chicken
Niger	415 ±21	460 ±14	515 ±21	710 ±14
Lagos	510 ±14	555 ±7	625 ±35	820 ±28
Average total	462 ±57	507 ±56	570 ±68	765 ±66

[18] Nigerian currency is Naira (N). 1 US$ = N 128 in 2003

Data is presented as mean ±Standard deviation. Nigerian currency is Naira (N). (1US$ = N128 in 2003).

5.3.4 Discussion

5.3.4.1 Consumption of fish species and meats

A large number of fish species were consumed in the fishing communities in two states in Nigeria. In total, 25 different species were recorded during the fish consumption survey in Niger and 22 in Lagos state. All the fish consumed in the inland region were fresh water species while those consumed in the coastal areas included both fresh and brackish water species. Freshwater species were also consumed in the coastal areas because the study areas included two local government areas (Epe and Ibeju / lekki) that had freshwater lagoon as their main source of fish. Most of the fish consumed were small species because they do not have high market value resulting in fishing households consuming these species rather than selling them and poor non–fishing households being able to purchase these species.

Tilapia was the most important species consumed in both states accounting for 19 and 32% of total consumption by weight in Niger and Lagos state, respectively. Tilapia species consumed in Lagos were both fresh and brackish water species. All tilapia species have one local name and so was difficult to identify the different types of tilapia species consumed. These results coincide with the abundance of tilapia in natural waters as reported by Ita (1993). According to the author, commercial catch statistics in river Niger, Nigeria showed numerical predominance of tilapia (26%) followed by *Synodontis* (25%). In terms of weight, tilapia also dominated the catch making up 20% followed by *Synodontis* (15%) and *Citharinus* (11%).

High consumption of tilapia species could also be due to preference. The findings of Dreschl *et al* (1995) showed that tilapia was highly preferred in fishing communities in Nigeria. High consumption of tilapia could also be as a result of low price (Figure 5.20) resulting in fishing households consuming these species rather than selling them and non–fishing households being able to purchase the species. In this study, fresh tilapia was 52% cheaper than *Gymnarchus niloticus* in Niger and 64% cheaper than Barracuda in Lagos state.

Beef was the meat that was consumed with high frequency followed by goat meat (Figure 5.21). These findings agree with those of Ladele *et al* (1996). Their study found that beef was the most consumed meat in Nigeria as a result of availability followed by goat meat. High frequency consumption of beef could also be due to low price. In the current study, beef was 10% cheaper than goat meat. Grass cutter was the bush meat that was consumed with high frequency. In a study of roadside bush meat markets in Edo state, Nigeria, Martin (1978) found that grass cutter and small antelopes were most commonly sold.

5.3.4.2 Household consumption patterns of fish and meats

There is a growing demand for fish as a source of protein in Nigeria. This increase is attributed to factors such as increasing population and increasing cost of meat and other livestock products (Mabawonku and Ogunyemi, 1989).

In the present study, highest weights of fish (103 kg) and meat (23 kg) per household per year were consumed in fishing households in Niger state (Table 5.4), while fishing and non-fishing households in Lagos state consumed the lowest weights of meat (12 kg / yr) and fish (26 kg / yr), respectively. Fish consumption was higher in fishing households in Niger state because fishing was their main occupation resulting in them not having to buy fish to eat. Low consumption of fish in Lagos state could be as a result of fishing households selling more of their fish catches for income as there is ready market in Lagos and prices are higher. Non–fishing households in Lagos state could also have found it difficult to buy fish because of high price, thus contributing to low fish consumption.

Table 5.4: Average weights of fish and meat consumed per household per year in fishing communities in Niger and Lagos states

State	Weight (kg / yr)			
	Fish		Meat	
	Fishing	Non-fishing	Fishing	Non-fishing
Niger	103	55	23	21
Lagos	64	26	12	16
Average of two states	84	41	18	19

Data based on households' fish and meat consumption survey

Household consumption of fish varied during the year. Consumption of fish was highest in March in fishing communities in two states in Nigeria (Figure 5.24). The seasonal variation in fish consumption followed the availability of wild fish from floodplains, rivers and lagoons. Higher consumption in March coincides with the period of maximal availability of fish. In Nigeria, fish landings peak from March to May at the end of harmattan[19] season. This is also the period of high income for most fishermen (Dreschl *et al*, 1995). According to these authors, the low income months for fishermen are the months of low fish catches during the harmattan season, from October to February and highlight the importance of fish to their livelihoods.

Consumption patterns of fish also appear to be related to time management of labour of household heads with respect to rains. Low consumption of fish in June and July coincides with rainy season. During this period, fishermen also work on

[19] A dry, cool wind blowing south–west and west off the Sahara into the Gulf of Guinea from December to February

their farmlands devoting more time to farming activities leading to a reduction in fishing activities. Low consumption of fish during this period may also be attributed to bulk sales of fish catches to generate income to procure seeds for their farms and to also hire labourers to assist in farming activities. Although, January and February are periods of low fish catches, fishermen are actively involved in fishing during this period as they do not work on their farms. The average daily weight of fish consumed in fishing communities in the study area was 24 g per person (9 kg per year) which is similar to 10 kg per caput fish consumption reported for the whole of Nigeria in 2003 (Nzeka, 2003).

In the current study, fish consumption was found to increase with family size ($r = 0.345$, $P < 0.001$) but there was no significant relationship between fish consumption and income ($r = -0.025$, $P = 0.801$). Adeniyi (1987) also reported a positive relationship between household size and fish consumption in Nigeria. Jolly and Clonts (1993), however, reported that as income increases, the relative preference for fish declines and that for red meat increases. The authors noted that the households in lower socio–economic strata spend more of their income on fish than on meat.

Meat consumption was higher in Niger than Lagos state (Figure 5.22a). Low consumption of meat in Lagos could be due to high price resulting in them not been able to buy meat. Beef, the most commonly eaten meat was 23% more expensive in Lagos than Niger state. Meat consumption varied during the year (Figure 5.24). Highest meat consumption was recorded in February. Higher consumption during this period could be due to Muslims' festival of 'Idl Kabir' which in 2003 took place in February. During the festival, Muslims slaughter rams as a sacrifice. About 77% of the heads of households in the study area were Muslims. Average weight of meat consumed per person per day in the study area was 7 g (3 kg per year). Meat consumption per person per year in this study is lower than the per caput meat consumption of 9 kg reported for the whole of Nigeria in 2002 (FAO, 2002).

The contribution of fish to animal protein intake was very marked. In fishing communities fish contributed 77% of the dietary animal protein intake by weight compared with only 23% for meats. Dreschl *et al* (1995) also reported low meat intake in fishing communities around Kainji Lake, Nigeria. They also found that fish was preferred by 95% of fishing households and 84% for non–fishing households. Essuman (1992) reported that fish consumption is particularly high among subsistence groups and others with low purchasing power. The author noted that in southern regions of Ghana, meat, eggs and chicken are generally considered as prestigious foods and are consumed mostly on festive occasions or are used to prepare food for important guests. The nutritional security (i.e. effective food demand and consumption at the household level) is influenced by economic factors such as prices and household income, by food habits and effective utilisation of consumed food by the human body which is significantly influenced by the health status and vice visa (UNICEF, 1990).

Fish contains high quality protein comparable with that of beef (Table 5.5). Protein content of fish ranges from 6 - 28% (Stansby, 1962). Crude protein of tilapia, the most commonly eaten fish appears to be between 7 and 16% (Tan, 1971; Watanabe and Dzekedzeke, 1971; Bell and Canterbury, 1976). *Clarias* species contain between 17 and 19.7% crude protein (Ayinla, 1993; Lilabati *et al*, 1993). Stansby (1962) considered protein content of fish to be high if it is between 15 and 20%. It would therefore, appear that tilapia has lower nutritive value but of the fish listed by Watanabe and Dzekedzeke (1971) for consumer preference in Zambia, tilapia scored the highest. This is generally true for the whole of Africa (Balarin, 1979), thus suggesting that although the nutritive value may be low, tilapia species are highly palatable and economically attractive.

Table 5.5: Principal constituents of fish and beef muscle

Constituent (%)	Fish (fillet) Average	Fish (fillet) Range	Beef (isolated muscle)
Protein	19	6-28	20
Lipid	5	0.2-64	3
Ash	1.2	0.4-1.5	1
Moisture	74.8	28-90	75

Sources: Stansby, 1962; Huss, 1995

Of consideration is the mineral content which Badawi (1972) estimated and found *Sarotherodon niloticus, S. galilaeus, S. aureus* and *T. zilli* to be among thirty species of low sodium content, suitable for diets during medical treatment of inadequate protein digestion and congestive heart failure. Importance of low sodium diets to dieticians in hospitals has also been stressed by Stansby (1962). Tilapias contain higher concentration of fat in the edible muscles than in the gut and also fair amounts of minerals such as calcium, potassium and phosphorus (Tan, 1971) which are important for child development. Beef, the most commonly eaten meat is also an excellent source of iron, copper, zinc and manganese, and play an important role in the prevention of zinc deficiency, and particularly of iron deficiency which is widespread (Bender, 1992).

About 95% of the fish eaten during the study were cooked in the fresh form. Only 4% of smoked fish were cooked and 1% for dried fish (Figure 5.28). This supports the findings of Adeniyi (1987). His findings revealed high preference for fresh fish in Nigeria particularly for tilapia and *Clarias* species. Members of the households were of the view that fresh fish is more delicious than smoked, dried or frozen fish. Consumption of fresh fish is important as sun drying has been found to destroy vitamin A content in small fish such as *Amblypharyngodon mola* (Roos, 2001). Stansby (1962) reported that frozen fish fillets or steaks that had been brine dipped before frozen contained high salt and may not be suitable for dieticians in hospitals requiring low sodium diets. There is also a gradual reduction in the B-vitamin content of fish during ice storage. During storage of chilled fish, the melting ice also removes some amino acids and water-soluble proteins (Bramsnaes, 1962; Bramstedt, 1962). Bramsnaes (1962), however, stated that vitamin A content in fish is stable during freezing and storage provided oxidation of the fats is prevented.

Smoking has also been found to cause slight reduction of protein and lipid contents in fish (Colowick and Kaplan, 1969; Lilabati *et al*, 1993). Cutting (1962), however, reported that processing loss due to sun drying, salting and smoking usually has relatively little effect on overall nutritive value including protein composition and digestibility. Lack of storage facilities like refrigerators led to some households to buy smoked fish for consumption. About 83% of meats eaten during the study were cooked in the fresh form. Only 12% dried and 5% roasted meats were cooked.

Roos (2001) reported that market was the most important source of fish for fish producing and non-fish producing households in rural Bangladesh. In the present study, traditional aquaculture systems and capture fisheries were the main sources of fish for fishing and non-fishing households contributing about 85% by weight to fish consumed. Market contributed 14.9% by weight while pond contributed 0.1% by weight to fish consumed. Low consumption of fish from ponds could be attributed to low supplies from this source. High consumption of fish from traditional aquaculture systems and capture fisheries confirms the importance of traditional systems to livelihoods of the people since these systems are often carried out in rivers and lagoons and require low capital investment. Jolly and Clonts (1993) also reported that the majority of fish consumed comes from such systems.

