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MEASURING THE ECONOMIC PERFORMANCE OF SMALL-SCALE RABBIT PRODUCTION AGRIBUSINESS ENTERPRISES

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Abstract: Reducing malnutrition and poverty remains at the centre of policy. Rabbit rearing, of great economic importance, is a critical pathway to achieving this. Good knowledge of the profitability of rabbit production and its driving factors can enhance participation in rabbit production. Thus, this study examined the economic performance (profitability) of rabbit production, the factors influencing profitability and its barriers. Descriptive statistics, profitability analysis, the Tobit regression model and Garret ranking were employed to achieve the objectives. The results indicated that rabbit production was economical, productive and profitable, with a gross margin of ₦675,990 (USD 1,633.5), a net income of ₦663,974 (USD 1,604.4), a profit ratio of 0.6, a benefit-cost ratio of 2.7, a return on capital invested of 1.7 and an operating ratio of 0.4. The factors that enhanced rabbit production profitability were stock size, education, experience, membership of the association and labour availability, whereas mortality, disease outbreaks and feeding costs were inhibiting factors to profitability. The major constraints affecting rabbit production are disease, a high mortality rate and poor access to credit. These call for the provision of disease management training and credits to motivate people to engage in rabbit farming, which will, in turn, lower poverty and increase protein availability.

Key Words: disease outbreak, driving factors, mortality rate, profitability, rabbit farming.

INTRODUCTION

Major concerns of the world today include how to eradicate poverty and feed the increasing population with a nutritious, protein-rich diet low in cholesterol to reduce malnutrition. Livestock production is a viable way of tackling these challenges. Livestock, especially small animals, can boost income and enhance animal protein availability to the growing population (Mukaila, 2022). One of the small livestock animals of great economic significance is the rabbit (Silva *et al*., 2021).

Rabbit is categorised as micro livestock, capable of meeting households' white meat demand. A doe can produce about 47 kg of meat per year through breeding, which is sufficient to meet the much-needed animal-based protein demands of a medium-sized family (Ugosor *et al*., 2016). Rabbit is feasible for both large-scale and small-scale production. They are noiseless animals and can therefore be raised without infringing on the peace of neighbours around them. They have several advantages over other livestock. Rabbits can be reared in a small area without causing environmental pollution. They can easily be acclimatised to a variety of conditions and are suitable for occupational therapy, particularly for disabled and retired people, as their care does not involve a lot of physical exertion (Owen and Amakiri, 2010). Another important feature of the rabbit is that they can feed on several foodstuffs, such as conventional feeds, cereal, sweet potato, corn silk, cassava leaves, spinach, mulberry leaves and other

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plants, without competing with human requirements (Lukefahr *et al*., 2010; Medenou *et al*., 2020; Moningkey *et al*., 2021). This is possible due to the presence of caecal microbes that allow the digestion of feeds rich in fibre (Taiwo *et al*., 1999).

Many nations, particularly developing countries, benefit from the rabbit industry in terms of social development, rural economic growth and poverty reduction (Wu, 2022). This is a result of its positive features, such as job creation, easy management, uncomplicated start-up, flexible investment and the production of high-quality meat (Wu, 2022). Rabbit meat represents a considerable cultural and nutritional value and serves as a traditional diet (Leroy and Petracci, 2021). Rabbit meat has distinct features and has been recommended for patients with coronary heart conditions for some years now by medical specialists (Cullere and Zotte, 2018; Escribá-Pérez *et al.* 2019). Furthermore, rabbit meat is rich in phosphorus, calcium and vitamin B, with low levels of sodium and cholesterol (Grădinaru, 2017; Nistor *et al*., 2013). These attributes encourage consumer interest and the farmers' decision to engage in its production.

