Determinants of Catfish Farmers' Use of Sustainable Environmental Management Practices in Enugu State, Nigeria
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Abstract

The study assessed the use of sustainable environmental management practices (SEMP) by fish farmers in Enugu state, Nigeria. Seventy-five catfish farmers selected through multistage sampling procedure were used for the study. Data were obtained with the aid of a well-structured questionnaire. Analysis of data was done using descriptive statistics, probit regression model and factor analysis. Results showed that most of the catfish farmers did not apply SEMP as only 25.33% of them had a score of 50% and above regarding the application of SEMP. The number of years spent in school and being a male significantly increased the likelihood of using SEMP. In contrast, the likelihood of use of SEMP significantly reduced with an increase in the number of production cycles carried out by a fish farmer. The fish farmers' constraints were grouped as poor technical knowledge and feed issues, financial uncertainties, and water supply problems. Government should deliver training packages and provide information on SEMP to catfish farmers through different media, including extension agents, radio and television messages, handbills and billboards. Supporting the farmers with credit facilities through existing credit programmes would help reduce their challenges in applying SEMP.

Keywords: sustainable practices, environmental management, catfish farmers

Introduction

Aquaculture, especially fish farming, gained prominence over the years due to the decline in biomass and catch of wild fish as well as the need to meet protein requirements and achieve food security among the world's surging population (Food and Agricultural Organization (FAO) 2016; Pauly and Zeller 2017). Aquaculture

accounts for more biomass than captured fisheries and is responsible for more protein than fish from wild catches; thus, the sector is considered the fastest-growing food technology globally (Golden *et al*., 2017; Edwards, Zhang, Belton, and Little, 2019). The sector contributes 47% of fish production globally, with a growth rate of 5.8% witnessed between 2001 and 2016 (FAO, 2016, 2018).

In Nigeria, output from aquaculture, mainly catfish farming (FAO, 2017), has increased over the years, growing from 21 700 tonnes in 1999 to 316 700 tonnes in 2015 (Federal Ministry of Agriculture and Rural Development (FMARD), 2017). However, despite increased production over the years, the average output of 1.5 tons/hectare/year from the sector is well below its potential of 15 tons/hectare/year (FMARD, 2017). The poor output per hectare could be due to fish farmers' inadequate production and weak environmental management practices in Nigeria. Boyd *et al*. (2020) echoed the need for technologies that enhance productivity while reducing the environmental footprint of aquaculture as increase in fish production has been linked to some negative environmental impacts (Obiero *et al*., 2019). Thus, one of the approaches for promoting good fish farming is promoting sustainable environmental management practices (Farm Africa: Kenya Market-Led Aquaculture Programme, 2016). Sustainability is seen as the ability of human activities to persist over time while maintaining a healthy environment (Boyd *et al*., 2020). Thus, sustainable management practices would help achieve more resilient and productive food systems and facilitate sustainable production, especially in aquaculture, which would help ensure food security and poverty reduction (Piñeiro et al. 2020).

Negative environmental impacts in fish production result mainly from waste production and improper waste management and disposal of untreated effluents to the surroundings, and escape of fishes which can result in changes in wild fish genotype and thus affect biodiversity (White, 2017; Dauda *et al*., 2019). Sustainable environmental management practices in fish production are facilitated through efficient pond management, including water quality management, adequate feed input and disease control and management practices, proper waste management (both solid and dissolved wastes) (Dauda *et al*., 2019).

Some previous studies have determined the factors that influence the adoption of improved technologies in aquaculture. Kumar *et al*. (2018) found that perception of technology as cost-effective and easy to manage, cheap in price, and high expected profits positively and significantly enhanced the likelihood of adoption. Obiero et al. (2019) found that having secondary education and above, fish farm size, diversified on-farm activities, attendance to extension training, ease of handling technologies, production levels and satisfaction with extension service are positively and significantly associated with aquaculture technology adoption. However, notwithstanding some studies on the adoption of production technologies, studies on sustainable environmental management practices in aquaculture that could guide evidence-based policy in environmental management are lacking. Hence the questions are: what is the level of involvement of fish farmers in carrying out some sustainable environmental management practices? What factors influence the use of sustainable environmental management practices? What are the constraints to the implementation of sustainable environmental management practice? This study, therefore, assessed the use of sustainable environmental management practices

and constraints militating against the application of sustainable environmental management practices by catfish farmers in Enugu State, Nigeria.