Market was the most important source of meat contributing 93% both by weight and frequency to meat consumed. Meats were occasionally obtained from bush through hunting (5%) and at times owned animals were slaughtered for consumption (2%). This agrees with the findings of Dreschl *et al* (1995). Their study revealed that most of the animals owned by fishermen and non-fishermen in the fishing communities in Nigeria are reared for capital and income reasons and only small percentage is used for own consumption.

5.3.4.3 Intra household fish consumption and distribution

In the current study, fish consumption by members of fishing households was almost twice that of non-fishing households (Table 5.6).

Table 5.6: Average weights of fish consumed by members of households in fishing communities in Niger and Lagos states

State	Fish consumption (kg / person / yr)					
	Head of household		Wife		Child	
	Fishing HH	Non-fishing HH	Fishing HH	Non-fishing HH	Fishing HH	Non-fishing HH
Niger	33	20	16	9	8	4
Lagos	31	12	14	6	5	2
Average of two states	32	16	15	8	7	3

Data based on the intra household fish consumption survey. HH = Households

In Niger state, heads of fishing households consumed highest quantity of fish (33 kg) per person per year than other members of households in Niger as well as Lagos state. Lowest weight of fish (2 kg) per person per year was consumed by children in non-fishing households in Lagos state. In this study, head of household consumed higher amount of fish (59%) than wife (29%) and child (12%), although there may be no significant difference in the fish consumption per body weight of members of households considering the fact that heads of households and wives may have higher body weights than children. Even though the absolute weight of fish consumed by wife was 2.4 times that consumed by child, when body weight was taken into consideration, the mean consumption of fish was the same (Table 5.7).

Table 5.7: Estimated average weights of fish consumed per body weight by members of households in fishing communities in two states in Nigeria

	Members of households		
	Head of household	Wife	Child
Mean weight of fish consumed (kg / person / yr)	24	12	5
Body weight (kg)[20]	90	70	30
Unit weight of fish consumed (kg / body weight / yr)	0.27	0.17	0.17

The present findings compare with those of Roos (2001). The author found that in the intra household distribution of traditional fish dish 'torcarry', prepared with *Amblypharyngodon mola*, women and children ate smaller portions of the fish than the male head of household in rural Bangladesh. Essuman (1992) also noted that, in many homes in Ghana the distribution of fish from the family pot favours the father, as head of the household. According to the author, children always receive very little of the available animal products. Posadas (1986), however, reported that in Philippines, male and female members of households consumed similar quantities of fish. The study was, however, carried out in a city and not in rural areas as the current study. In rural Nigeria, male heads of households are seen as 'kings' and are always given the best and higher portion of any food than other members of the households.

In the present study, the overall average weight of fish consumption obtained by 24 hour recall method was 57 g per household per day compared with 170 g obtained

[20] Estimated body weights of members of households

by actual measurement of fish using simple scales, thus suggesting that recall method only accounted for one third of the actual consumption of fish. Previous studies (Zhai *et al*, 1996; Core, 2003) also found significant under reporting of food intake using 24 hour dietary recall method. Therefore, great care has to be taken in planning a nutritional programme based on the findings obtained by 24 hour recall method as a result of its drawback.

In fishing communities in two states in Nigeria, fish was often eaten whole. If a single fish is shared by members of the household, body of fish was often given to the head of household, tail to the wives and head of fish to the children (Figure 5.13). Small fish were eaten whole but chewed bones were discarded when big fish were eaten. Welcomme (2001) reported that small whole fish tend to contribute far more to dietary balance than do prepared portions of larger fish. This is so because small whole fish are rich source of minerals and vitamins such as calcium, zinc and vitamin A (Guha, 1962; Rao, 1962; Roos, 2001) that could help in body development especially in children. Most of the women interviewed noted that their husbands may be embarrassed if given the head or tail of fish. According to them, children eat mostly heads of fish because they are not as busy as their parents so they have time to spend on eating the head. This is important to children as head of fish is rich in vitamin A (Roos, 2001). In the present study, about 90% of the children were below the age of 16 years. Only one child was below two years and was regarded as non-fish eaten member of the household.

5.3.4.4 Prices of fish

Fish prices fluctuate considerably in response to quality, time and quantity of landings and supply of other foodstuffs (Essuman, 1992). The seasonal variation of fish prices in two states in Nigeria was pronounced. Fish price was 23% higher in

January than March (Figure 5.18). High price of fish in January could be due to low catches of fish probably due to harmattan[21]. There was also variation in price between fish species reflecting variable availability as well as preference of the fish species. *Gymnarchus niloticus* and Barracuda were highly priced in Niger and Lagos state, respectively. Low priced species were tilapia and *Synodontis* probably due to their availability (Figure 5.20). Prices of fish species were twice higher in Lagos than Niger state due to better markets.

Currently, the European Union supplies more than 70% of Nigeria's imported seafood demands while United State's share is only 1%. Nigeria's domestic fishing industry contributes marginally (13%) to markets and thus has a limited impact on prices (Nzeka, 2003a; 2004). According to the author, outlets are continually looking for low–cost, high–quality products. Nigeria's conventional retail food sector consists of large supermarkets, frozen food stores (convenience stores) and traditional (open air) markets. These sub–groupings usually account for 2%, 30% and 68%, respectively, of total retail food stores. However, for imported fish, 96% of the total fish is sold in the traditional markets, about 1% via supermarkets and 3% at the frozen food stores. Prices in the open markets are usually 20–30% lower because of minimal overhead costs than in convenient stores and supermarkets (Nzeka, 2004). In these markets, customers and vendors often negotiate prices on the spot. Frozen fish such as mackerel, herring, croaker and titus fish (*Scomber japonicum*) are the major species imported into Nigeria (Nzeka, 2003a).

The mean expenditure on fish per household per day in fishing communities in two states in Nigeria was N 4. This is because the bulk of the fish consumed came from

[21] A dry, cool wind blowing south–west and west off the Sahara into the Gulf of Guinea from December to February

traditional aquaculture systems and capture fisheries at no or low monetary cost and only small percentage were bought from market. In this study, the overall average weight of fish consumed per household was 62 kg / yr. Fishing communities in the two states would have spent N 8 866 per household per year[22] on fish had they bought all the fish they consumed. This approximates to 18% of the annual income of the heads of households in the two states (Table 5.1). Mean expenditure on fish was highest in January (N 8) instead of March (N 3); the month of highest fish consumption due to low availability of fish in January. In this study, fresh fish was 22% more expensive in January than March which is the period of maximal availability of fish in Nigeria.

During the period of low availability of fish from wild fishing communities spent more money on frozen fish. In the present study, highest mean expenditure (N 48) was on frozen fish. Titus fish (*Scomber japonicum*) and mackerel were the frozen fish mostly purchased by the households as a result of availability. A study in the United States by Cheng and Capps (1988) has shown that price, household income, household size, geographic region, urbanization, race and seasonality are the factors that explain the variation of expenditures on seafood commodities. Mean expenditure on meats was N 24 per household per day which is higher than that of fish. This is because market was the main source of meat.

[22] N 143 / kg. Nigerian currency is Naira (N). 1 US$ = N 128 in 2003

Chapter 6: General discussion and conclusion

6.1 Introduction

This study has examined the role of traditional aquaculture systems and fish in food security and livelihoods of fishing communities in two states in Nigeria. The research focused on productivity, sustainability and profitability of the aquaculture systems including social and economic conditions of farmers. The study also compared the relative importance of fish as a high quality protein source with meats in fishing communities in two states in Nigeria. The purpose of this chapter is to go back to original aims and hypotheses and consider what the study has shown and what are the development implications.

6.2 Aquaculture systems

6.2.1 Modern aquaculture

In the present study, modern aquaculture consisted of small fish ponds with average size ranging from 0.01 to 0.40 ha. Aquaculture is an important rural development option in the third world. It has been promoted as a major provider of animal protein and a potential source of employment (for poor farmers and displaced capture fishermen), as an instrument through which under exploited land and water resources can be utilised and, since its production can also be exported, as a potential foreign currency earner (Ben-Yami, 1992). However, the success of fish farming depends on production technology, inputs, management and markets.

Species are currently farmed in aquaculture in culture facilities as diverse as rice fields, static or running water ponds, cages and pens (Edwards, 1998). In the present study, integrated fish farming was not widely practised by farmers probably due to lack of awareness of the farming technology. Farmers could take advantage of this farming technology to get fish crop in addition to other crops like rice and poultry. Yaro (2001) reported that despite the great potentials of low land (fadama) for the development of rice–cum–fish culture, only 0.37 ha out of 495000 ha of available fadama is presently being cultured at experimental stage in Niger state. Fish culture in rice fields provides the means for the contemporaneous production of grain and animal protein on the same piece of land (Coche, 1967). It is an ideal method of economic land use. Reports have shown that pisciculture in rice fields contributes to rice grain yields in the range of 4.6 to 28.6% in countries like China, India, Indonesia, Philippines and Thailand. These increases can be explained in terms of the possible impacts of fish in control of pests and diseases and in nutrient supply. Fish as a biological control for weeds, insects, snails and certain diseases of rice, offer an attractive and safe alternative to chemical method of control (Cagauan, 1995). Integrated fish farming systems offer great prospects for the development of sustainable third–world agriculture with minimal adverse impact and can sustain farmer's income as well as nutritional needs.

Success of fish farming also depends on the availability of inputs such as seeds. As shown in chapter 3, majority of the farmers (90%) obtained their seeds from the hatcheries though the supply was inadequate especially in Lagos state. Agricultural Development Projects and Research institutions such as NIFFR and NIOMR supplied most of the farmers with tilapia and *clarias* fingerlings. Aquaculture in Nigeria will need a better and more widely distributed supply of fry if production is to develop. While this can be achieved in some areas by improving and upgrading existing facilities, there are important prospects for placing fry production into the hands of local farmers. In overall terms, successful hatchery production depends on matching up the biological and environmental requirements of the chosen fish species, the physical requirements of the hatchery facilities, and the technical requirements of the operating system in a way which is appropriate to the socio–cultural and economic situation (Haylor and Muir, 1998).

Stocking density is one of the factors that determines the growth and production of fish. In the present study, average fish stocking density was 5730 ha^{-1} (0.57 m^{-2}). The stocking rate was lower than the 3 fish m^{-2} recommended by extension agents of ADP (Ajana, 1995). Fish stocking has a limit and this limit depends upon the natural productivity of species and for each species, according to age and size of each individual fish (Huet, 1975). Under stocking can affect relative growth rates due to social dominance and competition for food and space, resulting in increased or big size variability at harvest, an attribute undesirable to most processors and wholesale buyers (Duarte *et al*, 1994). Similarly, overstocking creates water quality problems, poor feed conversion and higher mortality rates from disease, resulting in low yield of marketable fish. If overstocking is done, then dwarfing would result which would lead to waste of food (Huet, 1975).

