# Adoption of Biosecurity Measures for Sustainable Aquaculture Production in Ekiti State, Nigeria

**Omitoyin, S.[1] and Osakuade, K.[2]**

[1*]Department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria

https://orcid.org/0000-0003-4219-9276

[2]Department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria

Corresponding author: sbomitoyin@yahoo.com, sa.omitoyin@mail.ui.edu.ng

## Abstract

The study examined fish farmers' acquiescence to biosecurity practices in Ekiti State, Nigeria. A multi-stage sampling technique was used to select 150 respondents from three Agricultural Development Programme zones of the state. Structured questionnaire was used for data collection while data were analysed using illustrative and inferential statistics at $p<0.05$ level of significance. It was observed that 91% of the farmers were aware of fish diseases and pathogens. Stunted growth ($\bar{x}$ = 3.48±0.647), loss of market value ($\bar{x}$ = 2.9±1.152), increased cost of production ($\bar{x}$= 2.86±0.811) and loss of fish stock ($\bar{x}$ = 2.6±1.353) were the observed mean effects of fish disease. Most respondents (82%) isolated sick fish, but only few (3%) were committed to laboratory test and use of foot dip. The adoption level was 40%, indicating that the respondents were partial adopters in Ekiti state. Level of awareness, age, education, monthly income, and stocking density had significant relationships with adoption of biosecurity measures. To boost fish production, there is need for the creation of platforms providing enlightenment on sound biosecurity measures. There is also an urgent need for the provision of accessible and affordable veterinary services. These can be facilitated by the extension agents, NGOs and relevant institutions.

**Keywords: Adoption, Fish diseases, Preventive measures, Sustainable aquaculture**

## Introduction

Globally, aquaculture is seen as a solution to wild fish stock depletion and could help meet the protein needs of the rising human population. In Nigeria, aquaculture is a viable option for boosting food security, directly by producing fish for food and indirectly by providing employment and generating foreign exchange through the export of fish and fish products [1]. In 2014, the World Bank predicted that aquaculture would become the prime and foremost source of seafood by 2030, especially as demand for fish grows among the middle class and wild capture fisheries approach their maximum take [2].

Sustainable fish farming systems have the capacity to provide fish products for the global population, which is expected to reach nine billion by 2050 [3]. Sustainable aquaculture can be achieved through the application of best standards and management practices which include; good management plans, facility sanitation,

disinfection, good water quality monitoring, good disposal plans and proper record keeping of operations on the farm [4]. The aquaculture industry has grown tremendously over the years, increasing food production and having a positive effect on the economy. However, disease outbreaks and parasitic infections have become major constraining factors to the growth and sustainability of the sector [5, 6, 7].

Parasitic infections reduce fish productivity because of their effect on fish physiology [8, 9]. These parasitic infections sometimes result in disease outbreaks and mass mortality among cultured fish. Moreover, environmental circumstances such as poor water quality, fluctuations in temperature, poor nutrition, overcrowding, poor handling and transportation, which are common in intensive fish farming, pose stressful conditions to the fish and make them more susceptible to a wide variety of pathogens [10]. Disease outbreaks result in economic losses, not only from mortality but also from increased cost of production during treatment or loss of the opportunity to sell the fish [11, 12]. Infectious agent gain access to aquaculture facilities through the addition of new stock, contaminated water or feed, humans, animals or equipment and subclinical carriers within the existing stock. Hence, fish farmers need to adopt effective biosecurity measures on their farm, to check the spread of pathogens and disease outbreaks.

Biosecurity is a set of management procedures that can prevent the risk of introducing new diseases to a farm and to minimize or to eliminate the spread of disease within the herd [13]. It involves practices, habits, procedures and policies used to prevent the introduction and spread of disease causing organisms as well as invasive species. Biosecurity measures range from simple practices such as daily cleaning of rearing units, equipment disinfection, and development of policies guiding admission of visitors to hatcheries [14, 15]. Biosecurity helps to safeguard plant and animal health, enhance food safety, promote environmental sustainability, improve human health, protect biodiversity and serve as a panacea to soaring food prices [16].

