Open Access Research Journal of
Science and Technology
Journals home page: https://oarjst.com/
ISSN: 2782-9960 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

Influence of agricultural extension services on uptake of improved indigenous chicken by poultry farmers in Konoin Sub-county, Kenya

Brendah Nyanchera Machuki *, Stephen Wambugu Maina and Mary Mwihaki Waiganjo

Department of Agricultural Education and Extension, Faculty of Education and Community Studies, Egerton University, P.O. Box 536-20115, Egerton, Njoro, Kenya.

Open Access Research Journal of Science and Technology, 2025, 13(02), 154-167

Publication history: Received on 25 February 2025; revised on 07 April 2025; accepted on 09 April 2025

Article DOI: https://doi.org/10.53022/oarjst.2025.13.2.0059

Abstract

This study aimed to determine the influence of agricultural extension services on the uptake of improved indigenous chicken by poultry farmers in Konoin Sub-county, Kenya. The study employed a descriptive survey design and a sample of 150 farmers was surveyed using interview schedules. The formula N≥104+8m was used to determine the sample size of 136 participants. The sample size was increased by 10% giving a total sample size of 150 farmers to maximise accuracy and take care of non-response. Systematic sampling was used to select the sampled farmers from a list of poultry farmers. Data was analysed using frequencies, percentages, and multiple linear regression. Most (94.6%) poultry farmers valued training, with 69% receiving their last training on poultry practices a year ago. Agricultural extension services significantly influenced improved indigenous chicken uptake with a p-value of 0.000. The study concludes that agricultural extension services have a statistically significant influence on the uptake of improved indigenous chicken by poultry farmers. The study recommended that the government; through the Ministry of Agriculture and Livestock Development and other stakeholders, should provide practical training to poultry farmers on production practices to promote the uptake of improved indigenous chicken.

Keywords: Agricultural extension services; Uptake; Adopters; Non-adopters; Improved indigenous chicken

1. Introduction

Improved indigenous chicken (IIC) has gained significant attention from farmers worldwide due to their numerous advantages and potential for sustainable poultry production (Waithaka et al., 2022). Farmers are increasingly recognising the value of these improved indigenous chicken as they offer a viable alternative to commercial breeds, especially in regions where traditional chicken farming practices are prevalent (Pius et al., 2021). These birds not only provide a source of income through increased egg production and meat yield but also contribute to food security and the preservation of indigenous genetic diversity (Manyelo et al., 2020). By supporting local economies and empowering poultry farmers, improved indigenous chicken are playing a crucial role in promoting sustainable and resilient agriculture worldwide.

In Kenya, Wambua et al., (2022a) indicated that the agricultural sector (crop production and livestock production) contributes 25% to the country's Gross Domestic Product (GDP), with the poultry subsector accounting for 30% of this contribution. The country has an estimated poultry population of 43.8 million. Accordingly, it is indicated that the poultry sector is highly diverse and produces more than 35,000 tonnes of meat and 1.6 billion eggs. Indigenous chicken contributes 71% of the total egg and poultry meat produced in Kenya and therefore impacts significantly on trade, welfare, and food security among farmers (Bukachi et al., 2023).

Indigenous chicken are kept under scavenging production systems with limited application of management interventions to improve flock productivity. With constraints such as diseases, lack of proper housing, and insufficient

* Corresponding author: Brendah Nyanchera Machuki

feed, the maturing rate and productivity of these chicken are usually low (Yusuf & Popoola, 2022). Indigenous chicken production is also influenced by the prevalence of transboundary animal and zoonotic diseases and pests, inadequate capacity for service delivery, weak delivery of extension services, and demographic factors (Wambua et al., 2022b). Consequently, to counter some of the problems like low productivity and slow maturity, the Kenya Agricultural and Livestock Research Organization (KALRO) bred a fast-growing chicken with high egg production, popularly known as KARI Kienyeji chicken also known as improved indigenous chicken (Wambua et al., 2022a).

A study on analysis of improved indigenous chicken adoption among smallholder farmers in Makueni and Kakamega Counties indicated that improved indigenous chicken production is mainly done for subsistence use by smallholder farmers (Kamau et al., 2019). Smallholder farmers and commercial producers have adopted improved indigenous chicken. Additionally, the average adoption rate of improved indigenous chicken is estimated at 24% among poultry farmers despite the awareness generated around improved indigenous chicken (Kamau et al., 2019).

Consequently, agricultural extension plays an important role in informing farmers on agricultural practices and the uptake of technologies. The roles agricultural extension plays in the agricultural sector include offering technical expertise, marketing, organisation management, and entrepreneurship (Abukari et al., 2021). A study by Kwapong et al. (2020) indicated that farmers accessed extension services from both agricultural extension agents and fellow farmers. For several farmers, learning from other local farmers was mentioned as an important source of information. Farmers exchange ideas and knowledge with other farmers and learn from each other.

The study by Aryemo et al. (2019) emphasised that extension agents, who are trained professionals in agriculture and rural development, work closely with farmers to address their specific needs and challenges. A study by Byamukama et al. (2022) indicated that one of the key roles of extension services is to disseminate up-to-date information on improved indigenous chicken production practices which assist the farmers in developing farm management plans, budgeting, and marketing strategies.

A study by Wambua et al. (2022a) indicated that improved indigenous chicken production is influenced by various factors. These factors include socio-economic factors, technological factors, policy and legal frameworks, and erratic and unpredictable weather conditions. Divergent factors have influenced the uptake of improved indigenous chicken. However limited information is known about factors influencing uptake of improved indigenous chicken. To fill the existing knowledge gap, there was a need to determine the influence of agricultural extension services on the uptake of improved indigenous chicken by poultry farmers in Konoin Sub-county, Kenya.