In spite of the developing interest in rabbit rearing, rabbit farming in Nigeria is dominated by smallholder farmers with minimum investments in management practices like housing and feeding. This could be a result of scant knowledge of the profitability (economic performance) of the venture. Several studies on rabbits concentrated on production with little emphasis on its profitability (McNitt *et al*., 2013; Oseni *et al*., 2014; Gidenne *et al*., 2017; Khan *et al*., 2017; Trocino *et al*., 2019; Cherwon *et al*., 2020; Medenou *et al*., 2020). Aminu *et al.* (2020) only examined income from rabbit production, which is not enough to show the economic performance of the enterprise. Krupová *et al.* (2020) developed a bioeconomic model to estimate the economic values and relative economic weights for rabbit traits in the Czech commercial rabbit production system. The study expresses rabbit rearing profit as a function of carcass performance, young rabbit growth and doe reproductive status. Mondin *et al.* (2021) evaluated the economic sustainability of six rabbit farms under different housing systems —enriched, conventional dual-purpose and bicellular cage designs— in Italy. These studies did not consider using several economic performance measures in their analysis to show how profitable the venture was and did not identify the factors responsible for the economic performance of rabbit farms. There is therefore a knowledge gap in the literature regarding the economic performance of rabbit production enterprises in terms of measuring their profitability. Thus, there is a need to examine the economic performance of the rabbit production enterprise to promote the venture.

Based on the foregoing, this study aims to describe rabbit production systems and management practices employed by farmers, identify the common diseases affecting the herd, examine the mortality rate, assess the profitability of rabbit production as a measure of economic performance, investigate the determinants of its profitability and identify the barriers to profitable rabbit production. This would serve as a reference point for policymakers towards promoting livestock farming and solving malnutrition and unemployment. It would also promote participation in rabbit production agribusiness enterprises and equip farmers with the knowledge needed to channel their resources profitably.

MATERIALS AND METHODS

Study area, sampling procedure and data collection

This study was conducted in south-western Nigeria. The larger population of the region is widely engaged in agriculture and allied activities.

A four-stage sampling technique was used in this study. Stage 1 involved a random selection of two states out of the six states in the region. Two local government areas (LGA) were selected at random from each state. After this, four communities were randomly selected from each LGA. At stage four of the sampling technique, ten rabbit farmers were selected using the snowball sampling technique from each community, making a total of 160 rabbit farms.

Data was obtained, primarily, via the use of a semi-structured questionnaire.

Data analysis

Descriptive statistics along with several profitability analyses and Tobit regression were employed for data analysis.

Descriptive statistics

They were used to describe the rabbit production systems and management practices employed by farmers, to identify the common diseases affecting smallholder rabbit farmers and examine the mortality rate on the farm.

Profitability analysis

The economic performance of small-scale rabbit farms was measured using profitability analysis. This is because the major objective of any business enterprise is to maximise profit. To estimate the profitability of the rabbit production venture, several variable and fixed costs were included in the analysis. The items included in the variable costs were the cost of weaners, feeding, water, drugs, transport and labour (this study considered labour outlay as variable cost because the hired workers employed by rabbit farmers were not permanent, as this workforce is hired to supplement family labour). The cost items included in the fixed cost incurred in the rabbit production system are the cost of the housing or cage, feeders and drinkers. The profitability analysis was based on 150 fattened rabbits per year.

Gross margin measures gross returns after the deduction of total variable cost from the total revenue obtained from the rabbit farm. This is expressed as:

Gross margin=total revenue–total variable cost (1)

Net income was further used to get the profit of the rabbit production enterprise by deducting total fixed costs from the gross margin or by deducting all expenses from the revenue. It is expressed as:

Net income=gross margin–total fixed cost (2)

The profit ratio was estimated to compare the earnings from a rabbit production enterprise to its sales. This is a vital indicator of the financial health and economic performance of an agribusiness firm. It is calculated as:

Profit ratio=(Net income)/(Total revenue) (3)

The benefit-cost ratio (BCR) assesses an enterprise's financial attractiveness, strength and viability, and monetary benefit. It assesses how successful or promising a firm is. A BCR value greater than one is an indicator that the firm is profitable and economically performing well. It is estimated as total revenue divided by the total cost.

Benefit cost ratio=(Total revenue)/(Total cost) (4)

The operating ratio calculates the proportion of variable costs in total revenue generated by the rabbit farm. A low operating ratio indicates a high profit and vice-versa.

Operating ratio =(Total varibale cost)/(Total revenue) (5)

Return on capital invested measures the return on a unit currency; that is, the percentage an investor made by investing one dollar. It is estimated by dividing net income by the total cost.