Adoption is a conscious decision to implement new practices on a continuous basis. It is a major criterion for achieving success in agricultural extension services [17, 18]. Participatory efforts of all stakeholders in the aquaculture sub-sector towards adoption of biosecurity measures will guarantee aquaculture sustainability and promote food availability.

In this study the level of adoption of biosecurity measures for sustainable aquaculture was examined in Ekiti State, Nigeria. The study ascertained the socio-economic characteristics of the fish farmers, assessed farmers' perceived effect of fish disease on fish production and identified the adopted biosecurity measures being practiced by the respondents.

## Materials and Methods

### Description of the Study Area

Ekiti State is located along longitude 4º 45´ - 5º 45´ E and latitude 7º 15´-18º 5´ N in the southwest geopolitical zone of Nigeria (Figure 1), on a total land area of 5887.89

km$^2$. It lies south of Kwara and Kogi States, East of Osun State and is bordered by Ondo State in the East and in the South. Ekiti State has 16 local government areas (LGAs) and approximately 2,384,000 residents. The State is characterised by tropical climate with two contrasting periods of wet (April – October) and dry (November – March) seasons. Annual temperature varies from 21$^o$C to 28$^o$C with high relative humidity of 65% -75%. The southwesterly winds and the north east trade winds blow in the rainy and dry (harmattan) seasons, respectively [19]. The mean annual total rainfall in the south is about 1800 mm while that of the northern part is approximately 1600 mm (20). Agriculture is the major occupation of Ekiti indigenes providing employment for more than 75% of the population.

