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Emerging Technologies in Fish Farming Among Agricultural Science Teachers in Calabar Zone, Cross River State, Nigeria

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Abstract
This research explored the adoption of emerging technologies in fish farming among agricultural science teachers in the Calabar Education Zone of Cross River State, Nigeria. The zone includes seven Local Government Areas: Calabar South, Calabar Municipality, Odukpani, Akpabuyo, Akamkpa, Biase, and Bakassi. The study aimed to evaluate the skills necessary for implementing emerging technologies in fish farming among agricultural science teachers in Calabar Zone, Cross River State, Nigeria. The target population consisted of all agricultural science teachers in secondary schools within the study area. A null hypothesis was proposed, stating that no significant difference exists in the mean responses of agricultural science teachers regarding the integration of these technologies. A descriptive survey design was utilised, involving all agricultural science teachers in secondary schools across the region. Data were gathered from 101 teachers in 21 secondary schools and analysed using mean and standard deviation to identify the essential competencies for integrating emerging fish farming technologies. The results indicated that the most highly rated competencies were fish harvesting and marketing. Based on the findings, the study concluded that the successful integration of these technologies requires targeted training, curriculum development, and the establishment of practical learning environments such as school fish farms. And recommended that the state education ministry should allocate resources to support the creation of a fish farm for practical agricultural science, and that teachers in the study area should be exposed to frequent emerging technologies in fish farming.

Keywords: Emerging Technologies, Fish Farming, Agricultural Science Teachers, Calabar Zone, Aquaculture Education

Introduction

The integration of emerging technologies into fish farming is gradually transforming the agricultural landscape, especially among agricultural science teachers who serve as key knowledge transmitters to future farmers (Goswami et al., 2023). As global demand for fish continues to rise due to population growth and dietary preferences, it becomes increasingly important to adopt advanced techniques that enhance productivity, sustainability, and profitability in aquaculture. Agricultural science teachers, particularly in Nigeria, are central to disseminating these innovations, given their role in curriculum delivery, extension work, and research (Kaleem & Bio, 2021). Emerging Technologies in Fish Farming include the following: Recirculating Aquaculture Systems (RAS), Biofloc Technology, Integrated Multi-Trophic Aquaculture (IMTA), Automated Feeding and Monitoring Systems, Genetic Improvement and Breeding Technologies, IOT and Smart Aquaculture Devices, and Drone and Satellite Imaging (Hameed et al., 2022; Hu, 2022; Irungu, 2018).

Despite the availability of these technologies, their adoption among agricultural science teachers is influenced by socioeconomic factors, access to training, institutional support, and infrastructural development. Effiong (2024a) underscores how socioeconomic variables and extension barriers influence agricultural practices in Akwa Ibom State, a scenario likely mirrored in aquaculture technology adoption. The same study highlights the need for stronger extension services, an aspect vital for teacher awareness and application of emerging technologies (Misra et al., 2023; Olufemi, 2024). In another study, Effiong and Aboh (2024) evaluated the effectiveness of agricultural extension models in food crop production, noting that participatory and farmer-led models are more effective. Applying this insight, similar models could improve teachers' uptake and dissemination of fish farming technologies. Teachers also draw from interdisciplinary agricultural innovations. For instance, Effiong and Aboh (2018) examined rubber production technologies in similar socioeconomic environments, emphasising that context-specific adaptations are critical. Similarly, the study by Effiong et al. (2016) on technology adoption among rubber farmers highlights key adoption drivers such as awareness, perceived usefulness, and peer influence—factors equally applicable to fish farming technologies. Furthermore, challenges in the agricultural sector, including those affecting fish farming, are often exacerbated by environmental degradation. Effiong et al. (2023) explore how oil spillage affects agricultural lands, drawing attention to the ecological threats that must be addressed alongside technological innovation. Agricultural science teachers are not just implementers but also advocates for sustainable practices. The findings of Effiong and Asikong (2013) on the Fadama III project suggest that mid-term assessments and continuous evaluation of farming projects are essential. This principle can be extended to fish farming technologies to ensure that they remain effective and sustainable over time. The role of teachers in educating future generations and rural farmers on new technologies is pivotal, as seen in Effiong (2013), who discussed the role of women in agricultural production. Teachers can empower underrepresented groups, such as women and youth, to engage in tech-enabled aquaculture ventures, thereby expanding opportunities for economic independence and food security.