2. Methodology

2.1. Study area

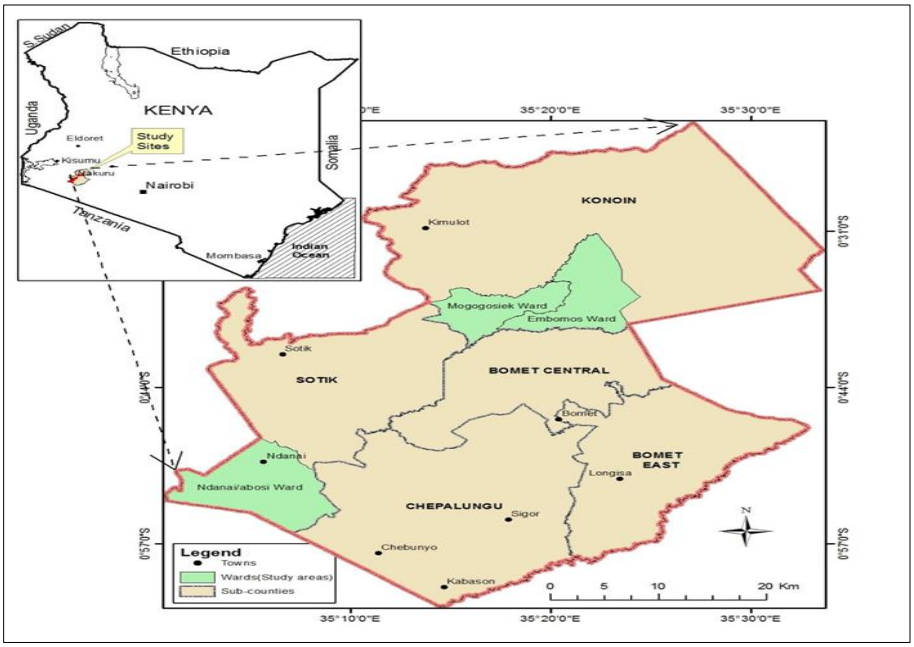

Figure 1 Map of Kenya showing the geographical location of the study area

This study was conducted among poultry farmers in the Konoin Sub-county. Konoin Sub-county has five wards which include Chepchabas, Kimulot, Mogogosiek, Boito, and Embomos. Konoin Sub-county spans approximately 0.8178° S in latitude and 35.3382° E in longitude (Bomet County, 2023). The Sub-county has a population of approximately 163,507 people. The number of households is approximately 36,278 where 83,120 are males, 80,384 are females and 3 are unisex people (Kenya National Bureau of Statistics [KNBS], 2019).

2.2. Theoretical framework

In terms of theoretical framework, the Technology Acceptance Model (TAM) was used to explain how users come to accept and use a technology. The present study analysed the influence of agricultural extension services on the uptake of improved indigenous chicken by poultry farmers in the Konoin Sub-county. The Technology Acceptance Model (TAM) was developed by (Davis, 1989). It assumes that when users perceive that a specific technology is useful and also easy to use, the users will be willing to use it. If the technology is easy to use, the barriers are conquered. If it is not easy to use and the interface is complicated, no one will have a positive attitude towards it. Based on the model, if the uptake of improved indigenous chicken was useful and easy, poultry farmers in Konoin Sub-county would be willing to keep improved indigenous chicken hence high uptake but if the technology is not easy, the farmers would not take improved indigenous chicken easily leading to low uptake. For example, if there were barriers such as lack of agricultural extension services uptake of improved indigenous chicken would be difficult.

2.3. Research design, sampling procedure and sample size

This study employed a descriptive survey research design since it mainly looks at phenomena, events, and issues the way they are (Catania et al., 2021). Purposive sampling was used to select two wards (Embomos and Mogogosiek) because the two wards had both adopters and non-adopters of improved indigenous chicken in Konoin Sub-county. The two wards were also purposively selected because they had lower average improved indigenous chicken flock size compared to the other wards in Konoin Sub-county. The study adopted the formula; $N \geq 104+8m$ by VanVoorhis & Morgan (2007) to determine sample size. The formula $N \geq 104 + 8m$ is used to determine the minimum sample size required for multiple regression analysis. Below is what each component of the formula means:

N = The minimum required sample size, 104 = A constant baseline number that accounts for a stable estimate of regression coefficients, 8 = The number of additional participants required per predictor variable, m = The number of independent variables included in the regression model.

The study considered four independent variables hence using this formula; the sample size was worked out as follows:

$N \geq 104+8(4)$ which gave a sample size of 136 participants.

Furthermore, during a research study natural attrition may occur, therefore to take care of drop-out the sample size should be increased by 10 percent (Junyong et al., 2020). In this study, there was an additional 10 per cent of 136 respondents to maximise accuracy and to take care of the non-response. Therefore, a sample size of 150 respondents was considered in the study as shown in Table 1.

Table 1 Number of poultry farmers and sample size in Embomos and Mogogosiek wards

Ward	Adopters of IIC	Adopters sample size	Non-adopters of IIC	Non-adopters Sample size	Total number of farmers	Sample size
Embomos	112	37	2305	37	2417	74
Mogogosiek	118	38	2320	38	2438	76
Total	230	75	4625	75	4855	150

In every research study with two or more different study groups, all the groups should have an equal number of participants. Therefore, an equal number of participants should be considered for each study group (Kumar & Yale, 2016). Consequently, an equal number of adopters (75) and non-adopters (75) participated in the study. Proportionate size formula was used to calculate the sample size of adopters and non-adopters drawn from each ward (Ndirangu et al., 2018).

Proportionate to size formula is as follows;

$$ni = \left(\frac{\mathrm{n}}{\mathrm{N}}\right) Ni$$

Where: *ni* = Sample size of the ward, n = Population of the ward, N = Total population and *Ni* = Sample size

Adopters in:

$$\text{Embomos; } ni = \left(\frac{112}{230}\right) 75 = 37$$

$$\text{Mogogosiek; } ni = \left(\frac{118}{230}\right) 75 = 38$$

Non-adopters:

$$\text{Embomos; } ni = \left(\frac{2305}{4625}\right) 75 = 37$$

$$\text{Mogogosiek; } ni = \left(\frac{2320}{4625}\right) 75 = 38$$

This was followed by systematic sampling in the field. Systematic sampling was used to select the sampled farmers from a list of IIC and IC farmers. Systematic sampling involved the selection of every third consecutive person among 112 and 118 adopters of IIC in Embomos and Mogogosiek, respectively, to arrive at the calculated sample size of 37 and 38, respectively. Systematic sampling was also used to select every 61st consecutive person among 2,305 and 2,320 non-adopters of IIC in Embomos and Mogogosiek, respectively, arriving at the calculated sample size of 37 and 38 per ward.

2.4. Data collection

Data was collected using interview schedules which were hand-delivered. Poultry farmers were reached at their homes. The researcher gave a brief self-introduction and explained to the respondents the purpose of the study. The interview schedules were administered face-to-face to ensure that all the items were correctly filled.

2.5. Data analysis

Data was analysed using frequencies and percentages and multiple linear regression. The hypothesis of the study stated that there is no statistically significant influence of agricultural extension services on the uptake of improved indigenous chicken by poultry farmers. The hypothesis was tested at a statistically significance level of $p \leq 0.05$. The multiple linear regression equation derived is as follows:

$$Y = \alpha + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4$$

Where Y = Uptake of improved indigenous chicken, X_1 = Training on poultry production practices leads to high production in poultry, X_2 = Last training on poultry production practices, X_3 = Seeking for advisory services helps to solve problems encountered in poultry production, and X_4 = Agricultural extension service provider.

3. Results and discussion

3.1. Perception of farmers on agricultural extension services on poultry production

Table 2 shows the opinions of poultry farmers on agricultural extension services on poultry production in Konoin Sub-county. The results clarify that a significant majority of the poultry farmers, 63.3%, strongly agreed that training on poultry production practices leads to higher poultry production. An additional 31.3% agreed, indicating a combined total of 94.6% expressing positive opinions about the importance of training. This overwhelming consensus underscores the perceived value of agricultural extension services in equipping farmers with the knowledge and skills necessary to improve productivity. In contrast, a very small proportion of respondents were either undecided (3.3%) or expressed negative opinions, with 1.3% disagreeing and 0.7% strongly disagreeing. The minimal dissent may reflect either lack of access to extension services, variations in training quality, or contextual factors such as resource availability and environmental conditions.

