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Utilization of Emerging Agricultural Production Technologies for Enhancing Sustainable Food Security among Rural Farmers in Rivers State

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Abstract
Using a descriptive research survey design, the study assessed the extent utilization of emerging agricultural production technologies will enhance sustainable food security among rural farmers in Rivers State. the study was guided by five objectives, five research questions and a null hypothesis tested at significance level of 0.05. The population of the study was 4,836 (4,763 registered farmers from rural communities and 73 extension officers in Rivers State). Multistage sampling technique was used to sample 370 (297 registered farmers and 73 extension officers) respondents. A structured Questionnaire designed in 4-point rating scale was used for data collection. Cronbach Alpha Reliability Coefficient method was used to test the consistency of the instrument, which yielded a reliability index of 0.83. Data were analyzed using frequency, mean, percentage, and standard deviation, while the hypothesis was tested using multiple regression. The study found out that awareness programmes such as farmer-farmer technology awareness, plots demonstration programme, technology existence campaign, and field-base production campaign among others would help in farmers' utilization of emerging agricultural production. In addition, it was found that utilization of automated cleaning system and dairy technologies for increased milk production, image recognition technologies, direct-fed microbial and enzymes technologies for feed additive will play significant role in achieving food security in Rivers State. The study thus recommends proper implementation of agricultural technology awareness programme in rural areas to keep farmers abreast of the emerging technologies required for improved food production and adequate credit facilities be made available to motivate farmers' utilization of these technologies for sustainable food production.

Keywords: Emerging Agricultural Production Technologies, Sustainable Food Security

INTRODUCTION

Agriculture is an important source of economy in almost all nations of the world, providing food and employment for the citizenry, and contributing significantly to virtually all production sectors. It plays a vital role in the social and economic development of most developing nations and is the main contributor to their economic growth and stability (World Bank, 2016). The products from various aspects of agriculture provide raw materials to many agro-allied industries. Similarly, agriculture has been the core activities of many dwellers in rural areas in Nigeria; and investment in the agricultural sector has been demonstrated to be an effective means of changing the livelihood of the poor and vulnerable. The activities in agriculture go beyond land cultivation and ranching (which are just farm-based production sector) to agri-business that transforms raw commodities into consumable products (off-farm enterprise).

Nigeria's agricultural activities are constrained by numerous factors. This constrains poses difficulty to the actualization of food security. As a result of this, the gap between demand and supply has continued to widen as production of food fail to meet the demand both in quantity and quality. Sustainable food security is the continuous availability and accessibility of quality and adequate food by a country's population for active and healthy living. Sadly, the current situation in peasant farming is that majority of them utilizes

crude tools and traditional method in food production; and this shows that there is no relative increase between agricultural production and the fast population growth in Nigeria. Considering this, Aleru (2022) posited that if Nigeria must have a sustainable food security and national development, then there is need for the sector to develop her mind into integrating emerging technologies in every aspect of food production activities.

As modern agricultural practices are evolving in a variety of directions, its primary focus is to adopt technologies to boost production. To enhance the utilization of agricultural technologies in Nigeria, Institute of Agricultural Research, Regional Agricultural Research Institutes (RARIs), and universities have been experimenting and releasing several improved agricultural technologies in crops, livestock, and natural resource management. Emerging agricultural technologies according to Djibo and Maman (2019) include improved seeds, inorganic fertilizers, land conservation practices, tractors, stall-feeding management and irrigation technologies. In addition, emerging agricultural technologies include automated agricultural devices for feed production, storage, pest and disease control, among others to enhance productivity and food sustainability.

Rural farming is the main source of food for the populace as well as an income generating occupation because it is the main activity for many rural parts of developing countries. This implies that smallholder agricultural productivity is very crucial in alleviating poverty and hunger. In assessing the constraints to utilization of improved processing technologies among farmers, Ewebiyi, Ikotun, and Olayemi (2020) revealed that most farmers were in their active age, expected to position themselves favorably towards utilizing improved processing technologies for their processing. This finding aligns with Adedeji, Muhammad and Shaufiq (2013) who carried out similar studies and reported that farmers were of the age range of 30 to 50 years that constituted the active force of the study population.

