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Thesis By

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SUSTAINABLE POLY-CULTURE FISH PRACTICES IN KANO STATE OF NIGERIA: AN ECONOMIC ANALYSIS

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DECLARATION

I hereby declare that this thesis is written by me and that is a result of my own research work. It has not been presented by any previous applicant for a higher degree anywhere else.

Amos, T.T.

25/09/2000
Date

The above declaration is confirmed.

Prof. A.O. Ogungbile
Chairman, Supervisory Committee

28/9/2000
Date

CERTIFICATION

This thesis entitled "Sustainable Poly-culture Fish Practices in Kano State of Nigeria: An Economic Analysis" by AMOS, TAIWO TIMOTHY meets the regulations governing the award of the degree of Doctor of Philosophy of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to the glory of the Almighty God who has been my source of strength. In addition, I dedicate this work to my parents, Chief and Mrs. Amos Mesogbe and to my wife and son (Ann and John).

ABSTRACT

The study was set to carry out an economic analysis of polyculture (aquaculture) and determine resource use in ponds. The study was conducted in Kano State of Nigeria. The specific objectives were; to determine the factors affecting the development of aquaculture in Kano State; describe the marketing of inputs and outputs in aquaculture production; determine the profitability of aquaculture in the State; determine the efficiency of resource use and economics of scale in ponds, make an economic comparison between species combination in ponds; and assess the sustainability of aquaculture in Kano State.

Data for the study were collected using questionnaire administered on 14 fish farmers who were purposively sampled in the 1999 cropping season and used for analysis. Descriptive statistics, farm business analysis, regression analysis and sensitivity analysis were used in the study.

The major findings of the study showed that variable cost was the major component of cost accounting for 70% of total cost in all the three types of combinations (Tilapia-Clarias, Tilapia- Bagrus- Clarias and Tilapia-Clarias-Clarotis- Mud Fish) considered. The third type of combination (four-Fishes combination) had the highest variable cost of ₦ 87,619.00 per hectare followed by Tilapia-Clarias, then Tilapia-Bagrus-Clarotis. The two fish combination had a profit of ₦21,900.00 per hectare followed by the three fishes combination. The four-fishes combination had the least profit of ₦4,389.00 per hectare. There was a significant difference in profit level for the three categories. Age of respondents, pond size, years of fish farming experience and feed quantity were important determinants of fish output in ponds. A negative relationship between age of aquaculturist and output is indicative of the tendency for younger farmers to adopt new innovations which could increase output when compared to their older counterparts. The result of the regression analysis (Cobb-Douglas production function) showed that farmers were experiencing decreasing returns to scale in resource use. The Marginal Value Productivity (MVP) of inputs such as feed, fertilizer and lime showed that farmers were not utilizing their resource efficiently.

Sensitivity analysis performed on the effect of feed and fertilizer price changes on profit in each combination showed that even at 100% price increase, aquaculturists were still making profits in all the three combinations. Aquaculture in Kano State could thus be said to be profitable and sustainable.

Some problems identified to be militating against aquaculture activities in the state include high cost of pellet feeds, scarcity of finger-ling for pond stocking and lack of technical assistance from research and extension agents. Based on these findings, it was recommended that aquaculturists be encourage to adopt new innovations in fish farming. Hatcheries in the State should be adequately funded and more should be established at strategic locations in the State.

Table of Content

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ACRONYMS

ADCP	=	Aquaculture Development and Coordination Programme
CIFA	=	Committee on Inland Fisheries of Africa (FAO)
EIFAC	=	European Inland Fisheries Advisory Commission (FAO)
UNDP	=	United Nations Development Programme (New York, USA).
UNEP	=	United Nations Environment Programme (Nairobi, Kenya)
KNARDA	=	Kano State Agricultural and Rural Development Authority
FAO	=	Food and Agricultural Organisation
KG	=	Kilogram
NIFFR	=	National Institute of Fresh-water Fisheries Research

CHAPTER 1

INTRODUCTION

1.1 Background

With a projected fish demand of 1.755 million metric tons in Nigeria (assuming an annual per capita fish consumption of 12.5kg and human population of 140.45 million, in the year 2000) and a total annual domestic production figure of less than 450,000 metric tons, Nigeria has a fish supply deficit of about one million tonnes (Tobor, 1991). Nevertheless, Nigeria has enough fish resources with exploitable yield potentials that can close the gap between demand and supply, though unrestricted fish importation with low risk and high profitability create effective disincentive to those interested in the development of local fisheries.

Ita (1993) estimated that a total of about 900,000 ha of water surface area must be cultivated to produce a minimum of about 900,000 metric tones of fish a year if Nigeria is to be self-sufficient in fish production through aquaculture. Fish and fish products constitute more than 60% of the total protein intake in adults especially in rural areas. Like any other animal product, 48-52% of fish meat is edible, easily digestible and contain low cholesterol level (Adeleye, 1992). Apart from food, fishes are used in medical preparation (fish oils), in fashion industry (crocodile skin), recreation (sport fishing), and other agricultural industries (fish meals, ornamental and decorations). The rate of exploitation of fish the world over is putting much pressure on aquatic resources. Although financial models indicate that small and large scale fish farming should be economically attractive, in practice, it has been observed that the majority of fish farms in Nigeria are unproductive (Ayeni, 1997). Problems identified with the national aquaculture by Ayeni, (1984) include: poaching, predation, lack of capital, insufficient supply of fingerling, lack of pelleted feed, lack of water, shortage of trained man power. These technical problems in addition to the seasonal nature of the water resources in the northern part of Nigeria are surmountable

Almost without exception, the reviews of fisheries have placed great emphasis on the importance of aquaculture in meeting the increasing demand for fish. This is based on the presumption that capture fisheries are in decline and can offer little or no opportunity for increased production (GLOBAL, 1998). Aquaculture has therefore been seen as the only means by which the inland fisheries production can be increased. Although the inland water mass is small (149,990 klm) compared with that of the marine environment, which is put at about 328,545 kilometre (Sado et al., 1985), it has a higher fishery potential. Estimates of fish potential in Nigeria by Sado et al., (1985) was given as 334,214 metric tons on a lower limit and 511, 703 metric tons on an upper limit, under adequate management. The later estimate is about double the potential from the marine sector. In addition to this, it is argued that more and more improvements are being planned in different parts of the country for irrigation and domestic water supply purposes. More private investments in fish farming are also being undertaken in inland waters than along the coastal marine shores (Ita, 1993).

Aquaculture is the farming of aquatic animals(fin-fish, spawns, oyster, snail, crabs, crocodiles, alligators etc) in confined waters. It is the least exploited and a potential option to artisanal fisheries (Ajana, 1991). It currently provides an estimated 10 percent of the worlds water-derived protein with a harvest of between 5 and 6 million metric tons valued in excess of $ 2.5 billion world over (Robert and Larry, 1980). Since 1984, when FAO started collecting aquaculture statistics from various countries, production has doubled from almost 7 million tonnes in 1984 to 14 million tonnes in 1992 (FAO, 1995). In 1993, it is estimated that aquaculture production increased by almost 2 million tonnes to 16 million tonnes or 24.4% of total world production of fish and 21.3 % of food fish supplies.

Significantly, aquaculture production (Table 1) has increased at a rate sufficient to offset the decreases from capture fisheries, and in 1993 the rate increased further to bring world production beyond previous production levels. The production from aquaculture of freshwater fishes already exceeds that of freshwater capture fisheries. The combined effect of this trend is an increase in the contribution of aquaculture to world food fish supply (Table 2a). However, the percentage contribution to Nigeria's Gross Domestic Product has being on the decline since 1983(Table 2b). The highest contribution to GDP was 2.4 in 1983 and subsequently, it has never been more than 1.9.

Table 1: World Fish Production

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Million tonnes	7	8	9	10	11	11	12	13	14	16

Source: FAO, 1995

There has been substantial investment made in aquaculture by both the private and public sectors: However, Global, (1998), and Sharma et al.(1995) noted that most of these farms are operating well below their capacity. There has been substantial investment made in aquaculture by both the private and public sectors: However, Global (1998) and Sharma et al.,(1995) noted that most of these farms are operating well below their capacity.

Since fish culture is basically a commercial venture, private investors are being encouraged to go into the business through various channels by government. Banks and commercial houses are known to have shown interest in granting loans to prospective commercial fish farmers and the interest in aquaculture is increasing due

Table 2a Contribution of Aquaculture to world food fish supply, 1984-1993

Year	'000 tons Capture Fisheries supply	Aquaculture contribution	% Contribution
1984	51,105	6.933	13.5
1985	52,302	7,729	14.7
1986	53,824	8,807	16.3
1987	55,962	10,150	18.1
1988	56,603	11,210	19.9
1989	58,891	11,497	19.5
1990	58,424	12,121	20.7
1991	57,026	12,781	22.4
1992	57,008	13,921	24.4
1993	56,470	15,800	

Source: FAO, 1995

to the sudden decline in the poultry industry due to high cost of feeds. Investors have been forced to explore new areas particularly in animal husbandry and aquaculture. Aquaculture has attracted some attention because of the assumption that it involves low risk (Ita, 1993). In terms of mortality+ from natural sources and feeding of fish, it is not as complicated when compared to other enterprises such as poultry. It does not necessarily require importation of feed concentrates with high foreign exchange needs.

Table 2b:Contribution of Fish to Nigerian Cross Domestic Production (at 1984 Constant Factor Cost)

Year	% Contribution	Total GDP
1981	2.2	70,395.9
1982	2.2	70,157.0
1983	2.4	66,389.5
1984	1.8	63,006.4
1985	1.0	68,916.3
1986	1.2	71,075.9
1987	0.9	70,741.4
1988	1.2	77,752.5
1989	1.9	83,495.2
1990	1.8	90.341.1
1991	1.8	94,614.1
1992	1.6	97,431.1
1993	1.1	100,015.1
1994	1.1	101,040.0
1995	1.1	103,302.9
1996	1.3	107,020.0
1997	1.4	110,400.0
1998	1.6	113,000.0

Source: CBN Statistical Bulletin Vol. 9, No. 2 1998.

Unlike other enterprises with imported packages, such as battery cage in poultry production, chemical fertilizer in cereal production, packages in aquaculture technology cannot be readily imported from temperate countries. This is due to the differences in water temperature between the temperate and tropical countries and the adaptation of different fish species to water temperature conditions in the two regions of the world (Ita, 1993).

Fish farming helps to conserve aquatic resources by reducing the pressure on the level of exploitation of the wild species. In Nigeria, it is estimated that about 1,010,000 hectares of perennial swamps and 741,509 hectares of brackish water are yet to be harnessed for aquaculture (NIOMR, 1984). The picture is likely to have changed slightly though current figures are not available. Ayeni (1991) and Global (1998) noted that the sector is dominated by illiterate farmers who indulge in the traditional fish farming. As a result of this, the expected national gross production is low and deficit for many years has been met through importation. Farmers are known to be using stagnant pools whereby wild fish are stocked and left unfed. This is contrary to the modern culture technique which involves the stocking of selected fish species which are fed up to maturity with compound diet.

There are about 29 species of fish under culture in Nigeria (Ezenwa, 1994). The main species used are the Nile Tilapia (Oreochromis niloticus), the cat fishes (Clarias gariepinus and (Heterobranchus bidorsalis) and common carp (Cyprinus carpio). Others include Heterotis niloticus, Lates niloticus and Citharinus citharus.

Based on an estimation of 25% of fry, 751,510 ha of perennial fresh and brackish water swamps available in Nigeria can be placed under cultivation and an achievable production rate of 3 tonnes/ha. It is estimated that a production of 1,313,634 tonnes annually is possible in Nigerian aquaculture alone (Tobor, 1991). However, there are biological and economic indications that the inshore fish resources are being put under severe pressure. To prevent an irreversible depletion of the inshore resources, this pressure must either be reduced or diverted to new fishing grounds.

There is a requirement of over 12 million seeds per annum in Nigeria (Ezenwa, 1990). Although the seeds of cultivable fish can be obtained from the wild, this can be done during the breeding season. The development of the culture systems based on indigenous species of fish is a viable option which can be investigated by researchers.

Projected fish demand in million metric tons in Nigeria was 1.547 in 1995 and is expected to increase to 1.755 by the year 2000. Projected figures are based on an annual per capita fish consumption of 12.5 kg and human population projection (Table 3a). With a total annual domestic production figure of less than 450,000 metric tons, Nigeria has a fish supply deficit close to a million. However, research surveys and fish potential yield assessments have shown that Nigeria has enough fish resources,
which if properly exploited can close the gap between demand and supply. Yield potentials figures are shown in Table 3b.

1.2 Problem Statement

With the advent of industrial fishing and the sophistication of fishing technology, the rate of exploitation is putting much pressure on this seemingly in-exhaustive aquatic resources. Fishes and other aquatic products have declined in Nigeria due to over exploitation, habitat loss due to sand filling operations, pollution from oil exploration

Table 3a: Projected population of Nigeria and demand for fish (1995 - 2000)

Year	Projected population (Million)	Projected fish demand (Million tonnes)
1995	123.759	1.547
1996	126.929	1.587
1997	130.180	1.627
1998	133.516	1.669
1999	136.933	1.712
2000	140.446	1.755

Source: Tobor, 1991

and industries, all year round trawling for fishes (Adeleye, 1992). The erroneous belief that the aquatic environment is self-regulatory held by individuals has not helped matters. The thought in some quarters that the presence of water hyacinth on Nigeria water bodies with its attendant impediment to fishing as being a natural device for the recovery of the over-fished water has contributed to the fast depletion of Nigeria's fishery resources. All these have led to the extinction of some species and a drastic reduction in many others Thus fish production in Nigeria has not been able to meet the demand (Central Bank of Nigeria, 1995) which is currently put at over 1.755 million metric tones. This trend had led the country into huge trade deficit incurred through the importation of frozen fish to offset the shortfall. For instance, in 1991, fish import was ₦2.25 billion (Ezekwe, 1991). There is thus a need to reverse the trend. Self sufficiency in Thus fish production in Nigeria has not been able to meet the demand (Central Bank of Nigeria, 1995) which is currently put at over 1.755 million metric tones. This trend had led the country into huge trade deficit incurred through the importation of frozen fish to offset the shortfall. For instance, in

1991, fish import was ₦2.25 billion (Ezekwe, 1991). There is thus a need to reverse the trend. Self sufficiency in fish production is therefore very important. This has led to some programmes by the federal government as far back as 1962 when the Nigerian government requested through the FAO, the assistance of some boat builders to undertake a reconnaissance survey of conditions in the Lake Chad and Chari River region in order to advise on which experimental boats should be built for the fishery station in Baga and the likely development of commercial fishing craft to be built, if possible, with indigenous materials. There was also FAO,(1963) report to the Nigerian government on improvement in the bulk smoking of *bonga* in the then Western Nigeria.

Table 3b: Estimates of fish yield potentials in agriculture and natural waters of Nigeria

Source	Annual Yield Potential (Tonnes)
Rivers and flood Plains	226,550
Lake Chad	24,500
Kainji Lake	8,500
Other Natural Lakes & Research	35,000
Coastal and brackish waters	190,000
In-shore waters	16,620
Off-shore waters	16,190
Aquaculture	1,313,634
Total	1,830,994

Source: Tobor, 1991

Other fisheries development projects include the National Accelerated Fish Production Project, Special Fish Development Project, Inshore Fisheries Development Project, Canoe Mechanisation Scheme and the Artisenal Fisheries Processing and Marketing Project by both the Federal Department of Fisheries and the States Fisheries Divisions. These projects and schemes despite their initial promise have not resulted in a permanent increase in our fish production. These and other projects show that there has been substantial investment made in aquaculture by the public and private sectors, however most farmers are operating below expected capacity (GLOBAL, 1998). There are recommendations as to the stocking densities and combinations to improve the efficiency and the productivity of participants especially in aquaculture production. However, there has not been any research to show the economic viability of these combinations. Therefore, a study of this nature will go a long way to provide the necessary information to help fish farmers, policy makers and researchers alike. No single fish species can effectively utilize all the natural resources of the pond. The maximum quantity of fish a pond can support or carry will be increased where two or three species of complimentary feeding habits are stocked because a wide variety of foods produced in the ponds or supplied to it will be utilized. It is important that maximum exploitation of the natural pond be achieved through the appropriate cultural system that strikes a balance between input and output. While overstocking of fish pond results in the harvesting of many but undersized fish species, under-stocking results in the harvesting of big sized fish but few in number. Commercial fish farmers are faced with the problem of pond management. This is in regard to the right species combination and density for sustainable resource use in ponds. There is the need for an economic study to justify the various combinations at the farmer's level and provide answer to such questions as:

-What are the factors affecting the development of aquaculture in Kano State?

-Is aquaculture profitable in Kano State?

-What is the optimum species combination for sustainable resource use in fish farming?

Hypotheses

The following hypotheses are postulated for testing:

i. There is no relationship between the socio-economic characteristics of the aquaculturists and their gross income.

ii. There is no difference in profitability among the various specie combinations in aquaculture in the study area.

iii. There is no difference between costs and returns in aquaculture production in Kano State.

1.3 Justification

There is the need to develop the fisheries sub-sector due to the reduction in meat availability in Nigeria as a result of the Sahelian drought and rinderpest infestation on animals especially cattle. In addition to this, there is an increasing population in Nigeria which leads to an increased demand for food. Fish, an established source of protein, is essential in the diet for healthy growth.

In the past, much attention has been given to technical aspects of the use of productive resources(land, labour, water, organic materials, tools) in aquaculture. The social and economic dimensions of aquaculture have not been properly considered, in terms of access and control of productive resources, the quantity of resources available for fish farming vis- a-vis other on-farm activities, and the disposal of fish produced. This has been a major reason why fish farmers in Nigeria have not applied their resources to produce fish using otherwise sound aquaculture techniques.

This research will therefore study the economic aspects of aquaculture in terms of access, use and allocation of resources which are or could be available for fish farming. It will also determine reasons for current level of resource allocation. It will also provide information for researchers in other aquaculture research programs and for extension workers in convincing farmers to adopt production systems that are cost effective, efficient in resource use, and ensure increased aggregate fish produce per hectare of water surface.

It will also provide the current information that would guide fish farmers in decision making regarding stocking density, feeding rate and fish combination, and government in formulating relevant policies towards the solution to fish supply deficit in Nigeria.

1.4 Objectives of the study:

The broad objective of this study is to carry out an economic and determine resource use in ponds for sustainable culture in Kano State of Nigeria. The specific objectives are to:

1) Determine the factors affecting the development of aquaculture in Kano State.
2) Describe the marketing of inputs and outputs in aquaculture production.
3) Determine the profitability of aquaculture in Kano State.
4) Determine the efficiency of resource use and economies of scale in ponds.
5) Determine the optimal feeding for maximum output in aquaculture.
6) Make an economic comparison between species combinations in ponds.
7) Assess the sustainability of aquaculture in the state.

This chapter has given the background of this study. It also presented the Justification for the study in addition to the specific objectives of the study. The next chapter is devoted to the review of some relevant literatures and the presentation of some conceptual frameworks relevant to aquaculture.

