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Comparative Estimation of the Costs and Returns of Integrated Fish-Based Farming Systems in Kaduna Metropolis, Nigeria

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Authors' Contribution

This is the result of collaboration between all authors. Author CJM designed the protocol and supervised the data collection process. Author SSM managed the literature searches, performed the statistical analysis and wrote the first draft of the manuscript while author JGA supervised the entire work and also edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted to know the costs and returns of three integrated fish-based farming (IFF) systems in Kaduna metropolis of Nigeria during 2015 to 2016 farming season. Primary data were collected through the structured questionnaire from 138 fished-based farmers and analyzed using net farm income and ANOVA. The results indicated that among the three integrated farming systems, fish-poultry farming was the most profitable farming with a net income of ₦1,166,441.80 and BCR of 1.69 followed by fish-vegetable farming with net income of ₦770,708.87 and BCR of 1.31. The least was fish-pig farming with a net income of ₦759, 052.11 and BCR 1.25. The ANOVA results showed that the calculated F value of 12.08 was significant at 1% probability level, implying that there was a significant difference in the profitability of the three fish-based

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farming systems in the study area. It was recommended that government and the private sector should provide adequate funding for livestock research that has to do with development of low cost, high quality feeds using local feed materials and manufacturing/fabrication of local machines.

Keywords: Comparative; estimation; costs; returns; integrated; fish-based.

1. INTRODUCTION

Integrated fish farming is the blending of various compatible agricultural enterprises into a functional or unified whole farming system for the purpose of sustainability. It is a "no waste", low cost and low energy production system in which the by-products of one enterprise are recycled into another as input. The benefits of integrated farming systems over traditional farming system cannot be over emphasized [1]. The reason is that integrated farming system has been confirmed to reduce cost of production and thus increase farmer's productivity, income, nutrition and overall welfare [2]. If properly adopted with investment in agriculture, integrated fish farming system improves the personal savings and health of farmers [3]. Othman [4] summarized the multifaceted benefits of integrated farming system to include economic benefits in terms of increased food production, social function in terms of provision of employment opportunity for excess labour force displaced from other sectors in the urban areas.

Integrated farming system can be complete integration encompassing crops, livestock, fisheries, processing and biogas units [5,6] or partial integration involving different combinations of the later units [7]. Integrated farming systems can remove all farming constraints by not only solving most of the existing economic and even ecological problems, but it also provides the needed means of production such as fuel, fertilizer and feed besides increasing productivity many-fold [8]. It can turn all the existing disastrous farming systems; especially in the world's poor countries into economically viable and ecologically balanced systems that will not only alleviate poverty, but can even eradicate it completely [6,9] observed that there is a possibility of recycling organic wastes, manures and farm effluents in fish ponds. The end product is an improved production of animal protein, particularly needed in developing countries. According to [10] the basic principles involved in integrated farming are the utilization of the synergetic effects of inter-related farm activities and the conservation including the full utilization of farm wastes.

About 75% of Nigeria's populations live in rural areas at subsistence or near subsistence level [11]. These rural folk face food availability challenges and need not only a large supplement of animal protein to their diet but also new sources of gainful employment. Fish culture could contribute substantially towards solving these crucial problems. One of the most serious constraints is the high cost of inputs especially fish feed and pond fertilizers [12]. This cost can be reduced considerably and fish production increased by combining fish culture with raising livestock and crops. If livestock such as pigs, ducks and poultry are raised on pond embankments and the fish utilized the wasted animal feeds and the animal excreta, then, fish production can be greatly enhanced by the increase in biological productivity of the water. Supplemental feed and fertilizers are not needed in such a system and the cost of inputs is therefore reduced [13].

Though there are several successful practices of integrated fish farming in Nigeria, the system of farming using integrated agriculture, aquaculture and livestock farming are not yet wide-spread in the country [14]. It is essential that scientific research should be directed to upgrade the existing technology and evolve appropriate technology after examining the socio-economic and other production constraints under varying conditions. The study will also serve as a means of providing information for prospective investors on profitability of integrated fish production in the study area.