Report by Food and Agricultural Organization (2013) showed that there is more female who are involved in crop production in Nigeria than male and more male in livestock farming than female. This was affirmed by Ewebiyi, et al (2020) who in a study revealed that 75.6% of cassava farmers in Oyo State were female, while 24.4% were males. Similarly, Nwaobiala and Anyanwu (2018) in a study revealed that 60 percent of farmers involved in agricultural production in Imo State were female while the remaining 40 percent were male. Report from Food and Agricultural Organization (2014) revealed that small scale farmers produced based on household size. Farmers' household from a study by Nwaobiala and Anyanwu (2018) was revealed to be 5-6 persons with a farm size of 1.3 hectare

Peasant farmers will find it difficult to adopt profitable Agricultural technologies without proper awareness campaign about their existence, use, and profitability; especially when the technologies are technically complex. As such to enhance the adoption and utilization of improving farming technologies, farmers may require targeted extension services, such as farmers-field schools, demonstration plots, or direct visits to farmers. According to the report from the study of Aleru, Lazarus, and Onwuamaegibu (2022), farmer-to-farmer training plays a huge role in dissemination of agricultural technology information to farmers thus improving their agricultural productivity for sustainable livelihood. In addition, farmers may also learn from the private sector, such as agro dealers who promote the products they sell. More recently, information and communications technology has become a more promising way to strengthen dissemination of agricultural information.

As smallholder farmers encounter several challenges in gaining access to good market for inputs, farm services and to connect to the right buyers, utilizing an awareness programme that would enable them access the right market with ease is the best form of support that can be given to smallholder farmers. The strategy of unlocking the market potentials of these farmers into the country agricultural economy should be the priority of any government with intention of increasing agricultural products for export. However, the recent assessment of government efforts at reforming markets for smallholder farmers has not yielded any tangible outcome as the measures implemented have not produced any improvement. Van Zanten, Van Ittersum and De Boer (2016) posited that providing knowledge, practical demonstrations, addressing concerns, and offering ongoing support, awareness programs play a vital role in encouraging farmers to adopt emerging agricultural technologies. They empower farmers with the necessary information and resources to make informed decisions and enhance their agricultural practices, ultimately leading to improved productivity, sustainability, and resilience in farming communities.

Livestock production plays a crucial role in ensuring global food security. However, it also presents environmental and sustainability challenges especially after the covid-19 pandemic. Several improved technologies have emerged to address these challenges and promote sustainable livestock production. Researchers (Irene, Aloyce, Elizaphan & Mdadila, 2018; Habiyaremye, 2017) have proven that technology is revolutionizing the world of livestock management, which runs the business of poultry farms, dairy farms, cattle ranches and other livestock-related agribusinesses. Concerning livestock production and management technologies, Irene, et al (2018) and Habiyaremye (2017) showed the positive causal effects of dairy and sericulture technologies on household income, respectively. The authors posited that utilization of improved species of livestock plays a significant role in farmers' output.

Emerging livestock technologies provide farmers with data-driven insights, allowing them to streamline farm management, improve animal care, and boost productivity. Modern technologies and digitalization can allow livestock farmers to optimize their operations. Creating more efficient production systems, reducing environmental impacts, lowering production costs, and enhancing farmers' productivity are the main goal for implementing emerging technologies in livestock production. Aleru (2022) posited that farmers' adoption of livestock technology innovation helps in redefining livestock farming. Emphasis should be directed on the importance of utilizing automated dairy installations in livestock production. This technology milk cows automatically without human intervention, and the milk sensors also help farmers to ascertain the milk quality for consumption and other industrial use. The integration of emerging livestock technologies such as automated cleaning system would help farmers maintain disease-free environment in livestock farming. The technology helps in removing waste from livestock farms thus reducing high risk of disease invasion.