CHAPTER 2

LITERATURE REVIEW

2.1 Conceptual Framework

The production function combines technical, biological and economic units. The biological unit is represented by fish stock and the technical unit is the management practises e.g. stocking densities. The output of fish depends on the stock of fish and management (Bardach et al, 1972 and Olomola, 1991). This function is characterised positive but diminishing marginal products of stocks and management.

An aquaculture unit is expected to continue operating as long as operating profit (gross revenue minus operating costs) is positive. Thus, as long as operating costs are covered, the unit will operate. However, unless all fixed costs are covered, the fishing operation is not feasible in the long run; it will terminate when the economic life of the existing fixed assets expire. Thus, net profit (gross revenue minus total costs) must not be negative if the unit is to be viable in the long-run.

For the purpose of this study, costs have been classified into two types: variable cost which is the operating expenses which vary with the quantity of fish produced during the production period, these include cost on finger-lings (seed), feed and hired labour. The other type of variable costs is the opportunity costs which are the imputed costs of family labour and farm land.

The second type is the fixed costs which do not vary with the level of output; they are incurred whether the fishing unit operates or not. Fixed costs are capital investments that cannot be retrieved at short notice without undue loss. They include costs of building fish ponds and that of obtaining some physical assets. The costs associated with these assets are measured in terms of the flow of services rendered during the production period. These rental costs are usually non-observable; however, the purchase price of the assets are observable and can be used to compute the rental as follows:

$$P_i = [(s + \%_i) Q_i - t_i]$$

Where

P_i = Rental price

s = Rate of interest

$\%_i$ = Rate of depreciation

Q_i = Price of asset i (cost of construction of pond)

t_i = Rate of inflation of the asset price

The rate of interest to be used shall be the prevailing rate charged by banks on agricultural loans at the time of study in the area. On an annual basis, the rate of depreciation is calculated.

$$1/N_i \quad = \propto_i$$

Where N_i is the estimated life of an asset, i, in years. The rate of capital gain, t_i, will be calculated as

$$t_i = (Q_i - Q^*_i) / n_i$$

Where Q_i is the current purchase price of the asset i, Q^*_i is the initial purchased price (construction price of pond) and n_i is the current present age of the asset (Pond) in years. Theoretically, allocative efficiency stipulates that the use of each input be expanded until the value of its marginal product equals its unit cost. The applicability of this concept in aquaculture has been demonstrated to be amenable to the traditional neoclassical technique (Smith, 1982; Chang and Lizarando, 1982). The resource-use efficiency of the fish farmers can be evaluated through marginal analysis.

The major factors affecting the productivity per unit of fish pond, are water surface area, the stocking rate, the survival rate at the time of harvesting, and the average weight of the individual fish at the time of harvesting. Therefore, an increasing stocking rate, survival rate and growth rate are the primary means of increasing production.

The primary interest in developing aquaculture is the establishment of viable industries for the purpose of domestic consumption, employment opportunity, income distributions, or a combination of these objectives. These development objectives cannot be achieved if a minimum income and profitability are not attained by the producers. The producer's profit or net income per unit of land or water area (Y) is mainly affected by quantity of fish (Q), the cost of production and marketing (C), and the price received (P)

i.e. $Y = QP - C$ (Fig. 1)

Therefore increasing yield, reduction in costs, and increases in price are the major means of increasing profits. Profit maximization of individual commercial aquaculture operations can be achieved by one of two related ways.

i. By maximizing production with given resources, or, in monetary terms, maximization of production revenue at a given production cost.

ii By achieving a given level of production with least possible resources, or, in monetary terms, by achieving a given production revenue at the least possible cost.

Production function analysis is a useful technique in determining the most profitable levels of input and output, given input and output prices; the most profitable combination of inputs for a specified output, given input prices, and the most profitable combination of products, given resources and relative prices of these products.

The production function, expresses the physical or bio-technical relationship between outputs and inputs. It can be expressed algebraically as

$$\oint = f\left(\propto_{1}, \propto_{2}, \propto_{3}, \propto_{4}, \propto_{5} \ldots\ldots\ldots\ldots\ldots\ldots \propto_{n}\right),$$ which

means that the quantity of output $\oint$ is a function of the quantity of inputs

$\propto_{i}$,(i=1..n).

In aquaculture, the total production of a particular species, per unit area is usually dependent upon input levels for labour, capital, feed, fertilizer, fry etc, and non market environmental factors such as water temperature, dissolved oxygen, salinity, PH value etc.

It is important to note that input-output relationships are meaningful only if (a) input and output are homogenous (b) the function refers to a specific period of time and a single technique, and (c) the inputs are used efficiently.

In aquaculture, the stocking rate of a fish pond varies mainly with the fertility of the pond. This fertility rate can be improved by fertilization and/or supplementary feeding. The purpose of fertilization is to increase the production of plankton, which fish prefer as food; and the purpose of feeding is to complement the nutrients that are in short supply in the fish pond.

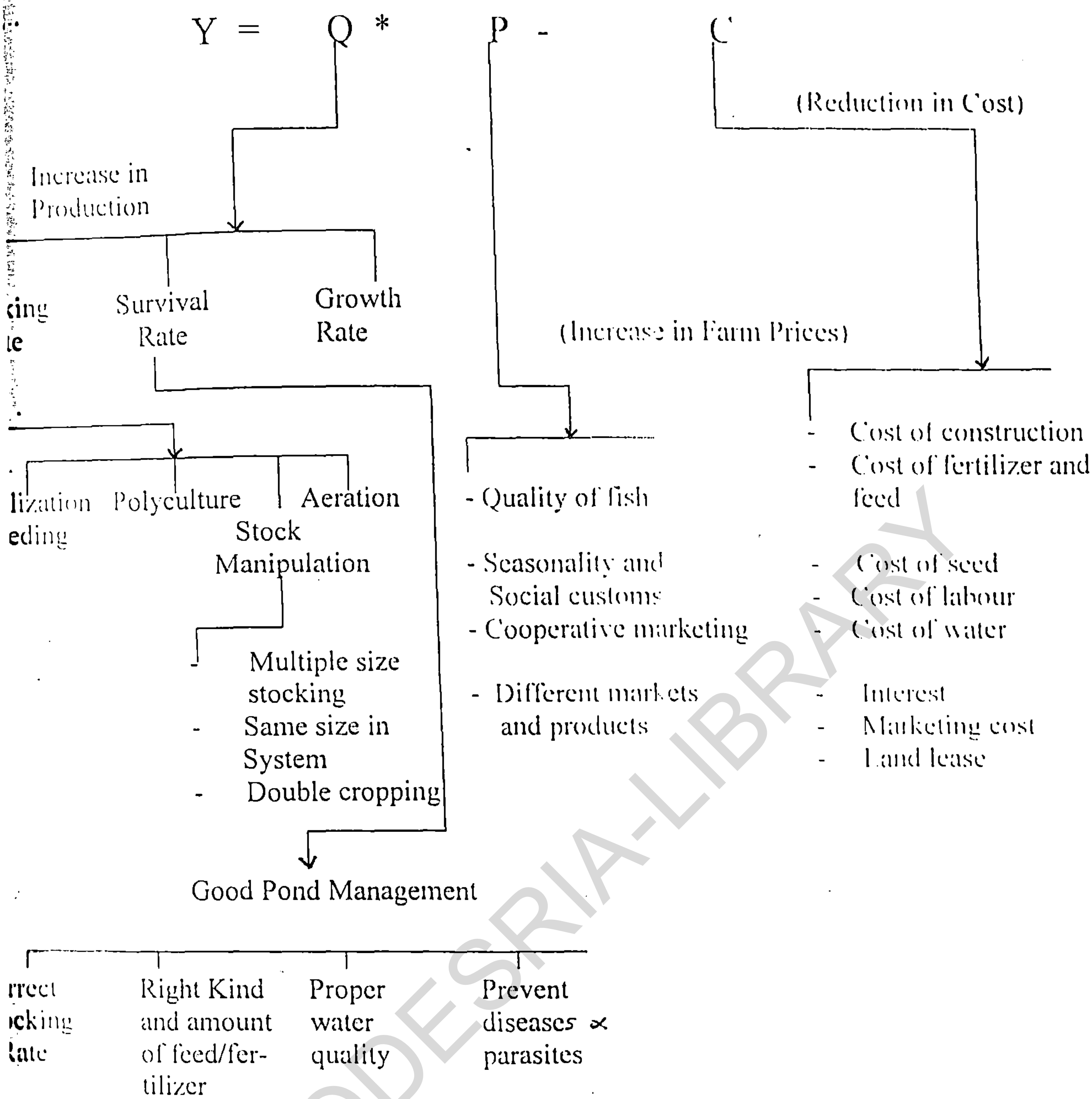

Fig. 1: Major Factors Affecting the Economics of Aquaculture

Source: Adapted from Shang, 1976.

A fish pond's production level is usually much higher with fertilization and supplementary feeding than without. The increased level of production is reflected in a higher stocking rate and faster growth rate of the fish. For instance, the fish-carrying capacity of ponds in Alabama was increased by 300 to 400% as a result of fertilization (Hora and Pillay, 1962).

Although the total cost of production is higher with fertilization and supplementary feeding than without, the production cost per unit of fish may be lower and the additional revenue generated may be higher than the additional cost involved.
Poly-culture is the rearing of several species together to make more efficient use of the growing space and the total pond environment. Poly-culture can thus lead to significant increase in the stocking rate and hence in the production of certain species. Most fish are selective in their diet, thus, stocking different fish will efficiently utilize not only space but also food. The stocking rate of a fish pond can be increased by different kinds of stocking systems such as multiple-size stocking, same-size stocking in a system of ponds, double cropping, etc. Again, increased survival and growth rates are important elements in increasing production, and mainly depend on genetic improvements, such as selective breeding and hybridization, and pond management. Correct stocking rate, on the other hand, is an important principle of aquaculture in that a suitable density of fish should always 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 decline in the survival and growth rates.

2.1.2. Empirical Studies on Aquaculture

In spite of increasing biological research activity in the Nigerian fisheries, inadequate attention has been devoted to management and economic issues. For example, the profitability of fish farming in Nigeria particularly aquaculture has not been clearly demonstrated (Olomola, 1991). Studies have not compared the economic aspects of various stocking densities in aquaculture. More critically, studies have been concentrated in the coastal areas with nothing on the northern hinterland.

Mabawonku (1978) found increasing returns to scale in Bendel, Cross River, and River states but found no evidence of scale economies in Ogun, Ondo and Lagos states in aquaculture. Otubusin et al., (1991) identified aquaculture as a more reliable alternative towards meeting the increasing fish demand by the teaming Nigeria population. He confirmed that cage system is economically viable. This was confirmed by Okoye et al., (1991) who observed that a five-hectare commercial fish farm based on polyculture of Heterobranchus bidorsalis and Oreochromis niloticus, yielded 34.1% of the total amount invested as profit within a period of 4.7 years.

Elsewhere, Hora and Pillay (1962) found the fish-carrying capacity of ponds in Alabama to have increased by 300 to 400% as a result of fertilization. Although the total cost of production was higher with fertilization and supplementary feeding than without, the production cost per unit of fish is often lower and additional revenue generated higher than the additional cost involved. It has also been found that the percentage increase in production for intensive operation exceeds the cost. Therefore, the cost of production as a proportion of output is often lower for intensive than for extensive operations. In the Philippines and Indonesia under intensive operation, Shang and Rabanal, (1976) observed that the production per hectare of milk fish under intensive operation can be increased to 3 times that of extensive culture by doubling the cost of production that results in a much higher profit. Also, studies of carp under intensive culture in Israel indicated that the cost of production per 100 kg of common carp was about 40% less than that of an extensive operation (Tal and Hepher, 1967), and the cost in India was about 25% less (Sinka, 1977).

In general, polyculture has been found for many species of fish(e.g Milk fish, shrimp, common carp and Tilapia) to have had increased production per unit of pond area, reduced fixed cost per unit of output, and generated more profit (Shang, 1976, Leopold, 1978 and Pillay, 1979).

On stock manipulation, the stocking rate of a fish pond has been found to be increased by different kids of stocking systems. Shang (1976) found that multiple-size stocking of milk fish in Taiwan doubled annual production. While Rabanal (1961), observed that the number of harvests of milk fish in the Philippines increased from 1 to 5 times. Brown (1970), found that double cropping of catfish and rainbow trout in the United States increased the net profit by over 30%, as compared to single cropping.

Other studies on correct stocking rate emphasised that a suitable density of fish should always be stocked in a pond. Leopold (1978) stated that studies of carp culture in

Europe, for instance, has revealed that excessive stocking density may lead to a decrease in individual weight of harvested fish, a reduction of the survival rate, and an increase of food conversion ratio.

There were studies on the cost of construction of ponds. The primary considerations in site selection are topography, water supply and soil quality (Chaston, 1984). On the other hand, the smaller the pond size, the greater the convenience of pond management and the lower the earth work maintenance (Tang, 1979). Fish ponds can be constructed with human labour or machines. The choice should be based on the relative costs and efficiencies of construction of the two methods. Other studies on seeds have found out that the level of use of seed accounted for a high percentage of total operating cost (Shang, 1976, Shang and Rabanal, 1976 and Leapold 1978). A further study revealed that the bigger the individual size of stocking material, the lower the cost of production per unit of market fish, consequently, the higher the profit.

Cook, 1976, observed that a well constructed sluice gate made of treated wood can last 8 to 10 years. On feed and fertilizer, Sinka, (1977) found an average production of 3.0 to 4.5 tons/ha in carp culture by using sewage in China, Hungary, and Israel. In India, a production of more than 3 times the normal yield was obtained from <u>Tilapia</u> ponds irrigated with domestic sewage. Woynarovich (1979) has shown that approximately 5 kg of carp can be produced by using 100 kg of pig manure as a fertilizer. The conclusion from studies on fish farming was that the costs of land and pond construction are the major capital investments and the costs of feed and/or fertilizer are the most important operating expenses. Therefore a joint culture of fish and animal husbandry is one of the alternatives that reduce these costs per unit of output.

2.1.3 Importance of Aquaculture and Advantage Over Conventional Fishing

The advantages of aquaculture over conventional fishing are many. First, fish culture is stock raising as opposed to hunting. Stock raising is more efficient than hunting in harvesting a resource because extension search efforts are not required, thus, harvest is proportional to effort and can be predicted. Second, environmental conditions can be controlled and genetics can be manipulated to improve yield. Moreover, exclusive rights to a resources can be established in most cases and international agreement is not usually necessary (Shang, 1981).

Aquaculture can be conducted on land that is not suited for agriculture. It can and does flourish on lands whose waters are mostly saline or brackish. Due to their nature as cold blooded, and live in fluid medium, they require less energy for body metabolism and thus are the most efficient converters of food. For example, the conversion rates of dry feed to wet weight gain is as follows: fish, about 1.5 to 1.0 or less; cattle, about 10.0 to 1.0; pigs, 4.0 to 1.0; and poultry, 2.5 to 1.0 (Ronsivalli, 1976). Thus the cost of producing fish flesh is lower than that of beef, poultry and swine. Fish also use space more efficiently than many land animals because they are three-dimensional habitants. In well-managed environments, 3000 kg or more of fish can be produced per hectare per year; contrastingly, the maximum figure for cattle is 500 to 700 kg (Bell and Canterbery, 1976)

Market demand for fish in aquaculture facilities can be expanded much easier than the demand for wild fish. In that case, aquaculture offers the possibility for species improvement by selective breeding to meet consumers' tastes and market requirements.

Only about 17% of total commercial sea catch is actually consumed directly by humans (Ryther, 1975). This is because a large proportion is wasted in processing, transportation, and marketing of sea production into fish meal and oil. In contrast, between 40 and 50% of the production from fish farms may actually go to human consumption.

Aquaculture can and often become a major income-generating activity in integrated rural development programs. Supplemented with agricultural crop production and animal husbandry, acquaculture can generate income and employment in the rural sectors of developing countries and improve the quality of life of the rural poor. It is estimated that the production of every four metric tons of fish requires one full-time job. Further, culturing valuable species for export contributes to foreign exchange earnings.

2.1.4 Classification of an Aquaculture System

The development of fish culture through a variety of methods and under different conditions has resulted in many different kinds of generations. Various criteria are used to classify and define different kinds of fish culture. Classification and definition are necessary because they ensure that proper economic efficiency assessment and comparative study can be conducted. Interpreting economic results without considering specific conditions of a given fish culture can lead to incorrect generalization. This is summarised below:

Criteria	Kind
Purpose of culture	-Human food -Improvement of natural stock -Sports and recreation -Ornamental fish -Bait -Industrial Products -Pond culture -Cage and pen culture -Raceway culture -Raff culture -Closed high-density culture -Sea ranching
Sources of Fry	-Natural waters -Captured gravid females -Hatching
Level of management intensity	-Extensive -Semi-intensive -Intensive
Number of species stocked	-Monoculture (single species) -Polyculture (more than one species)
Water Salinity	-Fresh water -Brackish water -Marine water
Water movement	-Running water -Standing water
Water temperature	-Cold water -Warm water
Food habit	-Herbivorous species culture -Omnivorous species culture -Carnivorous species culture
Combination with agriculture production	-Rice-fish farming -Poultry-fish farming -Pig-fish farming

Adapted from (Shang, 1976).

2.2.1 Aquacultural Farm Types

Fish farming can be distinguished based on different criteria. Shang (1976) classified fish farming into three based on input level. These are intensive, semi-intensive, and extensive types.

Extensive: In this, economic inputs are usually low. Natural food production plays a very important role, and pond productivity is relatively low. Fertilization may be used to increase pond fertility and thus fish production.

Semi-intensive: In this fish farming method, moderate level of inputs is used and fish production increased by the use of fertilizer and/or supplementary feeding. This means higher labour and food costs, but higher fish yields more than compensate for this usually.

Intensive: In this, a high level of inputs is used and the ponds are stocked with as many fish as possible. The fish are fed supplementary food, and natural food production plays a minor role. Some management problems can occur due to the high feeding costs and risks due to high fish stocking densities and thus increased susceptibility to diseases and dissolved oxygen shortage. The farmer is thus forced to charge high price in order to make the fish farming economically feasible. With proper management, intensive aquaculture practice is highly profitable with higher returns on investment.

2.2.2..1 Other Fish Culture Types.

Integrated aquaculture: This is a combination of fish with other forms of agriculture e.g. poultry, pig, duck, cattle and goat rearing and arable crops in such a way that some of the by-products of these animals that are considered as wastes can still be recycled for either direct or indirect consumption by fish. Different models of integrated aquaculture exist. These include:

Fish-Poultry Combination

Birds are raised in cages under a shed normally constructed over the pond embankment or in the vicinity of the pond or directly over. It is recommended that about 400-600 birds per hectare are raised.

Fish-Duck Culture

This is based on the principle of waste recycling. The duck house is constructed on the pond water on a floating platform. The duck dropping act as fertilizer. About 200-400 ducks to one hectare is recommended. There are two major types of this integrated system. The first system involves raising of ducks in a pond using a construction just above water level. Two duck shelters are built on a raft of bamboo, and joined by a rectangular platform. Underneath the platform, and submerged in the water is a metal frame in which the duck can swim and feed, but from which they cannot escape. The bottom of the frames made with a net through which the droppings can pass and be used by the fish. Among the advantages of this system are the fact that the ducks cannot catch and eat the fish, nor can they eat the plants in the pond. The fish, safe from predators, move around a great deal and fatten up quickly. Furthermore, the droppings can be spread around evenly, as the construction can be easily moved.