Research supports the notion that training programs provided by agricultural extension services play a pivotal role in enhancing productivity and technology adoption among farmers. For example, Ngaiwi et al. (2023) argue that access to extension services significantly increases the likelihood of adopting improved agricultural practices. Similarly, Nwobodo et al. (2023) highlight that extension services positively influence the adoption of improved indigenous chicken, emphasising the importance of knowledge dissemination and technical support in improving poultry production systems. Moreover, Lamm et al. (2023) found that targeted training programs tailored to the specific needs of farmers are more effective in improving production outcomes. This aligns with the results of the study, which show that most farmers highly value training as a mechanism to enhance their production practices.

From the findings, a substantial majority of the poultry farmers either strongly agreed (60.0%) or agreed (35.3%) that extension services effectively address challenges in poultry production. This indicates that agricultural extension services play a critical role in equipping farmers with the knowledge and skills needed to adopt improved practices and overcome production challenges. Moreover, this observation aligns with previous studies, such as Akintuyi (2024), which noted that extension services bridge knowledge gaps and provide farmers with tailored advice, thereby enhancing productivity and adoption of improved practices. Similarly, Anyona et al. (2023) emphasised that farmers who regularly interact with extension agents are more likely to implement improved poultry farming techniques, including the use of improved indigenous chicken breeds. Farmers who have access to agricultural extension services are more likely to adopt improved poultry breeds compared to their colleagues with limited or no access to the respective service (Wang et al., 2020). In addition, agricultural extension services determine the quality of information that farmers obtain on poultry production practices and the advantages of improved indigenous poultry breeds (Kamau et al., 2023).

On the other hand, a minimal proportion of respondents were undecided (2.7%), disagreed (1.3%), or strongly disagreed (0.7%) with the effectiveness of extension services. This minority could be attributed to factors such as limited access to quality extension services, dissatisfaction with the services provided, or challenges in translating advisory services into practical solutions on the ground, as highlighted by (Nyokabi et al., 2023)

Table 2 Perception of farmers on agricultural extension services on poultry production

Item	Response in frequencies and percentages						
		SD	D	U	A	SA	Total
Training in poultry production practices by agricultural extension service providers leads to high production of poultry.	Freq.	1	2	5	47	95	150
	%	0.7	1.3	3.3	31.3	63.3	100
Seeking agricultural extension advisory services helps to solve problems encountered in poultry production.	Freq.	1	2	4	53	90	150
	%	0.7	1.3	2.7	35.3	60.0	100

3.2. Frequency of training farmers on poultry production practices

Figure 2 shows that a significant proportion (69%) of the poultry farmers had their last training on poultry production a year ago. This indicates that periodic training is a prominent feature of agricultural extension services in the area. Research indicates that frequent training sessions help farmers stay updated on best practices and innovations in agriculture (Raji et al., 2024). However, training held a year ago may require reinforcement to ensure knowledge retention and practical application. Furthermore, a smaller fraction of the poultry farmers (12%) received training less than a year ago. This group is likely to demonstrate better uptake of improved indigenous chicken farming practices since recent training tends to increase the likelihood of knowledge application and innovation adoption (Ipara et al., 2024). Continuous engagement with farmers is crucial to maintain this momentum and address emerging challenges. Farmers who were trained over a year ago (10%) may face challenges in maintaining the knowledge and practices acquired, as information can become outdated or forgotten over time. Studies have shown that ongoing and refresher training enhances long-term adoption and productivity (Shaji & Hovan, 2023). This group may benefit from refresher courses to enhance their farming practices. A small but significant proportion of the poultry farmers (9%) had never received training on poultry production practices. Lack of access to extension services limits their ability to adopt improved techniques, reducing productivity and profitability. Providing training to this group should be a priority to promote inclusivity and equitable development in the sector.

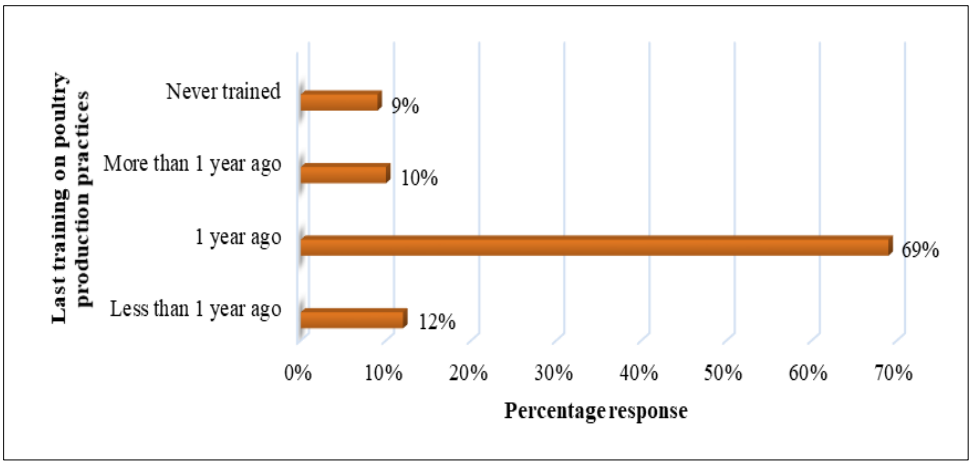

Figure 2 Last training on poultry production practices

3.3. Sources of agricultural extension service providers

Table 3 reveals that veterinarians (70%) were the predominant source of extension services, reflecting their critical role in providing specialised knowledge on poultry health, disease management, and nutrition. Studies have shown that farmers are more likely to adopt improved poultry practices when they receive regular, technical advice from veterinarians (Sawadogo et al., 2023). Their expertise directly addresses challenges such as high mortality rates and poor productivity, which are significant barriers to the adoption of improved poultry practices.

Private agricultural extension service providers had a higher influence (13.3%) on the uptake of improved indigenous chicken compared to public extension officers (10%). This is likely due to their demand-driven, specialised advisory services that are more market-oriented and tailored to farmers' specific needs (Allahyari & Sadeghzadeh, 2020). They also have better access to modern extension tools and technology, enhancing farmer learning and adoption (Khatri et al., 2024). Additionally, commercial-oriented farmers are more willing to pay for private services, expecting higher productivity (Kyambo, 2023). In contrast, public extension services face challenges such as understaffing, limited resources, and logistical constraints, reducing their effectiveness. Their broad and generalised approach often lacks poultry-specific recommendations, limiting their impact on adoption (Dakarai et al., 2023). Furthermore, high farmer-to-extension officer ratios hinder frequent training and follow-ups, leading to lower uptake (Tafida et al., 2024). The public agricultural extension officers despite being the traditional agents of agricultural extension, the relatively low involvement of agricultural extension officers could suggest capacity challenges, understaffing, or limited access to rural areas (Mapiye et al., 2023).