Van Zanten, et al (2016) in their study revealed that farmers who adopt the agro-ecological approaches in livestock production have higher yield and income than those who still make use of the conventional techniques in livestock production. Agro-ecology emphasizes the integration of ecological principles into agricultural systems. By applying agro-ecological approaches to livestock production, farmers can promote biodiversity, optimize resource use, and enhance animal welfare thus ensuring sustainable quality production of food. In similar line, Hailu, Abrha and Weldegiorgis (2014) posited that farmers' utilization of armenta's non-antibiotic treatment enables them combat bovine mastitis to mitigate annual losses of the animals. Armenta's

non-antibiotic treatment uses acoustic pulse technology (APT) for the disease control.

As input determines output, farmers must gain knowledge on the available technologies (inputs) that has the capacity of enhancing yield. This prompts the assertion of Khandker, Koolwal, and Samad (2010) that incorporating emerging technology such as automated feeders in livestock production enable farmers provides animals with feed mixtures that are tailored to their specific needs and in the right amount. This technology enhances productivity, thus, making available good quality food in the market. The adoption of breeding technologies such as genomic selection, and gene editing is capable of advancing livestock breeds with improved production efficiency, disease resistance, and environmental adaptability (Nnodim & Raji, 2023). These technologies have been able to enhance farmers' livestock productivity while reducing the environmental impact of livestock farming. Furthermore, Neethirajan (2021) stated that the use of electronic feeding systems can help farmers optimize the use of feed as they enable farmers monitor feed intake in individual animals, and adjusting their feed rations. The feed intake of animals may vary according to their age, activity level, and energy consumption. This technology allows farmers to adjust the feed supply according to these variables, thereby reducing feed waste, by controlling feed supply and optimizing feed usage in different species.

The utilization of emerging feed production technologies has a significant influence on farmers' food production by improving livestock productivity, enhancing feed efficiency, and increasing overall agricultural sustainability. On improved livestock productivity, Owusu-Asiedu, and Adeola (2019) listed precision nutrition, precision feeding, and feed additives as feed production technologies that can enhance the nutritional value and digestibility of animal feeds, resulting in improved livestock productivity. Furthermore, on feed additive, innovative feed additives have been developed to enhance animal performance, reduce methane emissions, and improve feed efficiency. Examples include enzymes, probiotics, prebiotics, and direct-fed microbials. These additives can optimize nutrient utilization, enhance gut health, and reduce the environmental footprint of livestock production. These technologies enhance farmers' milk production; growth rates, and better reproduction rates, ultimately contributing to food security. In addition, Li, Dijkstra and Stuart (2018) were of the opinion that utilization of advanced technologies like remote sensing and data analytics will enable farmers optimizes feed formulation, feeding strategies, and farm management practices. This optimization leads to improved feed efficiency; reduce feed waste and increased the conversion of animal products into feed (Nnodim & Raji, 2020). By utilizing these technologies farmers can produce more food with fewer resources, contributing to food security.

In emphasizing on the importance of utilizing alternative protein sources to promote sustainability in feed production, Makkar (2020) stated that the utilization of insect meal, algae, or single-cell proteins can substitute farmers' reliance on traditional feed ingredients like soybean meal or fishmeal, which are associated with deforestation and overfishing. By adopting sustainable feed production practices, farmers can contribute to long-term food security. Similarly, Lal (2020) in assessing the role of soil in mitigating climate change in croplands posited that emerging feed production technologies help farmers adapt to the challenges posed by climate change. Citing relevant example to the assertion above, utilization of drought-tolerant feed crops or precision irrigation systems will enable farmers achieve a stable feed supply during periods of water scarcity or extreme weather events. Similarly, by improving resilience in feed production, farmers can maintain livestock productivity and secure their food supply.