Fish-Pig Culture

The Pig pens are constructed either on the pond embankment or near the pond to facilitate easy drainage of wastes directly into the pond which act as fertilizers and support dense growth of natural fish food organisms. Fish also feed on excreta and the pond system does not need other feed or fertilizer.

Fish-cattle/Goat/Sheep Farming

The pond is constructed near the animal houses where the droppings can easily be applied at appropriate quantities to the pond. The droppings also serve as food directly to the fish. It is recommended that about 400 goat/sheep or 30 cattle to one hectare of fish pond are kept.

Fish-Rice Combination

Fish culture in swamps where rice is cultivated. Such suitable fish include Clarias and Tilapia. Also rain-fed low-land rice growing areas can also be inter-cropped with fish. Rice are normally planted before water reaches the required peak level when fish finger-lings are introduced.

Advantages of Integrating Fish Culture with Animal Husbandry includes:

1. Manure will be readily available to fertilize pond. In this case, the dung dropping from the animals will serve as fertilizer for the fish pond.
2. The pond environment cools the animal especially during hot weather. This is important as the water evaporating from the pond could cool the animals.
3. Animal can utilize the pond water or the drainage from animal house to pond site to cool the body or swim in e.g. duck, pigs, etc.
4. Birds like duck increases Oxygen content (O_2) of pond water through swimming.

5. Population of fish can be controlled e.g. Tilapia can be controlled by ducks. The animals can feed on some of the fish.

6. Farmers will have meat and fish to eat and increase income through sales of any or both types of livestock.

7. Integration makes maximum utilization of available land space.

8. Encouraging integration of fish and livestock in farming is a way of promoting farmers interest in fish cultures.

2.2.2.2 Seasonal Burrow Pits Fish Farming.

Burrow-Pits are unconventional excavations or depressions that can be utilized for water holdings in agriculture. Other unconventional depression common are ponds, bore hole-outflow, swamp lands, mining paddocks and stagnant pools. All these can be utilized for fish culture.

Burrow pits are of 2 types:

i. **Natural** - This includes natural depressions like stagnant pools, rock crevices etc.

ii. **Constructed** - Excavated paddocks e.g. Mining Pits, and Road construction pits.

In most parts of Northern Nigeria, burrow-pits are seasonal in their water holding capacities and retain water for not more than 3-5 months. Depending on soil structure and the environment, some burrow-pits are rich in humus deposit and can be fertile. Some are unsuitable for fish farming especially those in high clay area. Species like Tilapia, Clarias and Heterobranchus grow well in burrow pits.

2.2.2.3 Stocking of Dams, Reservoirs and Lakes

Many dams, reservoirs and lakes available in Nigeria with estimated potential annual yield (if stocked with fish) of about 80,000 tonnes. Potential yields of most of these water bodies have been documented by Research Institutes such as NIFFR. Fortunately, over 85% of dams and reservoirs in Nigeria are in the north, and all the culturable fish species survive very well in dams and reservoirs. Since most of these water bodies are owned by State Governments, Local Governments or communities, stocking them with suitable fish species will be of economic and nutritional benefit to the society.

2.2.2.4 Cage and Net Culture

Amongst the known modern aquaculture systems for increased fish production, cage and net enclosure culture are about the cheapest to operate (Otubusin, 1983). Unlike pond culture which is one of the earliest and widely practiced aquaculture systems cage culture does not compete with other land use for urbanization, agriculture and other industrial development. This culture system is preferred to pond culture because it requires limited investment, allows higher stocking of fish, ensues complete control of the harvest and generally provides high returns on investment when effectively managed and the fish species and site are suitably selected for the culture system. Fish yield from this system could be as high as 10 to 20 times more than from pond culture considering the surface area/space and the inputs(Anon, 1979).

This system of aquaculture has undoubtedly proved to be one of the main alternatives for fish production in many countries. For example, trouts raising in Norway and Great

Britain; and Tilapia/Milkfish culture in the Philippines to mention a few of the centers of greatest activity utilizing this innovation in aquaculture. Even though Nigeria is well-endowed with vast bodies of water and resources suitable for this culture system,(Fig. 2), the potentials are yet to be tapped (Otunbusi, 1985). A description of this system has been given by Otunbusi (1985).

2.3 Advantages of Fish Culture

It is an interesting practice to watch fish grow from baby stage (finger-lings) to adult size.

i. A farmer can readily learn the art of fish culture since the techniques are simple. From small ponds that the farmer has gained experience, he can expand to bigger commercial ventures.

ii. Fish will be readily available to improve the family protein intake.

iii. Sales from fish harvest will bring extra income to the family.

iv. Many of the fish types we have in Nigeria can be grown successfully in ponds.

v. House food wastes like brans or cooked grains etc will be readily eaten by fish in ponds.

vi. A farmer can grow fish in pond, rear his animals and practice arable farming on the same piece of land. Animal wastes and crop residues can be used to feed the fish.

vii. Lands that are not suitable for arable farming can be used for fishpond construction.

viii. Where the fish farmer has excess production, the market for fish is always available, i.e. consumers are always ready to purchase fish.

ix. Fish have low production cost and when supervised well, can be financially rewarding to the farmer.

2.4 Specific Advantages of Polyculture

Although aquaculture can be carried on in monoculture, the nature of the aquatic matrix makes poly-culture more advantageous(Shell, 1983). Ecologists have long known that multiple species animal and plant communities are more stable and more efficient in the utilization and transfer of energy than single species systems. By combining species of fish with differing feeding habits and spatial preferences with phytoplankton, zooplankton, and insect production, a food web can be devised that will produce large quantities of high quality protein food.

Poly-culture is currently receiving considerable attention throughout the world. If an experiment is to be designed to learn of the maximum amount of fish that can be produced in a hectare of water in a period of time, a combination of species should be used. Generally, combinations of species will result in higher production than a single species. Kilgen (1969) showed that the presence of blue Tilapia in ponds containing channel catfish receiving feed resulted in significantly increased production without reducing the growth rate of the catfish. Up to 3,395 kilogram per hectare of blue Tilapia were produced while production of the channel catfish was enhanced. The Tilapia fed on the wastes and phytoplankton resulting from feeding of the catfish. Other studies (Yashauv, 1977 and

Pretto, 1976) have shown that stocking three species with different feeding habits significantly increased total production of fish in ponds compared to production in ponds containing either one or two of the species.

2.5 Trends in World Aquaculture Production

There was a sustained expansion of aquaculture between the 1980s and 1994. Aquaculture increased its contribution to world fisheries production and maintained its position as one of the fastest growing food production activities in the world. In 1994, total production of fin fish, shell fish and aquatic plants reached a record 25.5 million tones with a value of US$39.83 billion(ex-farm), representing overall increase of 11.8 and 10.3% over 1993 production in weight and value respectively (Andre et al., 1996). Asia increased its dominance as an aquaculture producer of fin fish, shellfish and aquatic plants in 1994; while China and India supplied 60% of total world production, all Asia accounted for about 80% of world aquaculture production.

In the developing countries, however, production continued to expand. In the low-income-food-deficit-countries(LIFDCs) generally, production rose sharply at an average annual rate of 17% or 19.1 million tones of world production of fin-fish, shellfish and aquatic plants.

In addition, the number of species under culture continues to grow likewise the number of countries reporting aquaculture production. However, few species still dominate aquatic production. Such species like carps in China and India; and oysters and mussels in Japan, the republic of Korea and France. Thus global aquaculture continued to be dominated in both weight and value by freshwater fin-fish production (Andre et al., 1996).

2.6 Fisheries in the Sub-Saharan Economy

Fisheries play an important role in many sub-Saharan African countries as a major contributor to annual protein supplies, a foreign exchange earner and a generator of rural employment. An estimated eight million people are directly or indirectly employed in the sector. Total production by the countries of the region amounted to 3.9 million tones in 1994 (excluding the production of foreign fleets that was not landed in the region). Food fish consumption has declined recently, from an average per caput supply of about 9 kg in 1990 to less than 7 kg in 1994 (Live weight equivalent). The overall trade balance of the region has been positive (in value terms) for the past decade even though the region plays only a marginal role in international trade (FAO, 1996).

Marine capture fisheries make up almost 60 % of regional fish production and attained some 4.2 million tones in 1994, including 2.3 million tones by regions fleets and 1.8 million tones caught by foreign vessels. Fisheries are concentrated in four main areas. These are in the South which includes the waters of Angola, Namibia and South Africa. Cape lakes provide the highest catch volumes. In the Central Zone, from Gabon to Guinea, resources are less abundant. The larger trigger fish stock has now virtually disappeared. In the Eastern Coast of Africa, catches represent less than ten percent of the total regional harvest(foreign and domestic production combined). In the Western Coast, small pelagic are less abundant than off the western coast. Most fin-fish species and crustaceans are intensively fished, except off Somalia and Eritrea.

Almost half of total regional marine production is still harvested by foreign fleets, mostly in the Atlantic ocean, even though their catches have been declining rapidly over the last few years(FAO, 1990).

The inland water capture fisheries production has increased over the past decade at an annual rate of about 3.5 %, attaining 1.6 million tones in 1994 and representing over 40 % of total regional fish production. The main species include Nile perch, Tilapia and Catfish.

Aquaculture though not a traditional practice as it is in Asia, is starting to expand in Africa (FAO,1996). Still, the continent contributes only 0.2% of total global production and several countries have only incipient or erratic aquaculture production. A total of 33,000 tones of fish were produced by the region's aquaculture in 1994 (FAO, 1995). Only Kenya, Madagascar, Nigeria, South Africa and Zambia produced more than 1000 tones each, but these countries have doubled their annual production several times over the last ten years.

The major species cultured include fin-fish (Tilapia, Catfish, Carp), molluscs and shrimp. Fresh water fish make up over 80% of the total aquaculture harvest and almost all sub-Saharan fish farming is carried out by subsistence rural operators in small freshwater ponds as a secondary activity to agriculture.

2.7 Fisheries Products and Markets in Sub-Saharan Africa

Fish is a popular food item in sub-Saharan Africa and provides 18% of total animal protein intake, with a share as high a 40 to 60% in some West African states. It is often consumed in small amounts with daily meals, which otherwise consist mainly of staple starch food items. Since most parts of the fish are eaten, it also contributes significantly to calcium and iodine supplies.

According to FAO statistics, fish consumption has declined by more than 2 kg per person annually over the past few years from a per caput supply of 8.8 kg in 1984 to 6.8 kg in 1994 (Live-weight equivalent). This is owing mainly to rapid population growth, a drop in imports aggravated by the weaker purchasing power of some countries bordering the Gulf of Guinea and the ever-smaller share of domestic production retained for local markets as artisanal fisheries increasingly turn to lucrative export markets.

Locally produced fishery products are generally marketed fresh, smoked-and-dried or salted-and-dried. Consumers prefer fresh products and about one-half of the consumption volume consists of fresh fin-fish, although, owing to transport difficulties, fresh products are usually available only near production centers (FAO, 1996).

On the outlook for the future, the United Nations projected population growth indicate a regional population of 700 million by the year 2000 and 915 million by 2010. Assuming current levels of per caput food fish consumption, an increase of total supplies in the order of 2 million tones would be needed to meet demand in 2010.

The main future possibilities for increasing food fish supplies in the Sub-Saharan Africa region include productivity enhancement, better utilization of small pelagic fish, relocation of foreign fleets and increased imports (FAO, 1996). Further gains could be obtained by implementing sound fisheries management regimes, reducing discards from industrial fisheries and better post-harvest handling practices and distribution networks. Given the above, the future prospects appear rather poor.

2.8 Aquaculture in Nigeria.

Fish culture in Nigeria, although becoming attractive is still at its infancy and fish production from this sector is only a minuscule of its potential. It has been estimated that over 1.5 million hectares of aquatic area is available for fish culture in Nigeria(Ajayi and Talabi, 1984). Fish farms are widely distributed and can be found in all the states of the Federation. The ponds are fed usually from streams and rivers but occasionally from bore-holes. The ponds can be barrage type, diversion or excavated type. The culture technique is either monoculture or polyculture. The ponds are maintained in most cases under an extensive management regime but a few intensively managed ponds exist.

Extensive surveys and reports of fish farms in many states had been made by the Federal Agricultural Co-ordinating Unit. Several constraints were identified as impeding rapid development of aquaculture in Nigeria and these must be tackled before Nigeria can make desired advancements(Ajayi and Talabi, 1984).

2.9 Species Combination and Stocking Density in Nigeria.

In Nigeria, some progress have been made in the culture of some indigenous and a few exotic fish species(Madu, 1986). Notable is the culture of Tilapia whose excessive breeding is an undesirable trait in an intensive system. In ponds therefore, some means are employed to control or prevent the breeding of fish with high breeding rate (Tilapia) after stocking. These are stocked with predatory fish species like Nile perch or mud-fish or male fish only. They are stocked into the pond by hand selection of large finger-lings or by crossing two closely related species to produce all-male hybrids.

2.10 Commonly Cultured Fish Species in Nigeria.

Nigeria is blessed with a number of fish species that are of commercial values and able to grow well in fish-ponds. Some fish(Plates 1 &2) that live in fresh water (Rivers, and lakes) that can be culture include the following;

Common Name		Local name (Hausa)
Tilapia (Boney fish)	-	Karfasa/Gargasa
Mud Cat-fish	-	Kulumi/Tarwada
Common Carp	-	Dubi
Red mud cat-fish	-	Ramboshi
Niger perch	-	Giwan ruwa/Wuri
African bony tongue	-	Balli
Trunk fish	-	Yauni

The common names of species that can be cultured in brackish water ponds (Lagoons) include:

i. Flat head grey mullet

ii. Tilapia

iii. Atlantic tarpon

iv. West African Lady Fish

The common names of species that can be cultured in brackish water ponds (Lagoons) include:

i. Flat head grey mullet

ii. Tilapia

iii. Atlantic tarpon

iv. West African Lady Fish

The finger-lings of these fish species can be collected from rivers, lakes, etc or purchased from fish hatcheries. Some of these fish species have certain qualities that make culturing them interesting to farmers. These include:

i. Fast growth
ii. Acceptance of locally available feeds like rice bran, corn bran, cotton seed cake, palm kernel cake, groundnut cake etc.
iii. They resist disease readily in water.

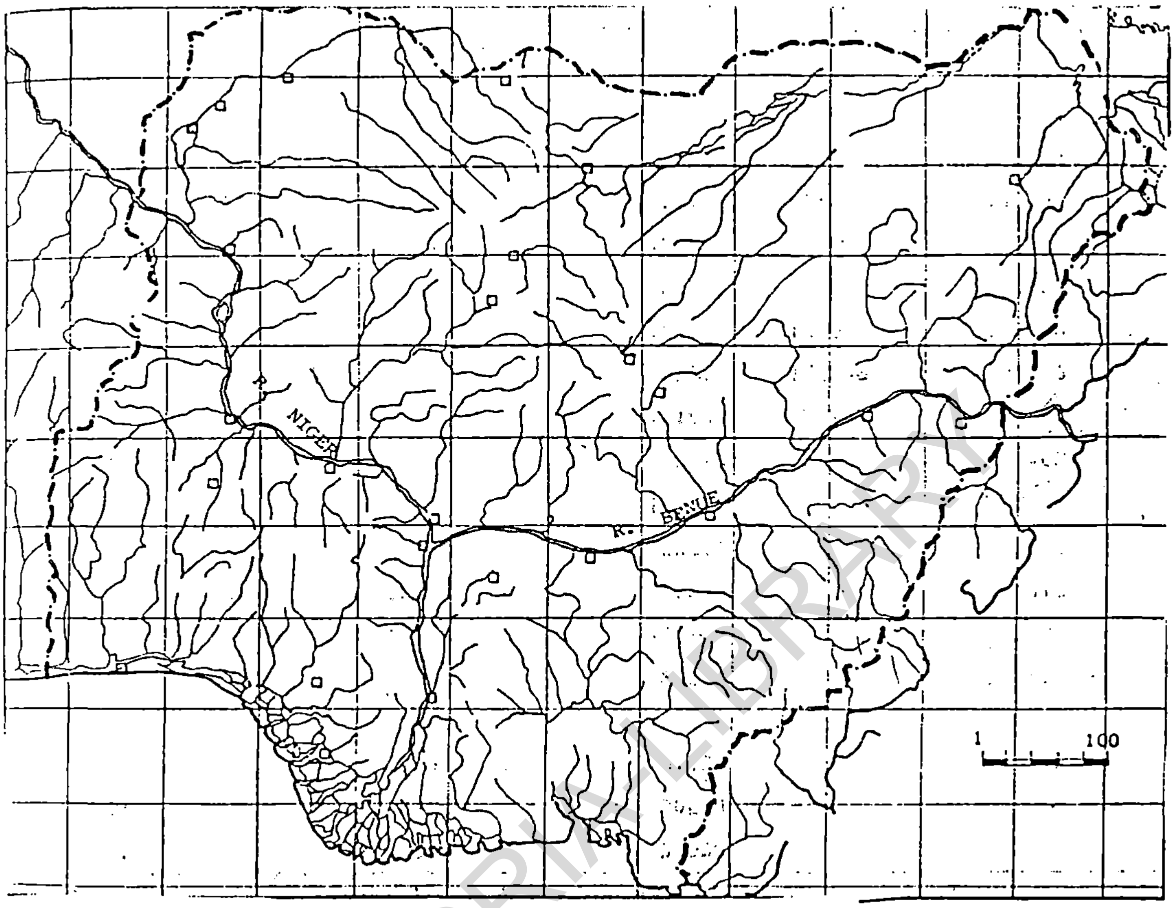

Figure 2: The spread and coverage of rivers and distributories in Nigeria.
Source: Adeleye, 1992.