Methodology

The study area was Enugu state, southeast geo-political zone of Nigeria. It is composed of 17 local government areas and 291 political wards. The state has a total landmass of about 8,022.96 km^2 and a population of about 4,185,509 (National Population Census (NPC), 2006). It lies between latitudes 5^0 56'N and 7^0 06'N and longitudes 6^0 53'E and 7^0 55'E.

Multistage sampling procedure was used in selecting the respondents. In the first stage, the predominant Local Government Areas where fish farming is practiced were mapped out with the help of officers in the Fisheries Department of Enugu State Ministry of Agriculture. In the second stage, from the mapped local government areas (LGA) in Enugu State, five LGAs were randomly selected for the study, namely; Udi, Enugu East, Enugu South, Nkanu West and Nsukka. Before the third stage sampling, a list of fish farmers in the sampled LGAs was compiled with the help of officers in the Fisheries Department of Enugu State Ministry of Agriculture and the staff of the agricultural department of the LGAs. The list was made up of 40, 40, 30, 20 and 20 fish farmers from Udi, Enugu East, Enugu South, Nkanu West, and Nsukka respectively. In the second stage, 50% of the compiled fish farmers were sampled using proportionate random sampling, giving a sample size of 75 fish farmers for the study.

Primary data were obtained through the administration of well-structured and validated questionnaires. The questionnaire was validated by five experts drawn from the faculty of agriculture and biological sciences, University of Nigeria Nsukka. The questionnaire was used to obtain information such as socioeconomic characteristics of fish farmers, various environmental management practices by the fish farmers, and constraints to sustainable environmental management. Eight different environmental management practices were provided to the fish farmers, from which they indicated the ones practiced. The practices include measuring dissolved oxygen in pond, having a security device in a pond, treat wastewater before disposing of, experience fish escape, proper handling of predators, clean pond after each production cycle, proper effluent disposal (not released indiscriminately to the surroundings) and having a documented waste management strategy to avoid waste build-up. The fish farmers were asked to indicate yes or no for each of the practices. The application of the itemized sustainable environmental management practices in their farms was confirmed during a visit to the farms for data collection. However, this was not applicable for some practices, namely, proper handling of predators, which the farmers indicated whether they killed predators or not, the experience of fish escape and cleaning of ponds after each production cycle, and proper effluent disposal.

Mean, and percentage, were applied to describe the socioeconomic attributes of the fish farmers and the sustainable environmental management practices they employed. A probit model was applied to estimate determinants of use of sustainable environmental management practices. First, the respondents were scored following their responses regarding the eight practices. Correct practice was assigned a score of 1. These scores were added up to obtain a percentage score. Those that scored

50% and above were considered as practicing sustainable environmental management in fish production, while those that scored less than 50% were considered as not practicing sustainable environmental management. Thus, in the probit model, the practice of sustainable environmental management in fish production, y_i, is the dependent variable (it takes a value of 1 if the fish farmer practices (having a score of 50% and above), and 0 if otherwise). In this estimation, the dependent variable is a latent variable y^* determined by a set of explanatory variables, which form part of the vector x'. The model is generally given as:

$$y_i^* = x_i'\beta + u_i \qquad (1)$$
$$y_{i=}1 \ if \ y_i^* > 0; \ y_i = 0 \ if \ y_i^* \le 0 \qquad (2)$$

where the subscript i means fish farmers; the vector β is the model parameters; and u is the error term, which is normally distributed with a 0 mean and variance that equals 1. Thus, the model for estimating the determinants of the practice of sustainable environmental management (SEM) is specified as follows:

$$SEM_i = \beta_1 + \beta_2 Hou\_size_i + \beta_3 Gender_i + \beta_4 number\_years\_school_i + \beta_5 credit\_access_i + \beta_6 num\_years\_expe\_fish\_farming_i + \beta_7 quantity\_finger\_stocked\_last\_one\_year_i + \beta_8 num\_cycles\_produ\_last\_one\_year_i \qquad (3)$$

Maximum-likelihood estimation of the probit models was carried out and the marginal effects were equally calculated. The variables included in the model were those with calculated variance inflation factor (VIF) of less than ten (10), suggesting that multi-collinearity was not present. According to Greene (2018), a variable is assumed to be collinear if VIF exceeds 10. The description of how the variables used in the model were measured is as shown in Table 1.