Return on capital invested=(Net income)/(Total cost) (6)

Tobit regression model

Tobit regression is a predictive model that estimates the linear relationship between a non-negative dependent variable and a set of explanatory variables. It is a censored regression model in which the dependent variable can be censored either left or right (also known as a lower or an upper limit, and below or above, respectively). The model is highly stable and reliable and can be used for semi-continuous dependent variables. The Tobit model was used to investigate the factors influencing the profitability of rabbit production. The choice of selecting a Tobit model and censoring it from below was made due to the nature and distribution of the data. The model was explicitly stated as:

$$y_I = \begin{cases} 0 \text{ if } y_I^* \leq 0, \\ y^* \text{ if } y_I^* > 0 \end{cases} \quad (7)$$

Where y_i is the observed variable (profit ratio of a rabbit farm), and y_i^* is the latent variable explained by:

$$y_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \varepsilon \quad (8)$$

Table 1: Description of independent variables (these data refer to 150 fattened rabbits per year).

	Variables	Description	Mean	Unit of measurement	Expected sign
X_1	Mortality	Number of dead rabbits	41.1	Number	Negative
X_2	Disease outbreak	Measures in cost incurred in treating sick rabbits	17 000	Naira	Negative
X_3	Labour availability	This is the total number of labour units in a rabbit farm	4.4	Number of people	Positive
X_4	Share of family labour	This is the share of family labour in the total labour units used in rabbit production	70.5	Percentage	Positive
X_5	Access to extension	This is access to agricultural extension services that educate the farmers on rabbit production	1.8	Number of contacts	Positive
X_6	Membership of association	Rabbit farmers belong to a social association	0.3	Dummy: Yes=1, No=0	Positive
X_7	Experience	Rabbit rearing experience	9.5	Years	Positive
X_8	Education	Educational qualification	8.9	Years	Positive
X_9	Access to credit	Amount of credit borrowed	120 091	Naira	Positive
X_{10}	Stock size	The number of stocks available on the farm i.e., buck and doe for breeding	28.5	Number	Positive
X_{11}	Access to market	Distance covered from the farm to the market	8.6	Kilometres	Positive or negative
X_{12}	Cost of feeding	Amount in naira spent on feeding rabbit	101 301	Naira	Negative

Where β_0 is the constant, $\beta_{1\text{-}11}$ are the coefficients of independent variables, $X_{1\text{-}11}$ (X_1=mortality, X_2=disease outbreak, X_3=labour availability, X_4=share of family labour, X_5=access to extension, X_6=membership of association, X_7=experience, X_8=education, X_9=access to credit, X_{10}=stock size, X_{11}=access to market, X_{12}=cost of feeding) are independent variables, and e is a stochastic error term which is assumed to be homoscedastic and normally distributed. Table 1 describes the independent variables included in the model.

Garret ranking

Garret ranking technique by Garret and Woodworth (1969) was used to rank the barriers faced by rabbit farmers in their production which affect their profitability level. The farmers were presented with constraints affecting them and were asked to rank them based on their perception. Their ranking was converted into a score using the Garret ranking formula, expressed as:

$$\text{Percentage Score}=[100(R_{ij}-0.5)]/N_j$$

Where R_{ij} is the rank of i^{th} constraint by j^{th} individual; N_j is the number of constraints ranked by j^{th} individual.

RESULTS AND DISCUSSION

Rabbit production systems and management practices employed by farmers

Understanding the breeds of rabbits, mating ratio, kindling rate, management system types and types of housing in small-scale rabbit production is important because it determines the sustainability and profitability of rabbit farms. The breeds of rabbit kept, mating ratio, kindling rate, types of management system and housing types involved in rabbit production are presented in Table 2.

Table 2: Rabbit production systems and management practices.

Variables	Categories	Frequency	Percentage
Breeds of rabbits kept	Dutch	62	38.8
	New Zealand	60	37.5
	Chinchilla	26	16.3
	Californian white	12	7.5
Mating ratio	1 buck to 1-4 doe	32	20
Mean=6.1	1 buck to 5-8 doe	112	70
	1 buck to 9-12 doe	16	10
Kindling rate	3-6	70	43.8
Mean=7	7-10	90	56.3
Type of management system	Intensive	140	87.5
	Semi-intensive	20	12.5
Type of housing	Cages	128	80
	Hutches	26	16.3
	Both (cages and hutches)	6	3.8

Source: Field survey data, 2021.