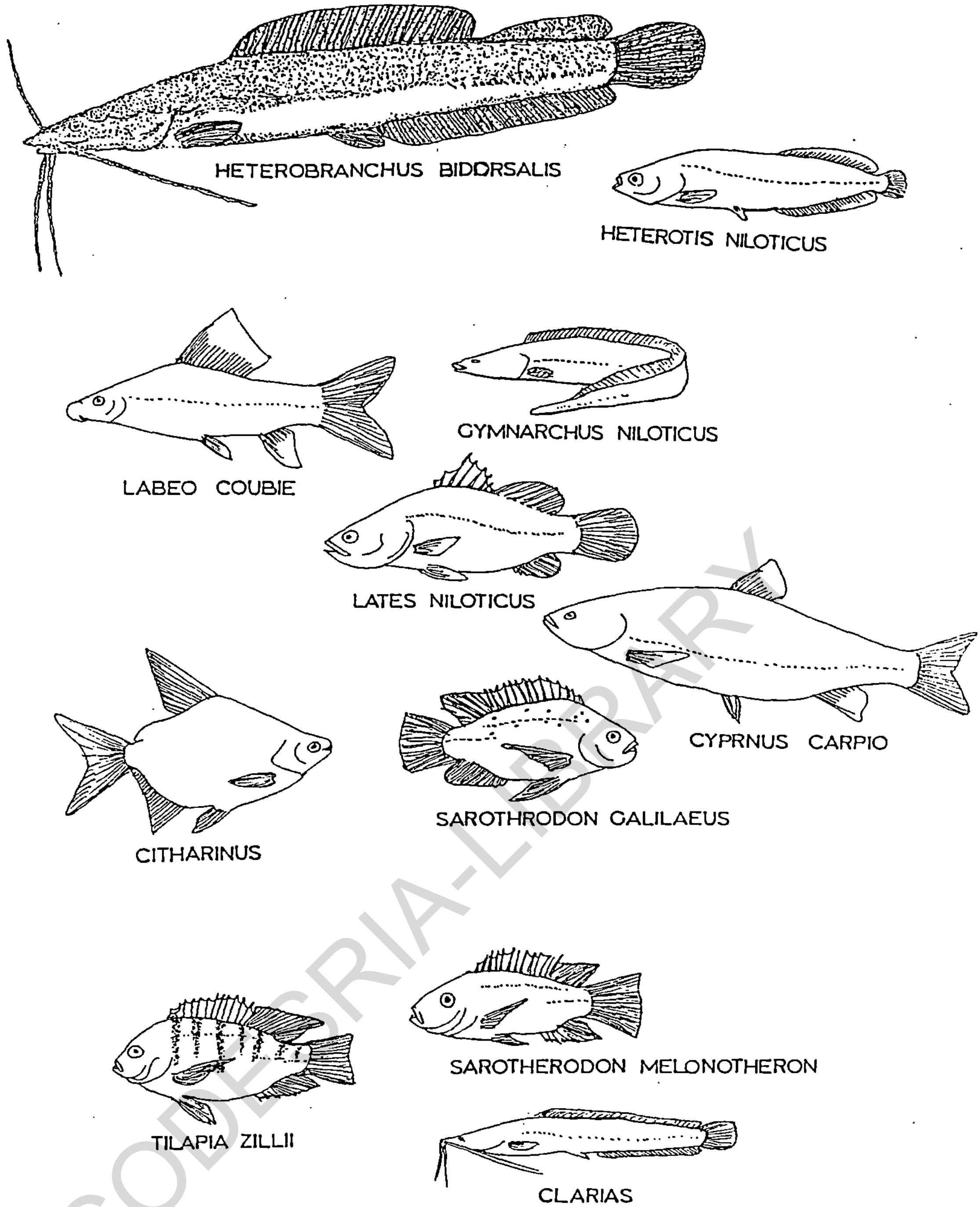

PLATE 1: SOME COMMONLY CULTURED FRESHWATER FISH SPECIES

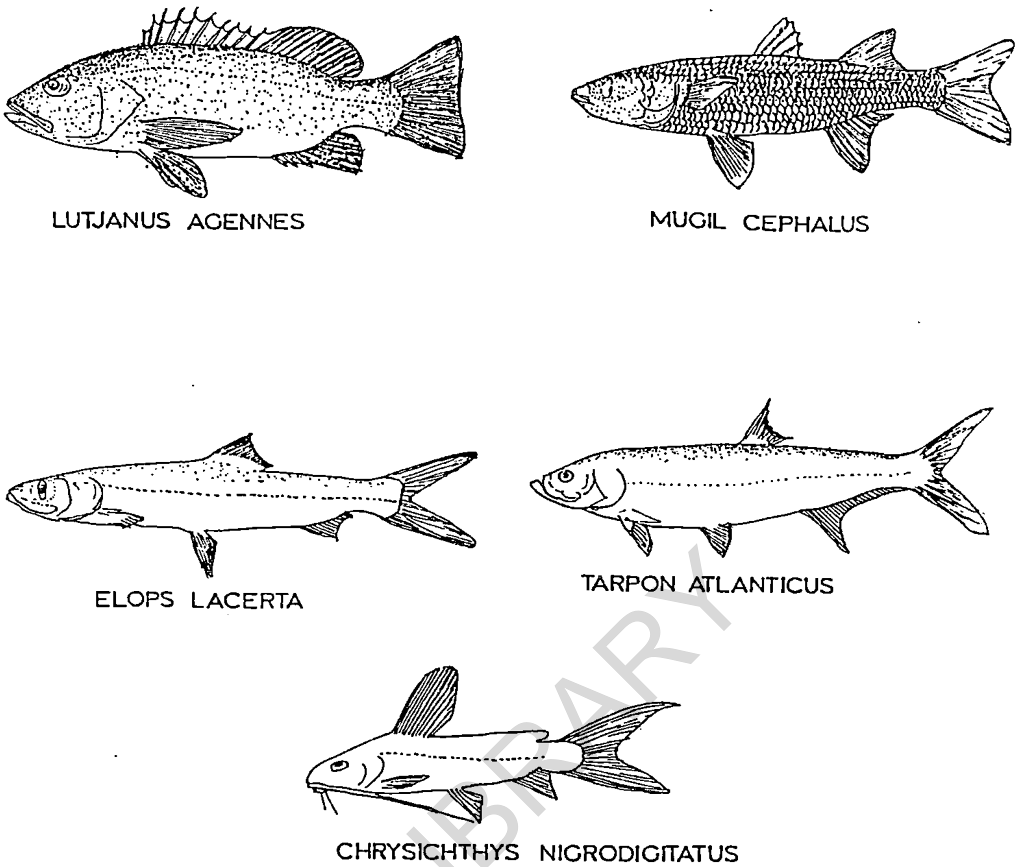

PLATE 2: SOME COMMONLY CULTURED FISH SPECIES IN BRACKISH WATER.

iv. If the water is accidentally contaminated (but not heavily polluted) they still survive.

V. They attract low production cost.

The review showed that aquaculture is a profitable venture in many countries of the world. It has been able to present some analytical framework of other studies too. It revealed that the use of some statistical tools such as regression analysis and sensitivity analysis were not fully exploited by previous researchers in aquaculture especially in Nigeria. This study will be a departure from this trend. The next section is devoted to the methodology used in the study and a description of the study area.

CHAPTER 3

METHODOLOGY

3.1 The Study Area

The area of study is Kano State of Nigeria. Kano State is in the northern Guinea and Sudan savanna ecological zone in northern Nigeria. The zone stretches from the Sokoto plain through the northern section of the high plains of the Chad Basin. It consist mainly of mature woodland with a fairly uniform structures of two distinct types associated with short grasses (KNRDA, 1994). Little traces of natural vegetation is said to remain as large areas are continuously cultivated. However, the zone provides the most favorable condition for the production of crop, livestock and fish.

Kano State lies between latitudes 10° 35' N and 12° 40' N of equation and longitudes 7° 42' E and 9° 15' E of Greenwich and occupies a land area of about 20,000 square kilometers(Fig. 3). The state is bordered in the north by Jigawa state, in the south by Bauchi and Kaduna states and in the west by Kaduna and Katsina states. The climate is characterized by two distinct seasons, the dry season which spans from October to May with a dry harmattan period between December and January. A temperature of about 10 °C could be recorded during the harmattan period. The rainy season is concentrated in the months of June to September and rains are preceded by violent dust and storm followed by rainstorms especially in the beginning of the rainy season of the month of May and the end of the season in the month of October. The mean daily maximum temperatures are 33.1 °C and 15.85 °C, respectively for the two seasons.

The state has a generally undulating topography, sloping to the east with physiographical uniform appearance. The soil pattern could be classified as granite basement complex in the north, pre-cambial rocks in the eastern part and smooth rounded inselberg in the southern and western parts of the state. These rocks are often covered by a thin sheet of laterite and in the areas that experience the yearly flooding, such basements are covered by rich alluvial soil annually deposited (KNARDA, 1994).

The vegetation is characterized by Guinea grassland. Crops cultivated under rain-fed condition are millet, sorghum, cowpea, groundnut, beans, cassava, cotton and maize. In the dry season, crops cultivated especially in the *fadamas* and some large-scale irrigation schemes in the state are: onions, tomatoes and sugarcane.

The state has a network of the Hadejia, Kano, Armatal and Jattan rivers. Other rivers within the system are River Jakara, Tomas and Gari that drain the northern part of the states and River Dudurum Gaya in the south-eastern part of the state. These river systems with their network of small streams provide considerable water resources for fisheries development. There are a total of over 41 reservoirs with an estimated total water surface area of 41.72ha. There are about 25 private fish farms (KNARDA, 1994).

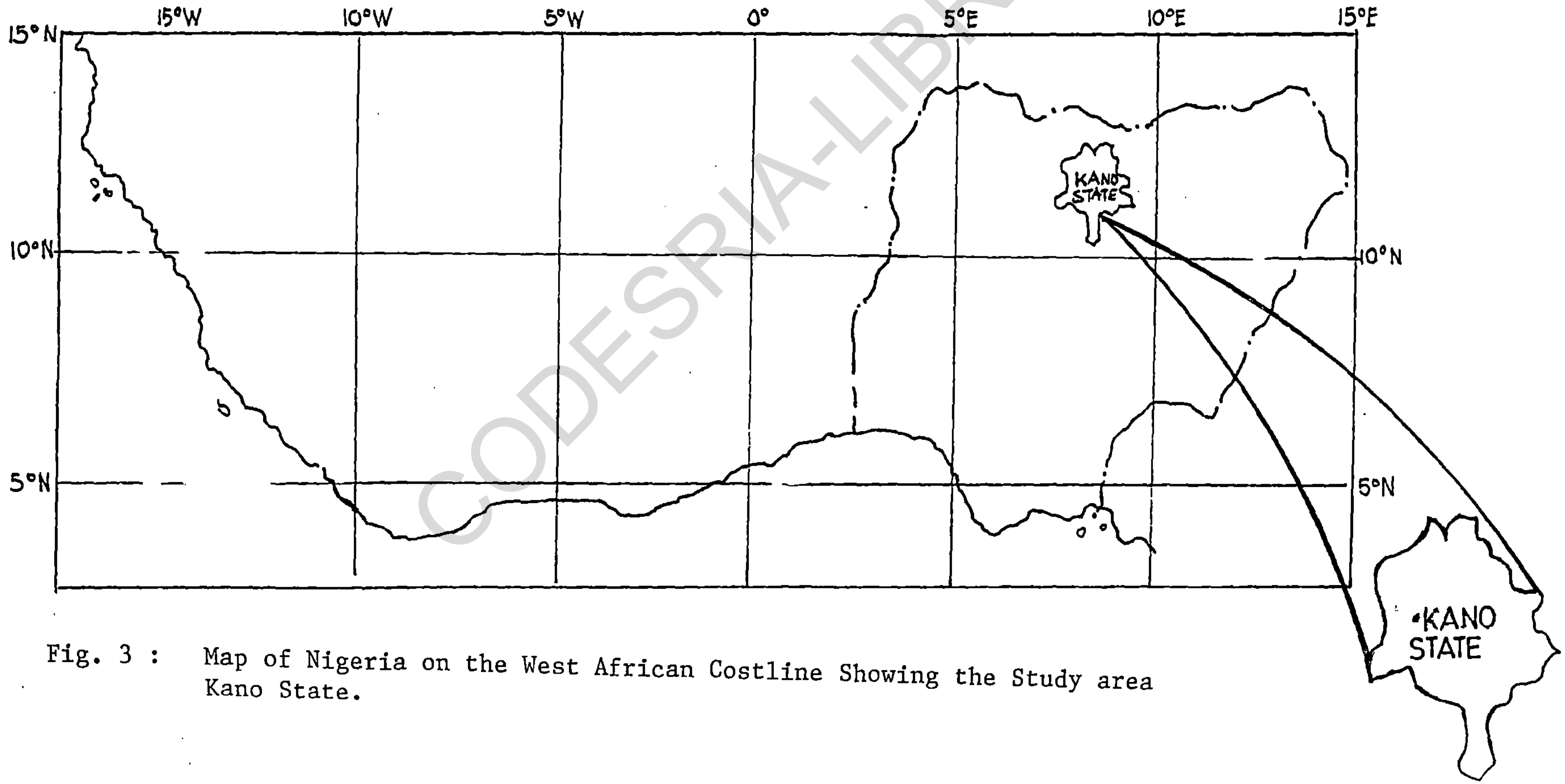

Fig. 3 : Map of Nigeria on the West African Costline Showing the Study area Kano State.

3.2 Data Collection

Both primary and secondary sources of data were relied upon for this study. Primary data were collected from ten private fish farms and four public fish farms using structured questionnaire administered in a single visit to each farm. The questionnaire was designed so as to capture such variables as size of pond, fish species stocked, population of stock, quantity of feeds used, fertilizer (organic/inorganic) used, labour cost, output in kilogram of each species, income from sale of harvest, markets for input and outputs.

Secondary data were collected from the head office and zonal office of Kano State Agricultural and Rural Development Authority (KNARDA) and other institutes such as the Kano State Ministry of Agriculture Fisheries Unit, Hadejia-Jamare River Basin Development Authority, National Agricultural Extension and Research Liaison Services (NAERLS), National Institute for Fresh-water Fisheries Research (NIFFR) field station, and Water Resources Engineering Construction Company (WRECA). Information about fishing in the state was collected from these establishments. This is because they are in constant touch with fish farmers in the state and are able to provide relevant information about their practices. Information provided helped in assessing the adoption of improved technologies in fish farming by farmers in the state. Table 4 shows the distribution of the respondents by Agricultural Development Project(ADP) Zones in the state.

Table 4: Distribution of respondents by ADP Zone

ADP Zone	Freq.	%
Gaya	3	21.3
Danbata	6	42.8
Rano	5	35.7
Total	14	100

Source: Survey data, 1999.

3.3 Sampling Technique

There are 25 fish-farms made up of eighteen and seven privately and publicly owned farms respectively in the state . From this, a sample of fourteen farms made up of ten private and four public farms were selected randomly. The first group consisting of ten private farms were randomly selected from the eighteen privately owned farms and four farms were randomly selected from the seven public ones. Numbers were thus assigned to each farm in each group and randomly selected the required number.

3.4 Analytical Frame Work

The analytical tools used in achieving the research objectives in this study include simple descriptive statistics, farm business analysis, production function and sensitivity analysis.

1. Descriptive statistics

To achieve objectives 1 and 2, simple descriptive statistics such as averages, percentages and range were used. This was also used to describe the marketing system of inputs and outputs in the area.

2. Farm business analysis

This was used to achieve objectives 3 and 6. It was used to show the levels of costs, return and net profit that accrue to aquaclture in the state. Different combinations of species and stocking densities exist in aquaculture. The profitability of three of these combinations were determined.

The net farm income is often used as an indicator of the strength and weakness of any farm business. It is the difference between the total revenue and total cost of production. The revenue items include sales from fish production while the cost items include the fixed and variable costs. The fixed cost include rents, tax, insurance premiums, salaries, interest on loans, and depreciation on equipment (straight line method was used). Items of variable cost include cost of seed, feed, fertilizer and veterinary services.

3. Regression analysis

Regression analysis was used to achieve objectives 4 and 5. Estimating regression equation produces useful quantities that include the marginal products of fishing inputs, and the input elasticity, which is the percentage change in output (yield) due to a 1% change in the quantity of the input used.

The function is implicitly specified as follows:

$$\phi = f(\propto_1, \propto_2, \propto_3, \propto_4, \propto_5, \propto_6, \propto_7, \propto_8, \propto_9, u)$$

Where

$\oint$ = Total fish output (kg)

$\propto_1$ = Labor (hrs)

$\propto_2$ = Number of (seed) finger lings stocked

$\propto_3$ = Number of species in pond

$\propto_4$ = Quantity of fertilizer (kg)

$\propto_5$ = Quantity of feed (kg)

$\propto_6$ = Size of pond (ha)

$\propto_7$ = Age of fish farmer (yrs)

$\propto_8$ = Fish farming experience (yrs)

$\propto_9$ = Quantity of Lime (kg)

$\propto_{10}$ = Membership of cooperative society (1= belong; 0=do not belong)

Various functional forms can be used (Heady and Dillon, 1964). Guides as to the selection of an appropriate form of or a particular situation are related essentially to three considerations. These are of the nature of the problems, the type of relationship deemed to exist between inputs and output, and the constraints or assumptions implied by the particular function. Any of single equation or simultaneous equation procedures can be used in estimating production function. However, most studies of farm productivity using cross-sectional data have used the single equation approach and the Ordinary Least Squares Estimate procedure.

The common statistical problems encountered in the estimation of production functions are related to the violation of the basic assumptions of the OLS model. Two such problems are simultaneous equation bias and specification error.

Single equation estimates are said to have simultaneous equation bias when the equation is a member of a system of equations, and some of the independent variables (besides the dependent variable) are functions of disturbance terms in the equations. Specification error on the other hand is a situation in which one or more of the following occur: exclusion of variables, using approximations in representing regressors, in appropriate aggregation of output and/or inputs, or committing various other sins of omission and commission (Griliches, 1957). Such errors can lead to a bias in the estimates of parameters and returns to scale.

The implication of such problems depends upon the cause of such problem. For instance, the effect of the omission of a relevant variable from an equation is dependent on the extent to which the excluded variable is correlated with any of the included variable, in that the estimated parameter of at least one of the included variable will be biased upwards if the excluded variable is positively correlated with any of the included variables. On the other hand, if negatively correlated, the bias would be downwards.

To reduce specification bias, the specification of a production function can be improved upon. This can be done by being very careful to ensure that the model does not over look quantity differences in inputs, and the relevant major variables are included prior to estimation. However, a common reason for committing a specification error is the lack of knowledge as to the correct specification of the regressions equation. Ramsey (1969) developed four tests to determine whether or not an equation has been mis-specified.

The ordinary least square estimate was adopted. Cobb-Douglas and linear functional forms were used for the analysis. Based on some statistical judgements that measures the goodness of fit, the Cobb-Douglas function gave the best fit. One major advantage of this functional form is the fact of its giving less loss of degrees of freedom when the parameters are many. Added to this is the ease of interpretation of result and computational ease.

It is given as follows:

$$\oint = a X_1^{a1} X_2^{a2}$$

which in log-linear form is as follows:

$$\text{In } \oint = \text{Ina}_o + a_1\ln X_1 + a_2\ln X_2 \quad \ldots\ldots 1$$

Where the variables are as defined above. Ownership pattern was observed not to have any significant effect on the model and was subsequently dropped too. The inclusion of this variable initially was to determine whether ownership pattern i.e. public or private ownership have any effect on resource utilization on the farm. In addition, a quadratic functional form was used in determining the optimum feed quantity in fish ponds.

4. **Sensitivity Analysis.**

The sustained ability of any economic system could better be assessed using sensitivity analysis. This was used to achieve objective 7. Sustainable agriculture is the science and art of cultivating crops and raising livestock to satisfy human needs(food, feed, fuel, shelter, clothing and medicine) while maintaining or even enhancing the natural resource base (land, water, flora, fauna and air). The concept is an Internet of three principles. First, human beings have a common destiny of interdependency with other living creatures. Second, the primary objective should render lives of most of the world population easier and more harmonious. Third, there is threshold of issues which transitional economies may not take into account (Obiefuna, 1999).