2. CONCEPT OF INTEGRATED FISH FARMING SYSTEM

Integrated farming is commonly and narrowly equated with the direct use of fresh livestock manure in fish culture [15]. However, there are broader definitions that better illustrate potential linkages. Integrated farming involving aquaculture is defined broadly as the concurrent or sequential linkage between two or more activities, of which at least one is aquaculture. These may occur directly on-site or indirectly through off-site needs and opportunities, or both [16]. An integrated farming system consists of a

range of resource-saving farming practices that aim to achieve acceptable farming practices and high as well as sustained production levels while minimizing the negative effects of intensive farming and preserving the environment [17]. In an integrated system, livestock and crops are produced within a coordinated framework [18]. The waste products of one component serve as a resource for the other.

Integrated fish farming is a system that focuses on diversified agricultural production with emphasis on fish. Integrated farming system can be complete integration encompassing crops, livestock, fisheries, processing and biogas units or partial integration involving different combinations of the later units [5]. It is the blending of various compatible agricultural enterprises into a functional or unified whole farming system for the purpose of sustainability. It is a low waste, low cost and low energy production system in which the by-products of one enterprise is recycled into another as input. In the words of [19], integrated fish farming systems refer to the production, integrated management and comprehensive use of aquaculture, agriculture and livestock, with an emphasis on aquaculture. Also, [20] posited that integrated fish farming is the association of two or more normally separate farming systems which become part of the whole farming system. The major features of this system include: recycling of waste or by-product in which the waste of one system becomes the input of other system(s) and efficient utilization of farm space for multiple production. Integrated fish farming strategies could be regarded as an alternative for efficient utilization of available resources, waste recycling and energy saving, and for maintaining ecological balance and circulation. Integrated fish farming practice is not new to Nigerian agricultural farming system [21]. This is due to the numerous benefits associated with the practice of integrated fish farming. [22] noted that integrated farming with poultry, fish and crops can play a significant role in increasing manifold production, income, and nutrition and employment opportunities of rural populations.

Integrated farming (or integrated agriculture) is a commonly and broadly used word to explain a more integrated approach to farming as compared to crop production. Integrated farming system has existing monoculture approaches [1]. It refers to agricultural systems that integrate livestock, aquaculture, horticulture, agro-industry and allied activities. It could be crop-fish integration, livestock-fish integration, crop-fish-livestock integration, or combinations of crop, livestock, fish and other enterprises [6].

3. METHODOLOGY

3.1 Study Area

This study was conducted in Kaduna State, Nigeria. Kaduna lies between Latitudes 10^0 21'and 10° 33' North of the Equator and Longitudes 7° 45' and 7° 75' East of the Greenwich Meridian. The State is divided into Northern Guinea savannah in the North and the Southern Guinea savannah in the south. The State occupies a total land mass of about 46,053 square kilometers and has an estimated population (projected to 2011) of 6, 848, 420 people [23]. The state is characterized by two main seasons: the dry and wet seasons. The hottest months are March and April which is the peak of the dry season while the coldest months are December and January. In Kaduna state, rainfall is heaviest in the South and decreases northwards with the mean annual rainfall varying between 942mm and 1000mm. The rainfall lasts from May to October. The people of the state engage in agricultural production activities. The main crops produced are maize, sorghum, millet, rice, groundnut and cowpea. Livestock kept include sheep, goats, poultry, cattle and swine and fishing activities.

3.2 Sampling Procedure

A two-stage sampling procedure was adopted for this study. In the first stage, all the four LGAs in Kaduna metropolis, namely: Chikun, Kaduna South, Kaduna North and Igabi, were selected. A reconnaissance survey conducted identified 138 integrated fish-based farmers in the four LGAs during the 2015 to 2016 farming season. The second stage was the selection of all the integrated fish farmers in the four LGAs to give a sample size of 138 fish based farmers in the study area.

3.3 Method of Data Collection

This study made use of primary data to achieve the objectives of the study. The primary data were collected from the fish based farmers using structured questionnaire. Information collected included the quantity of inputs/costs (fingerlings, labour, pond size, drugs, seeds, fertilizer, feed, piglets, day old chicks, pen size, lime, pesticides)

used in fish, poultry, vegetables and swine production as well as fish and poultry; vegetables and swine output realized from the production process.

3.4 Analytical Techniques

3.4.1 Net farm income model

The net farm income model was used to calculate the profitability of the farmers. It was calculated by deducting total cost of production from total revenue in each of the integrated fish based farming system.