For decade agriculture has failed to keep pace with the rapid population growth in Nigeria due to mismanagement, inconsistent and poorly conceived government policies. These however, become contributory factors to the pressures faced by rural farmers on the need to produce more with crude tools and traditional techniques in order to feed the rapid growing population and curb the increasing food security challenges. Idachaba (2011) reported that small farm ranging from 0.01 to 5.99 hectares constitute about 80 percent of the farm holding in Nigeria and contribute about 98 percent of the food produced in the nation. Judging from the farming practices utilized by these farmers, there is no doubt that lack of capital and technical knowledge imposes serious limitations on the level of traditional farming system. This situation put the country's food production at a very low point thus affecting the achievement of food sustainability. It is against this background that the study deemed it fit to assess the emerging agricultural production technologies required for enhancing sustainable food security in Rivers State.

Purpose of the Study

The general purpose of the study was to assess the extent utilization of emerging agricultural production technologies will enhance sustainable food security among rural farmers in Rivers State. Specifically, the study sought to:

1. Ascertain the demographic characteristics of rural farmers in Rivers State.
2. Determine the extent technology awareness programme will enhance the utilization of emerging agricultural production technologies for sustainable food security among rural farmers in Rivers State.
3. Ascertain the extent utilization of emerging livestock production technologies will enhance sustainable food security among rural farmers in Rivers State.
4. Examine the extent utilization of emerging feed production technologies will enhance sustainable food security among rural farmers in Rivers State.

Research Question

The following research questions guided the study

1. What are the demographic characteristics of rural farmers in Rivers State?
2. To what extent will technology awareness programme enhance the utilization of emerging agricultural production technologies for sustainable food security among rural farmers in Rivers State?
3. To what extent will the utilization of emerging livestock production technologies enhance sustainable food security among rural farmers in Rivers State?
4. To what extent will utilization of emerging feed production technologies enhance sustainable food security among rural farmers in Rivers State?

Hypotheses

The study tested the hypothesis at a significance level of 0.05:

1. There is no significant relationship between the demographic characteristics of rural farmers and their utilization emerging agricultural production technologies for sustainable food security in Rivers State.

METHODOLOGY

The study was carried out in rural communities in Rivers State. The state is dominated by Ikwerre, Etche, Ogoni, Ogba/Egbema/ Ndoni, Andoni, Opobo and Ekpeye with majority of the dwellers depending mainly crop, fish and livestock production for sustainable livelihood. A descriptive research survey was used for the study. The population of the study was 4,876 (4,763 registered farmers from rural communities and 113 extension officers in Rivers State). The multi-stage sampling technique was used to select a

sample size of 370 respondents from nine selected rural communities based on the agricultural zones in Rivers State. The instrument for data collection was structured by the authors of the study in a 4-point rating scale. Data were analyzed using frequency, percentage, mean and standard deviation with a criterion mean of 2.50 and above. Regression analysis was used to test the hypothesis as to ascertain the significance relationship between the demographic data of rural farmers and their utilization of emerging food that was formulated to ascertain the relationship between the demographic characteristics of rural farmers and their utilization of emerging agricultural production technologies for sustainable food security.

RESULTS

Research Question 1: What are the demographic characteristics of registered farmers in Rivers State?

Table 1: Socio-Demographic of Registered Farmers in Rivers State

S/N	Variables	Registered Farmers (n=297) Frequency	Percentage (%)
1.	**Gender**		
	Male	143	48.15%
	Female	154	51.85%
2.	**Average Age Range**		
	30-35yrs	48	16.16%
	36-41yrs	69	23.23%
	42-47yrs	78	26.26%
	48-60 yrs	102	34.35%
3.	**Income Per Month**		
	50,000-79,000	56	18.85%
	80,000-100,000	78	26.26%
	120,000-150,000	71	23.90%
	160,000-200,000	50	16.84%
	200,000-above	42	12.14
4.	**Membership of Organization**		
	Poultry Farmers Association	84	28.28%
	Social Club	92	30.97%
	Farmers' Cooperative	76	25.59%
	Timber Association	45	15.15%
5.	**Educational Status**		
	Non-formal education	61	20.53%
	Primary	103	34.68%
	Post-primary/vocational school	88	29.62%
	Tertiary education	45	15.15%

Table 1 revealed the demographic information of the rural farmers in the study area; indicating their gender, educational status, membership of organization, monthly income from food production, marital status and average age.