Thus sustainable agriculture involves intensifying production methods while reducing use of costly inputs. This is achieved by exploiting mutual cooperation between crops and livestock in space (rotation) and in time (rotation) and be cheap but effective techniques for soil and water management. Therefore for an agricultural production to be considered sustainable, it must be ecologically sound, socially just, humane and adaptable and economically viable. For the purpose of this study, economic viability is considered very critical while others are assumed given.

To determine the economic viability of any system, sensitivity analysis can be used among other tools. One of the main advantages of careful economic and financial analysis of a project is that it may be used to test what happens to earning capacity in case something goes wrong. One can ask how sensitive is a project internal economic or financial return to increased or decreased prices? Reworking an analysis to see what happens under these changed circumstances is termed sensitivity analysis. This is one way of dealing with project uncertainties.

There are four main types of uncertainties namely: price, implementation, cost and output/yield uncertainties. For the purpose of this study, price uncertainty was used as a means of testing the sustainability of resource use in fish farming.

In sensitivity analysis, the calculations are repeated using the new estimates for one or another element of cost or return. A 25%, 30%, 40% and 100% price increases were assumed for various components of variable cost then leaving fixed cost and output price constant. The "what if" of a Lotus application software was used with the aid of a computer to determine the sustain ability of resources in the study area. However, since fish prices have not been changing so rapidly over the years (GLOBAL, 1998), it was assumed to be stable in the calculations.

Having presented the method of data collection and a description of the study area, we now proceed to the results and discussion of the data collected and analyzed.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Socio-economic Characteristics of Respondents.

In this section, some important characteristics of the respondents that are relevant to this study are presented.

4.1.1 Age Distribution of Respondents.

The mean age of respondents was 46 years. The distribution is as presented in Table 5. From the table, majority (64%) of the fish farmers were above the average age of all the respondents. Thus most of the decision taken by the farmers are likely to be rational in line with Hill (1972) who reported that the age of a farmer could influence his/her farm allocative decision, performance and productivity.

4.1.2 Fish Farming Experience

Though capture fishing has been long in existence in the state, aquaculture seems to be a recent development. From Table 5, most (78.5%) of the respondents have not more than ten years of fish farming experience. Only about 21.4% had fish farming (aquaculture) experience of between 11 and 15 years. This confirms earlier assertion of (FACU, 1994) that aquaculture is still at a young stage in the state. It implies that aquaculture in the state should be expected to expand in the nearest future when many of the farmers may have acquired appreciable experience in fish farming.

4.1.3 Membership of Cooperative Societies

Membership of cooperative societies has generally been accepted by researchers as a means of assisting farmers to increase productivity. This is due to better access to farm inputs and credits. This is because through the societies, some farmers could better be able to pool their resources together. From the survey, majority of the respondents (64.3%) do not belong to any fish co-operative society in the state (Table 5).

This is not a welcome development as it will not enable farmers to make the best use of all opportunities available to them if they had belonged to any co-operative society.

4.1.4 Pond Acquisition Pattern

From Table 5, 57.8% of the respondents inherited their ponds while only about 14.3% purchased theirs. This implies that the control of the pond as regards resource use and allocation is wholly vested in the fish farmers. Land is communally owned in the state with individuals possessing rights to the piece of land he owned.

Land is the most valuable physical assets of the rural agricultural population. It is important for individual farmers to acquire enough land for their farming purposes.

4.2 Background Information on Ponds.

Of all the farms studied, 10 (71.4%) are privately owned (Table 6). The remaining 28.5% being publicly owned. The pattern of ownership could affect the management of resources on the farms.

Table 5. Socio-economic characteristics of respondents

Variable	Freq.	%		Mean
Age (yrs)				
≤31	2	14.3	-	
32-41	3	21.4	-	
42-51	0	0.0	-	
≥52	9	64.3	-	
Total	14	100.00		46.2
Fish farming Experience (Yrs)				
≤5	5	35.7	-	
6-10	6	42.8	-	
11-15	3	21.4	-	
Total	14	100.0	7.35	
Membership of cooperative Societies				
No	9	64.3		
Yes	5	35.7		
Total	14	100.0		
Pond acquisition Pattern				
Inheritance	8	57.1		
Purchase	2	14.3		
Government	4	28.5		
Total	14	100.0		

Source: Field Survey, 1999

Table 6: Background information on ponds

Variable	Freq.	%	
Ownership Pattern			
Private	10	71.4	
Public	4	28.5	
Total	14	100.0	
Year of Experience			Mean
<5	5	35.7	
6-10	6	42.8	
>11	3	21.4	
Total	14	100.0	6.2
Pond size (ha)			Mean
<0.5	8	57.1	
0.6-1.0	3	21.4	
>1.1	3	21.4	
Total	14	100.0	0.8
Source of Water			
Reservoir	11	78.6	
River	3	21.4	
Total	14	100.0	

Source: Field Survey, 1999

Majority of the fish ponds (78.5%) were established less than ten years ago. Only 21.4% have been in existence for more than ten years (Table 5). With these ages of the ponds, it is expected that they will afford the managers enough experience for profitable fish farming.

Ponds are considerably small sized. Majority are less than one hectare. (Table 7). This is in agreement with previous authors (FACU, 1994) who said that aquaculture was practised on a small scale in the state. This is similar to what obtains in crop production in Nigeria whereby it is still in the hands of small-holder farmers.

On the sources of water, 78.6% (Fig. 4) got their water supply from reservoirs while only 21.4% got theirs from rivers. These reservoirs are as a result of the river systems and its network in the state. The rivers and streams have been harnessed to form about 41 reservoirs and man-made-lakes in the state. These reservoirs form about 41.74 ha of total water surface area which could be harnessed for fishing purposes.

4.3 **Fish Farming Information.**

Mono-culture the practice of farming one specie of fish was not found among the aquaculturists in the state. The commonly practised system was poly-culture. The average number of specie kept by the farmers was three. The common combination

Table 7: Information on fish stocking in ponds

Variable	Freq.	%	Mean
Species kept per Cropping			
2	3	21.4	
3	3	21.4	
4	8	57.1	
Total	14	100.0	3
Species kept			
Tilapia Oreochrromis niloticus	14	100	
Mud-fish Clarias gariepinus	14	100	
Red-mud fish Heterobranchus bidorsalis	6	42.8	
Niger Perch Lates Niloticus	3	21.4	
Bagrus Bagrus bayad	6	42.8	
Clarotis Clarotis lenticeps	2	14.2	
Synodontis	2	14.2	
Source of Fry/seeds			
Hatchery	3	21.4	
River	11	78.6	
Total	14	100	

Source: Field Survey, 1999.

was four species per pond which was practised by 57.1% of the respondents. Three and two species combinations were practised by 21.4% of the respondents respectively. The common advantage was that different fish species have different feeding regimes. While some feed at the bottom of the pond, others feed at the top layer. Resources on the ponds especially feeds could thus be maximally utilized.

Since no single fish specie could adequately utilise the feed in a pond, it is more economical to practise polyculture. It thus becomes more appropriate for the different fish species that live in different ecological niches in the ponds.

All the aquaculturists grew both Tilapia and Clarias. Thus the two commonly grown fish species were Tilapia and Clarias. These were followed by Red mud-fish *Heterobranchus* and Bagrus which were grown by 42.8% respectively of the respondents. Niger perch *Lates niloticus* and Clarotis came last with only 21.4% and 14.2% of the farmers growing them, respectively (Table 6).

On their sources of seeds, majority (78.6%) of the farmers got their seeds from the wild i.e. rivers while only about 21.4% got their seeds from hatcheries(Fig. 5). This testifies to the fact that there were no adequate hatcheries in the state. The Bagauda hatchery complex, a state government outfit, for example, is presently operating below its installed capacity. Farmers cover an average of 38 kilometre in order to get their seed.

4.4 Cropping Per Year

Of great importance is the number of cropping per year. The cropping regime per year determines to a large extent the fish output from each pond. From Figure 6, 35.7% of the aquaculturists practised two cropping per year, while others cropped once, thrice and four times per annum. This is to take advantage of the maturity period of the fish and the period it takes to reach market size weights by fishes. However, too frequent harvesting could lead to small undersized fishes. The major reasons given by farmers for this regime include: availability of fry (42.9%) and optimisation of production (35.7%).

4.5 Mortality Rate

The rate of mortality determines to a large extent the final output obtainable from each pond. Farmers who experienced between 3 and 5% mortality rate were 35.7% while those with about 10 percent mortality were just 21.4% of all the farmers. It is best to keep the mortality rate as low as possible for maximum output and profit. This could be done by proper handling of finger-lings in transit and good management practices.

Three major reasons were given for the mortality rates(Table 8). These are: sudden changes in weather (35.7%), lack of proper feed (21.4%) and water pollution (21.4%). While some factors could be controlled by the farmers, others are beyond the farmer's control especially water pollution from industrial wastes. It is therefore important that the appropriate organ of the state responsible for environmental protection be contacted to prevent water pollution by industrialists in the state. Proper feeding and management practices could be ensured to reduce the mortality of fish in ponds.

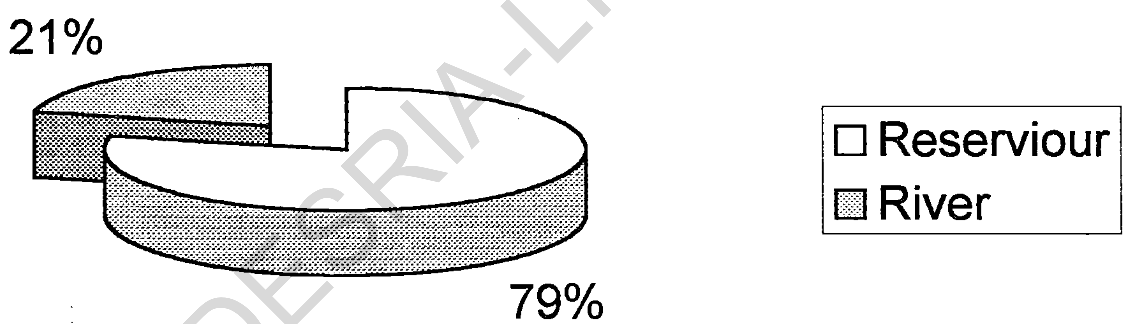

Fig. 4:Distribution of Respondents by Source of Water

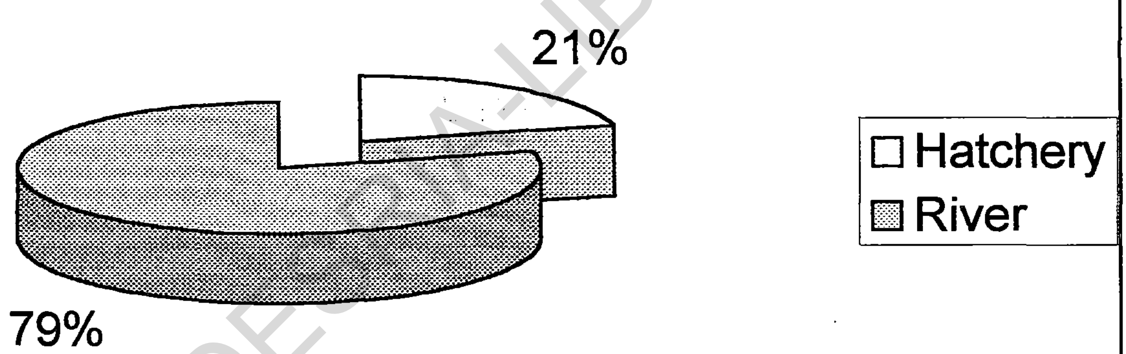

Fig. 5:Source of Fry/Seeds

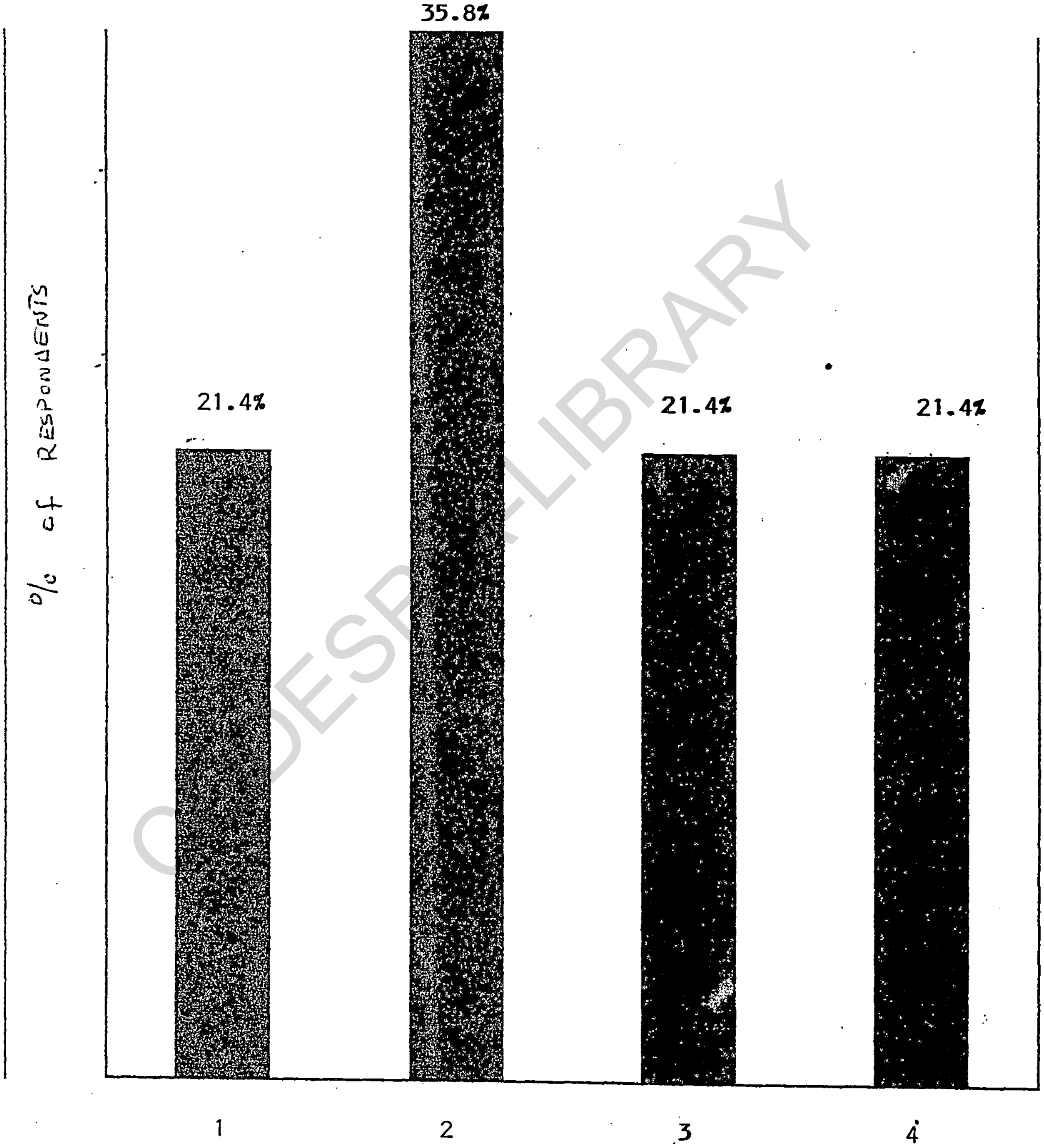

FIG. 7: NUMBER OF CROPPING/YEAR

Table 8. Reasons for mortality of fish

Reason	Freq.	%
Sudden changes in weather	5	35.7
Lack of proper feed	3	21.4
Water pollution	3	21.4

Source: Field survey, 1999

4.6 Harvest per cropping

Over 50% of the respondents harvested their fish twice per cropping and 42.9% harvested once per cropping. This harvesting regime is important in order to prevent harvesting undersized fish in a multiple harvest per crop.

4.7 Feed and supplementary feeding

Feeds and/or fertilizer are probably the most important cost items in aquaculture (Shang, 1976). On the average, a total of 781.25 kg of feed was used per hectare per cropping by the farmers. This is low when compared with recommended quantity of about 1500 kg by Nigerian Institute for Fresh-water Fisheries Research(NIFFR) in 1996.

Table 9 shows the distribution of farmers by the quantity of feed per hectare. From the table, 54% of the respondents fed their fish with 300 kg of feed per cropping per hectare. The price per kilogram of feed was ₦5.00 for all the fish farmers. This is because all of the farmers bought their feed from the open market (in Kano town). All the farmers interviewed fed their fish twice daily. This is in line with recommendations (NIFFR, 1996).

Table 9: Distribution of respondents by weight of fish feeds (Kg/ha)

Feed Quantity(kg/ha)	Freq.	%	Mean
<100	2	14.3	
100-200	6	42.9	
>250	6	42.9	
Total	14	100.0	781.25

Source: Field survey, 1999.

On supplementary feeding, only 14.3% of the respondents gave supplementary feeding to their fish. A total of 22.25 kg of supplementary feed per hectare was given to fish. The feed used include rice bran, millet bran as supplementary feed.

Application of fertilizer (organic and inorganic) helps in production of plankton that fish prefer as food and this increase yields in ponds (Shang, 1976). Farmers in the area applied an average of 8.75 kg inorganic fertilizer per hectare per month in their fish ponds. This amount is low when compared with recommended quantity of 55 kg/ha/month(NIFFR, 1996). Fertilization is often done twice per cropping and purchased to fertilize their ponds. This attitude of non fertilization may be as a result of competing uses of inorganic fertilizers for the cultivation of crops. Sinka (1977) has observed an average production of more than three times normal yield for Tilapia ponds irrigated with domestic sewage. Liming as a type of fertilization was done by farmers with an average of 12.9kg per hectare. The lime was purchased from the open market and applied once per cropping.

4.8 Harvest and Harvesting Schedule

Harvesting was done twice by most of the farmers interviewed. The reason for this schedule was to maximise output since various species of fish do not reach market size at the same time. An average of 689.3 kg of fish was harvested per hectare of fish pond.

). However, majority (64.2%) of the farmers had yield below the average. On the disposal of produce, it was observed that only about 68% of the produce was actually sold by farmers(Table 11), while 16.3% and 15.6% were given out as gift and eaten respectively (figure 7). Thus fish farming in the study area could be concluded as not yet being fully commercialised.

The yield obtained was low when compared with an average of 2.5 metric tonnes obtainable else where. This further confirms the fact that aquaculture is yet to be well developed in the study area. There is the need to practise improved technologies. These include growing of improved varieties, proper management of pond and keeping of farm records.