Many fish species show an inverse relationship between growth rate and stocking density (Reftsie and Kittelsen 1976; Reftsie, 1977; Canario *et al*, 1998; Mahika, 2002), although the reverse has also been observed (Joergensen e*t al*, 1993). Huet (1975) and Rosario (1984) reported that the growth of fish will be slow at higher stocking density because the capacity of natural food to support the fish population will be limited. At such density, larger fish acquire more food resources than smaller fish and as a result smaller fish lose appetite (Jobling, 1985). In order to circumvent the disparity in growth between large and small fish Jobling (1985) suggests that fish be fed sufficiently at short intervals. However, fish will always feed to satisfy their nutritional requirements (Hepher, 1988) after which they will see falling food particles as fascinating playing objects (Mahika, 2002). Correct stocking density results in fish growth and production but wrong stocking density could limit the growth and survival of fish, hence low yield.

Productivity of fish ponds is closely related to management techniques such as liming, fertilisation and feeding. In the current study, liming was not widespread among farmers with fish ponds but fertilisation was done before stocking by applying fertilisers of both organic and inorganic origins even though the rate of application was below the international standard. Productivity from fish ponds could be increased through liming and fertilisation although the total cost of production per hectare is higher with fertilisation and supplementary feeding than without, the production cost per kg may be lower and the additional revenue generated may be higher than the additional cost involved. Fertilisation of water is a means of increasing the natural food for fish, which may be sufficient, and no supplementary feeding is required. Feed costs can markedly be reduced if advantage is taken of naturally available foods. Jensen (1987) reports that fish pond fertilisation can increase fish yields three to four times. Farmers could use organic manures like dung of cattle, sheep, pig, goat and poultry droppings to fertilise fish ponds. The disadvantage of using organic manures, however, lies in the fact that they are required in large quantities, thereby making the procurement, transport and application somewhat troublesome and costly though the manure itself is cheap.

Farmers were found to feed their fish with local feeds including fish trash, animal intestines, coco nut, cassava wastes, corn and rice bran. Fish meal and pelleted feeds were not widely used by farmers probably due to high cost. Given the high costs of feeds it is only wise to consider optimal utilisation of locally available food resources as effective means of reducing such costs.

The existence of markets for trading fish is important to stimulate fish supply and promote products from aquaculture as well as capture fisheries. A species has the potential for commercial development only if there is a ready market for it at affordable prices that also provide a reasonable profit and if the marketing infrastructures and channels are adequate for and efficient in handling increased production (Shang, 1990). If the marketing system is poorly developed for example due to infrastructure or unfavourable market regulations, fish production could be affected. Marketing infrastructure refers to the facilities and services of wholesale, retail, transportation, storage, ice plant, processing and packaging (Shang, 1990; Liao, 1994). In the current study, majority of the farmers (57%) had access to rural markets (Chapter 4) but most of these markets lacked stalls, good roads, water and electricity. A study in Los Rios province of Ecuador by Holguin (2005) has also shown that fish markets in most of the cantons lack stalls and retailers sell their fish in the streets completely exposed to sun, dusts and other pollutants. Alam (2001) also reported that conditions in urban and retail markets in Bangladesh are not satisfactory regarding stalls, parking, spacing, sanitation and drainage. Poor infrastructure, especially roads, may limit the distribution of cultured products. Poor transportation and marketing facilities decrease farm prices because they result in poor and over supply.

Government support is often necessary in the establishment of marketing infrastructure. An effective approach may be for government to increase investment in roads so that market can be enlarged and also to improve communications, especially by telephone, so that market information of cultured products can be widely and quickly disseminated. The use of telephone in communication between traders in Bangladesh has been reported by Coulter and Disney (1987) and this keeps wholesale prices in line throughout the country (FAO, 2001).

In the current study, landing prices of fish from modern aquaculture were higher than those from traditional aquaculture systems which means that people are prepared to pay more for fish from fish ponds than those from traditional aquaculture systems, suggesting that in the longer term, modern aquaculture might develop in Nigeria. Modern aquaculture products in Nigeria are usually purchased by middlemen and taken to big cities to serve hotels and restaurants patronised mostly by better off individuals while majority of those from traditional aquaculture systems are taken to open markets. In the present study, standard deviations were quite high perhaps due to wider variety in methods and skills suggesting that there is scope for efficient producers to emerge.

This study has shown that aquaculture is now carried out by a range of people, generally with better assets and education and that it is profitable and appears to be expanding, but there are large variations in performance suggesting an important need to improve and optimise this in local conditions.

6.2.2 Traditional aquaculture

The current study showed that fish shelters and fish fences are the traditional aquaculture systems that are widely practised in two states in Nigeria. Fish shelters in this study include fish parks, tube shelters (*ihos*) and pots (*ikokos*).

Fish parks consisted of branches or bushes that were stuck into muddy bottoms of lagoons, lakes or rivers. Fish parks are traditional means of aggregating and protecting aquatic resources that could also create improved habitats for naturally occurring fish (Townsley, 1998). As seen in chapter 4, there was no significant (p = 0.449) difference in yield of fish from fish parks and fish ponds. Studies (Welcomme, 1972; Welcomme and Kapetsky, 1981) have also shown that fish parks are extremely productive and their yields are comparable to modern intensive aquaculture operations. The high productivity is attributed to high nutrient loading resulting from the decomposition of the wood in the brush parks. The wood and branches in the brush parks act as growth substrates for periphyton and epiphytic algae and also attract insects providing natural food in sufficient quantities for the fish eliminating the need to feed them. The branches also offer shelter from predators and provide suitable places for breeding (Welcomme, 1972; ICLARM–GTZ, 1991; Van Dam *et al*, 2001).

The mechanism is understood to be such that when brush parks are first put in the water, bacteria and micro–algae as well as larger algae start growing on it. These house a large number of smaller animals and together attract smaller species of pelagic fishes that feed on them. The smaller fish in turn attract individuals of larger species feeding on the smaller ones. In the present study, local feeds were used to increase the power of attraction and yield of the brush parks.

The current study showed that fishermen prefer fishing in the vicinity of fish parks because they make more catches around the installations. Welcomme (1972) also reported that productivity of fish parks is supported by the tradition that yields from cast–nets, gill–nets, hook and lines are increased in the vicinity of the fish parks, whilst the catch of those set in the open waters remains demonstrably unchanged. Despite their small areas relative to the total areas of the water bodies in which they are installed, fish parks contribute significantly to the catch. Welcomme (1972) reported that brush and vegetation parks in the Oueme River together contributed about 33% of the total 6483 t annual catch while brush parks alone contributed 77% of the 5238 t catch of Lake Nokoue and Port Novo lagoon.

In the current study, mean yield of fish from fish parks ranged from 0.13 to 1.35 t ha^{-1} yr^{-1} which is lower than those obtained by Welcomme (1972), Solarin and Udolisa (1993). They obtained 1.26 to 12.6 t ha^{-1} and 0.75 to 4.35 t ha^{-1} in coastal lagoons of Benin Republic and Lagos, respectively. Lower yield in the present study may be due to lower unit density of branches used. Fish yield was found to increase with density of implantation of the brush parks. The correlation was significant ($r = 0.242$, $p < 0.001$).

Ihos consisted of hollow bamboo poles or PVC pipes. This is a special method for catching fish especially catfish by providing artificial hiding place. They are tube shelters that stop fish from getting out backwards. However, fry can enter them freely and leave again without difficulty thus making the method sustainable. Some *ihos* were baited with either cut pieces of fish or any local food to attract fish. *Ihos* have been used elsewhere in the world for catching eels and burbots by providing shelters for them (Von Brandt, 1984). High catch of pelagic fish has been reported in the vicinity of PVC pipes in India (Bergstrom, 1983). Clay pots (*Ikokos*) were provided with non–return valves through which the fish enters. Female catfish were kept in some pots in order to attract male fish of the same species thus improving catch. *Ihos* and clay pots are widely in use in Lagos state. The present study showed that these systems are profitable suggesting that they are capable of development.

Fish fences were constructed in order to aggregate fish. Some fish fences had kerosene lanterns hung close to catching chambers for showing the location of the fences and also to assist in attracting fish at night (Udolisa *et al*, 1994). Von Brandt

(1984) reported that artificial light helps to attract, concentrate and keep fish in one place till they are caught. The fish are guided into catching chambers where they are periodically scooped or collected with traps. Artificial light has been shown to aggregate animal life as a community of predators each feeding on another predator of a lower trophic order (Ben-Yami, 1976) and thus increasing the productivity of the water body as insects serve as natural food for fish. Fish on seeing an isolated single light source in the complete darkness of the sea at night, become optically disorientated and lose sense of direction (Verheijen, 1959). The reason is that only one eye is stimulated at a time, while the other is not, hence the irregular and erratic motions of fish in the illuminated area (Ben–Yami, 1976). Fish fences can contribute a large proportion of the total annual catch in some systems. In the Lubuk Lampam (Indonesia) guide fences accounted for about 50% of the fish caught in 1975 and on the African Barotse plain the 'maalelo' fishery produced about 25% (631 t) of the total fishery in 1969 (Welcomme, 1979). Fish fences are widely in use in the study areas. The present study showed that fish fences are profitable suggesting that they may be capable of development if suitable sites are available.

Traditional aquaculture systems are simple methods to improve fish production from natural water bodies. They are meant to aggregate and protect scattered schools of fish, rendering their capture easier and fishermen spend less time scouting for fish. Traditional aquaculture involves the application of local knowledge to improve the productivity of water bodies.

The current study has shown that traditional aquaculture systems (fish shelters and fish fences) are more diverse, more widely in use and more profitable but with higher cost of production per hectare in Lagos than Niger state perhaps due to more development, higher prices and more availability of open access water bodies in

Lagos being coastal state, suggesting that these systems have more potential to expand further in Lagos than Niger state.

As seen in chapter 4, the level of investment required to set and maintain traditional aquaculture systems (fish parks, *ihos*, *ikokos* and fish fences) is quite low compared to returns obtained from them. The practice is cost–effective because substrates used in their construction are relatively cheap. In this study, profitability of traditional aquaculture was closely related to decreased input costs when compared with modern aquaculture. Fish production from traditional aquaculture has been shown to create additional income to fishermen than modern aquaculture due to higher cost of production from fish ponds. In the current study, fish parks were successful production systems even when the opportunity cost of wood was taken into account in the cost-return model, suggesting that in the longer term, these systems might expand further in Nigeria as a result of their profitability. However, there are concerns about the long term sustainability of the systems as a result of competing use of wood, local deforestation and limited access to fishing especially in Niger state where access and rights are controlled by traditional authorities and those who own ox bow lakes. In the present study, mean income from fish per farmer (US$439) was comparable to national GDP per capita (US$430) in 2003.

6.3 Sustainability of traditional aquaculture systems

FAO (1995) defines sustainability as:

> the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agricultural, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non–degradable, technically appropriate, economically viable and socially acceptable.