Furthermore, exploratory factor analysis was used to group the constraints to sustainable environmental management practices identified by the fish farmers. The factor analysis was implemented using the principal factor model with varimax rotation. After varimax rotation, variables whose loadings are from 0.45 and above, suggesting a 20% overlapping variance considered fair were used to name the factors.

Table 1: Variables used in model estimated

Variable	Description
Number of years spent schooling by the household head	Number of years spent in school
Household size	Household size of members of the household
Gender of household head – Males	Dummy takes the value of 1 if male and 0 otherwise
Access to credit facilities	Dummy takes the value of 1 if fish farmer has access to credit facilities and 0 otherwise.
Number of years of experience in fish farming	Number of years of experience

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Number of fingerlings stocked in the last one year of operation	Number of fingerlings stocked
Number of cycles of production in the last year	Number of cycles of production

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Results and Discussion
Descriptive Statistics of Explanatory Variables Used in the Model

Table 2 shows the means and standard deviation of the explanatory variables used in the model. The result shows that the fish farmers' average number of years spent in school was 14, suggesting that the majority had some secondary and above education. The average household size was six persons, and the average number of years of experience in fish farming was five years. Also, the average number of production cycles and fingerlings stocked in the last year preceding the interview were 3 and 6,183, respectively. In addition, 77% of the fish farmers were males.

Table 2: Description, variable means and standard deviation

Variables	Means	Standard Deviation	Maximum	Minimum
Number of years spent schooling by the household head	13.89	3.74	6	24
Household size	5.61	3.44	0	22
Gender of household head – Males	0.77	0.42	0	1
Access to credit facilities	0.36	0.48	0	1
Number of years of experience in fish farming	5.31	4.37	1	28
Number of fingerlings stocked in the last one year of operation	6182.80	17456.28	60	100,000
Number of cycles of production in the last year	2.8	1.76	1	10

Source: Field survey data, 2021.

Sustainable Environmental Management Practices by farmers

The result regarding the fish farmers' sustainable environmental management practices is shown in Table 3. The overall result shows that only 25.33% (based on the score of 50% and above) of the fish farmers employed sustainable environmental management practices. Although the majority (76.00%, 73.33%, and 60.00%) of the fish farmers had security devices in ponds, clean ponds after each production cycle, and did not experience fish escape respectively, a very low proportion (13.33% and 1.33%) of the fish farmers did not have a strategy for reducing waste build-up and do not treat wastewater before disposal respectively. This finding suggests that the majority of fish farmers in the area did not employ sustainable environmental management practices in aquaculture. This finding equally suggests that fish

production in the area is polluting the environment and that output is sub-optimal with reduced income for the fish farmers. This result could be one of the reasons why the 1.5 tons/hectare/year average output from aquaculture in Nigeria is well below its potential of 15 tons/hectare/year (FMARD, 2017).

Table 3: Sustainable environmental management practices used by the fish farmers

Sustainable Environmental Management Practice	% of fish farmers using the practice
Measure dissolved oxygen in ponds	30.67
Have a security device in a pond	76.00
Treat wastewater before disposing	1.33
No fish escape from ponds	60.00
Handle predators properly- not killing predators but scare them aware	38.67
Clean pond after each production cycle	73.33
Has strategy for reducing waste build-up in ponds	13.33
Proper effluent disposal (not released indiscriminately to the surrounds)	46.67
Percentage with sustainable environmental management practice (overall score of 50% and above)	25.33

Source: Field survey data, 2021

Determinants of Sustainable Environmental Management Practices by Fish Farmers

The parameter estimates and marginal effects of the determinants of sustainable environmental management practices employed by the fish farmers are presented in Table 4. The result shows that the likelihood of applying sustainable environmental management practices by fish farmers significantly (at a 5% probability level) increases with being a male farmer (1.276) and the number of years spent in school (0.150). Specifically, the result shows that the likelihood of using sustainable environmental management practices increases by 31.6% and 3.7% with being a male and spending more years in school. The result suggests that fish farmers who are male and have spent more years in school are likely to employ sustainable environmental management practices in fish farming. This high marginal effect of education underscores the need to provide fish farmers, especially male ones, with good training and knowledge of sustainable environmental management practices in fish farming. The finding is in line with Obiero et al. (2019) that secondary education and above and extension training are positively and significantly associated with aquaculture technology adoption.