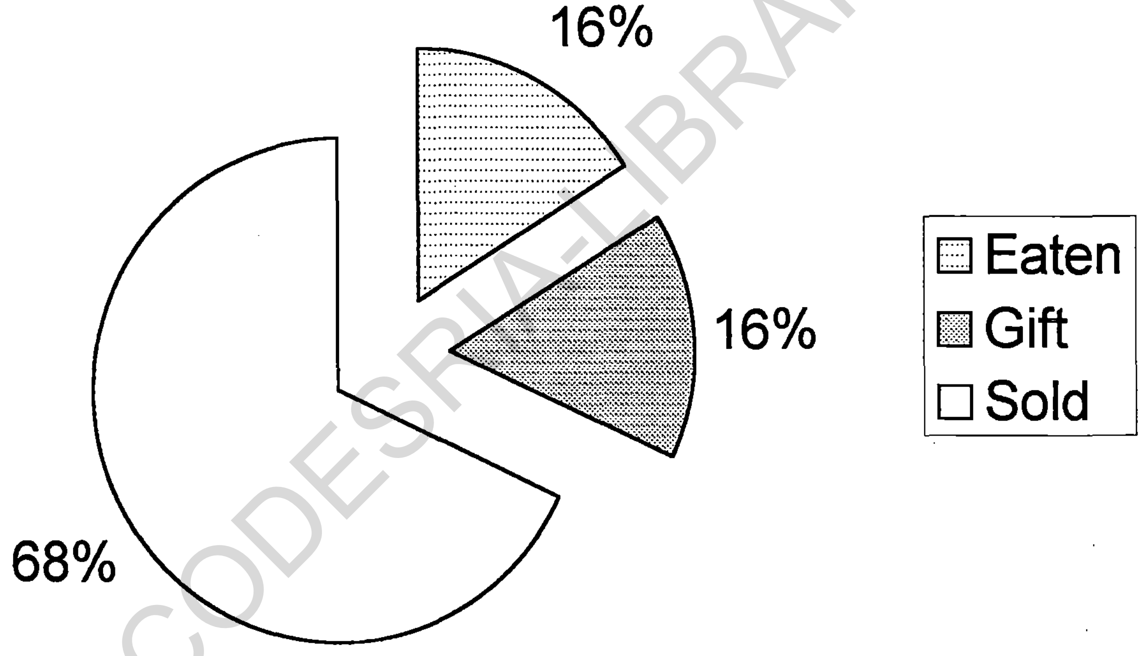

Fig. 7:Distribution of Produce

Table 10: Distribution of farmers by the quantity of harvest per hectare (in Kg)

Quantity(Kg)	Frequency(Kg)	Percentage	Mean
<500	9	64.2	
501-1000	2	14.3	
>1001	3	21.4	689.3
Total	14	100	

Source: Field Survey, 1999

Table 11: Distribution of respondents' produce

	Weight(Kg)	Percentage
Total output	689.31	100
Sold	468.94	68
Eaten	107.55	15.6
Gift	112.8	16.3

Source: Field Survey, 1999

4.9 Market and Marketing of fish

Most of the farmers purchased their inputs such as nets, lime and feeds from the open market. Some farmers (21.4%) travel up to 90 kilometres to hatcheries to purchase fry/seeds for their ponds. Depending on the species, prices ranged from ₦5.00 per finger-ling/fry of <u>Tilapia</u> to ₦15.00 per finger-ling for <u>Clarias</u>. However, some farmers go to the wild (rivers) to source for their fingerling/fry.

Prices for other various inputs were fairly uniform since they are sold in competitive market. For the lime, one kilogram sold for ₦20 in all the markets on the average. Fertiliser was sold at ₦30.00 per kilogram and feed was sold at ₦5.00 per kilogram. It could thus be concluded that the market for inputs is well developed in the state. This cannot however, be said of the produce.

Farmers were observed to be selling their produce on the farm. One kilogram of <u>Tilapia</u> sold for between ₦20 and ₦38.00 while the same quantity of <u>Clarias</u> sold for between ₦84.27 and ₦100.00 depending on the location. For <u>Clarotis</u>, one kilogram was sold for ₦86.1. It was observed that there are a high number of intermediaries between fish farmers and consumers in Kano State. Due to lack of storage facilities, many of the farmers had to sell their produce on the farm. This will not give farmers the maximum profit they ought to get from selling their produce if it was done in the open market. Icing of fresh fish is one important means of preserving fish for sale. Where there are no electricity for cold preservation, fish produce have to be disposed of as soon as harvested to prevent deterioration of the produce. This was done on the farms as soon as fish reach market weight.

However, a visit to the few fresh fish markets in Kano showed that fresh fish from Hadejia (Jigawa State) were sold in the markets in addition to those from Kano State. The major characteristic of fresh fish marketing in Kano State is the high specialization of various participants who include the processors, who buy and process fresh fish from farmers. The fish is then resold in the nearest primary market (Kano township) and along the major high ways without traveling long distances.

Participation of women in the marketing of fresh fish is very minimal. During the survey, no female marketer of fresh fish was observed. This is understandable given the culture of the predominantly Moslim Kano State. Fresh fish was observed to be preferred especially by a small group of the society i.e. the affluent ones. Traders thus target this group. Unsold fish is however often smoked to avoid spoilage of the product.

4.10 **Preferred Species**

Some of the farmers were observed to prefer to grow some species than the ones presently grown by them. Three species: Gymnarcus, Protopterops and Lates were preferred by the aquaculturists interviewed. About 21.4% of them preferred to grow Gymnacus and 14.3% preferred to grow either of both Protepterops and Lates.

The reasons given were: fast growth rate, hardiness and fast reproductive rates. However, they do not grow these species because of lack of fry in the locality. Farmers need to be enlightened on the various sources from where they could obtain their fry/seeds.

4.11 Costs and Returns in Aquaculture Production

4.11.1 Tilapia-Clarias

From Table 12a, The performance of public versus private enterprise (fish farm) is presented . There are speculations as to the fact that public enterprises are not well managed in terms of resource use compared with private ones. This was one of the reasons given for returning communal lands to individuals in the former Soviet Union. From the table, variable cost constituted the major cost component accounting for 73.3% and 97% of total cost in the public and private fish farms respectively. The difference was accounted for by the labour component. While labour cost was recorded as variable in the private farm, it was recorded as fixed in the public farm. The reason being that while salaries were paid for the labour on public farms, the private farms paid wages for labour. In addition, labour supply was mainly through family members and were often not paid for in the private sector. The opportunity cost of such labour were used in arriving at the cost of labour for the private farms.

Of the variable cost, seed cost was highest. It accounted for 55.9% and 51.3% of total cost or 76% and 52.8% of variable costs for the public and private farms respectively. The quantity of seeds per hectare in both farms were observed to be far below the recommended. Not only was this so, appropriate ratios of fish for combination as recommended (NIFFR, 1996) were not adhered to by farmers. Farmers were observed to adopt the ratio they could afford.

On returns, while the public fish farms made a profit of ₦24750.00 per hectare, the private sector made a profit of ₦25350.00 per hectare. However, for naira invested in the public sector, 21kobo was realized while the private farm was making 20kobo. On the other hand, private farmers were getting 6.7 kg of fish for each of kg of feed used as compared to the 4.88 kg realized by the public farms.

4.11.2 **Tilapia-Bagrus-Clarias**

Table 12b showed that while ₦92,250.00 was incurred as cost in the public farm, ₦90,740.00 was incurred on the private farms. Of this, variable cost was 65.6% of total cost on the public farm but was 98.9% in the private farm. The difference could be accounted for by the family labour which was recorded as a component of variable cost. Like in the case of the two-species combination, both categories of farms were observed not to adopt recommendations on right combination of species, thus they are not maximizing resource used in ponds. Fixed cost in both cases was 34% and 0.1% of total cost for the public and private fish farms respectively. The main reason been the cost of salary which was taken as fixed cost in the public farm.

On returns, public farms got ₦102,750.00 as gross income per hectare while the private farms got ₦106200.00. These translated to a profit of ₦10500.00 and ₦15460.00 per hectare for the public and private farms respectively.

Table 12a: Costs and returns in aquaculture poduction per hectare (<u>Tilapia</u>-<u>Clarias</u>) in Public and Private farms in Kano State

Public					Private		
Items	Unit Price(N)	Qty (Kg)	Value (N)	% of Total Cost	Qty (Kg)	Value (N)	% of Total Cost
A. Cost	-	-	-	-	-	-	-
i. Variable	-	-	-	-	-	-	-
- Labour	120	-	-	-	310 mandays	37200	29.3
- Feed	5	450kg	2,250	1.9	350	1750	1.3
- Seeds	-	-	-	-	-	-	-
Tilapia	5	4000	20,000	17.2	4000	2,000	15.8
Clarias	15	3000	45,000	38.7	3000	45,000	35.5
- Fertilizer	30	-	12,000	10.3	440	13.200	10.4
- Lime	20	300kg	6000	5.1	300	6000	4.7
- Others	-	-	-	-	-	-	-
Total variable cost	-	-	85250	73.3	-	123150	97.2
ii. Fixed							
- Salaries	-	-	-	-	-	-	-
- Depreciation	2,500	12months	30,000	25.8	-	-	-
- Taxes	-	-	-	-	-	-	-
- Int payments	-	-	-	-	-	-	-
- Others	-	-	-	-	-	-	-
Total fixed cost	-	-	-	-	-	2500	1.9
Total Cost	-	-	30,000	25.8	-	2500	1.9
	-	-	115250	100	-	125650	100
B. Return	-	-	-	-	-	-	-
- Tilapia	200	1000	20000	-	1050	21000	-
- Clarias	100	1200	120000	-	1300	130000	-
Gross Income	-	-	140000	-	-	151000	-
C. Net Income	-	-	24750	-	-	25,350	-
Rate of return on investment	-	-	0.21	-	-	0.20	-
Rate of Return on Operating Cost	-	-	0.21	-	-	0.20	
Production per kg of feed	-	-	4.88	-	-	6.7	-

Source: Survey data, 1999.

Table 12b: Costs and returns in aquaculture production per hectare (Tilapia - Bagrus-Clarias) in Public and Private farms in Kano State

Public					Private		
Items	Unit Price	Qty	Value	% of Total Cost	Qty	Value	% of Total Cost
A. Costs	-	-	-	-	-	-	-
i. Variable	-	-	-	-	-	-	-
- Labour	120	-	-	-	302mandays	36240	39.9
- Feed	5	750kg	3750	4.0	700kg	3500	3.9
- Seeds	-	-	-	-	-	-	-
Tilapia	5	3150	15750	17	3050	15250	16.7
Bagrus	5	570	11250	12.1	700	3500	3.9
Clarias	15	1200	18000	19.4	1300	19500	21.5
- Fertilizer	30	400kg	12000	12.9	400kg	12000	13.2
- Lime	-	-	-	-	-	-	-
- Others	-	-	-	-	-	-	-
Total variable Cost	-	-	60750	65.6	-	89990	98.9
	-	-	-	-	-	-	-
ii. Fixed	2500	12months	30000	32.4	-	-	-
- Salaries	-	-	1500	1.6	-	750	0.1
-Depreciation	-	-	-	-	-	-	-
- Taxes	-	-	-	-	-	-	-
- Int payment	-	-	-	-	-	-	-
- Others	-	-	31500	34.0	-	750	0.1
Total fixed cost	-	-	92250	100	-	90740	100
Total Cost							
B. Return	-	-	-	-	-	-	-
- Tilapia	20	900	18000	-	910	18200	-
- Bagrus	30	325	9750	-	300	9000	-
- Clarias	100	750	75000	-	790	79000	-
Gros Income	-	-	102750	-	-	106200	-
C. Net Income	-	-	10500	-	-	15460	-
Rate of return on Investment	-	-	0.11	-	-	0.17	-
Rate of return on Operating Cost	-	-	0.17	-	-	0.17	-
Production per kg of feed	-	-	2.6	-	-	2.8	-

Source: Survey data, 1999.

For every Naira invested therefore, the private fish farms realised 17 kobo while 11 kobo was realised by the public farms. Also, a kilogram of feed fed to the fish yield 2.6 kg and 2.8 kg of fish for the public and private farms respectively. It could thus be concluded that both private and public farms were making profits.

From Table 12c, variable costs constituted over 50% of total cost in all the three major types of aquaculture. This is typical of most fish production enterprises. Of the variable cost, seed/fry cost was highest being over 30% of total cost. Feed cost and cost of labour were next in importance. Fixed cost was very low when compared with variable cost. This implies that fish cultivation does not require much capital outlay on fixed assets. Farmers can therefore shift to other enterprise at short notice in any case of unforseen situations.

Labour wage was high. It however, could be reduced if labour is used in other complementary enterprise aside from aquaculture. Labour was used more in feeding of fish in ponds. The cost of seeds/fry was between 20% and 30% of total cost. This could be further reduced if farmers produce their own finger-lings. The cost outlay for one hectare of <u>Tilapia</u>-<u>Clarias</u> was the highest about ₦118,100.00 when compared to the other two combinations.

On returns, one hectare of fish farm yields a profit margin of ₦21,900.00, ₦17,610.00 and ₦4,389.00 for the two-, three- and four-species combination systems respectively. From the costs and returns table , the two-specie combination of Tilapia-Clarias had the highest profit per hectare among the three combination types. These translated to 18, 20 and 5 Kobo respectively, for every naira invested in the business for the two, three and four fish combinations. On further analysis, it shows that for every naira invested in operating cost, 27, 20 and 5 kobo were realized respectively for all the three types of fish specie combination. In physical quantities, every kilogram of feed led to 5.5, 2.6 and 1.6 kilogram of fish respectively for the two-, three- and four-specie combinations.

It could thus be concluded that aquaculture (polyculture) fish production as was being practised by the farmers was profitable in the state. It appears that the most profitable combination was Tilapia-Bagrus-Clarias followed by Tilapia-clarias and lastly, Tilapia-clarias-Clarotes-mudfish. When tested statistically, the profit margins were statistically different from each other with a t-value of 3.678 at 1% level of significance. It could thus be concluded that there is a significant difference in profitability among the various specie combinations in aquaculture in the study area. However, there was no significant difference between the profit margins of the private and the public farms with a t-value of -1.180. It could not be concluded that any of the two types are better managed than the other.

Table 12c: Cost and returns in aquaculture production (per hectare) all farms combined

		Tilapia-Clarias				Tilapia-Bagrus-Clarias			Tilapia-Clarias-Clarotes-mudfish		
Items	Unit Price ₦	Qty	Value ₦	% of Total cost	Qty	Value ₦	% of Total cost	Qty	Value ₦	% of Total cost
A. Costs										
i, Variable										
- Labour	-	-	-	-	302man days	36240	4.1	320man days	38400	43.2
- Feed	5	400kg	2000	1.6	750kg	3750	4.2	750	3750	4.2
- Seeds										
Tilapia	5	4000	20000	16.8	3100	15500	17.7	1787	8935	10.0
Clarias	15	3000	45000	37.8	1200	18000	20.0	930	13950	15.9
Bagrus	5	-	-	-	750	3750	4.2	-	-	-
Clarotes	10	-	-	-	-	-	-	915	9150	10.3
Mudfish	86	-	-	-	-	-	-	69	5934	6.7
- Fertilizer	30	420kg	12600	10.5	400	12000	13.7	250	7500	8.4
- Lime	20	300kg	6000	5.0	-	-	-			-
- Others	-	-	-		-	-	-	-	-	-
Total Var. Cost			85,600	71.9	-	85490	97.0	-	87619	98.6
						-	-	-	-	-
ii, Fixed										
- Salaries	2,500	12	30,000	25.2	-					
- Depreciation	-	-			-	1100	1.2	-	-	-
- Taxes	-	-			-	-	-	-		
- Interest payments	-	-			-	-	-	-	-	-
- Others	-	-	2500	2.1	-	500	0.6	-	1200	1.3
Total fixed cost								-	-	-
Total cost			32500	27.4	-	1600	1.8			-
			118100	100.0	-	87090	100	-	1200	1.3
								-	88819	100.0

B. Returns on output							
- Tilapia	20	1000	20000	905	18100	333	6660
- Clarias	100	1200	120000	770	77000	378	37800
- Bagrus	30	-	-	320	9600	-	-
- Clarotes	86	-	-	-	-	278	23908
- Mudfish	-	-	-	-	-	-	24840
Gross Income	-	-	140000		104700	276	93.208
Net Income			21900		17,610		4389
Rate of return on investment			0.18		0.20		0.05
Rate of Return on operating cost			0.27		0.20		0.05
Production per kg of feed			5.5		2.6		1.6

Source: Survey data, 1999.

4.12 Sensitivity Analysis

Given that prices could fluctuate depending on the market forces of demand and supply, the price of fish (both seed/finger-ling and market size) were kept constant. The price of feed which was a major component of cost was allowed to increase by 25%, 30%, 40% and 100% respectively. The effects on profit of these were thus examined and presented in Table 13a below.

Table 13a: Effect of feed price changes on Profit Margin(₦) in aquaculture fish production

	Level of price change			
Combination	**25%**	**30%**	**40%**	**100%**
Tilapia-Clarias	21,500	21,300	21,100	19,900
Tilapia-Bagrus-Clarias	16,672.5	16,485	16,110	13,860
Tilapia-Clarias-Clarotis-Mudfish	3451.5	3,264	2,889	639

Source: Survey data, 1999

From Table 13a, price changes in feed of up 100% level though led to a reduction in net income for the three categories of fish farming, there was positive net income recorded. Thus, it could be concluded that aquaculture is sustainable in the state with up to 100% increase in feed prices. In addition, when a combination of price increase on feed and fertilizer were assumed, a positive net profit was recorded for the two-and three species combinations (Table 13b). This was not the case with the four-species combination as the returns could not sustain the assumed price increase of 40% and 100% respectively.

Table 13b: Effects of feed and fertilizer price changes on Profit Margin (₦) in aquaculture fish production.

	Level of price increase (%)			
Species	25%	30%	40%	100%
Tilapia-Clarias	18980	17,520	16060	7300
Tilapia-Bagrus-Clarias	3672.5	12,885	11310	1860
Tilapia-Clarias-Clariotis-Mudfish	1576.5	1,014	(111)	(6861)

4.13 Determinants of Fish production and Resource-Use in ponds

Due to the low sample size, the independent variables were grouped into two. These are: socio-economic and technical factors. From Tables 14 to 16, four factors were observed to significantly affect the output of fish in the study area. These are: the age of respondents, pond size, years of farming experience and quantity of feed. They were all significant at 1% level. With R^2 values of 98.4% and 88.5%, and significant F values at 1% level, the model could be assumed to best represent the relationship between fish output and some exogenous variables.

There existed a negative relationship between age and output of fish in the study area. This implies that the younger farmers got more output than the older ones. This is expected since younger people are apt to try new innovations than older people. Probably the younger aquaculturists adopted better management practices in fish farming.

It was also observed that a negative relationship existed between number of harvest and number of seed, years of farming experience, age of respondents and pond size. This is probably because if fishes are harvested too frequently, it may lead to the harvesting of under-sized fish. It is therefore expected that the fewer the number of harvest per cropping the larger the size of fish obtainable. Also, It will not be economical to harvest large ponds as it may thus become expensive to harvest too frequently.

Membership of cooperative societies, number of species stocked in ponds, quantity of fertilizer applied, quantity of a lime applied and total number of fry/seed were however, not significant in determining fish output. However, these were all jointly significant in determining fish output given the two significant F values. The null hypothesis one was therefore, rejected

Table 14: Double log function for total output and some variables

Variables	Coefficients	t -value	R^2	$\overline{R}^2$	F- value
Constant	9.353	15.396			
Age	-0962	-4.812*			
Fish pond size	0.623	10.508*			
Membership of Cooperative society	0.093	-1.029			
Years of Experience	0.411	5.045*	0.984	0.972	139.5*

Source: Field Survey, 1999

Table 15: Correlation matrix some variables.