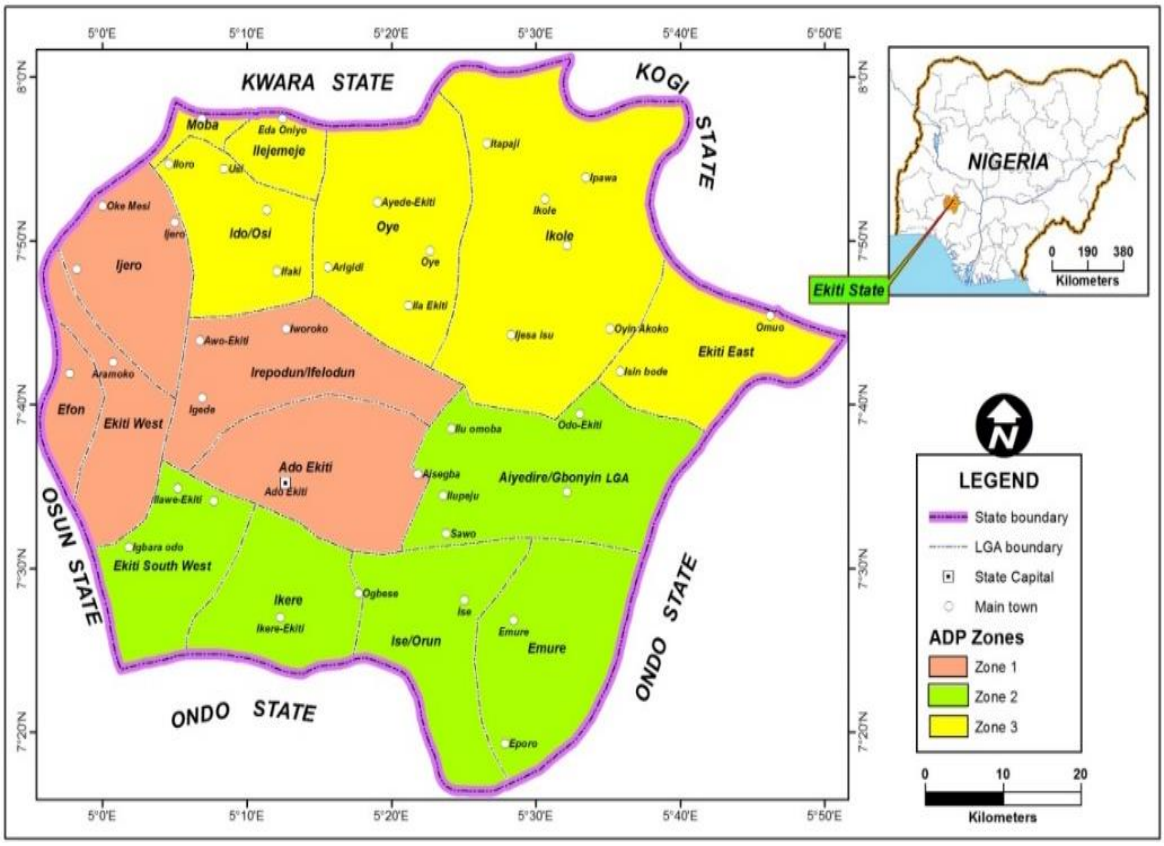


**Figure 1: Map of Ekiti State showing the three Agricultural Development Programme zones (inset: Map of Nigeria) Source: Department of Geography, University of Ibadan (2017).**

**Data Size and Sampling Technique**

One hundred and fifty (150) fish farmers from the three ADP zones in Ekiti State were chosen through multi-stage sampling technique. This form 10% of the total registered fish farmers in the state when the research was carried out. According to Singh and Masuku (2014), a good maximum sample

size is usually 10% provided it does not exceed 1000; to compensate for the persons that the researcher was unable to contact. All 16 Blocks (the Local Government Areas) were selected. However, 58 cells (fish farming communities) were purposively selected. These were the communities with the highest fish farming operations based on the secondary data obtained from the Department of Fisheries, Ministry of Agriculture and Natural Resources, Ekiti State. Ten percent (10%) of fish farmers were proportionally selected from each cell. Forty (40) respondents were randomly chosen from 5 blocks in Ikere zone, from within four cells in each of the 5 blocks. Forty (40) respondents were randomly chosen from 6 blocks in Isan zone, from three cells purposively selected from within the 6 blocks, then seventy (70) respondents were selected from 5 blocks in Aramoko zone, from four cells within each of the 5 blocks. A total of one hundred and forty-four (144) questionnaires were recovered and analysed from the 150 questionnaires administered (Table 1).

**Data Analysis**

A total of 144 questionnaire were recovered and used for data analysis.

Perceived effect of disease on fish production was obtained through a four-point Likert scale (most serious (4), more serious (3), serious (2) and not serious (1) [21, 22].

The biosecurity adoption level (eqn. 1) was computed using the adoption index described by [23, 22].

$$Adoption\ index = \frac{\text{nterviewees overall score x 100}}{Overall\ probable\ score} \ldots\ldots\ldots\ldots (1)$$

Based on the degree of adoption of biosecurity measures, the respondents were categorized as follows:

(1) Low adopters (up to 33%)
(2) Partial adopters (34 – 66%)
(3) High adopters (67 – 100%)

Using a multiple regression analysis (eqn. 2), the factors influencing the adoption of biosecurity measures by fish farms in Ekiti State were determined following the method of [24].

$$Y = X_0 + X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + e \ldots\ldots\ldots\ldots (2)$$

Where: Y = Adopted biosecurity measures
$X_0$ = Constant term
$X_1$ = Age of respondents (in years)
$X_2$ = Level of Education
$X_3$ = Stocking density (number of fingerlings stocked per pond)
$X_4$ = Monthly income (in ₦)
$X_5$ = Awareness (Yes =1, No=0)
$X_6$ = Formal training in fish farming (Yes =1, No = 0)
$X_7$ = Number of dependents (Actual number)
$X_8$ = Household size (Actual number)
e = error term

Data were analysed using descriptive and inferential statistics with the aid of Statistical Package for Social Sciences (SPSS-Version 21) software.

