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Resource Use in *Tilapia* Production among Small-Scale *Tilapia* Farmers in the Savanna Zone of Northern Nigeria

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Abstract: Productivity of *Tilapia* farmers in northern Nigeria was studied among small-scale fish farmers in Kano State, Nigeria. Data were collected from 14 farmers using purposive sampling technique, which include only *Tilapia* farmers. Data were analyzed using descriptive statistics, budgeting technique and production function analysis. Results showed that *Tilapia* farmers make a Net Income of ₦140,000 ($1,000) ha^{-1} of *Tilapia*-catfish production. For every kg of feed, farmers realized 5.5 kg of fish for *Tilapia*-Catfish. Total numbers of seed/fry and pond size were the major determinants (1% significance level) of the quantity of fish realized on the farm. Farmers were observed to still be making positive profits even with a 100% increase in critical input prices. The major limiting factors towards profitable *Tilapia* production in the area include lack of proper infrastructure, limited market, lack of effective extension service and shortage of good quality of cultivable fry. In order for farmers to increase their profit margin and thus alleviate their poverty, they have to increase the quantity of feed, fertilizer and lime use.

Key words: *Tilapia*, small-scale farming, inputs, resource use

INTRODUCTION

Fish is an important protein food in the tropics. The consumption of animal protein and especially fish is low in Nigeria. This could be attributable to poverty that is on the increase in Nigeria especially in the rural areas. In Nigeria, fish constitutes 40% of the animal protein intake of the people. To meet the protein needs of the teeming population who are mainly rural dwellers, there is need to increase the level of fish production. Thus, individuals and corporate organizations need to be encouraged to go into aquaculture (Aromolaran, 2000). 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 (Ilawole, 2005). It has been estimated that over 1.5 million hectares of aquatic area is available for fish culture in Nigeria (Ita, 1993). 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 boreholes and wells. 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.

In Nigeria, some progress have been made in the culture of some indigenous and a few exotic fish species (Ita, 1993). 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 one 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.

Nigeria is blessed with a number of fish species that are of commercial values and able to grow well in fishponds. Some fish that live in fresh water (Rivers and lakes) that can be cultured include: *Tilapia* (Boney fish), Mud Cat-fish, Common Carp, Red mud cat-fish, Niger perch, African bony tongue and Trunk fish

MATERIALS AND METHODS

The study area: The study was conducted in 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 (Kano Agricultural and Rural Development Agency, 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 Meridian and occupies a land area of about

20,000 square kilometers. 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 that spans from October to May with a dry harmattan period between December and January. A temperature of less than 10°C could be recorded during the harmattan period. The rainy season is concentrated in the months of June to September and 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 precede rains. 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. A thin sheet of laterite and in the areas that experience the yearly flooding often covers these rocks, such basements are covered by rich alluvial soil annually deposited (Kano Agricultural and Rural Development Agency, 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. Residents of the state engage in livestock such as cattle, small ruminants, poultry and aquaculture.

The state has a network of (Hadejia, Kano, Armatal and Jattan) rivers. Other rivers within the system are River Jakara, Tomas and Gari that drain the northern part of the state and River Dudurum and Gaya in the southeastern 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 41.72 hectare.

Data collection: Both primary and secondary sources of data were relied upon for this study. Primary data were collected from fourteen fish farms using structured questionnaire administered to each farmer. 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 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) 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 able to provide relevant information about farmers' practices. Information provided helped in assessing the adoption of improved technologies in fish farming by farmers in the state.

Sampling technique: The study relied on random sampling techniques for selecting respondents. There are 25 fish farms in the State. From this, a sample of fourteen farms was selected randomly. Numbers were thus assigned to each farm and randomly selected the required number.

Analytical frame work: The analytical tools used in achieving the research objectives in this study are; simple descriptive statistics, farm business analysis, production function analysis and sensitivity analysis.

Descriptive statistics: Simple descriptive statistics such as means, percentages and range were used.

Farm business analysis: The farm business analysis was carried out to determine the profitability of aquaculture production in the state. The Net Farm Income (NFI) was used to show the level of costs, return and net profit that accrue to aquaculture in the study area. It 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 involved in the production process. The revenue item include sales from fish production while the cost items include the variable costs on items such as seed, feed, fertilizer and veterinary cost and the fixed cost. A positive NFI is indicative of profitability of the enterprise. It is written as:

$$\text{Net Farm Income (NFI)} = TR-(TVC + FC)$$
$$=\sum P_iQ_i - \sum C_{ij}X_{ij} - FC$$

Where: TR = Total Revenue per hectare
P_i = price per kilogram of fish produced;
Q_i = quantity (kilogram) of fish produced by farmer i
C_{ij} = price per unit of input j used by farmer; and
Xij = quantity of input j used by farmer i