	Total output	Age	Pond size	Cooperative membership	Years of experience
Total output	1				
Age	0.185	1			
Fish pond size	0.96*	0.254	1		
Coop. membership	0.218	0.557**	0.279	1	
Years of experience	0.642*	0.826	0.632*	0.544**	1

Source: Field Survey, 1999

* = Significant at 1% level

** = Significant at 5% level

Table 16: Double log for total output and some variables

Variables	Coefficients	t-value	R^2	$\bar{R}^2$	F value
Constant	0.525	0.629			
Feed quantity	0.721	4.490*			
Number of species	0.284	0.723			
Quantity of fertilizer	0.133	1.096			
Quantity of lime	-0.121	-1.252			
Number of Seed	0.124	1.331	0.885	0.812	12.259*

Source: Field Survey, 1999

* = Significant at 1% level

Tables 17 to 19 however, showed that cooperative membership and years of experience were correlated with age, years of experience was also correlated with pond size and cooperative membership, also, Feed quantity was correlated with number of species, number of seed and quantity of fertilizer, number of species was correlated with quantity of lime and quantity of fertilizer. These may account for few numbers of factors that were significant in determining fish output.

Table 17: Correlation matrix of total output and some variables

	Output	Feed Qty	No. Of species	Qty of fertilizer	Qty of Lime	No. of Seed
Total output	1					
Feed quantity	0.906*	1				
Number of species	0.647*	0.575*	1			
Quantity of Fertilizer	-0.355	-0.372***	0.430**	1		
Quantity of lime	-0.312	-0.302	-0.201	0.868*	1	
Number of seed	0.650*	0.534*	0.690*	0.204	0.22	1

Source: Field Survey, 1999

* = Significant at 1% level

** = Significant at 5% level

*** = Significant at 10% level

Table 18: Regression analysis of value of total output with some variables (Cobb-Douglas)

Variables	Coefficients	t-ratio	R^2	$\bar{R}^2$	F
Constant	10.984	6.362			
Number of harvests	0.02147	0.162			
Total number of seed	0.273	4.362*			
Years of experience	0.193	0.945			
Age of Respondents	-0.720	-1.510			
Fish pond size	0.354	3.449*	0.96	0.936	38.848*

Source: Survey data, 1999

* = Significant at 1% level

However, when the values of the total output of fish and feed cost, fertilizer cost, Lime cost and seed cost were considered, seed cost, fish pond size and total number of seed were the only significant factors determining the value of total output. From Table 18, seed cost, was significant in determining the value of total output of fish. All the variables considered jointly were significant in determining variability in the value of total fish output from pond with a significant F value.

From Table 19, number of seed and years of fishing experience were highly correlated with the value of total output confirming the regression results. Also, number of seed was correlated with the pond size. This is expected, as the larger the pond, it is also expected that the more the number of fish to be stocked in the pond. From Table 20, only seed cost was significant in determining the value of total output. However, seed cost was significantly correlated with fertilizer cost and lime cost(Table 21). This shows that the more the number of seed, the more the quantity of fertilizer and lime needed in the pond and it is expected. However, it was not significantly correlated with feed cost.

On resource use, the value of the marginal physical products were compared with the factor cost. This is presented in Table 22. From the table, it could be observed that aquaculturists were only efficient in the use of fry/seeds among all the various factors considered. The productivity of aquaculturstis was observed to be characterized by decreasing returns to scale. Farmers could therefore increase their profit margin by increasing the quantity of feed, fertilizer and lime used in ponds.

Table 19: Correlation matrix of some variables

	Value of Output	Number of Harvest	Number of seed	Years of Experience	Age	Pond size
Value of output	1					
Number of harvest	-0.113	1				
Number of seed	0.874*	-0.109	1			
Years of experience	0.541*	-0.129	0.505*	1		
Age of respondent	0.030	-0.011	0.071	0.826*	1	
Pond size	0.787	-0.075	0.486*	0.632	0.3	1

Source: Survey data, 1999

* = Significant at 1% level

Table 20: Double log function for value of output and some variables.

Variables	Coefficients	t value	R^2	$\bar{R}^2$	F value
Constant	9.716	1.430			
Seed cost	0.439	2.681**			
Feed cost	-0.431	-0.511			
Fertilizer cost	-0.095	-1.605			
Lime cost	0.023	0.303	0.537	0.331	2.608[NS]

** = Significant at 5% level

NS=Not significant

Table 21: Correlation matrix of some variables.

	Value of total output	Seed cost	Feed cost	Fert. Cost	Lime cost
Value of total output	1				
Seed cost	0.619*	1			
Feed cost	-0.192	-0.357	1		
Fertilizer cost	0.065	0.531**	-0.709	1	
Lime cost	-0.057	0.075*	-0.810	0.686*	1

* = Significant at 1% level

** = Significant at 5% level

Table 22: Factor cost(₦) and Marginal Value Product(₦) per hectare in fish ponds

Variable	Elasticity	FC	MVP
Seed/fry	0.439	10	18.56
Feed	-0.431	5	-22.76
Fertilizer	-0.095	30	-8.93
Lime	0.023	20	2.32
Returns to scale	-0.63	-	-

Source: Survey data, 1999

4.14 Optimum Feeding in Fish Ponds for Maximum Fish Output

The following quadratic equation selected based on its giving better result in terms of the F-value and the R^2, gave the relationship between output and feed quantity in fish ponds.

$$Y = 252.468 + \underset{(0.495)}{0.2174}X - \underset{(0.001)}{0.001}X^2 \text{ --------------- } 1$$

$$R^2 = 0.909 \qquad \bar{R}^2 = 0.892 \qquad F = 54.849^*$$

Where Y=quantity of Fish

X=quantity of feed

A first differential of equation 1 gave an optimum value of 157.18 kilogram of feed per hectare. However this is a little low when compared with the average of 781.25kg used. The probable reason could be as a result of the low sample size or inaccurate records kept by farmers.

4.15 Problems of Aquaculture in Kano State

4.15.1 Private Farms' experience

The respondents ranked some problems according to the perceived level of importance. Seven problems were identified as affecting aquaculture in Kano State. From Table 23, lack of proper infrastructure and limited market were rated as 'very important' by 78.5% of the respondents. The next important problem is lack of extension service which was given by 64.2% of the respondents. Other very important problems include shortage of good quality and quantity of cultivable fry which was given by 42.8% of the respondents. Lack of skilled manpower was given by 35.7% of the respondents. High feed price and unavailability of credit was rated by 21.4% of the respondents as very important.

The problems rated as just important were: unavailability of credit, lack of skilled manpower and shortage of fry. These were rated by 35.7%, 21.4% and 14.2% of the respondents respectively. Limited market and lack of skilled manpower were rated as "not so important" by 21.4% of the respondents.

On personal contact with farmers, it was observed that some other constraints existed that were militating against the development of aquaculture in the state. These include the low level of awareness for pond construction techniques by farmers at the rural level. In addition, there is the lack of awareness by fish farmers on other fish culture systems. Integration of fish with crops and livestock production has not been fully embraced by farmers in the state. They need to be encouraged to try such on their farms. It was observed that water scarcity during the dry season posed serious problems to some farmers. Those adversely affected were the farmers relying more on reservoirs for water supply.

4.15.2 Public Farms' experience

The respondents(farm managers) enumerated some problems militating against their operations. The most important being the bureaucratic bottlenecks that they were subjected to. These operators complained of delays in getting official permission to carry out some important operations that needed prompt attention. All the managers complained of late release of fund and when funds were released, it was often below the budget submitted to the head office in Kano.

Another constraint enumerated by the managers was inadequate training to update their knowledge in aquaculture. All of them complained of not being sponsored to attend any in-service training on aquaculture in recent times. Few of the staff also gave lack of adequate equipment as another constraint to their production.

Table 23: Distribution of respondents by problems encountered in fish production

Problem	Severity					
	Not so Important		Important		Very important	
	Freq.	%	Freq.	%	%	Freq.
Lack of proper infrastructure	-	-	-	-	11	78.5
Unavailability of credit	-	-	5	35.7	3	21.4
Shortage of fry	-	-	2	14.2	6	42.8
High feed price	-	-	-	-	3	21.4
Limited market	3	21.4	-	-	11	78.5
Lack of extension service	-	-	-	-	9	64.2
Lack of skilled manpower	3	21.4	3	21.4	5	35.7

Source: Field Survey, 1999

The next chapter is devoted to the summary, conclusion, policy implication and recommendations based on the result of this study.

CHAPTER 5

SUMMARY, CONCLUSION, POLICY IMPLICATIONS AND RECOMMENDATIONS

5.1 Summary

The study on aquaculture (poly-culture) fish production in the fisheries sub-sector in Kano state was designed not only to identify the factors determining its practice but also to provide some useful guidelines on the efficiency of resource use in aquaculture production. It was also designed to provide useful information on the profitability of aquaculture in the state. Data were collected from 14 purposively sampled aquaculturists during 1999 cropping season and used for analysis. Descriptive statistics, farm business analysis, sensitivity analysis and regression analysis were used in the study. The results are summarized below.

5.1.1 Costs and Returns in Aquaculture Production

The nature of costs and returns in aquaculture production among the farmers were examined. Costs and returns were measured in Naira per hectare of fish pond. Three major combinations were considered in the study. They are Tilapia-Clarias, Tilapia-Bagrus-Clarias and Tilapia-Clarias-Clarotis-Mudfish.

Variable cost was the major component of cost accounting for over 70% of total cost in all the cases considered. Of the variable cost, seed cost was highest taking over 30% of total cost. The third type of combination(four-fishes combination) had the highest variable cost of

₦87,619.00 per hectare followed by Tilapia-Clarias, then Tilapia-Bagrus-Clarotis. Total cost outlay was highest per hectare for Tilapia-Clarias production. Tilapia-Bagrus-Clarias had the least cost of ₦66,625.00 per hectare.

On Returns, Tilapia-Clarias had the highest Gross Income of ₦140,000.00 per hectare and a Net Farm Income (NFI)/profit of ₦21,900.00. The four-fish combination type yielded the least Gross Income of N93,208.00 and a profit of ₦4,389.00 per hectare. This translated to 20k on every naira invested in Tilapia-Bagrus-Clarias; 18k on Tilapia-Clarias and 5k on Tilapia-Clarias-Clarotis-Mudfish production. This pattern was observed when the rate of returns on operating cost was considered. On the productivity of feed, one kilogram of feed yielded 2.6 kilogram of fish in Tilapia-Bagus-Clarias, 5.5 kilogram of fish in Tilapia-Clarias and 1.6 kilogram of fish in Tilapia-Clarias-Clarotis-Mudfish combinations respectively.

5.1.2. Sustainability of Resource Use

A sensitivity analysis was performed to see the effect of feed and fertilizer price changes on profit in each combination. It was observed that even at 100% price increase, aquacultrists would still be making positive profit in all the three combinations. Aquaculture in Kano state could thus be said to be sustainable given that feed and fertilizer prices were important exogenous factors that farmers do not have control over.

5.1.3 Multiple Regression Analysis

Result of the fitted Cobb-Douglas function indicated that some explanatory variables such as age of respondents, pond size, years of farming experience and quantity of feed were important in determining the output from ponds at 1% level of significance. A negative relationship between age of aquacultrist and output is indicative of the tendency for younger farmers to adopt new innovations which could increase output when compared to their older counterparts.

The coefficient of multiple determination R^2 ranged from 53 to 98% for all the four equations fitted. All the exogenous variables considered jointly determined the variability in fish output as the F-values obtained were significant at 1% level in all the models.

The Cobb-Douglas production was used in determining the returns to scale. The result of the regression analysis showed that farmers were experiencing decreasing returns to scale in resource use. The Marginal Value Productivity of the inputs such as seed/fry, feed, fertilizer and lime showed that farmers were not utilizing their resources efficiently. They could thus increase the quantity of feed, fertilizer and lime used in ponds. However, the ratio showed that they were efficient in the utilization of seeds/fry. This points to the need for the introduction of better management practices in terms of input use to the farmers by the extension component of the agricultural system in the state.

5.2 Conclusion

This study was designed for the assessment of the profitability of aquaculture in Kano state. It set out to emphasis the costs and returns in such a production system.

The farm business analysis indicated that the aquaculturists were making profit in the 2-, 3- and 4- fish combination types of aquaculture. Identified inputs such as feeds, fertilizer and lime were not efficiently utilized because their marginal value productivities were not equal to the factor costs. They could achieve more by increasing the quantities of these inputs used in the production process.

Variable costs accounted for over 70% of total cost in all the three systems of aquaculture. For every kilogram of feed used, farmers were realizing 2.6, 5.5 and 1.6 kilogram of fish in the three-, two- and four- species combination respectively. They were making 20, 18 and 5 kobo on every naira invested in the three-, two- and four- fish species combinations respectively. Fish farming in Kano State is thus a profitable venture.

The quadratic equation fitted for feed on output of fish showed that farmers could increase fish output by increasing the quantity of feed fed to fish. The Cobb-Douglass production function fitted for fish output showed a tendency towards a decreasing returns to scale in fish production.

Problems identified as militating against aquaculture activities in the state include: high cost of pellet feeds, scarcity of finger-lings for pond stocking and difficulty of having ready access to technical assistance from research and extension agencies.

5.3 Policy Implications and Recommendations

An important implication of these research findings is the need for the various tiers of government to pay more attention to efforts aimed at increasing inland fish production. There is an abundant evidence from the study to show that even though aquaculturists are making some profits in their current production system and level, profit margins would be greatly increased if better production environment is provided to the fish farmers.

It is therefore strongly recommended that the aquaculturists be encouraged to adopt new innovations in fish farming and to practice integrated fish farming.

The participatory approach to extension delivery system is also recommended. The extension should be farmer centred and front-line extension staff be made to visit farmers in groups. Farmers too are to be encouraged to contribute towards extension delivery costs. They need training on site selection, pond construction and management.

The hatcheries in the state should be adequately funded so that they could meet the demands of the aquaculturists for finger-lings. There are presently two in the state, these are expected to service the over 20 private fish farms in the state with an estimated demand for over 5 million finger-lings. There is the need therefore for an urgent action to make the hatcheries efficient as to meet the finger-lings demand of aquaculturists.

It was observed that none of the aquacultists got credit facilities from financial institutions. It is recommended that linkages between the aquacultuists and financial institutions be established so that the farmers could obtain credit facilities from these agencies. It is also recommended that subsidies be given by government on inputs such as finger-lings, feed and fertilizer.

Farmers should be encouraged to form cooperatives so as to avail themselves of some opportunities.

There is also the need to construct hatcheries at strategic locations across the state. This will reduce the mortality of the finger-lings in transit. Farmers should also be taught how to handle the finger-lings properly in transit to prevent high mortality.

There is the need to rehabilitate the few hatcheries in the state to supply fry to farmers.

The extension system in the state need to focus on the fisheries sub-sector. Attention has not been adequately given to this sector in the state and that has led to the low number of species of fish grown by farmers in the state.

There is also the need for an increase in the efforts of the front-line extension agents to enlighten farmers on the appropriate combinations and ratios for maximum yield and profit.

5.4 Limitations of the Study and Suggestions for Further Research

The major shortcoming of this study is the lack of adequate records by aquaculturists. This is typical of traditional agriculture in Nigeria. Most of the information provided were based in memory-recall of aquacultuists. This can be defective. However, this problem was minimized through personal interviews with front-line extension agents in the state.

There is need to conduct further studies on the productivity of fish ponds in other states of the Federation especially in the northern part. This is with a view to comparing productivity in ponds thus enabling government and policy makers to formulate and implement sound policies in the inland fisheries of Nigeria.

REFERENCES

Adedipe, N.O, A.Aliyu, S.O Fagade and H.U. Ahmed.(1996). "Agricultural Research in Nigeria: Assessment and Implications for food security"._Shaib , Adedipe, N.O and Aliyu,A.1996. ed Integrated Agricultural production in Nigeria: Strategies and mechanisms for food security .NARP Monograph No.5 PP242 - 253.

Akpa, N. H. (1999). Economic Analysis of Crop-livestock Integration among the Agro-pastoralists in the Northern Guinea Savannah of Nigeria. Verlag Ulrich E. Graner. Stuttgart. Germany.

Allen, G.H. (1969). " A preliminary bibliography on the Utilization of sewage in fish culture". FAO Fish (308). 15p.

Amos, T.T. (1992). Economies of Scale and Resource-use Efficiency in Maize Production in Selected Villages of North-west Zone of Nigeria. An unpublished M.Sc Thesis in the Dept. Of Agricultural economics, Ahmadu Bello University, Zaria.

Agrawal, R. C. and Heady E. O (1972). Operations Research Methods for Agricultural Decision. Iowa State University, Iowa, U. S. A.

ADCP, 1975. *Aquaculture Planning in Africa.* Report of the First Regional Workshop on Aquaculture Planning in Africa. Accra, Ghana, 2-17 July 1975. Rome.

ADCP (1978). *Aid for agriculture development.* Report of the FAO/UNDP Ad Hoc consultation on aid for Agriculture development, La. Toja (Pontevedra, Spain) 20 - 25 June 1978. Rome, UNDP/FAO,ADCP/REP/78/4:30p.

ADCP, (1983). *Agriculture and Profiles*. A summary of information on agriculture projects external aid components. Rome, UNDP/FAO,ADCP/AP/83/7:22p.

Afinowi, M.A and I.Maripghae (1987). "Summary of Aquaculture activities in Nigeria". In Howard Powles (ed). Research Priorities for African Aquaculture. International Development Research centre, Ottawa, Canada.

Ayyappan, Tm.(1999). "The Tale of the Duck and the Fishes". Technical Center for Agricultural and Rural Cooperation(CTA). - ACP-EU. 84:16P.

Ayeni, A.M (1991). "The Role of Extension Services in Fish Production". In Proceedings of the forth Annual CODRI Seminar, NIOMR, Lagos.

Adeleye, O. A. (1992). "Conservation Needs of Fisheries Resources and Reorientation for Sustainable Capture and Culture Practices". In Proceeding of Fisheries Society of Nigeria Annual Conference. Abeokuta, 16-20 to Nov.

Ayeni, J. S. O. (1997). "Management for Sustainable Exploitation of lakes and Reservoirs". FISON. Quarterly lecture Series.

Anon, (1979). Proceedings of International Workshop on Pen and cage Culture of fish.Iloilo, Philippines, 164p.

Bardach, J.; E. Rigther and W. O. Mclamry. (1972). Aquacuture, The Farming and Husbandry of Fresh Water and Marine Organisms.. Wiley Inter-Science, John Wiley and sons inc, NY.

Bell, F.W., and E.R. Canterbery. (1976). Aquaculture for the developing Countries: A Feasibility Study. Cambridge Mass.: Ballinger Publishing Co.

Berka, R, (1973). "A Review of Feeding Equipment in Fish Culture". EIFAC Occasional Paper, (9):32p.