Sustainability may be expressed in terms of three interrelated aspects (Figure 6.1): Production technology, social and economic aspects, and environmental aspects (AIT, 1994). An aquaculture farming system needs to be sufficiently productive to make it an attractive option to alternative or competing uses of resources, i.e. land, water, capital, labour and farm by–products (Edwards, 1998).

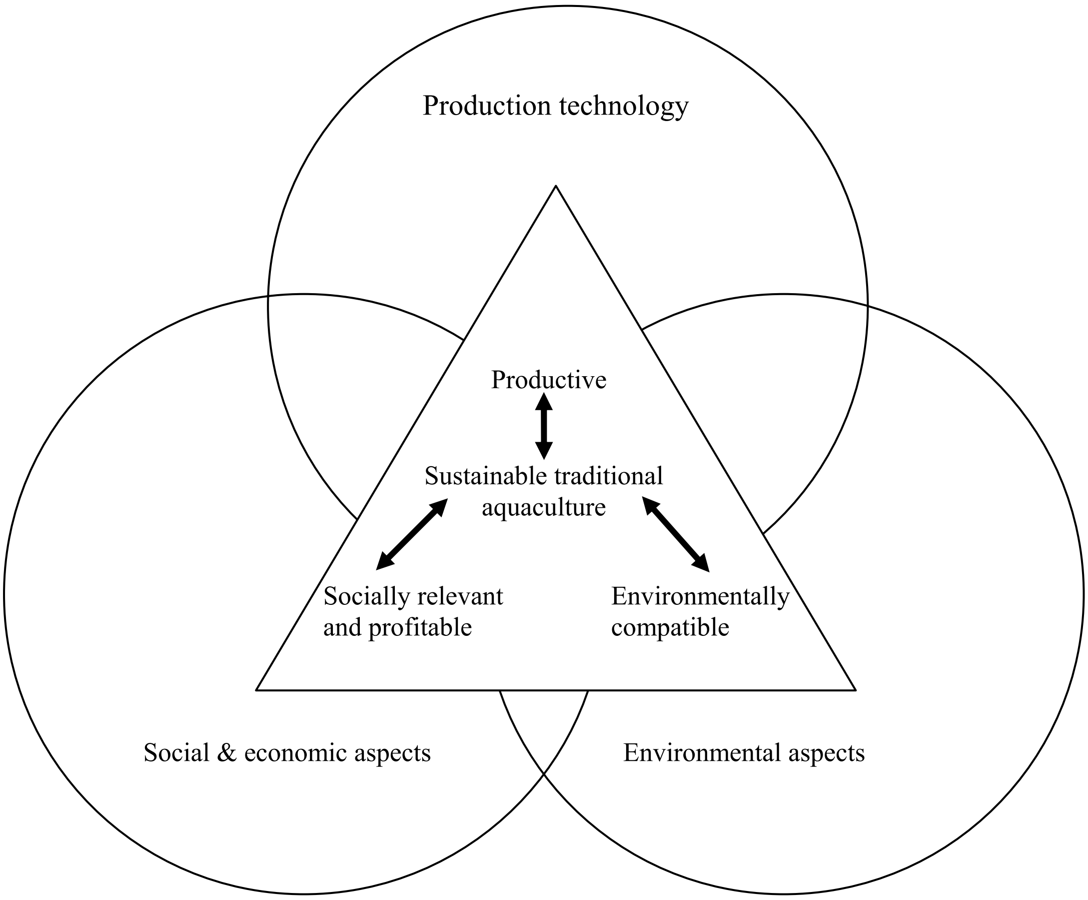


Figure 6.1: The three inter - related aspects of the sustainability of traditional aquaculture system (Adapted from AIT, 1994).

6.3.1 Production technology

Production technology may be subdivided into three main aspects: cultured species, culture facility and husbandry (Edwards, 1998). The choice of species influences the type of facility and together these determine the type of husbandry needed for the various stages of production. Species are currently farmed in aquaculture in culture facilities as diverse as rice fields, static or running water ponds, cages and pens; and breeding programmes to produce better strains of some species are increasing in number. Husbandry may involve various methods of stock management (monoculture or polyculture, stocking and harvesting strategies), use of different feeds, management of substrate and water quality, and disease prevention and therapy (Edwards, 1998).

In the present study, traditional aquaculture systems were carried out in lagoons, rivers and floodplains and fish were drawn from the wild. Various materials were used in the construction of traditional aquaculture systems including branches, grasses, worn out tyres, PVC pipes and clay pots. These materials provided shelters and aggregated fish in large numbers. Local feeds, kerosene lanterns and live female catfish were used to increase the power of attraction of the installations. In Niger state, the use of charms as a management technique to control poaching in brush parks and fish fences was common and effective because people believe in charms. Farmers were also found to set traps to capture reptiles that are destroying their nets.

6.3.2 Social and economic aspects

In general, social and economic aspects of aquaculture have received relatively little attention compared to production aspects and are major constraints to development through aquaculture (Ruddle, 1993). Traditional aquaculture systems are widely practised and socially accepted in Nigeria. Traditional aquaculture has contributed to the livelihoods of the fishermen through improved food supply, employment and income. However, the rural economy is characterised by inadequate social services and infrastructural development. Access of the fishing communities to vital services such as health and education is poor. Infrastructures such as roads and transportation are inadequate and electrification is slow resulting in poor rural standard and quality of life.

Social and economic factors influencing sustainable traditional aquaculture systems may be considered at macro–level and micro–level. Macro–level issues include world trade, national development goals, government policy and social characteristics such as cultural attitudes and input supply and marketing. Micro–levels are mainly alternative uses of resources. Traditional aquaculture generates work in the construction of the installations and in fish collection though production cost is generally low when compared to modern aquaculture. The materials used in the construction of traditional aquaculture are used in local households for other purposes as well, such as cooking. This means that traditional aquaculture must compete with other activities for resources. However, this is not a constraint since the increased production of fish more than compensates for the effort involved in finding alternative materials.

6.3.3 Environmental aspects

The environment is defined as being external to the aquaculture system and includes the natural resources used for aquaculture development such as land, water, nutrients and biological diversity. The internal environment of the aquaculture system is considered as part of the husbandry of the production technology (Edwards, 1998).

The current study showed that brush parks, *ihos* and fish fences can contribute to local deforestation and environmental degradation including siltation. Farmers also reported that the systems could cause problem to navigation. However, fish parks can contribute to overall production of water body in which they are found by increasing reproduction, fry survival, cover for adults and, when properly managed, overall recruitment to the fishery in general. Besides improving productivity and thus food availability, the presence of periphyton on branches has a positive effect on water quality and the health of the system and the animals in it (Manissery *et al*, 2001; Shankar and Mohan, 2001) and are thus sustainable on those grounds. However, the overall balance between resource use and impact needs to be more widely assessed.

Tube shelters (*ihos*) also conserve fishery by protecting fry. The use of kerosene lanterns in fish fences can also increase the productivity of the water body by attracting insects which serve as natural food for fish and the fact that traditional aquaculture produces less wastes means that the system is sustainable. However, there are concerns about the long-term sustainability of brush parks, *ihos* and fish fences as a result of local deforestation, multiple user conflict and competing uses of resources. In order to minimise deforestation and to increase the sustainability of the traditional aquaculture systems, fishermen proposed the planting of more trees, use of PVC pipes and worn out tyres in their constructions.

6.4 Fish and meat consumption

In this study, a large number of species were consumed in the fishing communities in two states in Nigeria confirming the relative abundance of the species in local rivers, floodplains and lagoons, and the importance of management of these systems. The consumption was concentrated on a few species with tilapia as the most important species. As shown in chapter 3, high consumption of tilapia was due to its perennial availability. High consumption of tilapia could also be due to preference (Dreschl *et al*, 1995) and low price as shown in chapter 5 resulting in fishing households consuming these species rather than selling them and non-fishing households being able to afford the purchase of these species.

Consumption of fish and meat varied during the year. Highest consumption of fish occurred in March corresponding to period of lowest meat consumption. Higher consumption in March coincides with the period of maximal availability of fish in Nigeria (Dresch *et al*, 1995). As shown in chapter 3, fish was preferred to meats confirming the findings of Abobarin (2003). The average daily weight of fish consumed in fishing communities in the study area was 24 g (9 kg per year) which is similar to the per caput fish consumption of 10 kg reported for the whole of Nigeria in 2003 (Abobarin, 2003; Nzeka, 2003). The contribution of fish to animal protein intake was very marked. In fishing communities fish contributed 77% of the dietary animal protein intake by weight compared with only 23% for meats and was eaten daily by fishermen (chapter 3). The fact that adequate fish at no monetary cost was available and accessible to fishermen confirms the importance of fish in the nutritional status and security of fishing communities in two states in Nigeria.

The nutritional status is the outcome of the food intake and the health status, which are determined by food availability, caring capacity, available health services and the environmental conditions to which the household is exposed (Figure 6.2).

In the framework, the linkage as well as the distinction between nutrition security and food security at the household level is emphasised. Food security is a constituent of nutrition security. A household can be said to be nutritionally secure if it is able to ensure a healthy life for all its members at all times.

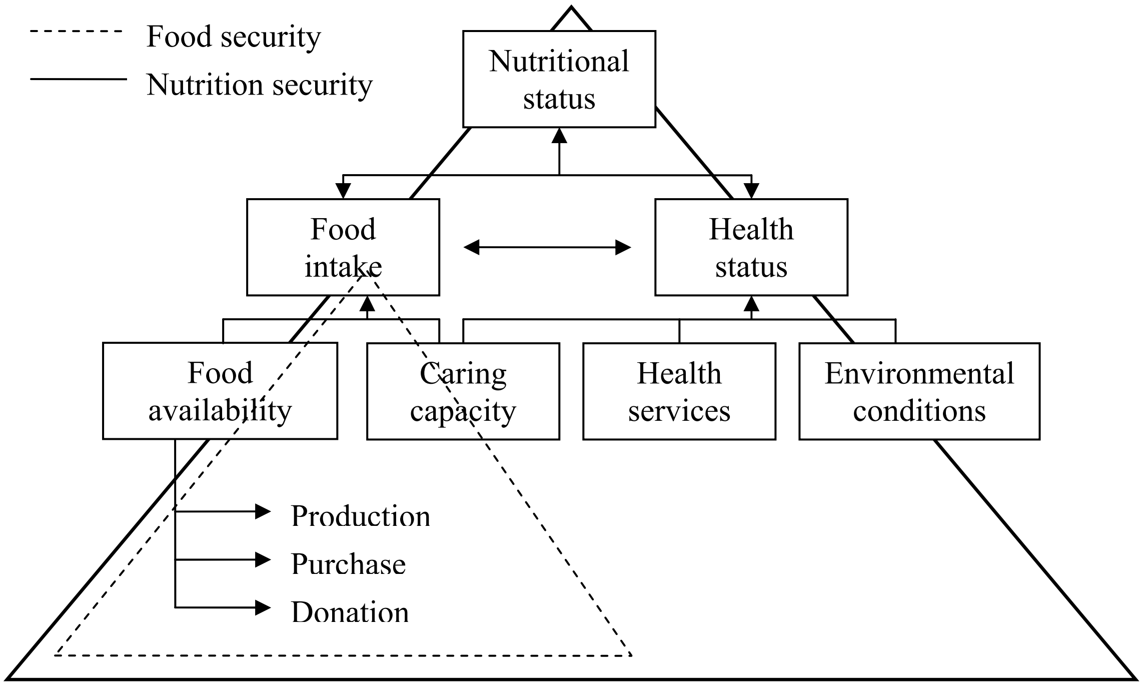


Figure 6.2: Conceptual framework of the nutritional status at household level
Gross *et al* (2000)

Nutritional security thus requires that household members have access not only to food, but also to other requirements for a healthy life, such as health care, a hygienic environment and knowledge of personal hygiene. Food security is a necessary but insufficient condition for ensuring nutrition security (IFAD, 1998).