**Table 1. Population of fish farmers selected from each Agricultural Development Programme zone in Ekiti State, Nigeria**

| ADP zones and their Headquarters | LGA/Blocks | Selected farming community/ Cells | No. of registered fish farmers | Sample size |
|---|---|---|---|---|
| **Aramoko** | Ado (Ado-Ekiti) | Ado, Aso, Erifun, Ajebamidele | 380 | 38 |
| | Irepodun/Ifelodun (Igede) | Igede, Iyin-ekiti, Igbemo, Iworoko | 80 | 8 |
| | Ijero (Ijero-Ekiti) | Ijero, Ipoti, Ikoro, Ijurin | 80 | 8 |
| | Ekiti West (Aramoko) | Aramoko, Ikogosi, Okemesi, Erinjiyan | 80 | 8 |
| | Efon (Efon-Alaaye) | Efon-Alaaye, Oro, Iwaji, Araromi, Igbo-Aba | 80 | 8 |
| | Total = 5 | 20 | 700 | 70 |
| **Ikere** | Ikere (Ikere-Ekiti) | Ikere, Oke-Osun, Okeruku, Ogbonjana | 80 | 8 |
| | Ekiti South West (Ilawe ) | Ilawe, Ogotun, Igbara-Odo, Igbara-Odo II | 80 | 8 |
| | Ise/Orun (Ise-Ekiti) | Ise, Orun, Oraye, Erinwa | 80 | 8 |
| | Emure (Emure) | Emure, Ose, Owode, Igboso | 80 | 8 |
| | Gbonyin (Ode-Ekiti) | Ode, Aisegba, Agbado, Ijan | 80 | 8 |
| | Total = 5 | 20 | 400 | 40 |
| **Isan** | Ikole (Ikole-Ekiti) | Ikole, Ayebode, Ajileye | 80 | 8 |
| | Oye (Oye-Ekiti) | Oye, Itapa, Osin, Ilafon | 80 | 8 |
| | Ido-Osi (Ido-Ekiti) | Ido, Ifaki, Aiyetoro | 60 | 6 |
| | Ilejemeja (Iye) | Iye, Otun, Eda-Oniyo | 60 | 6 |
| | Moba (Otun) | Otun, Igogo, Osan, Aaye-Oja | 60 | 6 |
| | Ekiti East (Omuo-Ekiti) | Omuo-Ekiti, Araromi, Isinbode | 60 | 6 |
| | Total = 6 | 18 | 400 | 40 |
| **Grand Total** | **16** | **58** | **1,500** | **150** |

## Results and Discussion

### Socio-economic Characteristics of Fish Farmers

Most of the fish farmers were male (86%), with a smaller proportion of females (13%), suggesting that fish farming was predominantly a male dominated occupation in Ekiti State (Table 1). It has been previously reported that more males tend to engage in fish farming in southwest Nigeria [25, 26, 27]. The mean age of the respondents was 41±10.43 years, indicating that most of them

were middle-aged men. The farmers were mature, in their productive age and could actively undertake the rigorous tasks associated with fish farming [28, 29]. The larger proportion of the respondents had tertiary education (89%) indicating a positive trend for the occupation. Education is believed to create a favourable attitude towards acceptance of new ideas and practices. High level of formal education could increase the interest of farmers in the search for additional information on biosecurity measures and practices. Aremu *et al.* [30] opined that educational training promoted innovation and enhanced effective documentation in farm business. The years of experience was low, with only 19% of the respondents having between 4-6 years of fish farming experience. This is similar to the report of [31]. The study revealed that 40% of the fish farmers had approximately 2 dependents. This indicated that the farmers could have relatively sufficient resources that could be channeled towards the implementation of biosecurity measures. Uddin *et al.* [32] concluded that large household sizes create keen competition for small household resources. The awareness of fish diseases among farmers was high (91%) (Table 2). This is a positive development, as it increases vigilance and the ability of farmers to identify when their farms are at risk, thus taking the necessary biosecurity measures [33, 30].

A high proportion of the fish farmers (46%) had been trained by extension agents of the government (Figure 2). Aremu *et al.* [34] mentioned that extension workers trained farmers and created awareness on new innovations. The extension workers use persuasive approaches to educate farmers on something new or perceived to be new. Hence, in this study, access to extension services was a key motivating factor for the adoption of technology. Investment in education and training is essential for new technology adoption and socio-economic development [35]. Furthermore, the choice of management practices and use of prophylactics were based on the farmers' knowledge and experience [36]. Extension agents also provide useful information that help increase productivity [37].