Beveridge, M.C.M, (1984). "Cage and Pen Fish Farming Carrying Capacity Models and Environment Impact". FAO fish. Tech Paper:(2.55): 131p Issued also in french, ref k251.

Bolorunduro P.I (1988). A comparative study of Fish marketing system in Lake Chad and lake Asejire. M.Sc. thesis, University of Ibadan, Ibadan.

Coche, A. G. and H. vander wal, (1981). "A Simple Methods for Aquaculture Water for Fish Culture". FAO Training series (4): P.

Chakroff, M.S, (1981). "Aquaculture Extension Services: Case Studies". FAO fish circ (740): 27p.

Chang, Kee-chai and M. A. lizarondo. (1982). "Input-output Relationships of Philipine Milk Fish Aquaclture". In Aquaclture Economics Research in Asia. IDRC-193c. Ottawa, Canada.

Chakroff, M. S. (1982). "Aquaculture Extension Services Review". FAO fish circ. (747); 25p.

Clinston, Z.M. (1984). Business Management is Fisheries and Aquaculture. Fishing NewsBooks. Ltd. Survey, England 130 p.

Commonwealth Secretariat. (1982). An overview of fisheries in the common wealthCommon wealth, London. 141 p.

Cook, H.L. (1976). Problems in Shrimp Culture in the South China Sea Region. South China Sea Fisheries Development and coordination program, FAO of the UN, Manila, Philippines.

Cheney, D. D. and U. R. Rabanal, (1984). "Remote Sensing and Its Application to Inland Fisheries and Aquaculture". FAO fish circ. (768)50p.

Coche A.G.(1985). "Simple Methods for Aquaculture: Soil and Fresh Water Fish Culture". FAO Training Series;(6) : 174p.

Eddie G. C. (1983). Engineering, Economic and Fisheries Management. Fishing News Books Ltd, survey, England 153 p.

Ezenwa, B. I. O. et al. (1990). "A Cultivable Fish Seeds in Nigerian Coastal Waters: A Research Survey". NIOMR Techical papers No. 66

Ezenwa, B. I.. O. and A. Ayinla. (1994)." Conservation Strategies for Endangered Fish Breeding and Nursery Grounds Within the Coastal Wet-land of Nigeria Aquatic Conservation". Marine and Fresh Water Ecosystems. vol.4, 125-135.

Ezekwe, G.O. (1991). Address at the Fourth Annual Seminar of the Committee of Directors of Research Institutes. NIOMR, Lagos.

FAO, (1981). "Better Freshwater Fish Farming". The FAO Better, farming series. (80): 48p.

Gietemu, B. (1992). Fish Farming. Gbemi Sodipo Press Ltd, Abeokuta. Nigeria 143p.

Gasson, R. (1973). "Goals and Values of Farmers". Journal of Agric.Economics. Vol 24(3).

FAO (1984). "A Study of Methodologies for Forecasting Aquaculture Development". FAO fish Tech. Paper. 248,: 47p.

FAO (1995). The State of World Fisheries and Aquaculture. FAO Fisheries Department Rome 57p.

Food and Agricultural Organization of the United Nations. 1996. *Food Requirements and Population Growth*. WF S961/TECH/10 provisional Tex, FAO. Rome.

Gamdet, J. L. (ed). (1967). "Symposium on Feeding in Trout and Salmon Culture". Symposium on sur alimentaion dans L'elevage de la trivte el du saumon fourth Session European Inland fisheries Advisory Commission Bellgrade, Yugoslavia, 9 - 14 May, 1966. EIFAC Tech. Pap/ADC Tech CECP1 (3): 94p.

GLOBAL (1998). Nigerian Fisheries Master-plan Study: Sector Review and Interventions. Vol. 1 & 2.A Report Prepared by GLOBAL/APC for the PTF.

Griliches, Z. (1957). "Specification Error in Estimates of Production Functions", Journal of Farm Economics, Vol. 39(1) pp. 8-20.

Heady, E.O. and J. L. Dillon. (1961). Agricultural Production Functions. Iowa State University Press, Ames, Iowa, U.S.A.

Heady, E.O and Candler , W. (1958). Linear Programming Methods. Ames Iowa, U.S.A.

Hora, S.L, and T.V.R Pillay (1962). Handbook on Fish Culture in the Indo Pacific Region. FAO, Rome, Italy.

Ita, E.O., E.K. Sado, J.K.Balogun, A. Pandogari and B.Ibitoye (1985). *Inventory Survey of Nigerian Inland Waters and their Fishery Resources :A preliminary checklist of inland water bodies in Nigeria with special reference to ponds, lakes, reservoirs and major rivers*. Kainji Lake Research Institute. Technical Report series no 14 , New Bussa 58p.

Ita E.O. 1993. Inland Fishery Resources of Nigeria. Food and Agricultural Organization of the United Nations, Rome. 120 p.

Jhingran, V.G.. and V. Gopala Krishnan (1974). "Catalogue of Cultivated Aquatic Organism". FAO Fish. Tech pap (130): 83p.

KNARDA (1994). Fisheries Appraisal Study. Main Report 101 P.

Kusemiju, K. (1991). "Fisheries Development in Nigeria. A critical Appraisal". Key note address presented at the 4th Annual Seminar of Committee of Directors of Research Institutes (CODRI). NIOMR, Lagos 10th Dec. 1991.

Leopold, M. (1978). "Main problems of Fish culture Economics". A working document on economics of the Ninth Session of European Inland fisheries Advisory Commission, June 1978, Hamburg, Germany.

Mabawonku, A. F. and A. S. Olomola (1986). "Regulations and Policies on the Importation of Fishing Materials in Nigeria 1970 - 1980". Fisheries Research 4: 2.3 - 222.

Mabawonku, A.F., Olayemi, O. Ogunfowora, and O. Akinyemi (1984). Evaluation of the Artisanal and Inshore Fisheries Development project. A study commissioned by the Federal Department of Fisheries, Lagos, Nigeria.

Mabawonku, A. F. (1978). "Fishing Efforts and Economics in the Nigerian Artisanal Fisheries". Journal of Rural Economics and Development 12 (2): 29.38.

Mayong A. M. and Jose Degande (1995). "Sustainability of African small holder Farming Systems: Case Study of Highland Areas of Central Africa". Journal of Sustainable Agriculture. Vol. 6 (4): 17 - 42.

Mistakedisa, M. N. (Ed) (1969). Proceedings of the World Scientific Conference on the Biology and Culture of Fish and pawns. Acts de la conference scuritifique modale surla biologise at l' elevage descrciefts. Acted de la conference cicentifica runaway sobre le biology cutive de cameround Y Dambas. Mexizo city. Mexico 12 -21 June. 1967/mexizo, (mexizue), 12 - 21 June 1967/ cinded de mexizo, mexizo 12 - 21 June 1967. Vol. 2. Review, Regional survey and experience papers. Express generout, resume. D. experiences. Documented de tasena resume regional Y documentions de in-vestigasion. FAO fish Rep./FAO 120PP. Peches/FAO in F. Desco (57) vol.2: 77-587.

Mistakidis M. N. (1977). "Culture of Marine fisheries in the Third World". FAO Fish Circ; (704): 6p.

NIFFR (1996). Species Combination and stocking Density in Ponds. NIFFR Extension Guide Series No. 6, New Bussa, Nigeria.

Obiefuna, J.C. (1999). "Sustainable Agriculture: A way out". NIPRANET NEWS. Kaduna. 8p.

Okoye, F.C., W.S. Omorinkoba, J.O. Ayanda and E.O. Ita. (1991). "Commercial Fish Farming in Earthen Ponds. Prospects and Problems". In Tobor J.G. and B.I.O. Ezenwa (ed). Proceedings of the Fourth Annual Seminar of Committee of Directors of Research Institutes, NIOMR, Lagos. 161 p.

Olomola, A.S. (1991). *Capture Fisheries and Aquaculture in Nigeria: A comparative Economic analysis*. Winrock International Institute for Agricultural Development. African Rural Social Science Series. Research Report no 13 28p.

Olomola, A.S. (1984). Policy Instruments and the Derived Demand for Inputs in Nigerian

Fishery: An Econometric Analysis'. M. Sc Thesis, University of Ibadan, Nigeria.

Olomola, A.S. (1988). Agricultural Credit and Production Efficiency: A case study. Monograph series No.4 Nigerian Institute of Social and Economic Research, Ibadan, Nigeria.

Otubusin, S.O.; J.O. Ayanda, G.O. Opeloye and I.G. Asekome. (1991). "Economic Feasibility of Cage Fish Farming". In Tobor J.G.(ed). Proceeding of the 4th Annual Conference of the Committee of Directors of Research Institues(CODRI).

Panayotau, Theodore (1985). "Production Technology and Economic Efficiency: A Conceptual Framework". In: theodore Panayotou (ed). Small-scale fisheries in Asia: Socio-economic analysis and policy. IDRC-229e, Ottawa, Canada.

Pillay, T.V.R., (1979). The State of Aquaculture. Farnham, England. Fishing News books Ltd.

Pilley, T.V. R.(ed) (1967). Proceedings of the World Symposium on Warm Water Pond Fish Culture, Rome, Italy, 18 - 25 may, 1966. FAO Fish Rep. (44) Vol. 1:55p. Issued also in French and Spanish.

Rabanal, H.R. (1961). Status and Progress of Fishery in the Philippines. A paper presented at the Ninth meeting of the Ind-pacific fisheries Council, Jan. 6-23, 1961, Karachi, Pakistan.

Ramsey, J. B. (1969). "Tests for Specification Errors in Classical Linear Least Squares Regression Analysis". Journal of the Royal Statistical Society, Serve, B, Vol. 31, PP. 350 - 371.

Rehman, T. and Romero, C. (1993). "The Application of the MCDIA Pundigon to the management of Agricultural Systems: Some Basic Commendations". Agricultural Systems 411:239- 255.

Romero, C. and T. Rehman. (1984). "Goal Programming and Multiple Criteria decision-making in farm planning: an expository analysis". Journal of Agric. Economics. 35(2): 177 - 190.

Ronsivalli, L.H.. (1976). "The Role of Fish in Meeting The World's Fish Needs." Marine Fisheries Review. 39, no.6:1-3. National Marine Fisheries Service, Seattle, Wash..

Shaib. B, N.O Adedipe, A.Aliyu and M..M Jir (1996). Ed . Integrated Agricultural production in Nigeria: Strategies and Mechanisms for Food Security. NARP Monograph No.5 254P.

Shang, Y.C. (1976). Economic Aspects of Gracilaria Culture in Taiwan.Aquaculture 8:1-7 elsevier Scientific Publishing company, Amsterdam, Netherlands.

Shang, Y.C., and H.R. Rabanal. (1976). Advances in Aquaculture. Farnham, England. Fishing News Books Ltd.

Shedadeh, Z.H. (Ed). (1975). Reports of the symposium on agriculture in Africa. Accra, Ghana, 30 Sept. - 2 Oct. 1975. CIFA Tech. Pup., (4): 36p. Issued also in French.

Shoemaker, P.J. (1980). Experiments on decisions under risk. The expected utility hypothesis. Martinus Hijhott Publishing, Boston.

Singh, J.P. (1975). "Resource Use, Farm Size and Returns to Scale in a Backward Agriculture". Indian Journal of Agricultural Economics 2:32-46.

Sinka, V.R.P. (1977). "Economic Evaluation of Composite Culture in Different Parts of India". Unpublished paper.

Smith, Ian. R. (1982). " Micro economics of existing aquaculture production system: Basic concepts and definitions". In: Aquaculture Economics Research in Asia. IDRC-193e-, Ottawa, Canada.

Smith, Ian R. (1982). "Resource use, Farm-size and returns to scale to back yard agriculture". Indian Journal of Agricultural Economics 2:32 - 46.

Song, Z. (1980). Manual of Small- Scale Reservoir Fish - culture. FAO Fish circ. (727). 15P.

Tal, S. and B. Hepher (1967). "Economic Aspects of Fish Feeding in the Near East" FAO Fish Report (44), Vol. 3:285-290. FAO. Rome, Italy.

Tang, Y.A. (1979). Physical Problems in Fish Farm Construction. Advances in Aquaculture . Farm ham, England.

Tobor. J, L. (1991). A Decade (1987 -1990) of fisheries Research Activities at the Nigerian Institute for Oceanography and Marine Research for self sufficiency in fish production in Nigeria. Paper presented at the fourth the Annual seminar of the committee of Directors of Research Institutes (CODRI), NIOMR, Lagos Dec. 10.1991.

Tokrisna, R., Theodore Panayotou and K. Adulavidhaya. (1985). "Production Technology and Economic Efficiency of the Thai Coastal Fishery". In: Theodore Panayotou (ed). Small-scale fisheries in Asia. Socio-economic Analysis and policy. IDRC-229e, Ottawa, Canada.

Tokyo University of Fisheries. (1976). An Assessment of the Effects of Population on Fisheries and Aquaculture in Japan. FAO fish Tech. Pap (163) 105P.

Upton, M. (1973). Farm Management in Africa: The principles of production and planning. Oxford University press.

Williams, C. (1983). Simple Economic and Book-keeping for fish farmers. FAO Fish Circ. 12, (763) :52p.

Woynarovich, E. (1979). The Feasibility of Combining Animal Husbandry with Fish Farming, with Special Reference to Duck and Pig Production. Advances in Aquaculture Farnham, England Fishing News Books Ltd.

Zenvy, F. B. (1969). *Comparative study of laws and regulations governing the international traffic in live fish and fish eggs.* Etude compare des mesunes legistatives et admistratives request les echanges internation and de poissions vivarts et d. oeuts de poission.

APPENDIX

Agricultural Economics and Rural Sociology Department

Ahmadu Bello University, Zaria.

Sustainable Poly-culture fish Practices in Kano state of Nigeria :An Economic and Programming Analysis

Farmer's Questionnaire

General Information

Name of Farm: ________________ Year of establishment ______________

Owner/Operator________________Manager__________________

Age of Manager_______________

Location of Pond____

Pond area

Nursery Pond(s); Area(ha) _____ Number of ponds________

Rearing pond(s); Area(ha) _____ Number of ponds________

Total area of farm(ha) ____________________________________

Pond ownership

Inheritance [ ] Purchase [ ] Both [ ]

Source of water

Well [ ] Reservoir [ ] Govt.[ ] Others [ ] River [ ]

Belong to any cooperative society: Yes [ ] No [ ]

If Yes, which one______________________

If No, why not?____

Years of experience of operator Manager___________________

Do you grow more than one fish species? Yes [ ] No [ ]

B. Stocking

Number of species kept___________ No of cropping/year

Name of species kept/stocked

____

____

____

____

3 Cost of fry per crop

Fry/fingerlings purchased	Fry/fingerlings purchased			Mortality rate from purchase to stocking (%)	No of stock	No of crops/year
Species	no	Price	Cost			
i						
ii.						
iii.						
iv.						
v.						

Beginning inventory

a. Fry/finger no or kg unit price value

Species

i. _______ _______ _______

ii. _______ _______ _______

iii.		________	________	________
iv.		________	________	________
v		________	________	________
b.	Growers	no or kg	unit price	value
	Species			
i		________	________	________
ii.		________	________	________
iii.		________	________	________
iv.		________	________	________
c.	Market size	no or kg	unit price	value
	Species			
i.		________	________	________
ii.		________	________	________
iii.		________	________	________
iv.		________	________	________
v.		________	________	________

Source of stocking:

Hatchery[ ]   Reservoir [ ]   River [ ]   Fish pond [ ]

Name of Location: ____________ distance travelled: ____________

Number of stocking per crop/year

	Species	No
i.		
ii.		
iii.		
iv.		

Reasons for stocking schedule

i To optimize production: [ ]

ii. Availability of fry for stocking: [ ]

iii. Others: ________________________

8. Feed/fertilizer/lime.

Give the following about your inputs

Items	kg/ha/crop	cost/kg	freq. of application	Source
i. Feed ii. Fertilizer iii. Lime iv. Supplementary /feed				

ii. Give the following information on your labour input (man/hour) use for crop.

Variables	Family			Hired (Cost)		Cost	
	Male	Female	Child	Male	Female	Manager	Caretaker
Pond preparation							
ii. Stocking							
iii. Feeding							
iv .Fertilization							
v. Weeding							
vi. Repairs & Maintenance							
vii. Harvesting							
viii. Processing							
ix. Marketing							
x Others							

3. Salaries

i. Hired labour/manday/month

Male ______

Female ______

ii. Caretaker/Manager

____

Harvesting/Ponds

Production/Crop

Species	Sold		Eaten	Given	Others
	Kg	Price/Kg	(Kg)	away(kg)	specify(kg)
i. ii etc					

Ending inventory

Species	Fry/Fingerling			Growers			Market Size		
	No or kg	unit price	value	no/kg	unit price	value	no/kg	unit price	value
i ii. iii. Iv. v..									

Mortality rate from stocking to harvesting ____________ %

Possible causes of mortality

Sudden change in weather [ ]

Water pollution [ ]

Lack of proper food [ ]

Overstocking [ ]

Disease [ ]

Flood [ ]

Others [ ]

Number of harvest per cropping ______________________

Reason for harvesting schedule.

To optimize production [ ]

To get highest price [ ]

Availability of fry for restocking [ ]

Need for money [ ]

Marketing

Give the source and cost of the following inputs.

	Ice	Containers	Marketing Cost/Crop	Waste (%)
			Transportation	
Cooperative Sale				
Direct sale				

What is your transportation cost per annum?____________

Where do you sell your produce?

Did you borrow any loan fund? Yes [] No []

If yes,

Amount of loan fund ________________

What are the sources

		Amount	Int paid	Maturity	Purpose
i.	Relatives				
ii.	Banks/Fin. Institution				
iii.	Others				

E-11 Why borrow from the source?

Accessibility ________________

Simple procedures ________________

Fast credit extension ________________

Others (specify) ________________

F-12. Give the annual expense on the following items

i. Fuel and oil ________________

ii. Electricity ________________

iii. Water ________________

iv. Supplies ________________

v. Insurance ________________

vi. Taxes ________________

vii. Others (Specify) ________________

List Assets owned

No	Year of Acquisition	Unit cost	Economic Life	Prevailing Mkt value	Use for Fish cultures(%)
i. Pond ii. Building iii Vehicles (transportation) a b c d iv. Nets i gill ii. seine iii. Others (Specify) v. Pump vi. Generator vii Feeding machine viii Refrigerator ix. Feed mixture x. Others (Specify)					

14. What problems do you encounter in this industry(Please Rank) in order of importance.

The 1 = most important; 10 = least important.

i. Unfavorable price structure []

ii. Lack of proper infrastructure []

iii. Unavailability of credit

iv. Shortage of fry []

v. High price of feed []

vi. High price of fertilizer []

vii. High price of ice []

viii. High fuel price []

ix. Limited market []

x. Lack of extension service []

xi. Lack of skilled worker []

xii. Others (specify) []

15. What percent of your income comes from fish culture? ____________

16. Source of other income (Specify) ____________________

17. Which species do you prefer to grow?

____

____

____

____

____

18. Why do you prefer the species?

a) Fast growth rate [ ]

b)Ease of handling [ ]

c)Hardiness [ ]

d) fast reproduction rate [ ]