Food security is achieved, if adequate food (quantity, quality, safety, socio–cultural acceptability) is available and accessible for and satisfactorily utilised by all individuals at all times to live a healthy and happy life (Gross *et al*, 2000). Conceptual framework of food and nutrition security is given in Figure 6.3.

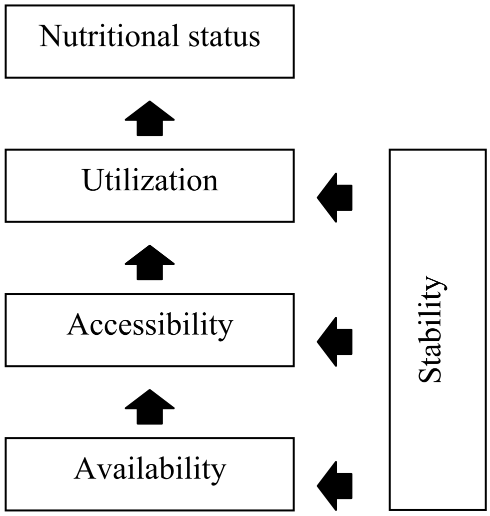


Figure 6.3: Elements of food and nutrition security
Gross *et al* (2000)

Two determinants influence the framework: a physical and a temporal determinant. The physical determinants include availability, accessibility and utilization. Availability is achieved when adequate food is obtainable by the people. Access is ensured when all households and all individuals within those households have sufficient resources to obtain appropriate foods (through production, purchase or donation) for a nutritious diet. Utilization refers to the ability of the human body to take food and translate it into either energy that is used to undertake daily activities or is stored. Utilization requires not only an adequate diet, but also a healthy physical environment, including safe drinking water and adequate sanitary facilities and an understanding of proper health care, food preparation and storage processes.

Stability or sustainability refers to temporal determinant of food and nutrition security and affects all three physical elements. It refers to temporality of food production and supply, for example repeated seasonal or annual shortage or the occurrence of unpredicted food crises. Fish production from traditional aquaculture systems and fish consumption in the present study are sub–components of food security. Traditional aquaculture systems and capture fisheries were the main sources of fish in the fishing communities contributing 85% by weight to fish consumed. Jolly and Clonts (1993) also reported that majority of fish consumed comes from such systems. High consumption of fish from traditional aquaculture systems and capture fisheries confirms the importance of these systems to livelihoods of fishing communities. The current study reveals high preference for fresh fish and meat. This supports the findings of Adeniyi (1987). As shown in chapter 3, high consumption of fresh fish was because it is more delicious.

Distribution of fish from the family pot has been shown to favour the male head of household (White, 1974; Hassan and Ahmad, 1984; Kent, 1987; Essuman, 1992; Roos, 2001). This was confirmed in the present study. In the current study, if a single fish is shared by members of the household, the body of the fish was always eaten by male heads of households, the tail by wives and the head by children. This is particularly important to children as greater concentrations of vitamin A can be obtained by eating the head of fish (Kent, 1987; Roos, 2001). In the present study, small fish were eaten whole but chewed bones were discarded when big fish were eaten. Small whole fish tend to contribute far more to dietary balance than do prepared portions of larger fish (Welcomme, 2001). This is particularly so as bones of fish are rich in calcium (Guha, 1962; Rao, 1962) that could help in body development especially in children.

Increased fish consumption by children may be beneficial in areas where lactose intolerance is common or where milk is expensive or in short supply (Kent, 1987). The author recommended the use of fish as a weaning food since small children are highly vulnerable to malnutrition. The appropriateness of fishery products for alleviating any sort of nutritional deficiency depends on particular local circumstances, taking into consideration issues such as acceptability, availability, and cost in relation to other sources of the required nutrients.

Fish is a good source of readily digested, high quality animal protein. It is high in lysine and sulphur amino acids which make it particularly suitable for complementing the high carbohydrate diets prevailing in many less developed countries (Kent, 1987). The author noted that, although it is most important as a source of protein, fish also has value as an energy source and provides preformed vitamin A and vitamin D if its oil is ingested. Most fatty marine fish and some freshwater fish such as Nile perch are high in healthy unsaturated acids, in particular omega–3 fatty acids. These are associated with health benefits including development of the nervous system and brain in children, development of bones, reduction of blood cholesterol and cardiovascular diseases, and also aiding against arthritis and asthma (Welcomme, 2001).

Apart from the specific nutrients it can provide, fish has a number of other distinctive qualities. Many find its taste and texture to be quite attractive and it is highly acceptable in many parts of the world, particularly in less developed countries. Fish is widely available and as flavouring it can help to make rice and other bland foods more palatable, thus facilitating the consumption of larger quantities. Fatty fish eaten with green leafy vegetables can facilitate the metabolization of vitamin A from the vegetables (Kent, 1987).

A report by the FAO's Committee on Agriculture acknowledges that "the poor usually cannot afford animal products in their diet" but then adds:

> However, a notable exception is constituted by fish products which have remarkable effects in improving the monotony of the diet, and in providing high protein supplements. This is particularly true for young children who often cannot derive sufficient protein from crop products

> even when their stomachs are full, because of the bulkiness of the product. Dried fish is to be found in parts of the world remote from water sources and where it is often available at a low price. It then becomes an important constituent of the diets of malnourished children (FAO, 1982).

Seasonal variation of fish prices was pronounced in the present study. Fish prices fluctuate considerably in response to quality, time, quantity of landings and supply of other food stuffs (Essuman, 1992). Fish price was lowest in March, most likely due to its maximal availability (Dreschl *et al*, 1995). There was also variation in price between fish species reflecting variable availability as well as preference of the fish species. *Gymnarchus niloticus* was highly priced in Niger state. Low priced species were tilapia and *Synodontis* due to their availability. Prices are the best indicator of incentives to both producers and consumers and have important implications for food security (Delgado *et al*, 2003). Higher prices indicate relative scarcity and lessen the ability of consumers to purchase the commodity, while lower prices represent increased availability to consumers. In the present study, average income from fish (N69 058) was higher in Lagos than Niger state (N43 220) perhaps due to higher average price of fish per kilogram in Lagos. High price of fish per kilogram in Lagos may have contributed to low average fish consumption as a result of fishing households selling more of their fish catches for income and non-fishing households not being able to purchase fish to eat because of the high price.

6.5 Sustainable livelihoods

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Carney, 1998). Scoones (1998) noted that five key indicators are important for assessing the achievement of sustainable livelihoods: 1) poverty reduction, 2) well–being and capabilities, 3) livelihood adaptation, 4) vulnerability and resilience and 5) natural resource base sustainability.

Sustainable livelihoods framework is given in Figure 6.4. The framework uses the concept of capital or livelihood assets as a central feature and considers how these are affected by the 'vulnerability context', and by 'transforming structures and processes', to constitute 'livelihoods strategies' which lead to various 'livelihoods outcomes'.

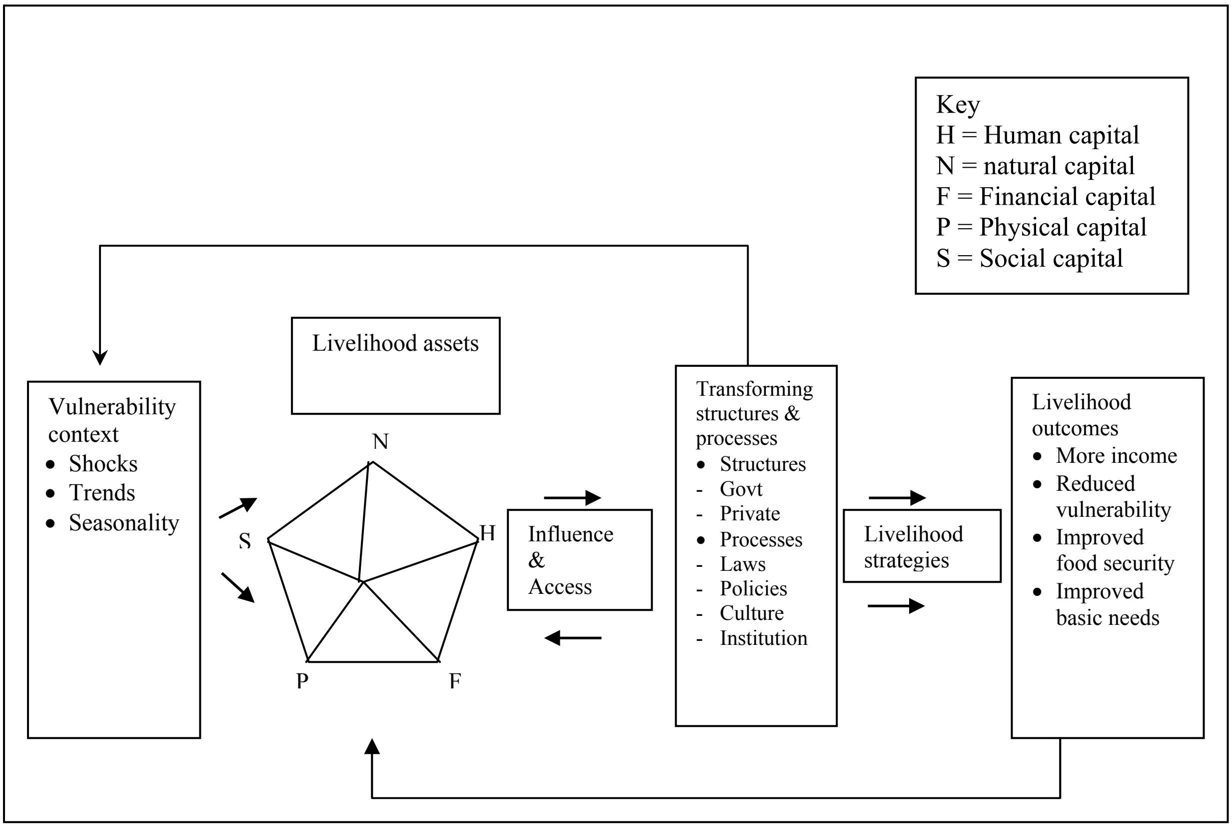


Figure 6.4: Sustainable livelihoods framework
Ashley and Carney (1999)

The framework shows how, in differing contexts, sustainable livelihoods are achieved through access to a range of livelihood assets which are combined in the pursuit of different livelihood strategies.