Research Question 2: To what extent will technology awareness programme enhance the utilization of emerging agricultural production technologies for sustainable food security among rural farmers in Rivers State?

Table 2: Mean Responses on Extent Technology Awareness Programme will Enhance Utilization of Emerging Agricultural Production Technologies for Sustainable Food Security

S/N	Statements	Extension Workers (n=73)			Reg. Farmers (n=297)		
		$\overline{X}_1$	SD	Decision	$\overline{X}2$	SD	Decision
1.	Farmer-farmer technology awareness will enhance utilization of automated irrigation system for improved food security	3.19	0.96	High Ext	3.30	0.66	High Ext
2.	Plots demonstration programme on vertical farming will enable farmers adopt it for urban farming thus enhancing food security	3.42	0.65	High Ext	3.21	0.89	High Ext
3.	One-on-one extension visits will encourage farmers utilization of disease resistance varieties for enhanced productivity	3.10	0.88	High Ext	3.37	0.77	High Ext
4.	Technology existence campaign will enhance farmers utilization of automated cleaning system to maintain disease-free environment in livestock farming	3.42	0.87	High Ext	3.14	0.89	High Ext
5.	Implementation of animal technology programme will encourage farmers' utilization of automated dairy machine for increased milk production	3.48	0.82	High Ext	3.13	0.36	High Ext
6.	Dissemination of technology information will enable rural farmers have understanding on benefits of abrasive peeler machine for increased food production	3.19	0.59	High Ext	3.29	0.87	High Ext
7.	Adoption of workshop-based training will enhance farmers utilization of dry type starch extruder in cassava processing	3.50	0.62	High Ext	3.26	0.59	High Ext
	Grand Mean/SD	**3.33**	**0.82**	**High Ext**	**3.22**	**0.73**	**High Ext**

Data analyzed in Table 2 showed that awareness programme will enhance the utilization of emerging agricultural production technologies for sustainable food security among rural farmers in Rivers State.

Research Question 3: To what extent will the utilization of emerging livestock production technologies enhance sustainable food security among rural farmers in Rivers State?

Table 3: Mean Responses on Extent Utilization of Emerging Livestock Production Technologies will Enhance Sustainable Food Security

S/N	Statements	Extension Workers (n=73)			Reg. Farmers (n=279)		
		$\overline{X}_1$	SD	Decision	$\overline{X}2$	SD	Decision
1.	Adoption of automated cleaning device in livestock farming will enables farmers maintain disease-free environment in livestock farming for sustainable food security	3.17	0.65	High Ext	3.04	0.74	High Ext
2.	Farmers' utilization of automated dairy technology would enable them have high milk production for the market, thus enhancing food security	3.58	0.56	High Ext	3.47	0.61	High Ext
3.	Proper utilization of agro-ecological approaches in livestock production enable farmers optimize yield and income	3.10	0.80	High Ext	3.39	0.92	High Ext
4.	Implementation of milking sensors in livestock farming help farmers to ascertain human consumable milk quality and other industrial use	3.05	1.00	High Ext	3.28	1.43	High Ext
5.	Utilization of improved species by livestock farmers will plays a significant role in output for meeting up food security	3.15	0.98	High Ext	3.00	0.44	High Ext
6.	farmers' utilization of armenta in livestock production would enable them record low bovine mastitis occurrence for sustainable food security	3.18	0.70	High Ext	3.29	0.59	High Ext
7.	Incorporating automated feeder in livestock rearing will help farmers gain accuracy in feed mixtures for sustainable food security	3.29	0.55	High Ext	2.75	0.86	High Ext
	Grand Mean/SD	**3.23**	**0.74**	**High Ext**	**3.14**	**0.76**	**High Ext**

Table 3 indicates that the utilization of emerging technology for livestock production would enhance sustainable food security of rural farmers in Rivers State.

Research Question 4: To what extent will utilization of emerging feed production technologies enhance sustainable food security among rural farmers in Rivers State?