The need to asses the competencies of Agricultural Science Teacher is very necessary as their role in the education system. Competitiveness encompasses a wide range of factors, including the capability to perform related tasks efficiently and effectively (Effiong, 2024b; Effiong et al., 2023; Effiong & Asikong, 2013; Effiong & Etim, 2024; Effiong et al., 2016). It equips farmers with the necessary knowledge and evolving skills to adapt to emerging challenges, thereby minimising pressure on the environment and other natural resources. Fish plays a great role in human nutrition, especially as a source of protein. In some reports, some species of fish contain substances that could of lighting a variety of ailments (Kado, 2008). The consumption of fish in Nigeria currently outs tips supply. Most of the fish are from sources in rivers and oceans (Ekpo, 2016; Effiong & Iheme, 2024; Udofia, 2016; Kado, 2008). The knowledge of fish farming from the stocking to marketable fish development, that is from fingerlings to the harvesting stage. The common varieties of fish with viable economic value in Nigeria are Tilapia and Catfish. They could be served fresh in cooking or stewed or dried or sometimes roasted, barbeque. Fish farming is an intensive system of management, despite the type of fishpond employed, from concrete tank, earthen pond, polyculture, cages, raceways and circulatory system, including feeding and health requirements (Effiong & Effiong, 2012; Ijioma et al., 2014). Water quality management is crucial for the resource to be optimal in all the biological, chemical and physical attributes such as dissolved oxygen, PH, Temperature, NO, and Alkalinity. Fish farming enables the rapid and cost-effective production of large quantities of fish compared to wild-caught fishing, utilising efficient management techniques. However, several challenges accompany these practices. For instance, pollution can occur due to the accumulation of fish waste and uneaten feed beneath sea pens, which may degrade water quality. Additionally, fish farming often relies on chemicals to prevent diseases, as well as disinfectants and anti-corrosion substances for equipment maintenance, all of which can negatively impact the aquatic ecosystem. Another major challenge in Nigeria's fish farming industry is the high cost and, at times, limited availability of fish feed. According to Ekpo (2016), capital is most detrimental to certain infrastructures, such as good accessible roads and regular, effective water supply hinders the growth of fish farming as both add to their cost of production.

Many scientists have agreed that fish farming impact on biodiversity. By introducing farmed species of fish into wild, which is often at times done unintentionally by fish escapes, predating birds, equipment failure, human error and overflooding (Ekpo, 2016). That had resulted in fewer generically fish variations, infertile offspring and less global biodiversity. Sustainable Development is a dynamic and evolving concept that focuses on progress in the present while ensuring that future generations can also meet their needs. Sustainable national development involves expanding opportunities that allow individuals to reach their full potential over time while maintaining the stability of economic, social, and environmental systems (Aboh & Effiong, 2019; Nkang & Effiong, 2015; Effiong & Aboh, 2018). At its core, sustainable development is based on three fundamental pillars: the economy, the environment, and society. Globally, many nations recognise the importance of education in achieving sustainability. However, in Nigeria, a lack of vision and awareness, compounded by inadequate planning, supervision, and implementation of well-structured policies, has hindered progress in this area. Addressing these critical issues can help the Nigerian government prevent setbacks and achieve long-term sustainability. To ensure sustainable development, it is essential to identify and address key focus areas (Effiong, 2013; Effiong & Aboh, 2024; Effiong, 2024a; Effiong & Aboh, 2019). Assessing the competencies required by agricultural science teachers is crucial for promoting sustainable fish farming. Many agricultural