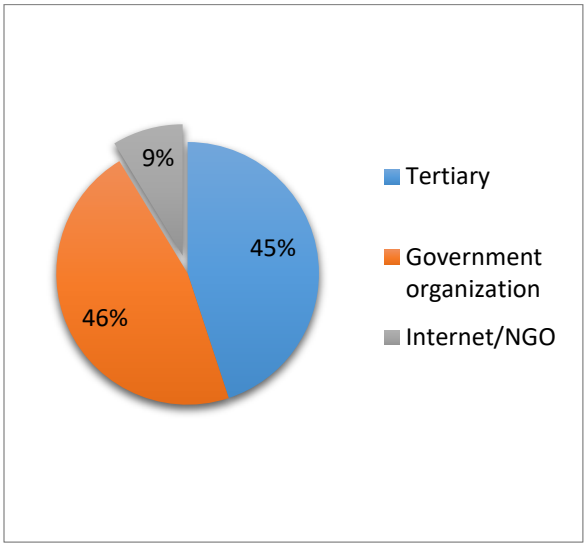


**Figure 2:** Pie chart indicating the source of training for fish farmers in Ekiti state, Nigeria

**Biosecurity Measures Adopted by Fish Farmers**

Different biosecurity measures adopted by the farmers in the management of their fish farms indicated that the isolation and treatment of sick fish (81.9%) was mainly used to prevent further transmission of disease (Table 2). This was followed by screening of ponds with nets (77%), which was used to shield ponds against predators. Regular monitoring of water quality (72%) and avoidance of variation within

**Table 2: Socio-economic Characteristics of Fish Farmers in Ekiti state, Nigeria**

| Variables | Freq. | Percentage (%) |
|---|---|---|
| **Gender** | | |
| Male | 124 | 86.1 |
| Female | 20 | 13.9 |
| **Age (mean = 41±10.43 years)** | | |
| 20 – 25 | 1 | 0.7 |
| 26 – 29 | 18 | 12.5 |
| 30- 39 | 57 | 39.6 |
| 40 – 49 | 37 | 25.7 |
| 50 – 59 | 20 | 13.9 |
| 60 and above | 11 | 7.6 |
| **Education Qualification** | | |
| Primary School | 3 | 2.1 |
| Secondary School | 11 | 7.6 |
| Tertiary Education | 128 | 88.9 |
| Informal education | 2 | 1.4 |
| **Years of fish farming Experience** | | |
| Less than 1 year | 16 | 11.1 |
| 1-3 years | 25 | 17.4 |
| 4-6 years | 28 | 19.4 |
| 7-12 years | 26 | 18.1 |
| Above 12 years | 13 | 9.0 |
| **Number of Dependents** | | |
| 1 – 2 | 58 | 40.3 |
| 3-5 | 47 | 32.6 |
| More than 5 | 10 | 6.9 |
| None | 29 | 20.1 |
| **Awareness of fish diseases and pathogens** | | |
| Yes | 131 | 91.0 |
| No | 13 | 0.9 |

stock (71%) were also popular measures. Other biosecurity measures included liming (58%) and cleaning or disinfecting equipment that was in contact with sick/dead fish/manure/contaminated feed (54%). Proper cleaning and disinfection can considerably reduce disease transmission because they lower the population of pathogens in the environment, below threshold levels [38, 39]. However, the respondents were lagging behind in some biosecurity measures. For example, only 36% of the respondents quarantined juvenile/fingerlings prior to stocking and 10% treated their water before use, probably due to inadequate knowledge on the importance of these practices [40]. Only a small number of fish farmers (3%) conducted post mortem analysis on dead or morbid fish, to ascertain the exact types of diseases responsible for fish death and prevent future disease outbreaks. In addition, only 3% of respondents had active foot dip/ hand hygiene facilities on their farms and subjected feed and diseased fish to laboratory diagnosis. The installation and use of foot dips help to decrease the load of organisms on boots [41]. The adoption index showed that the fish farmers were partial adopters (40%) of biosecurity measures (Table 3). This level of adoption was lower than that reported by Lestari *et al.* [22], who reported that cattle farmers in South Sulawesi province of Indonesia had a biosecurity adoption level of 47% (Table 4).