Table 4: Mean Responses on Extent Utilization of Emerging Feed Production Technologies will Enhance Sustainable Food Security

S/N	Statements	Extension Workers(n=73)			Reg. Farmers (n=279)		
		$\overline{X}_1$	SD	Decision	$\overline{X}2$	SD	Decision
1.	Integrating feed additive like probiotics enables farmers optimize nutrient utilization and ultimately contributes to food security	3.13	0.65	High Ext	3.02	0.76	High Ext
2.	Mixing prebiotics in feed production will help farmers improve feed efficiency	3.03	0.86	High Ext	3.21	0.64	High Ext
3.	Farmers' utilization of direct-fed microbials enhances gut health, and reduces the environmental footprint of livestock production	3.23	0.71	High Ext	3.30	0.79	High Ext
4.	Utilizing enzymes technology in feed additive will enhance livestock farmers' milk production for sustainable food security	3.33	1.10	High Ext	3.42	0.54	High Ext
5.	Adopting remote sensing in feed production will enable producers optimizes feed formulation and reduce feed waste for improved food security	3.48	0.89	High Ext	3.34	1.04	High Ext
6.	Farmers' utilization of algae to substitute other feed ingredients like fishmeal will enhance sustainable food security	2.85	0.76	High Ext	2.95	0.61	High Ext
7.	Utilization of organic proteins will reduce farmers' reliance on traditional feed ingredients like soybean for sustainable feed production	3.41	0.92	High Ext	3.27	0.73	High Ext
	Grand Mean/SD	**3.20**	**0.84**	**High Ext**	**3.21**	**0.73**	**High Ext**

The result from Table 4 indicates that rural farmers' utilization of emerging feed production technologies will enhance sustainable food security in Rivers State.

Result of Hypothesis

The results of the null hypotheses tested were presented below:

Hypothesis 1: There is no significant relationship between the demographic characteristics of rural farmers and their utilization of emerging agricultural production technologies for sustainable food security among rural farmers in Rivers State.

Table 5: Regression Analysis on Demographic Characteristics of Registered Farmers on Utilization Emerging Agricultural Production Technologies for Sustainable Food Security

Variables	Coff	x-coff	R^2	Rmrk
Gender	1.38	0.010	0.849	No Sig
Average Age Range	10.27	0.548	0.009	Sig
Income Per Month	14.37	-0.430	0.011	Sig
Membership of Organization	13.06	0.525	0.048	Sig
Educational Status	10.48	0.435	0.016	Sig
Constant	54.62			

Model Summary

R-value	R Square	Adjusted R Square	Std. Error of the Estimate
0.860	0.739	0.68	5.86734

From Table 5, the analysis shows that the R-value of 0.86 indicates that there is a strong positive relationship in the prediction. The "**R Square**" (R^2) value of 0.739, explains that the independent

variables (gender, age, income, household size, membership of organization, and educational status) indicate 73.9% contribution to the variability of the dependent variable, (utilization of emerging agricultural production technologies). The table also showed that there is a significant relationship between predictors such as age, income, membership of organization, educational status and utilization of emerging agricultural production technologies for sustainable food security in Rivers State. However, there is no significant relationship between gender and utilization of emerging agricultural production technologies for sustainable food security in Rivers State.

Discussion of Findings

The finding on research question 1 indicated that the respondents were basically adult females, married and majority of them within the age range of 48-60 years. This is in corroboration with the report of FAO (2013) that female are more involved in crop production in Nigeria than male. However, the finding is contrary to the report of Adedeji et al (2013) that majority of farmers that constitutes the active agricultural production were of the age range of 30-50 years. It was also revealed that the respondents have varied forms of education ranging from non-formal education to tertiary education with majority having only primary education certificates. Also, the study found out that majority (43.09%) of the registered farmers was married followed by widows (23.23%). These reports are in line with Ewebiyi, Ikotun, and Olayemi (2020) who observed that nearly half (45.5%) of rural cassava farmers in Oyo State had secondary education, 35.2% had primary education, 11.4% had no formal education, and 6.8% had tertiary education while infinitesimal number of respondents (1.1%) had vocational education. On monthly income of the rural farmers, it was found out that majority of (26.26%) of the respondents earn 80,000-100,000 naira as monthly while 12.14% earns 200,000 and above from food production. This could be attributed to the utilization of crude and traditional food production techniques.