On the other hand, the result also shows that the likelihood of use of sustainable environmental management practice significantly (at 5% probability level) reduces by

10% with an increase in the number of production cycles carried out by a fish farmer. This finding suggests that fish farmers who carry out many production cycles are less likely to employ sustainable environmental management practices. This finding equally shows that increased production level does not support the use of sustainable environmental management practices, contrary to Obiero et al. (2019), who reported that production level significantly enhances the adoption of aquaculture technology. This result is expected as fish farmers may neglect sustainable environmental practices with increased production levels to meet the commitments that many production cycles will involve, especially when they do not have the required knowledge.

Table 4: Determinants of sustainable management practices employed by the fish farmers

Explanatory Variables	Coefficients	Marginal Effects
Gender	1.276* (0.497)	0.316* (0.106)
Number of years in school	0.150* (0.075)	0.037* (0.017)
Access to credit	-0.175 (0.538)	-0.043 (0.133)
Number of years of experience in fish farming	-0.045 (0.049)	-0.011 (0.012)
Household size	-0.042 (0.058)	-0.010 (0.014)
Number of fingerlings stocked	-3.63×10^{-6} (0.00003)	-8.97×10^{-7} (8.31×10^{-6})
Number of production cycles	-0.406* (0.204)	-0.100* (0.046)
Constant	-0.286 (1.209)	
Number of observations	75	
LR chi (7)	18.33	
Prob> chi2	0.010	
Log likelihood	-33.283	

Source: Computed from field survey data, 2021. Note: *$P \leq 0.05$. Variables in parenthesis are standard errors.

Constraints to Sustainable Environmental Management Practices by Fish Farmers

Furthermore, the result of factor loadings regarding the constraints to sustainable environmental management practices, as indicated by fish farmers, is presented in Table 5. Three factors were extracted as those that constrain the fish farmers from using sustainable environmental management practices. Factor 1 was named poor technical knowledge and feed issues, while factors 2 and 3 were named financial uncertainties and water supply problems, respectively. The findings suggest the need to provide fish farmers with adequate knowledge, financial incentives and improved water supply to facilitate sustainable environmental management practices. Having adequate knowledge was also found to be one of the significant

determinants of the application of sustainable environmental management practices in aquaculture.

Table 5: Constraints to the use of sustainable environmental management practices

Constraints	Factor 1 (Poor Technical Knowledge and Feed Issues	Factor 2 (Financial uncertainties)	Factor 3 (Water supply problems)
High illiteracy level among the catfish farmers	0.814		
Inadequate monitoring and evaluation	0.778		
Poor technical knowledge	0.655		
Inadequate feed supply	0.636		
Lack of quality feed	0.575		
Lack of capital		.777	
Poor access to credit		.739	
High cost of feeds		.630	
Lack of adequate space for fish farming		.594	
Fear of uncertainties		.496	
Inadequate water supply			.806
Insufficient water in the dry season			.608
Lack of adequate information			.499

Source: Field survey, 2021

Conclusion and Recommendations

Based on the findings, one can conclude that most fish farmers do not apply sustainable environmental management practices. Given the effect of poor sustainable environmental management practices on fish production, this could be one of the reasons for the low output per hectare recorded in fish farming in Nigeria. Enhancing the education and knowledge of male catfish farmers can stimulate the use of sustainable environmental management practices in aquaculture. On the other hand, deliberate targeting of female fish farmers with training and information

on sustainable environmental management practices is required to encourage them to adopt the practices. Also, targeting farmers with increased production levels, especially those involved in many cycles of fish production, who are likely to avoid sustainable environmental management practices are required to reduce the environmental footprint of aquaculture. In addition, enhancing access to credit for fish farmers will reduce their challenges in employing sustainable environmental management practices.

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