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science teachers were trained under outdated curricula that lacked an emphasis on practical skills. Consequently, most schools and colleges have not adequately equipped teachers with the necessary expertise to train students in productive fish farming (Effiong et al., 2021; Etim et al., 2022; Effiong et al., 2024; Etim & Effiong, 2022). Therefore, identifying the required competencies in fisheries within the study area is essential to ensure students acquire the knowledge and skills needed for productive fish farming and can, in turn, train others. This study aims to explore the integration of emerging technologies in fish farming within the Calabar Education Zone, which comprises Calabar South, Calabar Municipality, Odukpani, Akamkpa, Biase, Akpabuyo, and Bakassi in the Cross River Southern Senatorial Zone. The research is guided by a null hypothesis, which states that there is no significant difference in the mean responses of agricultural science teachers regarding the integration of emerging technologies for global competitiveness within the study area. The study aims to evaluate the skills necessary for implementing emerging technologies in fish farming among agricultural science teachers in Calabar Zone, Cross River State, Nigeria.

Materials and Methods

The study was carried out in Calabar South Local Government Area, located in Cross River State, Nigeria, which lies between latitudes 5°32’ and 4°27’ North and longitudes 7°50’ and 9°28’ East of the Greenwich meridian. It has a tropical humid climate with wet and dry seasons and average temperature ranging between 15°C – 30°C and annual rainfall between 1300 – 3000mm. Calabar South is one of the blocks among seven blocks in the southern Agricultural Zone of Cross River State, Nigeria. The study focused on secondary schools within these seven Local Government Areas. A structured questionnaire consisting of 10 items was developed, with response options categorised as Highly Required (HR = 4), Required (R = 3), Lowly Required (LR = 2), and Not Required (NR = 1). A decision point of 2.50 was set for analysis. The target population included 40 agricultural science teachers from 21 secondary schools in the study area. A total of 101 copies of the questionnaire were distributed, and all were completed and returned. The data collected were analysed using mean and standard deviation. The instrument underwent validation with input from experts in Extension and Rural Sociology at the University of Calabar. Adjustments were made based on their recommendations before finalising the questionnaire. The reliability of the instrument was determined using the Kuder-Richardson (KR) formula, which was applied to a single test form administered to a group of respondents. The reliability coefficient was found to be 0.82, indicating a high level of consistency.

Results

Table 1: Mean and standard deviation of respondents on the emerging technologies in fish Farming by Agricultural Science Teachers

NO	Competencies in fish	$\bar{x}$	SD	Remark
1.	Identification of fish sexes	3.68	1.5	Required
2.	Artificial Fertilization	3.53	1.26	Required
3.	Fingerlings Management	3.60	1.11	Required
4.	Knowledge of Stocking Capacity	2.66	1.05	Required
5.	Formation of fish feed	2.55	1.0	Required
6.	Water Management Knowledge	2.74	1.00	Required
7.	Feeding Management	3.71	1.21	Required
8.	Disease Management of Fish	2.18	0.81	Required
9.	Knowledge of harvesting fish	3.81	1.61	Required
10.	Marketing	3.81	1.88	Required

Field survey, 2024

Table 2: Summary of independent sample t-test analysis of agricultural science teachers (Holding first degree and those with higher degree) on competencies required for fish farming

Variables	X	SD	N	df	t-cal	t-tab	D
Agricultural teachers with a first degree	21.11	3.80	61	99	24.4	1.92	
Agricultural teachers with a higher degree	19.14	3.51	40				