Table 2 found that awareness programmes such as farmer-farmer technology awareness, plots demonstration programme on vertical farming, one-on-one extension visits, technology existence campaign, implementation of animal technology programme, awareness on hand-fed tuber peeling machine, and dual-powered sifting technology will enhance farmers' utilization of emerging agricultural production for sustainable food security. These are in consonance with the assertion of Jack (2013) that new agricultural technologies that are profitable will not be taken up without proper awareness campaign about their existence, use, and profitability. Similarly, the findings are in line with the report of Van Zanten, et al (2016) that peer-to-peer interaction helps build trust, confidence, and motivation among farmers to adopt new technologies.

Data gathered from Table 3 found out that adoption of automated cleaning device in livestock farming, utilization of automated dairy technology for high milk production, proper utilization of agro-ecological approaches in livestock production to optimize yield, automated feeder, implementation of milking sensors in livestock farming, and utilization of improved species by livestock farmers will plays a significant role in increasing farmers' output for achieving food security in Rivers State. The findings are in tandem with Aleru (2022) who posited that farmers' adoption of livestock technology innovation helps in redefining livestock farming. It was also found that farmers' application of armenta in livestock production, and incorporating automated feeder in livestock rearing are livestock production technologies for sustainable food security. The findings align with the assertion of Irene, et al (2018) who posited that improved species of livestock such as dairy and sericulture technologies play a significant role in farmers' output.

Table 4 found out that integrating feed additive such as probiotics enables, mixing prebiotics in feed production to improve feed efficiency, farmers' utilization of direct-fed microbials to enhance gut health, and reduces the environmental footprint of livestock production, and utilization of enzymes technology in feed additive will enhance livestock farmers' milk production for sustainable food security. Furthermore, the study found out that adopting remote sensing in feed production would enable producers optimize feed formulation and reduce feed waste, utilization of algae to substitute other feed ingredients like fishmeal would reduce cost of feed production, and utilization of organic proteins would reduce farmers' reliance on traditional feed ingredients for sustainable food security. The findings are in agreement with the statement of Makkar (2020) on the importance of utilizing alternative protein sources such as insect meal, algae, or single-cell proteins to promote sustainability in feed production and mitigating the environmental impact of livestock production. Similarly, the assertion of Owusu-Asiedu, and Adeola (2019) supports these findings as they stated that precision nutrition, precision feeding, and feed additives are feed production technologies that can enhance the nutritional value and digestibility of animal feeds thus resulting in improved livestock productivity.

CONCLUSION

Based on the findings, the study deduced that awareness programmes/campaigns are the perquisites for enhancing farmers' knowledge on available agricultural technologies that cut-across all areas of food production. Similarly, the adoption and utilization of these agricultural production technologies is the key to quality food production, food availability, accessibility and sustainability in Rivers State. However, this would be more encouraging if agricultural extension officers are fully engaged in disseminating agricultural production technology information to rural areas where majority of food producers are settled.

RECOMMENDATIONS

Based on the findings and the conclusions, the study recommends that:

1. There is need for implementation of agricultural technologies awareness programme in rural areas to keep farmers abreast of the emerging technologies required for improved food production. This will enable farmers produce quality food thus enhancing food security.
2. Adequate credit facilities should be made available to motivate livestock farmers on adoption and purchase of these livestock production technologies for sustainable food production. This could be through subsidizing cost of agricultural inputs or implementation of non-interest credit to livestock farmers for sustainable livelihood. This recommendation aligns with Amadi and Aleru (2020) who recommended the need for making zero interest loans to rural farmers for increased productivity.
3. Programmes on agricultural value-addition should be scheduled for farmers to enable them see other ways agricultural feed can be produced with agricultural wastes using emerging technologies. This will enable farmers to record zero agricultural waste in food production thus enhancing food security.

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