The adoption of biosecurity measures is further constrained by inadequate dissemination of information on fish diseases, shortage of diagnostic infrastructures, insufficient human resource with expertise on fish health, high cost of diagnosis, lack of

well-equipped veterinary laboratories for identification of pathogens, absence of outbreak reports due to poor record keeping by farmers and the poor socio-economic status of the farmers [42].

The analysis of the adoption level of total biosecurity measures revealed that 77% of the fish farmers accomplished partial levels of adoption. Hence, fish farmers need to be encouraged and enlightened on the benefits and importance of biosecurity in aquaculture. This enlightenment drive should be managed by extension workers, with adequate funding from government and NGOs. Lestari *et al.* [43] also reported that cattle farmers in South Sulawesi Province were partial adopters of biosecurity measures. However, Susilowati *et al.* [44] reported that majority of chicken layers smallholders in West Java were high level adopters of biosecurity measures.

**Table 3: Ranking of biosecurity measures adopted by fish farmers in Ekiti State Nigeria**

| Variables | Percentage | Rank |
|---|---|---|
| Isolation of sick fish | 81.9 | 1st |
| Pond screening against predators | 77.1 | 2nd |
| Water quality monitoring | 72.2 | 3rd |
| Avoidance of variation within stocked fish | 70.8 | 4th |
| Use of liming as preventive measures | 58.3 | 5th |
| Cleaning and disinfection of equipment that is in contact with sick/dead fish/manure/contaminated feed | 53.5 | 6th |
| Quarantine of juvenile/fingerlings for a period of time before stocking | 36.1 | 7th |
| Treatment of water before usage | 10.40 | 8th |
| Proper post-mortems and diagnostic tests | 6.30 | 9th |
| Use of active foot dips and hand hygiene facilities | 2.80 | 10th |
| Subjection of fish feed to laboratory test | 2.80 | 10th |
| Laboratory test of dead/moribund fish | 2.80 | 10th |
| **Adoption level** | **39.6** | |

**Table 4: Level of Adoption of Biosecurity Measures among Fish Farmers in Ekiti state, Nigeria**

| Level of Adoption | Number of Respondents | Percentage (%) |
|---|---|---|
| Low adopters (33%) | 6 | 4.2 |
| Partial adopters (34-66%) | 111 | 77.1 |
| High adopters (67-100%) | 27 | 18.7 |
| Total | 144 | 100 |

**Perception of Fish Farmers on the Effects of Fish Diseases on Fish Production**

Most farmers identified 5 perceived effects of diseases and believed that stunted growth (3.48±0.64) was the major challenge posed by fish diseases to production (Figure 3). Other effects were the loss of market value (2.9±1.52); increased cost of production (2.86±0.81); and loss of fish stock (2.6±1.35). Previous authors have shown that cost of production tends to increase due to the additional cost incurred during treatment of diseased or sick fish, or during re-stocking, after fish loss [10, 45, 46].

The adjusted R-squared value of the multiple regression analysis indicated that the independent variables explained 40% of the variation in adoption of biosecurity measures by fish farmers in Ekiti state. Hence, independent variables such as awareness, age, education, monthly income from other sources and stocking density had significant effects on biosecurity measure adoption ($P < 0.05$). However, training on fish farming and household size had no significant effect (Table 5). This findings are in agreement with [41] and [47]. The farmers age ($\beta = 0.067$) was found to be significant and positively related to adoption levels, implying that age increase could promote the adoption of biosecurity measures. Older farmers are assumed to have gained knowledge and experience over time and have better ability to evaluate technology information than younger farmers [48]. On the contrary, Emmanuel [49] opined that younger farmers would comparatively favour the adoption of new technology, while older farmers were more conservative in technology adoption.

Similarly, the level of formal education ($\beta = 0.061$) of fish farmers significantly improved the adoption of biosecurity measures. It has been confirmed that formal education tends to have progressive influence on the behaviour of the farmers [37, 50].