Net Farm Income = Total Revenue – Total Cost
NFI=TR - (TVC + TFC) (1)

Where:

NFI=Net Farm Income in Naira of the different fish-based integrated farming systems,

TR= Total Revenue in Naira (the proceeds from sales of products like fish, poultry meat, egg, pork and vegetables, depending on enterprise combinations of each fish-based farming system

TVC= Total Variable Cost in Naira (the costs of variable inputs like feed, drugs, fertilizer, piglets, day old chicks, seeds, labour, lime, pesticides) and

TFC= Total Fixed Cost in Naira (depreciated for pond, poultry house, pens, pelletizing machine, pumping machine, hammer mill and mixer).

The fixed inputs are not normally used up in the production process and were therefore depreciated using the straight line method. The choice of this method is based on its ease of computation. The depreciation is given by:

$$D = \frac{P - S}{N} \ldots \quad (2)$$

Where:

D= depreciation,
P= Purchase value of the asset,
S= the salvage value, which is the price of the asset after its expected years of usage, and,
N= the life span of the asset measured in years.

3.4.2 Analysis of variance (ANOVA)

ANOVA provides a statistical test of whether or not the means of several groups are all equal, and therefore generalizes t-test to more than two groups. This was used to test the hypothesis which states that ‘‘There is no significant difference in the profitability of the identified integrated fish based farming systems in the study area’’. This was achieved by comparing the profitability of the three fish based farming enterprises in the study area. The model for the One-way ANOVA test is expressed as:

$$F = \frac{\text{Variance between treatments}}{Variance\ within\ treatments} \ldots \quad (3)$$

more explicitly,

$$F = \frac{[\sum e^2 p - (\sum e^2 fpo + \sum e^2 fve + \sum e^2 fpi)]/K}{(\sum e^2 fpo + \sum e^2 fve + \sum e^2 fpi)/(n_1 + n_2 + n_3)} \quad (4)$$

Where:

$\sum e^2 p =$ unexplained variation of the profitability of the pooled fish based farmers,
$\sum e^2 fpo$ = unexplained variation of the profitability of integrated fish-poultry farmers,
$\sum e^2 fve$ = unexplained variation of the profitability of integrated fish-vegetables farmers,
$\sum e^2 fpi$= unexplained variation of profitability of integrated fish-pig farmers,
K = total number of estimated parameters,
n_1= sample size of integrated fish-poultry farmers,
n_2= sample size of integrated fish-vegetables farmers and
n_3= sample size of integrated fish-pig farmers

4. RESULTS AND DISCUSSION

4.1 Costs and Returns of Integrated Fish-Based Farming Systems

The results presented in Table 1 shows that the total variable cost (TVC) was the highest component (97.02%) of the total cost (TC) of production in the integrated fish-poultry farming system with the total fixed cost accounting for only 2.98%. Among the cost items, feeds were the major cost item which shared 43.23% of the total costs in the study area. This is consistent with the findings of the study [24] conducted in Ogun State, Nigeria. The high cost of feeds could be due to the high requirement of feeds to ensure healthy growth of fish and poultry. In terms of the revenue generated, fish sold accounted for the largest share (51.22%) of the total revenue while the value of spent layers sold constituted the lowest proportion (8.21%). This implies that the fish component of the integrated

fish-poultry farming system generated more revenue than that of the poultry component which is in contrast with the findings of [25] conducted in South West, Nigeria. It was found that fish based poultry farming was more profitable to the individual investors in the study areas which is in consonance with that of an earlier study [22] conducted in Pabna, Bangladesh.

Table 1. Average costs and returns in integrated fish-poultry farming system per annum

Items	Amount(₦)	Percentage (%)
A. Variable cost		
Cost of labour	125, 319.58	18.40
Cost of fingerlings	71,012.18	10.28
Cost of drugs	42,810.76	6.20
Cost of lime	8,561.43	1.24
Cost of feeds	298,572.11	43.23
Cost of day-old chicks	106,328.15	15.39
Cost of fertilizer	17,519.00	2.54
Total variable cost (TVC)	670,123.21	97.02
B. Fixed cost		
Depreciation on:		
Pond construction	8,953.12	1.30
Pen construction	10,057.00	1.46
Pumping machine	980.50	0.14
Feeders	210.73	0.03
Drinkers	386.44	0.06
Total fixed costs(TFC)	20,587.79	2.98
Total cost(TC)	690,711.00	100.00
C. Revenue		
Value of fish sold	951,310.80	51.22
Value of broilers sold	257,910.17	13.87
Value of eggs sold	495,430.00	26.68
Value of spent layers sold	152,501.83	8.21
Total revenue (TR)	1,8 57,152.80	100.00
D. Net farm income	1, 166,441.80	
Benefit-cost ratio (BCR)	1.69	