The finding that non-governmental organisations played the least role (6.7%) in providing agricultural extension services for poultry farmers is due to various factors. Non-governmental organisations often prioritise broader rural development initiatives, such as food security and climate resilience, rather than specific enterprises like poultry farming (Nyabvudzi & Nkwana, 2024). Their project-based, short-term interventions, which rely on donor funding, limit sustained support for poultry farmers (Moreno & Corral, 2024). Additionally, non-governmental organisations tend to focus on vulnerable and marginalised groups, emphasising food security over commercial poultry production. They lack specialised poultry extension officers and operate on a smaller scale, restricting their technical capacity and outreach (Gordon et al., 2025).

Table 3 Agricultural extension service providers

Agricultural extension service providers	Percentage	Sample size
Veterinarians	70.0	105
Private agricultural extension service providers	13.3	20
Public agricultural extension officers	10.0	15
Non-governmental organisations	6.7	10
Total	100.0	150

3.4. Uptake of improved indigenous chicken by poultry farmers

The results in Table 4 reveal that 51.3% of the poultry farmers were keeping between 0 and 10 IIC. However, within this group, only 1.3% of the poultry farmers were adopters of IIC, keeping fewer than ten birds, while the remaining 50% of the poultry farmers were non-adopters. These non-adopters continued to keep IC but had not yet transitioned to IIC. Several possible explanations for this include lack of awareness about the benefits of IIC and financial constraints preventing investment in improved breeds. Low hatchability of IIC or a preference for IC due to cultural familiarity or market demand could also be possible explanations (Ochora et al., 2023). Additionally, farmers might be hesitant to adopt improved breeds due to perceived risks related to disease susceptibility, input costs, or uncertainties about productivity and profitability (Bogueva et al., 2023). The presence of only two adopters keeping fewer than ten IIC may indicate that some farmers are testing the IIC before fully integrating them into their flocks. This could reflect a cautious adoption approach influenced by the availability of extension services, market incentives, or previous experiences with IIC performance (Birhanu & Jensen, 2023). The category of poultry farmers keeping between 10 and 20 IIC was 4.7%, representing a small segment of farmers. These results may indicate a transitional phase where farmers are beginning to scale up from a smaller flock but are not yet fully committed to larger-scale poultry farming. This trend could be influenced by a desire to test the performance of improved chicken before making larger investments. The small percentage might also reflect limitations in access to capital or support systems for scaling up poultry production (Mdletshe & Obi, 2023). A significant portion of farmers, almost half (44.5%), were maintaining larger flocks of over 20 IIC. This suggests a higher level of adoption among some farmers, likely indicating that they perceive tangible benefits from the improved chicken, such as better disease resistance, higher productivity, and marketability. The results are consistent with studies that show increased flock size as farmers become more confident in the benefits of IIC (Kamau et al., 2023).

The results indicate that more than half (52%) of the poultry farmers were selling between 0 and 10 improved indigenous chicken per year. However, within this group, only 2% of the poultry farmers were adopters of IIC, selling fewer than ten IIC annually. The remaining 50% of the poultry farmers were non-adopters who were only keeping IC; not keeping IIC and, therefore, not selling IIC. These findings suggest that the commercialisation of IIC remains low among IIC farmers. Some factors may contribute to this trend, including limited access to improved chicken breeds, lack of awareness of their market potential, or financial constraints that hinder investment in improved stock (Karamchedu et al., 2022). Additionally, farmers may be cautious in expanding their production due to uncertainties in market demand, pricing, and profitability of improved indigenous chicken (Zziwa et al., 2023). The low number of adopters selling improved indigenous chicken could also indicate that some farmers are in the early stages of adoption and may not yet have reached full production capacity. Furthermore, non-adopters keeping indigenous chicken but not keeping IIC and, therefore, not selling improved breeds may suggest a preference for IC due to factors such as lower production costs, cultural significance, or established market networks (Behera & Adhikary, 2023).

Additionally, another category of poultry farmers selling between 10 and 50 IIC per year was 11.3%, representing a middle tier of adoption. These farmers might be in a transition phase, scaling up their production gradually as they gain confidence in the profitability and sustainability of IIC farming (Bartolacci et al., 2023). A substantial portion of farmers, 36.7%, were selling more than 50 IIC per year. This indicates that a smaller group of farmers have embraced improved practices and achieved a higher level of production, potentially due to access to better resources, markets, or support systems that facilitate larger-scale poultry farming. The greater volume of sales could also reflect the economic viability and market demand for improved indigenous chicken breeds (Ramukhithi et al., 2023). Overall, while a large proportion of farmers are selling fewer IIC, a significant percentage are scaling up production. Therefore, this could indicate growing confidence in the benefits of IIC farming, such as higher productivity and market demand, despite challenges in uptake (Bulte & Lensink, 2023).

The findings suggest that 53.3% of the poultry farmers produced between 0 and 150 eggs from improved indigenous chicken (IIC) monthly. Within this group, only 5.3% of the poultry farmers were adopters of improved indigenous chicken, producing fewer than 150 IIC eggs monthly. The remaining 50% of the poultry farmers were non-adopters, keeping only IC; not keeping IIC, therefore not producing any IIC eggs. These findings suggest that the adoption of improved indigenous chicken for egg production is still relatively low among poultry farmers. Some factors could explain this, including the age and health of the chicken, feed quality, management practices, and environmental conditions. For instance, research by Kumalasari et al. (2023) indicated that IIC often show increased productivity, but this can be contingent upon proper management and feed. Low egg production may also be a result of genetic limitations, where some IIC strains are not as prolific as others in terms of egg-laying capacity (Mensah et al., 2023).

A smaller portion of farmers (13.3%) producing between 150-200 eggs per month suggests that a middle ground of egg production exists. This could reflect varying levels of management, feed, or other environmental factors that affect egg

output. As Balabaygloo et al. (2023) indicate, intermediate production levels often occur when farmers are beginning to optimise conditions but may not have yet fully harnessed the genetic potential of the IIC for higher egg output. The breakdown of egg sales among poultry farmers provides insights into market trends, consumer behaviour, and the overall reach of IIC eggs. The poultry farmers producing more than 200 eggs per month were 37.7%. This figure shows that a significant portion of farmers are seeing relatively high egg production from their IIC. This could be attributed to improved management practices, better feed, or genetic improvements in the stock of IIC being used by these farmers. Improved indigenous chicken with proper breeding and nutrition can produce significant numbers of eggs, often exceeding 200 per month, aligning with the experiences of these farmers (Yadav et al., 2024).