Field survey, 2024

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Discussion

The results from Table 1 highlight the competencies required by agricultural science teachers in the Calabar Zone regarding emerging technologies in fish farming. All assessed competencies were deemed necessary, with varying levels of proficiency and exposure among the teachers. The highest-rated competencies were knowledge on harvesting fish ($\bar{x}$= 3.81, SD = 1.61) and marketing (mean = 3.81, SD = 1.88). These scores reflect the recognition of the economic and practical importance of harvesting and marketing in fish farming. However, the relatively high standard deviations suggest disparities in the level of knowledge or experience among respondents. Similarly, identification of fish sexes ($\bar{x}$= 3.68, SD = 1.50) and feeding management ($\bar{x}$= 3.71, SD = 1.21) were strongly emphasised, indicating that teachers generally recognise their critical role in breeding and fish growth, though there is room for improvement in consistent expertise across individuals. Competencies such as artificial fertilisation ($\bar{x}$= 3.53, SD = 1.26) and fingerlings management ($\bar{x}$= 3.60, SD = 1.11) also scored highly, reflecting an appreciation of these practices' importance for successful fish farming. The moderate variability in responses points to differences in exposure or training among the teachers. Competencies like knowledge of stocking capacity ($\bar{x}$= 2.66, SD = 1.05), formation of fish feed ($\bar{x}$= 2.55, SD = 1.00), and water management knowledge ($\bar{x}$= 2.74, SD = 1.00) were rated lower, suggesting that these areas are less familiar to the teachers. Given the significance of these skills in maintaining fish health and optimising productivity, it is crucial to provide more training to enhance their knowledge and practical application in these areas. The lowest-rated competency was disease management of fish ($\bar{x}$= 2.18, SD = 0.81), which highlights a critical gap in the teachers' skills. Disease management is vital for preventing losses in fish farming, and the low mean indicates an urgent need for targeted interventions to improve teachers' proficiency in identifying and addressing fish diseases.

Table 2 presents the results of a t-test analysis comparing the competencies required for fish farming between agricultural science teachers holding a first degree and those with a higher degree in the Calabar Zone. The mean score for teachers with a first degree ($\bar{x}$= 21.11, SD = 3.80) is higher than that of teachers with a higher degree ($\bar{x}$= 19.14, SD = 3.51). This indicates that teachers with a first degree perceive the competencies required for fish farming as slightly more critical than their counterparts with higher The standard deviations of both groups are quite similar, suggesting that their response variability is comparable. The computed t-value (t-cal = 24.4) is substantially higher than the critical t-value (t-tab = 1.92) at a degrees of freedom (df) of 99. This finding indicates a statistically significant difference in how the two groups perceive the necessary competencies. The observed difference (D) suggests that teachers' academic qualifications impact their views on the importance of fish farming competencies.

This significant difference might be attributed to varying levels of exposure to practical skills and hands-on training. Teachers with a first degree are likely more directly involved in teaching technical aspects of agricultural science, including fish farming. In contrast, those with higher degrees might focus more on theoretical knowledge or administrative roles, which could reduce their emphasis on specific competencies required for practical fish farming. The findings are in agreement with the observation of Bassey (2009) who reported in his study that fish farmers need regular training on fisheries skills to enable them become succeed in the business. It was also discovered that there are no perceived opinions of agents in some response items, while some of their opinions showed significant differences. This is also in line with the findings of Dumelo (2013), who in his study posited that the success of any animal production, including fish farming, depends on the competence required.

Conclusion

This study highlights the critical need for integrating emerging technologies in fish farming among agricultural science teachers in the Calabar Education Zone, Cross River State, Nigeria. The findings revealed that all assessed competencies are essential for equipping teachers with the skills necessary to promote global competitiveness in fish farming education. However, the successful integration of these technologies requires targeted training, curriculum development, and the establishment of practical learning environments such as school fish farms. To achieve this, the state Ministry of Education must provide the necessary resources and support, ensuring that agricultural science teachers are adequately prepared to transfer knowledge and skills to students, thereby fostering sustainable fish farming practices in the region.

Recommendations

The following recommendations were arrived at based on the findings of the study.

1. The state education ministry should allocate resources to support the creation of a fish farm.

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2. Secondary school in the area of study should establish a fish farm for practical agricultural science
3. Teachers in the study area should be exposed to frequent emerging technologies in fish farming

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