6.5.1 Traditional aquaculture and sustainable livelihoods

The key components of the sustainable rural livelihood framework are discussed below in relation to traditional aquaculture and other findings of the study.

Livelihood assets

At its heart lies an analysis of the five different types of assets upon which fishing communities in two states draw to build their livelihoods. These are:

- Natural capital: In this study, natural resources used in the production of fish from traditional aquaculture systems were water bodies such as lagoons, rivers and lakes, branches of trees and elephant grasses. The water bodies are open access but fishing rights are controlled by traditional authorities and individuals owning ox bow lakes in Niger state. Diversity of fish species exist in these water bodies upon which fishing communities depend for their protein and micro nutrient requirements. The water bodies are also sources of fingerlings for pond production. Branches of trees and elephant grasses are stuck into muddy bottom of lagoons, lakes or rivers to provide habitat, feeding and breeding grounds for fish. Cow dung and poultry droppings are used in fertilising fish ponds. Live female *Chrysichthys nigrodigitatus* are also kept inside pot shelters by some fishermen in order to lure males, thereby increasing production through enhanced natural spawning.
- Social capital: This refers to networks, membership of groups, relationships of trust, access to wider institutions of society upon which people draw in pursuit of livelihoods**.** In the present study, fishing communities organized themselves into self help associations such as fishermen or multipurpose co–

operative societies through which they get financial assistance, though they were not well organised and effective, resulting in resource conflicts. Although there were health institutions in most of the villages they commonly lacked drugs and qualified health personnel, resulting in fishing communities consulting traditional healers or resorting to Islamic and Christian preachers for solutions through prayers and charms at little or no monetary cost resulting in mutual support. In the present study, poaching was pronounced. However, traditional institutions played a significant role in controlling the poaching especially in Niger state. In Niger state, charms were also used in checking poaching and the method was effective because people believe in charms.

- Human capital: Human capital represents the skills, knowledge, ability to labour and good health important to the ability to pursue different livelihood strategies. In this study, fishermen used various materials in the construction of traditional aquaculture in order to attract fish, which means that they have local knowledge and skills necessary to improve fish production from water bodies. The substrates used in the construction of fish parks, tube shelters and fish fences can be produced within the local farming systems, with the fishermen using their own labour and resources. In the current study, the dependency of fishing communities on fish was high and while fish production has remained good this has had positive impact on their health. Average age of the fish producers was 55 years and average number of children was eight. The current study showed that majority of the farmers (96%) had no formal education and they may therefore be unable to benefit from available literature even if they are widely disseminated, and this may limit the development of aquaculture in Nigeria.

- Physical capital: Physical capital includes basic infrastructures like transport, shelter, water, energy and communications and production equipment which enable people to pursue their livelihoods. Very few of the fishing settlements in the coastal areas are accessible by roads. The only viable means of transportation include canoes and boats. The terrain (creeks and estuaries) are difficult to reach by research providers, extension agents and teachers, thus alienating the fishing villages from capacity building and identification of felt needs. Lack of good roads also makes transportation of fish to urban markets where prices are better difficult. Lack of good drinking water in fishing communities could result in water borne diseases. Lack of electrification affects processing of fish by refrigeration and also limits potential for media communications. Housing in most of the fishing communities is poor. The majority of the homes are temporary or semi–permanent structures – walls and roof of huts made of bamboo and thatch. Better off individuals in fishing communities prefer to build houses in cities for rent, thus resulting in gradual accumulation of wealth related to housing and private goods over time, particularly things which would enable better future livelihood. The vast majority of the fishermen live in poor conditions in remote and isolated areas. In terms of productive assests, this study showed that most of the fish ponds lacked outlet structures resulting in difficulties in draining water during harvest. Inlet structures were not properly screened resulting in predators entering the fish ponds.

- Financial capital: This refers to financial resources that people use to achieve their livelihoods whether savings, supplies of credit or regular remittances or pensions. In this study, most of the farmers had no access to formal sources of credit. Their main sources of investment capital were their own meagre savings but a few farmers (9%) obtained loans from government at an interest rate of 8% per annum and 4% obtained funds from co-operatives and NGOs both at interest rate of 10% per annum. Farm animals are occasionally used as sources of capital. This is quite limited and can hardly meet the financial requirement of fish production and improved technology.

Vulnerability context

Vulnerability context refers to shocks, trends and seasonality that affect the livelihoods of the fishermen.

- Shocks: In the current study, floods, storms, tides, net destruction by reptiles, multiple user conflicts and poaching were shocks that affected the fishing communities. Net destruction by reptiles increased financial burdens as fishermen had to buy new nets or mend them. Farmers were found to set traps for reptiles destroying their nets. Traditional authorities played significant role in controlling poaching and in conflict resolution especially in Niger state resulting in the reduction of the vulnerability.
- Trends: Trend such as increase in population presents a formidable challenge to food security and employment. In the coastal communities, population densities per habitable area are high as the wetland ecology of the region restricts habitation to relatively small area. This therefore translates to

higher pressure on the fisheries resources that are the bedrock of these coastal communities' livelihoods. Migration of youths to cities for employment outside fishing may affect the expansion of traditional aquaculture systems. Urban migration of youths may also encourage farmers to increase production both from modern and traditional aquaculture systems due to better demands for fishery products in the cities as a result of high population density. Increased incidence of sexually transmitted diseases such as gonorrhoea and HIV / AIDS may affect the productivity of the existing traditional aquaculture systems as infected people might not be able to continue with fish production. Sexually transmitted diseases could also lead to social disruption and more costs for health care resulting in increased financial burden.

- Seasonality: Fishing is highly seasonal. Catches may vary between dry and rainy seasons because of differences in fish behaviour. In flooding rivers seasonality in the fishery is much pronounced and is subject to a combination of temperature and hydrological conditions. Seasonality is linked to the flood cycle or to the behavioural characteristics of the fish (Welcomme, 2001) and affects the livelihoods of fishermen. In the present study, seasonal shifts in employment opportunities such as crop farming and petty trading were ways by which the fishing communities effectively minimized the vulnerability context (Chapter 4). The current study has also shown that fishers are vulnerable due to post–harvest losses as a result of poor processing methods and lack of refrigeration facilities resulting in them selling their catches at give – away prices.

Transforming structures and processes

Transforming structures and processes are the institutions, organisations, policies and legislation. The institutions and policies of the transforming structures and processes have profound influence on access to assets. Understanding institutional processes allows for the identification of barriers and opportunities to sustainable livelihoods.

Awareness of the problems of fishing communities and the need for proper management, control and sustainable exploitation of artisanal fisheries resources prompted the establishment of two fisheries research institutes in Nigeria in 1975, the National Institute for Freshwater Fisheries Research (NIFFR) and the Nigerian Institute for Oceanography and Marine Research (NIOMR). NIOMR in collaboration with African Regional Centre for Technology (ARCT) developed the Chorkor oven, an improved fish processing technology that has assisted in the reduction of post harvest losses. However, there is a low adoption rate of improved technologies because of inappropriate extension methods or because the introduced methods have incremental cost implications which the fisher–folk cannot afford.

Fisheries extension officers from NIOMR, NIFFR and Agricultural Development Authority (ADP) also address the problems of fish farmers especially in the areas of fish pond management (Ajana, 1995) and this may result in increased fish production. Extension agents also help in the enforcement of fisheries laws and regulations (NSFD, 1997) and this could improve the productivity of the water bodies. Farmers also sourced their fingerlings from these institutes including ADP. Traditional institutions also played a significant role in the management of traditional aquaculture systems especially in Niger state by controlling poaching.

Nevertheless, fishing communities are vulnerable due to changes in macro-economic policies such as removal of subsidy on fishing inputs (DFID-FAO, 2002). This results in higher cost of fishing inputs, and potential reduction in returns, and the ability to invest in improved production methods..

Livelihood strategies

Livelihood strategies refer to the range and combination of activities and choices that people make or undertake in order to achieve their livelihood goals. It is a dynamic process in which people combine various assets they can access, taking account of vulnerability context, supported or obstructed by policies, institutions and processes leading to livelihood outcomes. In fishing communities, livelihood strategies fully depend on natural resources. Fishermen are highly mobile in response to movement of the fish stock in lagoons, rivers and floodplains and are organised into co–operative societies. Different gears are employed by fishermen according to fishing season and both motorised and none motorised boats are used. For example, fish fences are constructed when floods are receding, thus preventing fish from returning to the river. The fish are then caught with other types of fishing gear such as gill nets, hooks, *gura* and *egun* traps. Cross-channel lift nets are commonly used as the flood begins to rise. They are removed during the highest water level but are operated again after the flood has fallen to about half-way mark (Reed *etal*, 1967). Motorised boats are used when fishing in deeper waters and non-motorised in shallow waters. Fishermen also engage in other non-fishing activities such as crop farming and petty trading. Youths in fishing communities also migrate to urban centres for employment opportunities outside fishing leaving behind other members of the families in the villages who may engage in other non-fishing activities such as crop farming and petty trading.

Livelihood outcomes

Positive livelihood outcomes can be thought of as the inverse of poverty. In spite of poor resources, livelihood outcome of fishermen is positive. Traditional aquaculture systems play significant roles in the livelihoods of fishing communities as seen from the net returns in this study even though a few farmers were not successful (chapter 4). In the present study, the contribution of fish to total animal protein intake was very marked and most of the fish consumed came from traditional aquaculture systems and capture fisheries suggesting that fishing communities mainly depend on fish for their protein requirement and highlights the need for sustainable management of these systems.

6.6 Conclusions and recommendations

6.6.1 Conclusions

This study sets out five main hypotheses. These were that:

1) Traditional aquaculture systems continue to be important in Nigeria, they are not uniform across the country, and in particular are likely to show differences across the environmental (coastal / inland), social and cultural contexts

2) Application of local knowledge can improve productivity from traditional aquaculture systems

3) Traditional aquaculture systems are potentially sustainable if appropriately managed and are competitive in terms of use of resources, and have the potential to play an important role in the livelihoods of fishing communities

4) Traditional aquaculture systems are economically viable

5) Fish supply associated with these systems play an important role in food security of fishing communities.

The types of traditional aquaculture systems varied between the states. The traditional aquaculture systems were more developed in the coastal region of Nigeria when compared with inland state such as Niger. The study also showed that farmers in the coastal and inland regions of Nigeria had different religious status, education level, family size and income as well as traditional authorities. Traditional authorities were stronger in Niger when compared with coastal state such as Lagos and played significant roles in conflict resolutions and access to fishing. Fish consumption patterns also differed between coastal and inland regions, with consumption being lower in the coastal state as a result of fishing households selling more of their catches for income and non-fishing households not been able to buy fish to eat due to higher prices in Lagos.