The results indicate that 54% of the poultry farmers sold between 0 and 100 eggs from improved indigenous chicken (IIC) monthly. Within this group, only 4% of the poultry farmers were adopters of improved indigenous chicken, selling fewer than 100 IIC eggs monthly. The remaining 50% of the poultry farmers were non-adopters, keeping IC only; not keeping IIC, therefore, not selling any IIC eggs. This suggests that the majority of the farmers may still be in the early stages of adopting improved breeds or that they are facing challenges in scaling up production. The relatively low sales of IIC eggs could indicate factors such as limited flock sizes, inadequate infrastructure, or insufficient market access (Vieira et al., 2022). This trend might reflect the caution with which some farmers approach the introduction of new breeds, possibly due to concerns about the cost and management of improved chicken, as well as the need for training and support. Research by Hasimuna et al. (2023) highlights that many small-scale farmers face difficulties in the transition to new breeds, including inadequate information on management practices and breeding strategies.

The 34% of the poultry farmers selling more than 200 eggs suggests a significant portion of the farmers can produce at a larger scale and have successfully adopted IIC for more commercial purposes. This indicates that these farmers may have larger flock sizes or more efficient production systems. This category of farmers is likely benefiting from the improved genetics of IIC, which can lead to better egg production rates compared to IC. The finding aligns with studies like that of Kpomasse et al. (2023), who found that improved indigenous breeds generally have better productivity metrics in terms of egg production. The poultry farmers selling 100-200 IIC eggs were 12%. This group represents those with moderate sales, possibly indicating a transition phase between small-scale and large-scale production. They might be experimenting with improved breeds or slowly increasing their flock sizes. These farmers could be facing barriers such as access to reliable feed, veterinary care, or marketing channels that would allow them to move to higher levels of production. According to Pansara (2023), a challenge often faced by farmers in this intermediate category is the ability to scale production effectively due to resource constraints or fluctuating demand.

Table 4 Uptake of improved indigenous chicken by poultry farmers

Uptake of Improved Indigenous Chicken	**Category of Uptake of Improved Indigenous Chicken Items**	**Percentage IIC Adopters**	**IIC Non-adopters**
The number of IIC kept	0-10	1.3	50.0
	10-20	4.7	0.0
	>20	44.3	0.0
Number of IIC sold per year	0-10	52.0	50.0
	10-50	11.3	0.0
	>50	36.7	0.0
Number of IIC eggs produced per month	0-150	3.3	50.0
	150-200	13.3	0.0
	>200	33.7	0.0
Number of IIC eggs sold per month	0-100	4.0	50.0
	100-200	12.0	0.0
	>200	34.0	0.0

3.5. Influence of agricultural extension services on uptake of improved indigenous chicken

The results in Table 5 indicate that the adjusted R^2 is 1.69 per cent. The adjusted R^2 (1.69%) indicates the change in uptake of improved indigenous chicken as a result of the change in the predictors if the data was to be generalised to the population and not the study sample.

The findings revealed that agricultural extension services have a significant influence on the uptake of improved indigenous chicken. The regression equation is significant with P = 0.000. The study, therefore, rejects the null hypothesis and accepts the alternative hypothesis that: "There is a statistically significant influence of agricultural extension services on uptake of improved indigenous chicken by poultry farmers in Konoin Sub-county, Kenya." This is explained by the fact that farmers need to be trained on poultry production practices, and seek advice on poultry production for example, control of pests and diseases and feeding which will help them in the uptake of improved indigenous chicken. These results agree with those of Udoh et al. (2024) who established that access to useful agricultural extension services is important for the adoption of improved poultry production.

The regression coefficient results highlight the significant role of training and advisory services in influencing the uptake of improved indigenous chicken by poultry farmers. Farmers who receive regular training and actively seek advisory services are more likely to adopt improved poultry farming practices, while limited access to extension services negatively impacts adoption rates. An increase in training on poultry production practices leads to a 0.043 increase in IIC uptake, indicating that exposure to proper farming techniques improves farmers' ability to manage poultry effectively. Similarly, seeking advisory services contributes +0.040 to IIC adoption, reinforcing the importance of professional guidance in decision-making and farm productivity. These findings align with Mburu et al. (2024), who found that extension services significantly improve technology adoption in agriculture by bridging knowledge gaps and increasing efficiency.

Conversely, a decrease in the most recent training on poultry production leads to a 0.174 decline in IIC adoption, suggesting that outdated or infrequent training restricts farmers' capacity to implement modern poultry practices. Furthermore, a reduction in the provision of agricultural extension services results in a 0.392 drop in IIC uptake, indicating that insufficient support from agricultural officers and advisors significantly hinders farmers' willingness and ability to invest in improved poultry breeds. This is consistent with Kalogiannidis & Syndoukas (2024), who emphasised that inadequate extension service delivery diminishes technology adoption among farmers.

Interestingly, despite the recognised importance of training and advisory services, the negative influence of recent training and agricultural service providers indicates inefficiencies in extension service delivery. Many farmers may not receive practical, up-to-date, or farmer-specific guidance during training, which reduces its impact. Similar findings were reported by Sahoo et al. (2024), who noted that weak extension systems and limited access to agricultural advisory services hinder technology uptake in rural areas.

Table 5 Multiple linear regression between agricultural extension services and uptake of improved indigenous chicken

Model		Adjusted R Square	Sig.	Standardised Coefficients
1	(Constant)	0.169	0.000[b]	
	Training on poultry production practices			+0.043
	Last training			-0.174
	Seeking for advisory services			+0.040
	Agricultural extension service providers			-0.392

4. Conclusion and recommendation

The study highlights the significant influence of agricultural extension services on the uptake of improved indigenous chicken by poultry farmers. Training on poultry production emerged as a critical factor, equipping farmers with the necessary skills and knowledge to adopt improved poultry practices. Additionally, the frequency and timing of the last visit by extension service providers demonstrated the importance of regular interactions in reinforcing adoption behaviours. Agricultural extension advisory services enhanced uptake of improved indigenous chicken. The role of agricultural extension service providers as trusted sources of information and support was evident in their ability to foster confidence and reduce barriers to the uptake of improved indigenous chicken.

Agricultural extension service providers should organise regular and targeted training sessions for poultry farmers to improve their knowledge of improved indigenous chicken breeds, housing, feeding, disease management, and marketing. Include practical demonstrations and hands-on sessions to ensure effective learning. Moreover, agricultural extension service providers should establish a schedule for regular visits to poultry farms by extension officers to provide on-site support and address specific challenges faced by farmers. Strengthen farmer-extension officer relationships to build trust and improve information flow. Offer a wide range of advisory services, including market linkages, disease surveillance, and business planning, to meet the holistic needs of poultry farmers. Implement a monitoring and evaluation framework to assess the effectiveness of training and advisory services. Agricultural extension service providers should use feedback from farmers to refine strategies and address gaps in service delivery.

Compliance with ethical standards

Acknowledgement

This work could not have been completed without the collaboration of my co-authors, [Names]. Their expertise, hard work, and dedication to this project were invaluable.