Production function analysis: This produces useful quantities that include the marginal products of fishing inputs and the input elasticity. A Double logarithm functional form was adopted from the four different types tried on the data in the analysis as it gave best result in terms of the significance of the independent variables. It is of the form:

$$\phi = a_o \sum X_i^{a_i}$$ which when in log-linear form is as follows:

$$In\phi = Ina_0 + a_i In\sum Xi$$

Where ϕ = Total fish production in kilogram per hectare,
X_1 = Age of respondents (years)
X_2 = Fish pond size in hectare
X_3 = Membership of cooperatives (Dummy: 1=belong; 0 = otherwise)
X_4 = Years of fishing experience (years)
X_5 = Number of harvests per annum
X_6 = Total number of seed/fingerlings (number ha^{-1})
X_7 = Quantity of Lime (kg ha^{-1})
X_8 = other costs (Naira ha^{-1}.)
a_i = Parameter estimates
In = Natural Logarithm

The estimated functions were tested as regards their effects and statistical significance of all independent variables using R^2, Student's t and f-value.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents: In this study, some important characteristics of the respondents that are relevant to this study are presented.

Age distribution of respondents: The mean age of respondents was 46 years. From Table 1, majority (64%) of the fish farmers were above the mean average age of all the respondents. Thus most of the decisions taken by the farmers are likely to be rational in line with (Mabawonku *et al.*, 1984) who reported that the age of a farmer could influence his/her farm allocative decision, performance and productivity.

Fish farming experience: Though capture fishing has been long in existence in the state, aquaculture seems to be a recent development. From Table 1, most (78.5%) of the respondents have less than ten years of fish farming experience. Only about 21.4% had fish farming (aquaculture) experience of between 11 and 15 years.

Membership of cooperative societies: Researchers have generally accepted that membership of cooperative societies could be a means of assisting farmers to increase productivity. This is due to better access to farm inputs and credits. In that case, through the societies, some farmers could better be able to pool their resources together towards a common goal e.g. sourcing for credit or marketing of produce. From the survey, many of the respondents (64.3%) do not belong to any fish farming or marketing co-operative society in the state (Table 1). This is not a welcome development, as farmers may not make the best use of all opportunities derivable from being cooperative members.

Table 1: 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	100.0	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 site acquisition pattern			
Inheritance	8	57.1	
Purchase	2	14.3	
Government	4	28.5	
Total	14	100.0	
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, 2003

Pond acquisition pattern: From Table 1, 57.8% of the respondents inherited their farm site for pond construction while only about 14.3% purchased theirs. This implies that the control of resource use and allocation on farms is wholly vested on 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 asset of the rural agricultural population. It is important for individual farmers to acquire enough land for their farming purposes.

Ponds are considerably small sized. Majority is less than one hectare (Table1). This is in agreement with previous findings (Federal Agricultural Coordinating Unit, 1994) that asserted that aquaculture was practiced on a small scale in the state. This is similar to what obtains in crop production in Nigeria that is still in the hands of smallholder farmers.

Table 2: Cost and returns in aquaculture production (per hectare)

Items	*Tilapia*-catfish Unit Price N	Qty	Value N	% of Total Cost
A Costs				
i, Variable				
-Labour		302 man days	36240	4.1
-Feed	5	400 kg	2000	1.6
-Seeds				
Tilapia	5	4000	20000	16.8
Catfish	15	3000	45000	37.8
-Fertilizer	30	420 kg	12600	10.5
-Lime	20	300 kg	6000	5.0
Total Variable. Cost			85.600	71.9
ii. Fixed				
-Salaries	2.500	12	30.000	25.2
-Depreciation			1100	1.2
-Others		-	2500	2.1
Total Fixed Cost			32500	27.4
Total cost			118100	100.0
B. Returns				
-*Tilapia*	20	1000	20000	
-Catfish	100	1200	120000	
Gross income	-		140000	
Net income			21900	
Rate of return on Investment			0.18	
Rate of return on Operating cost			0.27	
Production per kg of Feed			5.5	

Source: Survey data, 2003. Note: $1 = ₦140

On the sources of water, 78.6% 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 that could, be harnessed for fishing purposes.

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

Source of seeds goes a long way in determining the productivity of the farm in terms of the quantity of fish produced. Majority (78.6%) of the fish farmers got their seeds from the wild i.e., rivers while only about 21.4% got their seeds from hatcheries. This may be indicative of the fact that there are no adequate hatcheries in the state or that the farmers do not know where such are located. The Bagauda hatchery complex, a state government outfit, for example, is observed to be operating below its installed capacity. Farmers therefore have to cover an average of 38 km in order to get their seed.

Mortality rate: The rate of mortality determines to a large extent the final output obtainable from each pond. About 35% of the farmers experienced between 3 and 5% mortality while those with about 10% 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. Proper handling of finger-lings in transit and good management practices could do this.