Source: Data analyzed from field survey, 2016

4.2 Costs and Returns of Integrated Fish and Vegetable Farming System

The total cost incurred and returns in integrated fish-vegetable farming system are shown Table 2. The total cost was largely accounted for by the total variable costs (97.16%) while the total fixed costs accounted for only 2.84% of the total cost of production. The costs incurred on feeds constituted the highest proportion (33.59%) of the total cost incurred while the costs incurred on pumping machine accounted for the lowest (0.7%). This finding agrees with that of [22] who found that the cost of feeds accounted for the largest proportion (26.0%) of the total cost of fish production. Of the revenue generated, the value of fish sold accounted for about 79.93% of the total revenue while the value of vegetable sold accounted for 20.07% of the total revenue. This implies that the fish component of the integrated fish-vegetable farming system generated more revenue than the vegetable component. The total cost of production was ₦590, 362.53 while the total revenue generated was ₦1,361,071.40, giving a net farm income of ₦770, 708.87. This result implies that integrated fish-vegetable farming system in the study area was profitable. The returns to Naira invested in integrated fish-vegetable farming system was estimated to be 1.31 implying that for every ₦1 naira invested in integrated fish-vegetable farming system, a profit of ₦1.31 was generated. This finding agrees with that of [26] who found that integrated fish and crop farming was profitable.

4.3 Costs and Returns of Integrated Fish-Pig Farming System

The results of the costs and returns in integrated fish-pig farming presented in Table 3 shows that the total variable cost constituted about 95.42% of the total cost incurred in the integrated fish-pig farming system while the total fixed costs accounted for only 4.58% of the total cost. The cost incurred on feeds constituted the highest percentage (41.87%), implying that the feed input cost constituted the bulk of the expenses incurred in integrated fish-pig farming system. Of the revenue generated, the value of fish sold accounted for (87.14%) of the total revenue while the value of pigs sold constituted the lesser fraction of the total revenue (12.86%). This implies that the fish component of the integrated fish-pig farming system generated more revenue than the pig component. The total cost of

production was ₦606,258.01 while the total revenue generated was ₦1,365,310.12, giving a net farm income of ₦759,052.11 per annum. This result implies that integrated fish-pig farming system in the study area was a profitable agricultural enterprise. The benefit-cost ratio in integrated fish-pig farming system was estimated to be 1.25, implying that for every ₦1 naira invested in integrated fish-pig farming system, a profit of ₦1.25 was generated. This finding is consistent with [27] in south west Nigeria.

4.4 Comparison of the Profitability of the Integrated Fish-Based Farming Systems in the Study Area

The three integrated fish-based farming systems were found to be profitable as shown in the results presented in Tables above. This implied that fish farmers who were hitherto into sole fish farming could integrate by adopting one or a combination of the three fish-based farming systems in order to enhance their profitability and invariably income generation. The most profitable of the three integrated fish-based farming systems was integrated fish-poultry farming system with a net farm income of ₦1,166,441.80 and a benefit-cost ratio of 1.69.This was followed by fish-vegetable farming whose net farm income was ₦770,708.87 and benefit –cost ratio of 1.31. The integrated fish-pig farming system had the lowest net farm income of ₦759,052.11 and a benefit-cost ratio of 1.25. It is important to note that the fish component of the integrated fish-poultry farming accounted for the largest (51.22%) of the total revenue while the value of spent layers sold constituted the lowest proportion (8.21%). This implied that the fish component of the integrated fish-poultry farming system generated more revenue than the poultry component. In similar manner, in the fish-vegetable farming, the value of fish sold accounted for about 79.93% of the total revenue while the value of vegetable sold accounted` for 20.07% of the total revenue. This implied that the fish component of the integrated fish-vegetable farming system generated more revenue than the vegetable component. Finally, of the revenue generated from the fish-pig farming, the value of fish sold accounted for (87.14%) of the total revenue while the value of pigs sold constituted the lesser fraction of the total revenue (12.86%). This implied that the fish component of the integrated fish-pig farming system generated more revenue than the pig component. From these, it could be concluded that the poultry, vegetable and pig component of the enterprises complemented the fish component at a reduced cost to the farmers. The ANOVA results in Table 4 shows that the calculated F value of 12.08 is significant at 0.01 probability level, implying that there was a significant difference in the profitability of the three fish-based farming systems in the study area.