Disclosure of conflict of interest

The authors declare that they have no conflicts of interest related to the publication of this article.

Statement of ethical approval

Before conducting fieldwork, ethical clearance was acquired from the Egerton University Institutional Scientific and Ethics Review Committee. In addition, a research permit was obtained from the National Commission for Science, Technology, and Innovation (NACOSTI). All participants provided informed consent prior to participation.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Abukari, A.-B. T., Bawa, K., & Awuni, J. A. (2021). Adoption Determinants of Agricultural Extension Communication Channels in Emergency and Non-Emergency Situations in Ghana. Cogent Food & Agriculture, 7(1), 1872193. https://doi.org/10.1080/23311932.2021.1872193

[2] Akintuyi, O. (2024). Adaptive AI in precision agriculture: A review: Investigating the use of Self-Learning Algorithms in Optimising Farm Operations Based on Real-Time Data. Open Access Research Journal of Multidisciplinary Studies, 7(2), 016–030. https://doi.org/10.53022/oarjms.2024.7.2.0023

[3] Allahyari, M. S., & Sadeghzadeh, M. (2020). Agricultural Extension Systems Toward SDGs 2030: Zero Hunger. In M. Dietrich, M. Borrello, & O. Harman (Eds.), Handbook of the Historiography of Biology (Vol. 1, pp. 1–11). Springer International Publishing. https://doi.org/10.1007/978-3-319-69626-3_2-1

[4] Anyona, D. N., Musyoka, M. M., Ogolla, K. O., Chemuliti, J. K., Nyamongo, I. K., & Bukachi, S. A. (2023). Characterisation of Indigenous Chicken Production and Related Constraints: Insights from Smallholder Households in Rural Kenya. Scientific African, 20, 01717. https://doi.org/10.1016/j.sciaf.2023.e01717

[5] Aryemo, I. P., Akite, I., Kule, E. K., Kugonza, D. R., Okot, M. W., & Mugonola, B. (2019). Drivers of Commercialization: A Case of Indigenous Chicken Production in Northern Uganda. African Journal of Science, Technology, Innovation and Development, 11(6), 739–748. https://doi.org/10.1080/20421338.2019.1573957

[6] Balabaygloo, B. J., Bekee, B., Blair, S. W., Fey, S., Fotouhi, F., Gupta, A., Menke, K., Vangala, A., Palomares, J. C. M., Prestholt, A., Tanwar, V. K., Tao, X., Carroll, M. E., Das, S., Depaula, G., Kyveryga, P., Sarkar, S., Segovia, M., Sylvestri, S., … Singh, A. K. (2023). Smart Connected Farms and Networked Farmers to Tackle Climate Challenges Impacting Agricultural Production (arXiv:2312.12338). arXiv. https://doi.org/10.48550/arXiv.2312.12338

[7] Bartolacci, F., Marcantoni, M., & Usci, R. (2023). How to Turn Poultry Manure into Valuable Resources: A Circular Business Model for Resilient and Sustainable Small and Medium-Sized Farms. Journal of Management and Sustainability, 13(2), 1. https://doi.org/10.5539/jms.v13n2p1

[8] Behera, R., & Adhikary, L. (2023). Review on Cultured Meat: Ethical Alternative to Animal Industrial Farming. Food Research, 7(2), 42–51. https://doi.org/10.26656/fr.2017.7(2).772

[9] Birhanu, M. Y., & Jensen, N. (2023). Dynamics of Improved Agricultural Technologies Adoption: The Chicken and Maize Paradox in Ethiopia. Sustainable Futures, 5, 100112. https://doi.org/10.1016/j.sftr.2023.100112

[10] Bogueva, D., Marques, M., Molento, C. F. M., Marinova, D., & Phillips, C. J. C. (2023). Will the Cows and Chicken Come Home? Perspectives of Australian and Brazilian Beef and Poultry Farmers Towards Diversification. Sustainability, 15(16), 12380. https://doi.org/10.3390/su151612380

[11] Bomet County. (2023). The County Government of Bomet: County Annual Development Plan. http://www.bometassembly.go.ke/blog/county-annual-development-plan-fy-2023-2024

[12] Bukachi, S. A., Ngutu, M., Omia, D., Musyoka, M. M., Chemuliti, J., & Nyamongo, I. K. (2023). Gender-Linked Dynamics and Sustainable Small Holder Poultry Value Chains in Makueni County, Kenya. Sustainability, 15(14), 10907. https://doi.org/10.3390/su151410907

[13] Bulte, E., & Lensink, R. (2023). Why Agricultural Insurance May Slow down Agricultural Development. American Journal of Agricultural Economics, 105(4), 1197–1220. https://doi.org/10.1111/ajae.12353

[14] Byamukama, W., Kalibwani, R., & Mbabazi, B. P. (2022). The Use of Information and Communication Technology (ICT) and the Challenges Faced by Ugandan Smallholder Farmers. Review Article. East African Journal of Agriculture and Biotechnology, 5(1), 108–113. https://doi.org/10.37284/eajab.5.1.642

[15] Catania, G., Zanini, M., Hayter, M., Timmins, F., Dasso, N., Ottonello, G., Aleo, G., Sasso, L., & Bagnasco, A. (2021). Lessons from Italian Front-Line Nurses' Experiences during the Covid-19 Pandemic: A Qualitative Descriptive Study. Journal of Nursing Management, 29(3), 404–411. https://doi.org/10.1111/jonm.13194

[16] Dakarai, A., Author, C., & Dakarai, A. (2023). Reviewing the Effectiveness of Public Service Policy Implementation to Enhance Citizen Satisfaction. Journal Social Civilecial, 1(2), 55–70.

[17] Davis, F. D. (1989). User Acceptance of Information Systems: The Technology Acceptance Model. Information Seeking Behaviour and Technology Adoption, 205–219.

[18] Gordon, J., Adeyemi, O., Baker, P., Dewi, D., Fracassi, P., & Memon, R. (2025). Development and Piloting of a Tool for Conducting Political Economy Analysis of Agrifood Systems and Food Security and Nutrition Policies and Programmes, Technical Report. Institute of Development Studies and Food and Agriculture Organization. https://doi.org/10.19088/IDS.2024.040

[19] Hasimuna, O. J., Maulu, S., Nawanzi, K., Lundu, B., Mphande, J., Phiri, C. J., Kikamba, E., Siankwilimba, E., Siavwapa, S., & Chibesa, M. (2023). Integrated Agriculture-Aquaculture as an Alternative to Improving Small-Scale Fish Production in Zambia. Frontiers in Sustainable Food Systems, 7(2), 1161121. https://doi.org/10.3389/fsufs.2023.1161121

[20] Ipara, B. O., Otieno, D. J., Nyikal, R. A., & Makokha, N. S. (2024). Farmers' Awareness and Perceptions on Newcastle Disease in Chicken: Evidence from High and Low Rainfall Regions of Kenya. Cogent Food and Agriculture, 10(1), 2292869. https://doi.org/10.1080/23311932.2023.2292869

[21] Junyong, I., Kang, H., Kim, J. H., Kim, T. K., Ahn, E. J., Lee, D. K., Lee, S., & Park, J. H. (2020). Tips for Troublesome Sample-Size Calculation. Korean Journal of Anesthesiology, 73(2), 114–120. https://doi.org/10.4097/kja.19497

[22] Kalogiannidis, S., & Syndoukas, D. (2024). The Impact of Agricultural Extension Services on Farm Output: A Worldwide Viewpoint. 05(01).