Application of local knowledge such as the use of substrates to construct traditional aquaculture systems improved the productivity of the water bodies. The study showed that fishermen prefer fishing in the vicinity of fish parks, tube shelters and fish fences because they make more catches around the installations, thus confirming that they can improve the productivity of water bodies.

The current study showed that traditional aquaculture systems are potentially sustainable although farmers acknowledged that brush parks, *ihos* and fish fences can contribute to local deforestation and environmental degradation including siltation. Farmers also reported that these systems could cause problem to navigation. In order to minimise deforestation and to increase the sustainability of the traditional aquaculture systems, fishermen used PVC pipes and worn out tyres in their constructions and proposed the planting of more trees. Nevertheless, fish parks can contribute to overall production of water body in which they are found by increasing reproduction, fry survival, cover for adults and, when properly managed, overall recruitment to the fishery in general and thus sustainable. Tube shelters (*ihos*) also conserve fishery by protecting fry. The use of kerosene lanterns in fish fences can also increase the productivity of the water body by attracting insects which serve as natural food for fish and the fact that traditional aquaculture produces less wastes means that the system is sustainable. However, there are concerns about the long-term sustainability of these systems as a result of local deforestation, multiple user conflict and competing uses of resources.

Cost–benefit analysis showed that traditional aquaculture systems are viable because of their high profitability and the low level of investment required to set and maintain them. The high profitability was closely related to the low cost of production when compared with modern aquaculture. The practice is cost–effective because substrates used in their construction are so far relatively cheap. Fish production from traditional aquaculture has been shown to provide more income to fishermen than modern aquaculture due to higher cost of production from fish ponds. Traditional aquaculture may be viable now but may not be able to grow substantially in scale or productivity, as it is limited by water area availability, and potentially by resource competition for substrates; modern aquaculture has considerable scope for growth but needs to be much more efficient.

Fish supply associated with traditional aquaculture systems play an important role in food security of fishing communities. The present study showed that traditional aquaculture systems and capture fisheries were the main sources of fish in the fishing communities contributing 85% by weight to fish consumed highlighting the importance of these systems to livelihoods of fishing communities. In this study, fish contributed 77% to total animal protein intake and was eaten daily by fishermen confirming its importance in the food security of fishing communities in two states in Nigeria.

6.6.2 Recommendations

Priority should be given to promoting and protecting the availability of fish stocks in rivers and lagoons as most of the fish consumed came from traditional fisheries. This could be done through improvements of fisheries in publicly accessible waters. Simple adaptations in the design of irrigation systems can also enhance their suitability for fish rearing. Local management systems should be used and developed as far as possible to promote collective responsibility and equitable access and benefit.

Production of low–cost fish for consumption by the poor should be encouraged. This could be done by supporting fisheries – small scale or large scale, capture or culture – whose production is likely to make a significant contribution to fish supplies used by the local poor. Support could be in the form of technical assistance, infrastructure development, extension services, or subsidies.

Traditional aquaculture systems should be encouraged since they are productive, sustainable and profitable. In order to increase their sustainability, worn out tyres, PVC pipes, drums and wooden boxes could be used in the construction of fish shelters. Hard wood that may last up to four to six years could be used instead of soft wood branches that are replaced annually in order to minimise deforestation. However, this should be done in conjunction with forestry and natural resources specialists to ensure that conservation aims can be met.

For public sector support, the extension component of Nigeria's Agricultural Development project (ADP) should recruit more fisheries oriented extension agents. The number of female extension agents should also be increased in order to reach women who are engaged in fish processing and marketing, especially in Niger state where Muslims are the majority. The extension agents should be provided with better incentive and relevant materials to ensure effective coverage at the grass root level.

Regular training of the present extension agents and fish farmers on fish farm management should be pursued. A critical issue is to get farmers to view fish farming more as integrated farming system. If farmers are encouraged to grow fish in combination with other agricultural crops, their income and local food supply has the potential to increase and their overall risk will decline. Farmers should also be encouraged to form self-help organisations like “Aiyejunikanse” in Lagos. Members contribute to the purse of the organisation and individual member’s needs are met from the purse (DFID-FAO, 2002). Government and other organisations should assist farmers with low–interest credit and fishing inputs at affordable price.

It is also necessary to provide women who are involved in fish processing and marketing with training on improved fish handling and processing technologies especially the chokor oven that has been proven to be efficient in fish smoking. Improving traditional technologies of smoking, salting and drying would help to reduce losses and increase the overall value created by aquaculture production. Opportunities could also be sought for women to participate in fishing activities and small scale aquaculture to provide more food for household consumption and income. Women should also be encouraged to form self-help organisations like “Egbe-elega” forum in Lagos state. The aim of this women’s group is self-help through savings mobilization and credit and price control (DFID-FAO, 2002). Furthermore, functional literacy, public health education and child education should be encouraged.

There is also the need for the promulgation and enforcement of the Inland Fisheries Laws and regulations by states and federal government, though some states including Niger and Lagos have promulgated their Fisheries edicts. Some aspects of the Niger state Fisheries Edict include prohibition of fishing: 1) without licence 2) during closed season 3) with gill net of less than 3 inches mesh size and 4) with explosives and poisons (NSDF, 1997). These laws, if properly enforced, could improve the productivity of water bodies and hence gainful employment for full –

time fishermen. Fishing communities should also be enlightened on banned fishing gears and responsible fisheries through radios and televisions. Fishing communities should also be encouraged to form viable associations or organizations such as Community Based Fisheries Management Committees (CBFMC) that would help in the management of fisheries. Involvement of the fisher-folk and community-based organizations in the management of fisheries is essential because legislation or policy decisions from top-down are not as effective as community action (DFID-FAO, 2002).

Traditional management of fisheries should also be encouraged especially in Niger state where traditional authority is stronger than in Lagos. The objectives of the traditional fisheries management include the control of fishing rights and reduction of conflict, generation of food and income, and conservation of fish stocks. The main method of management is the control of access, and the decision authorities are the leaders of the community and traditional government (Neiland and Ladu, 1997).

More broadly, there is the need to provide marketing infrastructure such as ice plants and cold rooms in Niger state to handle increased production of fish both from aquaculture and capture fisheries since there is no ready market for fish in the state. Warehouse could also be built in the state to store smoked fish. There is also the need to have good network of roads linking Lagos with fishing villages and other parts of the country so that fish traders can have easy access to ready market where fish fetches higher price per kilogram. Government should also provide the fish markets with good stalls, electricity, water and good drainage system. The area of policy that is also needed is to give information on markets to those harvesting fish, fishing communities and fishing companies. Good up to date information could be provided to fishing communities using mobile phone network or through radios on current prices of fish in Lagos so that fish farmers can harvest when market conditions are good.

Cage culture could be encouraged in Lagos since the state is endowed with enormous open access water bodies, in which sites could be allocated under appropriate management arrangements. There is urgent need to increase the availability of fingerlings through production in government and private hatcheries and low–cost feed in Lagos state in order to cope with the high demand. In the long term fisheries development and food security can be achieved through the following actions: 1) collecting and making use of reliable data on fish consumption patterns 2) developing production systems that make use of local fish species including small species 3) increasing accessibility of poor households to different species of culture 4) protecting women in fisheries; sharing training information on fisheries among men and women and 5) developing low-cost technologies for fish processing.

Further research

Further research is required on the role of fish in the diet of fishing and non–fishing villages in Nigeria taking into account the nutritional values of commonly consumed fish species, especially those consumed by children. Further research is also required on the sustainability of traditional aquaculture systems in Nigeria.

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Apendix

Questionnaire for fish farmers

Please write down or tick the appropriate answer.

Date of interview Time started Time ended

State of study

Local government area

Village

Section A: Socio-Demographic profile

1. Name of respondent
2. Age
3. Sex
4. Family size
5. No. of wives ….
6. No. of children
7. Religion

Islam	1
Christianity	2
Others (please specify)	3

Occupation

8. Main occupation
9. Secondary occupation
10. Educational attainment

Primary education (up to 6)	1
Junior secondary (up to J. S 111)	2
Secondary education (up to S. S 111)	3
Tertiary	4
Vocational	5
Others (Please specify)	6

Section B: Fish farming information

1. Type of aquaculture system

Earthen pond	1
Fish shelter	2
Fish fence	3
Others (Please specify)	4

Earthen pond

1. Pond area sq.m
2. Species cultured

Tilapia	1
Clarias	2
Common carp	3
Others (Please specify)	4

3. Do you culture more than one species at a time? **Yes = 1 No = 2**
4. If yes, what are the species combined?
5. How many numbers of fish do you stock in the pond?

6. How do you prepare your pond for stocking?
No pond preparation
Allowing the pond to dry
Applying chemicals (specify)
Others (Please specify)
7. How many times do you change water from your pond per crop?
8. What is your reason for changing the water?
9. Where do you drain the water to?
Irrigation farm 1
Others (Please specify) 2
10. Do you culture fish with other agricultural crops? **Yes = 1** **No = 2**
11. If yes, what type of crop?
Rice
Banana
Pigs
Poultry
Others (Please specify)
12. Yield of the crop (banana or rice) per harvest (kg)
13. Number of fish production cycle per year
14. Days per culture period
15. Source of seed**.** **Hatchery = 1** **Wild = 2**
16. Cost of fingerling ….(Naira / fingerling) Total cost of fingerlings…..Naira / crop
17. How many times do you buy the seeds in a year?
Fish shelter
1. Type of fish shelter
Acadjas(Brush park) 1
Clay pot shelter 2
Hollow bamboo poles shelter 3
Others (specify) 4
2. Why do you put these materials in the lagoon / river?
***Acadjas* (Brush parks) ------------------------------**
1. Materials used in the construction of Brush Park
Fresh grasses 1
Fronds of oil palm 2
Bamboo poles 3
Others (specify) 4
2. Size of Brush Park
3. Shape
4. How many times do you install and harvest *acadja* in a year?
5. Installation period before harvest
6 Number of branches per M^2
7. Do you put worn out tyres and pipes in the enclosure? **Yes = 1** **No = 2**
8. If yes, why?
9 Do you put net or fence the enclosure? **Yes = 1** **No = 2**
10. If yes, at what time?
During harvest only 1
The whole period of installation 2
11. Dominant species found in the brush park

Clay pot shelter (   )
1. Diameter of the mouth of the pot
2. Height of the pot
3. At what period of the year do you put the pots in water?
4. Installation period before harvest
5. Name of material used to cover mouth of pot
6. Distance between pots in water
7. Total number of pots per production cycle
8. How do you put the pots in water?

Horizontally	1
Vertically	2

9. Do you put gravid female in all the pots? **Yes = 1** **No = 2**
10. If no, do you put in some of the pots? **Yes =1** **No = 2** (Tick)
11. If yes, why?
12. Name of gravid female used
13. Dominant species caught

Hollow bamboo poles / PVC pipes (   )
1. Name of material used to cover one side of bamboo hole
2. Diameter of the pole / pipe
3. Length of the pole / pipe
4. At what period of the year do you put the pole / pipe in the lagoon?
5. Installation period before harvest
6. Distance between poles / pipes in water
7. How do you put the poles / pipes in water?