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

Costs and returns analysis: From Table 2, the total cost outlay for one hectare of *Tilapia*-Catfish was ₦118,100.00. Of the Total Cost of production, variable cost accounted for 71% alone. This confirms earlier writings that variable cost constitutes the bulk of cost item for farmers in developing countries. Of the variable cost, seed cost was highest. It accounted for 55.9% of total cost. The quantity of seeds per hectare on farms was 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. Another important component of cost is fertilizer that accounted for about 10% of total cost.

On returns, one hectare of *Tilapia*-Catfish farm yields a profit margin of ₦21,900.00, while an hectare of *Tilapia* fish farm yield ₦17,610.00. From the costs and returns Table 2, this translated to 18 Kobo for every Naira invested in *Tilapia*-Catfish production. In physical quantities, every kilogram of feed led to 5.5 kilogram of fish. It could thus be concluded that aquaculture fish production as was being practiced by the farmers is profitable in the state.

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) was kept constant though the current bird flu scar is expected to lead to increase in price of fish as a result of increase in demand for fish. The price of fish was kept constant for easy analysis. The price of feed, which was a major component of cost, was allowed to increase by

Table 3: Effect of feed price changes on Profit Margin (N) in aquaculture fish production

	Level of price change:			
Variables	25%	30%	40%	100%
Seed	21.500	21.300	21.100	19.900
Fertilizer	18.960	17.520	16.060	7.300

Source: Survey data, 2003

Table 4: Cobb Douglas production function in *Tilapia*-Catfish Production.

Variables	Coefficients	t-value	R^2	R^2 adj.	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, 2003

25, 30, 40 and 100% respectively. The effects of these price changes on profit of farms were thus examined and presented in Table 3.

From Table 3, price changes in feed of up to100% level though led to a reduction in net income for the two types of fish farming, there was positive net income recorded. Thus, it could be concluded that aquaculture is sustainable in the Kano State even with up to 100% increase in feed prices. In addition, when a combination of price increases on feed and fertilizer (as both were critical to fish production) were assumed, a positive net (income) profit was recorded.

Determinants of fish production and resource-use in ponds: The independent variables were grouped into two for easy analysis. These variables are: socio-economic and technical factors. From Table 4 and 5, five factors were observed to significantly affect the output of *Tilapia*-catfish in the study area. These are: The age of respondents, pond size, years of farming experience, Total number of Seed and Cost of fertilizer.

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. The result of expected younger people are apt to try new innovations than older people. Probably the younger aquaculturists adopted better management practices in fish farming.

For the *Tilapia* farmers, membership of cooperative societies, other production cost such as cost of transportation and utilities, quantity of lime applied and total number of fry/seed were however, not significant in determining *Tilapia* output.

Problems of aquaculture production in the area: The respondents ranked some problems according to the perceived level of importance. Seven problems were identified as affecting aquaculture in the State. From Table 6, lack of proper infrastructure such as storage facilities 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/seed, which was given by 42.8% of the respondents. Lack of skilled manpower to work on farms 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.

Table 5: Cobb douglas production function in *Tilapia*-catfish production.

Variables	Coefficients	t-ratio	R^2	R^2adj.	F
Constant	10.984	6.362			
Number of harvests	0.02147	0.162			
Total number of seed	0.273	4.362*			
Other Costs	0.193	0.945			
Quantity of lime	-0.720	-1.510			
Cost of fertilizer	0.354	3.449*	0.96	0.936	35.848*

Source: Field Survey, 2003, * = Significant at 1% level

Table 6: Distribution of respondents by identified problems

Problems	Frequency	%	Rank
Lack of proper infrastructure	11	78.5	1st
Limited market	11	78.5	2nd
Lack of extension service	9	64.2	3rd
Shortage of good quality and quantity of cultivable fry	5	35.7	4th
Lack of skilled manpower	5	35.7	4th
High feed price	3	21.4	5th
Unavailability of credit	3	21.4	5th

Other constraints existed that was militating against the development of aquaculture in the state. These include the low level of -awareness of 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 poultry or other livestock were relatively unknown by the respondents.

CONCLUSION

This study examined the resource use in fish farming in dry savanna zone of northern Nigeria. Fish farmers were observed to be making positive profit in their production endeavors One hectare of *Tilapia*-catfish yielded a total of ₦140,000 ($1,000) per hectare. Of the total cost of production, Variable cost accounts for the larger proportion compared with the fixed cost. The cost of Feed and fingerlings constitute a large proportion of Variable Cost. Thus aquaculture production can be a means of poverty alleviation in Nigeria. A Cobb Douglass production function fitted on the data generated showed

that Age of respondents, pond size, fish farming experience, number of seeds and cost of fertilizer were the determinants of farmers' income in the area.

Problem encountered in their production process include lack of proper infrastructure for processing and storage of products, limited market and lack of extension services on new innovations in fish production techniques.

Thus to improve aquaculture production in the area and in Nigeria as a whole, there is need for enlightenment programs on the potentials of aquaculture in Nigeria towards poverty alleviation. This will encourage the teeming population of unemployed youths to venture into aquaculture production.

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