[23] Kamau, C. N., Kabuage, L. W., & Bett, E. K. (2019). Analysis of Improved Indigenous Chicken Adoption among Smallholder Farmers: Case of Makueni and Kakamega Counties, Kenya. International Journal of Agricultural Extension, 7(1), 21–37. https://doi.org/10.33687/ijae.007.01.2809

[24] Kamau, C. N., Majiwa, E. B., Otieno, G. O., & Kabuage, L. W. (2023). Intention to Adopt Improved Indigenous Chicken Breeds among Smallholder Farmers in Machakos County, Kenya. Do Socio-psychological Factors Matter? Heliyon, 9(11), e22381. https://doi.org/10.1016/j.heliyon.2023.e22381

[25] Karamchedu, A. K., Syndicus, I. S., & Tak, M. T. (2022). Identifying Economic and Financial Drivers of Industrial Livestock Production—The Case of the Global Chicken Industry. Tiny Beam Fund. https://doi.org/10.15868/socialsector.40548

[26] Kenya National Bureau of Statistics [KNBS]. (2019). Kenya Population and Housing Census. http//www.knbs.or.ke

[27] Khatri, A., Lallawmkimi, M. C., Rana, P., Panigrahi, C. K., Minj, A., Koushal, S., & Ali, M. U. (2024). Integration of ICT in Agricultural Extension Services: A Review. Journal of Experimental Agriculture International, 46(12), 394–410. https://doi.org/10.9734/jeai/2024/v46i123146

[28] Kpomasse, C. C., Kouame, Y. A. E., N'nanle, O., Houndonougbo, F. M., Tona, K., & Oke, O. E. (2023). The Productivity and Resilience of the Indigenous Chicken in the Tropical Environments: Improvement and Future Perspectives. Journal of Applied Animal Research, 51(1), 456–469. https://doi.org/10.1080/09712119.2023.2228374

[29] Kumalasari, C., Adriani, L., Yudha Asmara, I., & Nayan, N. (2023). Administration of Probiotics to Increase Egg Production and Extend the Productivity on Late-Phase Laying Hen: A Review. Advances in Animal and Veterinary Sciences, 11(8), 14. https://doi.org/10.17582/journal.aavs/2023/11.8.1236.1249

[30] Kumar, C. S., & Yale, S. S. (2016). Identifying and Eliminating Bias in International Research Studies: A Qualitative Indicator. International Journal of Contemporary Medical Research, 3(6).

[31] Kwapong, N. A., Ankrah, D. A., Boateng-Gyambiby, D., Asenso-Agyemang, J., & Fening, L. O. (2020). Assessment of Agricultural Advisory Messages from Farmer-to-Farmer in Making a Case for Scaling up Production: A Qualitative Study.

[32] Kyambo, O. M. (2023). The Impacts of Agricultural Sector Devolution on Delivery of Agricultural Extension Services and Agricultural Productivity in Kitui County, Kenya [A Thesis Submitted in Fulfilment of the Requirements for the Award of the Degree of Doctor of Philosophy in Agricultural Economics]. South Eastern Kenya University.

[33] Lamm, A. J., Lamm, K. W., Trojan, S., Sanders, C. E., & Byrd, A. R. (2023). A Needs Assessment to Inform Research and Outreach Efforts for Sustainable Agricultural Practices and Food Production in the Western United States. Foods, 12(8), 1630. https://doi.org/10.3390/foods12081630

[34] Manyelo, T. G., Selaledi, L., Hassan, Z. M., & Mabelebele, M. (2020). Local Chicken Breeds of Africa: Their Description, Uses and Conservation Methods. Animals, 10(12), 2257. https://doi.org/10.3390/ani10122257

[35] Mapiye, O., Makombe, G., Molotsi, A., Dzama, K., & Mapiye, C. (2023). Information and Communication Technologies (ICTs): The Potential for Enhancing the Dissemination of Agricultural Information and Services to Smallholder Farmers in Sub-Saharan Africa. Information Development, 39(3), 638–658. https://doi.org/10.1177/02666669211064847

[36] Mburu, M., Mburu, J., Nyikal, R., Mugera, A., & Ndambi, A. (2024). Role of Agricultural Extension in Learning for Uptake and Intensification of Less-Practiced Dairy Climate-Smart Practices in Kenya. Cogent Food & Agriculture, 10(1), 2330182. https://doi.org/10.1080/23311932.2024.2330182

[37] Mdletshe, S. T. C., & Obi, A. (2023). Investigating the Profitability of Government-Funded Small-Scale Broiler Projects in Northern Kwazulu-Natal, South Africa. Agriculture, 13(12), 2269. https://doi.org/10.3390/agriculture13122269

[38] Mensah, P., Adomako, K., Hagan, B. A., Hamidu, J. A., & Olympio, S. O. (2023). Qualitative Mutant Traits Within the Indigenous Chicken Population in Selected Ecological Zones of Ghana. Scientific African, 20, e01695. https://doi.org/10.1016/j.sciaf.2023.e01695

[39] Moreno, R. V., & Corral, J. R. (2024). The Government´s Role in Sustainable Food Chains Facing the Climate Change. Journal of Food Science and Nutrition Research, 7(3). https://doi.org/10.26502/jfsnr.2642-110000163

[40] Ndirangu, S., Mbogoh, S., & Mbatia, O. (2018). Evaluation of the Elasticity of Farm Output among Smallholder Farmers in Selected Agro-Ecological Zones of Embu County, Kenya. Asian Journal of Agricultural Extension, Economics & Sociology, 26(3), 1–10. https://doi.org/10.9734/AJAEES/2018/43048

[41] Ngaiwi, M. E., Molua, E. L., Sonwa, D. J., Meliko, M. O., Bomdzele, E. J., Ayuk, J. E., Castro-Nunez, A., & Latala, M. M. (2023). Do Farmers' Socioeconomic Status Determine the Adoption of Conservation Agriculture? An Empirical Evidence from Eastern and Southern Regions of Cameroon. Scientific African, 19(2), e01498. https://doi.org/10.1016/j.sciaf.2022.e01498

[42] Nwobodo, C. E., Okoronkwo, D. J., Eze, R. I., Ozorngwu, A. M., Iwuchukwu, J. C., Azuka, V. C., & Udoye, C. E. (2023). Knowledge Capabilities for Sustainable Poultry Production in Sub-Sahara Africa: Lessons from Southeast Nigeria. Sustainability, 15(14), 11174. https://doi.org/10.3390/su151411174