Regarding the breeds of rabbit kept by the farmers, a larger proportion (38.8%) kept Dutch rabbit, followed by New Zealand (37.5%), Chinchilla (16.3%) and California white (7.5%). This implies that the common rabbits kept by the farmers in the study area were Dutch, New Zealand, Chinchilla and California white rabbits. This indicates that the farmers had access to exotic breeds, which are highly prolific and good for meat production, and that the cost of purchasing them was within a good price range. This would increase rabbit production and economic performance among farmers. The respondents indicated that these rabbit breeds are among the best because they adapt to the environment, have high productivity, rapid fertility, high growth rate, and a big impact on net return from the enterprise.

Regarding the mating ratio, which refers to the number of females that are served by one male, the majority (70%) of the farmers served one buck to 5-8 does. Twenty per cent of the rabbit farmers served 1-4 does to one buck, and ten per cent served between 9 and 12 does to a buck. On average, the rabbit farmers had 1:6 buck to doe on their farm. This means that the rabbit farmers mated one buck (up to one year of age) to six does in a week, which is good practice, as it improves rabbit mating success. The majority of rabbit farmers (56.3%) recorded a kindling rate (number of kits per birth by a doe) of between seven and ten, while 43.8 per cent of them recorded between three and six. They had an average kindling rate of seven per birth. This suggests a high degree of prolificity in rabbit production, compared to other livestock, which gave a lower average. This supports Onifade *et al.* (1999), who reported that rabbits had an average of seven kits per kindling.

The majority of rabbit farmers (87.5%) used an intensive rabbit production system in which rabbits were given complete and adequate care. A few (12.5%) of them practised a semi-intensive rabbit production system. The high level of intensive production would enhance productivity and profitability. This supports Khatun *et al.* (2012), who found that rabbits grown intensively are good and increase the profitability of the farmers. This is because rabbits require a suitable environment for excellent production. The majority (80%) of the farmers kept their rabbits in cages; 16.3 per cent housed their rabbits in hutches, and the remaining 3.8 per cent used both cages and hutches. This indicates that cages were widely used to house rabbits among the farmers. This could be due to the ease of management of rabbits housed in a cage system compared to hutches.

Common diseases affecting the herd and mortality rate

Table 3 shows the most common diseases affecting rabbit production and mortality records as a result of diseases, the environment and mismanagement. Mange infestation affected more than half of the rabbit farms, indicating that it is a major disease affecting rabbit production. This is followed by mastitis (51.3%), coccidiosis (38.8%), pneumonia (35.6%) and pasteurellosis (23.1%). This corroborates El-Ashram *et al.* (2020) in that mange infestation, coccidiosis,

Table 3: Common diseases affecting the herd and mortality rate.

Disease	Frequency	Percentage
Pasteurellosis*	37	23.1
Coccidiosis*	62	38.8
Mange*	123	76.9
Pneumonia*	57	35.6
Mastitis*	82	51.3
Mortality rate (%)		
≤10	26	16.3
11-20	45	28.1
21-30	83	51.9
31-40	2	1.3
>40	4	2.5

NB: *Multiple choice allowed. Source: Field survey data, 2021.

pneumonia and mastitis affected the rabbit herd. More than half of the rabbit farms recorded a mortality rate of between 21% and 30%. They registered an average mortality rate of 27.6%, which was mainly due to disease outbreak. This means that roughly three out of ten rabbits died before reaching marketable size. This is an indication that mortality is a serious concern among this group of farmers, which is in line with El-Ashram *et al.* (2020) and Rosell and de la Fuente (2016).

It is worth noting that a larger proportion of this mortality rate was recorded for newborn kits and during the preweaning stage (first month). This is in line with the findings of El-Ashram *et al.* (2020), who reported a high mortality rate of 77.6% for newborn kits, 67.1% during preweaning, and 31.9% during post-weaning in Egypt. In the same vein, Ahmed *et al.* (1998) and Tameem *et al.* (2012) also reported a 49.1 to 62.1% mortality rate in Egypt. However, the mortality rate recorded among Nigerian and Egyptian rabbit farmers was higher than that of Czech rabbit farmers, with a 13.5% mortality rate of kits until weaning, as reported by Krupová *et al.* (2020). This is an indication that the developing countries are faced with a higher mortality rate than developed nations. The differences in this mortality rate could be due to diseases, harsh environmental conditions and poor management affecting rabbits, especially young kits in pre- and post-weaning (Mohammed *et al.*, 2012; Rosell and de la Fuente, 2016; El-Ashram *et al.*, 2020).