Table 2. Average costs and returns in integrated fish-vegetable farming system per annum

Items	Amount(₦)	Percentage (%)
A. Variable cost		
Cost of labour	137,521.35	23.29
Cost of fingerlings	88,304.10	14.96
Cost of drugs	25,120.22	4.26
Cost of lime	10,548.85	1.79
Cost of feeds	198,275.33	33.59
Cost of seeds	22,960.12	3.90
Cost of fertilizer	74,360.00	12.60
Total variable cost (TVC)	557,089.97	97.16
B. Fixed cost		
Depreciation on:		
Pond construction	12,650.13	2.14
Pumping machine	4,121.93	0.70
Total fixed costs(TFC)	16,772.06	2.84
Total cost(TC)	590,362.53	100.00
C. Revenue		
Value of fish sold	1, 087,950.65	79.93
Value of vegetables sold	273,120.75	20.07
Total revenue (TR)	1,361,071.40	100.00
D. Net farm income (NFI)	770,708.87	
Benefit-cost ratio	1.31	

Source: Data analyzed from field survey, 2016

Table 3. Average costs and returns in integrated fish-pig farming system per annum

Items	Amount(₦)	Percentage (%)
A. Variable cost		
Cost of labour	94,111.18	15.52
Cost of fingerlings	72,560.00	11.97
Cost of drugs	28,310.58	4.67
Cost of lime	14,849.60	2.45
Cost of feeds	253,850.14	41.87
Cost of piglets	91,984.00	15.17
Cost of fertilizer	22,815.75	3.76
Total variable cost (TVC)	578,481.25	95.42
B. Fixed cost		
Depreciation on:		
Pond construction	18,345.11	3.03
Pen construction	8,110.00	1.34
Pumping machine	1,321.65	0.22
Total fixed costs(TFC)	27,776.76	4.58
Total cost (TC)	606,258.01	100.00
C. Revenue		
Value of fish sold	1,189,760.00	87.14
Value of pigs sold	175,550.12	12.86
Total revenue (TR)	1,365,310.12	100.00
D. Net farm income (NFI)	759,052.11	
Benefit-cost ratio (BCR)	1.25	

Source: Data analyzed from field survey, 2016

Table 4. ANOVA result for the difference between profitability of the three integrated fish-based farming systems

	Sum of squares	Df	Mean square	F value	Sig.
Between Groups	3.64E+10	2	1.82E+10	12.08	.01
Within groups	1.16E+12	132	8.77E+09		
Total	1.19E+12	134			

Source: Data analyzed from field survey, 2016

5. CONCLUSION AND RECOMMENDATIONS

The findings of the study showed that the fish-based integrated farming systems in the study area were profitable; hence have the potential for creating employment opportunities and generating income for the improvement of the standard of living of the populace. The results of the Costs and Returns of integrated fish-based farming systems showed that the total cost of production of integrated fish-poultry farming was ₦690,711.00 while the total revenue generated was ₦1,857, 152.80 and this gave a net farm income of ₦1,166, 441.80. For integrated fish-vegetable farming, the average total cost of production was ₦590, 362.53 while the average total revenue generated was ₦1, 361, 071.40 and this gave a net farm income of ₦770, 708.87. For integrated fish-pig farming, the total cost of production was ₦606,258.01 while the total revenue generated was ₦1,365, 310.12 and this gave a net farm income of ₦759,052.11. The three fish-based farming systems were therefore profitable. The ANOVA result shows that the calculated F value of 2.08 was significant at 1% probability level and this implies that there is a significant difference in the profitability of the three fish-based farming systems in the study area.

From the study, the cost of feeds constituted the largest share of the total cost of production in the three fish based farming enterprises. Hence, it is recommended that government and the private sector should provide adequate funding for livestock research that has to do with development of low cost high quality feeds using local feed materials and manufacturing of local machines. The farmers could also be trained on feed formulation. The fish based farmers should also ensure proper utilization of feeds to avoid

waste. Finally, there is need for more private sector participation in the production of high quality fingerlings to address the problems of stunted growth and susceptibility to early mortality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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