[43] Nyabvudzi, R. M., & Nkwana, H. M. (2024). Public-Private Partnership Strategies Supporting Smallholder Farmers to Enhance Food Security in South Africa. Administratio Publica, 32(3), 88–108. https://doi.org/10.61967/adminpub.2024.32.3.6

[44] Nyokabi, N. S., Phelan, L., Gemechu, G., Berg, S., Mihret, A., Wood, J. L. N., & Moore, H. L. (2023). Exploring Animal Husbandry in Smallholder Dairy Systems in Ethiopia Using Photovoice. Agriculture & Food Security, 12(1), 16. https://doi.org/10.1186/s40066-023-00420-w

[45] Ochora, S., Kasima, J. S., Okot, W. M., & Ndyomugyenyi, E. K. (2023). Performance of Local and Local X Improved Chicken Crosses Under Semi-Intensive Management System in Northern Uganda. Cogent Food & Agriculture, 9(1), 2213925. https://doi.org/10.1080/23311932.2023.2213925

[46] Pansara, R. R. (2023). Seeding the Future by Exploring Innovation and Absorptive Capacity in Agriculture 4.0 and Agtechs. International Journal of Sustainable Development, 5(2), 46–59.

[47] Pius, L. O., Strausz, P., & Kusza, S. (2021). Overview of Poultry Management as a Key Factor for Solving Food and Nutritional Security with a Special Focus on Chicken Breeding in East African Countries. Biology, 10(8), 810. https://doi.org/10.3390/biology10080810

[48] Raji, E., Tochukwu Ignatius Ijomah, & Osemeike Gloria Eyieyien. (2024). Improving Agricultural Practices and Productivity Through Extension Services and Innovative Training Programs. International Journal of Applied Research in Social Sciences, 6(7), 1297–1309. https://doi.org/10.51594/ijarss.v6i7.1267

[49] Ramukhithi, T. F., Nephawe, K. A., Mpofu, T. J., Raphulu, T., Munhuweyi, K., Ramukhithi, F. V., & Mtileni, B. (2023). An Assessment of Economic Sustainability and Efficiency in Small-Scale Broiler Farms in Limpopo Province: A Review. Sustainability, 15(3), 2030. https://doi.org/10.3390/su15032030

[50] Sahoo, M., Ghosh, S., & Rout, S. K. (2024). How to Make Agricultural Innovation and Extension System Effective in Delivering Agro-Advisories? Current Science, 127(11), 1279. https://doi.org/10.18520/cs/v127/i11/1279-1286

[51] Sawadogo, A., Kagambèga, A., Moodley, A., Ouedraogo, A. A., Barro, N., & Dione, M. (2023). Knowledge, Attitudes, and Practices Related to Antibiotic Use and Antibiotic Resistance Among Poultry Farmers in Urban and Peri-Urban Areas of Ouagadougou, Burkina Faso. Antibiotics, 12(1), 133. https://doi.org/10.3390/antibiotics12010133

[52] Shaji, G., & Hovan, G. (2023). Optimising Poultry Production through Advanced Monitoring and Control Systems. Partners Universal International Innovation Journal, 1(5), 2583–9675. https://doi.org/10.5281/ZENODO.10050352

[53] Tafida, I., Bulus, T. V., & Nazifi, B. (2024). Strengths, Weaknesses, Opportunities and Threats to Extension Service Delivery in Kaduna State, Nigeria. Journal of Agricultural Extension, 28(1), 29–36. https://doi.org/10.4314/jae.v28i1.4

[54] Udoh, E. D., Vihi, S. K., Dalla, A. A., Binuyo, G., & Mbah, J. J. (2024). Perception of Poultry Farmers' on Effectiveness of Poultry Extension Service Delivery in Calabar Municipal Area of Cross River State, Nigeria. Journal of Applied Sciences and Environmental Management, 28(7), 2025–2032. https://doi.org/10.4314/jasem.v28i7.13

[55] VanVoorhis, C. R. W., & Morgan, B. L. (2007). Understanding Power and Rules of Thumb for Determining Sample Sizes. Tutorials in Quantitative Methods for Psychology, 3(2), 43–50. https://doi.org/10.20982/tqmp.03.2.p043

[56] Vieira, L. M., Nacimento, R. A., Mendes, C. M. I., De Carvalho, Í. C. S., & Demattê Filho, L. C. (2022). Assessing Smallholder Farmers' Perception of Value Creation and Appropriation in Sustainable Production. International Journal of Environment and Sustainable Development, 1(1), 1. https://doi.org/10.1504/IJESD.2022.10052369

[57] Waithaka, M. K., Osuga, I. M., Kabuage, L. W., Subramanian, S., Muriithi, B., Wachira, A. M., & Tanga, C. M. (2022). Evaluating the Growth and Cost–Benefit Analysis of Feeding Improved Indigenous Chicken with Diets Containing Black Soldier Fly Larva Meal. Frontiers in Insect Science, 2, 933571. https://doi.org/10.3389/finsc.2022.933571

[58] Wambua, S., Macharia, I., & Mwenjeri, G. (2022a). Challenges and Opportunities in Improved Indigenous Chicken Production in Kenya. East African Agriculture Journal, 88(3), 180–189.

[59] Wambua, S., Macharia, I., & Mwenjeri, G. (2022b). Cost Efficiency of Improved Indigenous Chicken Producers in Kenya: A Stochastic Frontier Approach. East African Agriculture Journal, 88(4), 220–226.

[60] Wang, G., Lu, Q., & Capareda, S. C. (2020). Social Network and Extension Service in Farmers' Agricultural Technology Adoption Efficiency. PLOS ONE, 15(7), e0235927. https://doi.org/10.1371/journal.pone.0235927

[61] Yadav, O. P., Singh, D. V., Kumari, V., Prasad, M., Seni, S., Singh, R. K., Sood, S., Kant, L., Rao, B. D., Madhusudhana, R., Bhat, B. V., Gupta, S. K., Yadava, D. K., & Mohapatra, T. (2024). Production and Cultivation Dynamics of Millets in India. Crop Science, 8(2), 26. https://doi.org/10.1002/csc2.21207

[62] Yusuf, S. F. G., & Popoola, O. O. (2022). An Evaluation of the Effectiveness of the Training Offered to Smallholder Scavenging Chicken Farmers in Raymond Mhlaba Local Municipality, Eastern Cape Province, South Africa. Sustainability, 14(23), 15735. https://doi.org/10.3390/su142315735

[63] Zziwa, A., Matsapwe, D., Kyeyune, R. K., Kizito, S. S., & Mukebezi, R. (2023). Innovative Pathways to Profitability: A Comprehensive Analysis of Value Addition and Resource Recovery in Peri-Urban Poultry Farming. 2(6).