Horizontally	1
Vertically	2

8. Total number of poles / pipes per production cycle
9. Dominant species caught

Fish fence (   )
1. Name of the material used for fish fence
2. Why do construct fish fence?
3. At what period of the year do you construct fish fence?
4. Do you construct fish fence alone? **Yes = 1** **No = 2**
5. If no, what type of fishing gear do you combine with the fish fence?
6. Dominant species found in the fish fence enclosure
7. Period of installation of fish fence

General section
1. Environment of culture / installation

Fresh water	1
Marine water	2
Brackish water	3

2. Source of water

Rain fed	1
Ground water	2
River	3
Lagoon	4
Others (specify)	5

Ownership

1. Who owns the land / river / lagoon where the farm / installation is situated?

Owner	1
Joint ownership	2
Leased	3
Open access	4
Others (Please specify)	5

2. If owned, how did you acquire it?

Inheritance	1
Others(specify)	2

3. Cost of land or rent   Naira / ha / year

4. Duration of lease?

5. Number of years in fishing / fish farming?

6. Where did you learn about this type of fishing / farming practice?

Parents	1
Fisheries extension agents	2
Others(specify)	3

Liming

1. Do you apply lime?   **Yes = 1**   **No = 2**

2. If no, why?

Do not know lime	1
Lack of money to buy	2
Others (Please specify)	3

3. If yes, why?

4. What type of lime do you apply?

Agricultural lime	1
Quick lime	2
Slaked lime	3

5. At what periods do you apply the lime?

Before stocking	1
After stocking	2
Both	3

6. At what rate do you apply?   Kg / week (Quantity applied / ha / year   )

7. How much do you buy the lime per 50kg of bag?   (cost   Naira / ha / year)

8. Source of lime

Government	1
Market	2
Others (Please specify)	3

Fertilization

1. Do you apply fertilizer?   **Yes = 1**   **No = 2**

2. If yes, what type of fertilizer?

Organic manure	1
Inorganic fertilizer	2
Both	3

3. If organic manure, what type?

Cow dung	1
Poultry droppings	2
Sewage	3
Others (specify)	4

4. If inorganic fertilizer, what type?

NPK	1
Urea	2
Ammonium nitrate	3
Others (specify)	4

5. At what periods do you apply the fertilizer?

Before stocking	1
After stocking	2
Both	3

6. At what rate do you apply inorganic fertilizer? Kg/week (Quantity applied / ha / year)

7. Source of in organic fertilizer

Government	1
Market	2
Both	3
Others (Please specify)	4

8. How much do you buy inorganic fertilizer per 50kg of bag? (cost Naira / ha / year)

9. Why do you apply fertilizer?

Feeds

1. Do you feed your fish? **Yes = 1** **No = 2**

2. If yes, what type of feed?

Local feeds
Fish meal
Pelleted feed
All of the above

3. If local feeds, what type?
4. Where do you obtain the feed?
5. Why do you use local feeds?
6. How much do you spend on buying the feeds per year?
7. How many times do you feed your fish in a day?
8. At what periods of the day do you feed them?

Morning
Afternoon
Evening

9. Source of pelleted feed

Feed mills	1
Government	2
Others (Please specify)	3

Disease

1. Have you ever-experienced disease out break in your fish farm? **Yes = 1** **No = 2**

2. If yes, which type of disease?

Bacteria disease	1
Fungal disease	2
Viral disease	3
Others (Please specify)	4

3. How did you deal with the disease out break?
By draining the pond 1
By the use of chemicals (Please specify) 2
Others (Please specify) 3
4. was the method successful? **Yes = 1 No = 2**
5. Have you ever experienced poaching? **Yes = 1 No = 2**
6. If yes, what measures did you take to prevent occurrence?
Fencing the farm 1
Employing security 2
Others (Please specify) 3

7. If employing security, how much does it cost you per crop?

Harvest

1. How many times do you harvest your fish per crop/installation period?
2. Harvesting method
Total 1
Partial / selective 2
Both 3
3. How do you harvest the fish?
By draining the pond 1
By using fishing gear 2
Both 3
4. If draining, how do you drain the pond?
By using water pump 1
Through outlet 2

Gear

1. What type of gear do you use in harvesting fish?
Drag net 1
Cast net 2
Gill net 3
Others (Please specify) 4
2. Mesh size of the nets
3. Where do you obtain this equipment?
Make myself 1
Market 2
Government 3
Others (Specify) 4
4. Are you satisfied with the use of the gear in harvesting fish? **Yes = 1 No = 2**
5. If yes, why?
6. How much did you buy the fishing gear? (Depreciation Naira / year)

Post harvest

1. Disposition of total harvest?
Volume Consumed Kg
Volume sold Kg
Volume processed and preserved Kg
Give away Kg
Others (Please specify) Kg

2. How do you preserve your fish?
Salting
Sun drying
Roasting
Smoking
Others (Please specify)
3. How do you smoke your fish?

Traditional kiln	1
Others (specify)	2

4. Do you think these methods of preservation of fish could lead to post harvest loss?

Yes	1
No	2

5. If yes, why?
6. If no, why?

Production

1. How is your current level of production compared with that of last year?

Higher than last year	1
Lower than last year	2
About the same	3
No basis of comparison	4

2. What are the reasons for the change in production?
Lack of funds
Pests and disease infestation
Siltation
Theft / poaching
Others (specify)
3. Total production of fish per crop / day kg
4. Total cost of fish production
5. Price of fish Naira / kg (Total income from fish Naira / ha / year)
6. Are you satisfied with the earnings? **Yes = 1 No = 2**
7. If no, why?
8. Do you want to change to other occupation? **Yes = 1 No = 2**
9. If yes, what occupation?
10. Why?

Fish consumption

1. Do you eat fish daily? **Yes =1 No =2**
2. In what form do you prefer eating fish?

Fresh	1
Smoked	2
Dried	3

4. Why?
5. Which type of species do you eat most?
6. Why?

7. Of the following, which do you prefer most?

Goat meat	1
Chicken	2
Rabbit	3
Duck	4
Fish	5
Other (specify)	6

Marketing information

1. In what form do you sell your fish?
Fresh only
Dried only
Smoked only
Others

2. Where do you sell your fish?

Landing site	1
Market	2
Both	3

3. How much do you sell the following fish per kg at the landing site?
Fresh tilapia , clarias and chrysicthys

4. Mode of payment
Cash only
Credit only
Both

5. Type of buyer

Wholesaler	1
Retailer	2
Other (specify)	3

6. How do you transport your fish to the market?
7. Does your wife preserve and market fishery products? **Yes=1 No=2**
8. Would increase in price of fish make you produce more? **Yes=1 No=2**

Labour

1. Do labourers work for you? **Yes=1 No=2**
2. If yes, how many labourers per crop?
3. If no, go to 6
4. In what areas of the farming activity do they work for you?
Pond construction / installation
Stocking
Feeding
Harvesting
Others (Please specify)
5. How much do you spend on the labourers per crop?
6. If no, who assists you on the farm?

Extension services

1. Do extension agents visit your farm / installation? **Yes=1 No=2**
2. If yes, how many times in a year?
3. What do you gain from their visits?

Cooperative society

1. Do you belong to any cooperative society? **Yes=1 No=2**

2. If yes, what type of cooperative society?

Fishermen cooperative society	1
Multipurpose cooperative society	2
Others (specify)	3

3. Length of membership
4. What is your position within the group?
5. What benefit do you get as a member?

Loan

1. Did you get loan for fishing / fish farming? **Yes=1 No=2**
2. If yes, fill the following table

S/no	Source of loan	Amount (Naira)	Interest per annum (%)	Comments
1	Government			
2	Bank			
3	Money lender			
4	Others (specify)			

3. Would you like to expand your fish farm / fish shelter / fence? **Yes=1 No=2**
4. If no, why?
5. What are your problems / constraints regarding the fish farming / fishing activity?

S/no	Problem	How do you overcome the problem?

6. Who do you normally contact when you have problem in fishing / your farm?
7. What response / assistance do you get from the person/organization/authority?

Section C: Environmental impacts

***Acadjas, ihos* and fish fence**

1. Do you think cutting of trees for use in *acadja, iho* or fish fence can bring deforestation? **Yes = 1 No = 2**
2. If yes, what measures do you think could be taken to minimize it?

Planting more trees	1
Others (specify)	2

3. Do you think *acadja* enclosures, *iho* or fish fence in lagoons and lakes can bring siltation? **Yes = 1 No = 2**
4. Do you think *acadjas*, i*ho* or fish fence in lagoons and lakes can cause problem to navigation? **Yes = 1 No = 2**
5. Do you have any problem with fishers fishing in the open water because of the installation of *acadjas, iho* or fish fence? **Yes = 1 No = 2**
6. Do you think *acadjas, iho* or fish fence in lagoons and lakes can increase the productivity of the water bodies? **Yes = 1 No = 2**
7. Do you think fishermen prefer fishing around *acadja, iho* or fish fence enclosures? **Yes=1 No = 2**
8. If yes, why?

Earthen ponds

9. Do you think water in the ponds could be used to irrigate vegetable farms?

Yes=1 No = 2

Section D: Socio-economics

1. Major source of income

Farming	1
Fishing	2
Others (specify)	3

2. Farmer's annual income
3. Farmer's annual expenditure
4. Farmer's size of house area
5. Housing type:

Bamboo hut	1
Mud –thatched	2
Mud - zinc house	3
Plank zinc	4
Others(specify)	5

6. Do you have access to electricity? **Yes = 1 No = 2**
7. Available health institution

Dispensary
Rural health centre
General hospital
Others (specify)

8. Availability of educational institution

Primary school
Secondary school
Others (specify)

9. Transport type available

Road
Water
Rail
Others (specify)

10. Type of market available

Rural market	1
Modern market	2
No market	3

11. Source of drinking water (can tick more than one)

River
Well
Tap
Bore hole
Others (specify)

12. Do you have good sanitary facilities like toilet? **Yes = 1 No = 2**
13. Source of fuel for cooking

Wood
Paddy straw
Kerosene
Others (Please specify)

14. Do you have the following facilities?

Item	Yes = 1,	No = 2
Radio		
Cassette player		
Television		
Video		
Telephone		

Questionnaire for fisheries departments and research Institutes

Research status

1. List of publications on traditional aquaculture systems in West Africa
2. Names and contact details of persons or organizations involved in the study.
3. Past and current research programmes on traditional aquaculture systems in West Africa.
4. Problems facing research activities in the area of traditional aquaculture systems in West Africa.

Production status

1. Production of fish from aquaculture in the previous years in the state or country (tonnes).
2. Production of fish from capture fisheries in the state or country (tonnes)
3. List of different types of fish ponds in the state, their sizes and locations