The number of dependents ($\beta = 0.047$) had a significant but negative influence on biosecurity measure adoption. This implies that adoption was higher among fish farmers with fewer dependents, in concurrence with [38] and [51]. Also, monthly income from other sources ($\beta = 0.028$) was found to be significant but negatively influencing adoption levels. This suggests that fish farmers with alternative sources of income might pay little attention to biosecurity measures on their farms, due to the extra time and energy required for their implementation.

The stocking density ($\beta = 0.016$) was found to negatively affect adoption levels, with fish farmers maintaining lower stocking densities, being more favourably disposed to biosecurity measures adoption. Stocking density is a pivotal factor affecting fish welfare, because it could trigger disease through pollutants emanating from increased metabolic waste when a pond has exceeded its carrying capacity [52, 53].

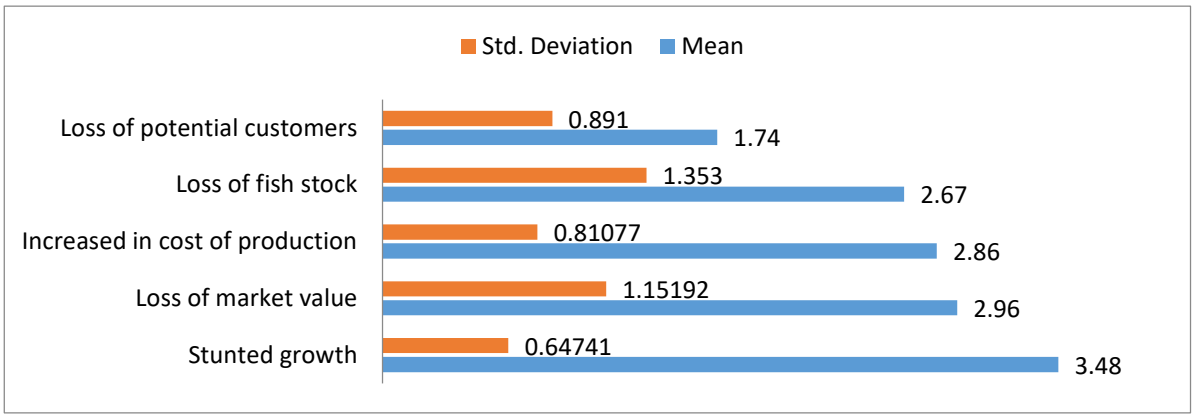


**Figure 3: Perceived effects of fish diseases on fish production in Ekiti state, Nigeria**

**Table 5: Factors influencing adoption of biosecurity measures among fish farmers in Ekiti State, Nigeria**

| Variables | Beta | Standard error | t-value | Significance |
|---|---|---|---|---|
| Constant | 1.374 | 0.176 | 7.793 | 0.000*** |
| Awareness | 0.173 | 0.024 | 7.128 | 0.000*** |
| Age | 0.067 | 0.015 | 4.493 | 0.000*** |
| Level of education | 0.061 | 0.030 | 2.035 | 0.044* |
| Household size | 0.028 | 0.020 | 1.381 | 0.170 |
| Number of dependent | -0.047 | 0.018 | -2.595 | 0.011** |
| Monthly income | -0.028 | 0.009 | -3.245 | 0.001*** |
| Stocking density | -0.016 | 0.006 | -2.554 | 0.012** |
| Training on fish farming | -0.077 | 0.080 | -0.971 | 0.333 |

Adjusted $R^2$ = 0.40; F-value = 12.93*; N = 144; (*10%, **5%, ***1% indicates the degree of statistical significance).

## Conclusion

Fish disease is a major problem in fish farming and most farmers were aware of the serious impacts it could have on their investments. Some of the perceived effects included stunted growth of fish stock, loss of market value, and increased cost of production. Hence, fish farmers adopted biosecurity measures such as isolation of sick fish, pond screening, monitoring of water quality and avoidance of variation within stocked fish. Nevertheless, most farmers in Ekiti State were partial adopters of these essential biosecurity measures. Some of the main factors influencing adoption of the measures included awareness, farmers' age, education, alternative sources of income and stocking density. This study revealed that

older farmers with formal education and high level of awareness were more likely to adopt biosecurity standards.

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