Economic performance (Profitability) of rabbit production

The result of the profitability analysis of rabbit production as a proxy for economic performance is presented in Table 4. The revenue (returns from the investments in rabbit production) from the sales was ₦1 065 800 (USD 2575.4) per 150 herd. The total cost of production was ₦401 826 (USD 971), out of which the variable costs (₦389 810) had the highest share of the production cost (97%) while the fixed cost (₦12 016) accounted for just three per cent. This supports Cartuche *et al.* (2014), who reported a higher share of variable costs in rabbit production. From the variable costs, the cost of weaners had the highest share (41.6%), followed by the cost of feeding (25.2%). This supports the opinion of Martínez-Paredes *et al.* (2022) that feeding costs account for a substantial part of the cost of rabbit production. The share of feeding cost in rabbit production cost reported in the current study (Nigeria) was lower than the cost of feeding rabbit reported in developed countries such as France (55 to 60%) and Spain (45%) (Coutelet *et al.*, 2015). This could be because some Nigerian rabbit farmers supplement rabbit feed with grass, which they consider cost-free.

Rabbit production had a gross margin of ₦675 990 (USD 1633.5) and a net income of ₦663 974 (USD 1604.4). The profit ratio of the rabbit production enterprise was 0.6, indicating the high profitability of rabbit farming. Also, the enterprise had a BCR of 2.7, which was positive and higher than 1. This further indicates the profitability of the ventures. The rabbit production enterprise had a return on capital invested of 1.7, which indicates that for every unit of currency (₦1 or USD 1) spent on rabbit production, there is a return of ₦1.7 or USD 1.7 to the rabbit production enterprise. The enterprise had an operating ratio of 0.4, which implies that 40 per cent of the gross revenue was

Table 4: Profitability of rabbit production per 150 fattened animals.

Variables	Values (₦)	Value (USD)	Share (%)
Total revenue (TR)	1 065 800	2575.4	
Variable cost			
Cost of weaners	167 000	403.5	41.6
Cost of labour	75 000	181.2	18.7
Cost of feeding	101 301	244.8	25.2
Cost of water	6000	14.5	1.5
Cost of drugs	17 000	41.1	4.2
Cost of transport	23 509	56.8	5.9
Total variable cost (TVC)	389 810	941.9	97
Fixed cost			
Cost of housing/cage	10 581	25.6	2.6
Cost of feeders	709	1.7	0.2
Cost of drinkers	727	1.8	0.2
Total fixed cost (TFC)	12 016	29	3
Total cost (TC)	401 826	971	
Gross margin (GM)=TR–TVC	675 990	1633.5	
Net income (NI)=GM–TFC	663 974	1604.4	
Profit ratio	0.6		
Benefit-cost ratio	2.7		
Return on capital invested (NI/TC)	1.7		
Operating ratio (TVC/TR)	0.4		

Source: Field survey data, 2021.

used as an operating cost. Thus, rabbit production had a low production cost. Akanni and Odubena (2003) reported a similar result, i.e. that rabbit production had a low operating ratio (43%), and the enterprise was profitable. From the results, it can be inferred that rabbit farming was an economical, productive, profitable and viable enterprise, which could be targeted as a means of eradicating poverty in both rural and urban areas.

Factors influencing the profitability (economic performance) of rabbit production

The results of the Tobit regression model used to ascertain the factors influencing rabbit production profitability among farmers are presented in Table 5. The significant factors influencing rabbit production profitability were mortality, disease outbreak, labour availability, share of family labour, membership of the association, rearing experience, education qualification, stock size and cost of feeding.

The coefficient of mortality had a negative influence on rabbit production profitability ($P<0.01$). This implies that as mortality increases, the profitability of rabbit production becomes reduced. As a result, mortality is a barrier to the profitability of a rabbit production venture. The death recorded on the farm lowers the revenue generated on the farm, which consequently leads to a loss in the agribusiness enterprise. Thus, high mortality can result in rabbit business enterprise failure (Abubakar and Bello, 2020).

The coefficient of disease outbreak was also negative and significant in relation to the profitability of rabbit production ($P<0.05$). This indicates that an increase in disease outbreaks in rabbit production will reduce the profitability of rabbit production. This means that the lower the frequency of the disease outbreak in production, the higher the profitability of rabbit production. This further means that disease outbreaks often lead to reduced productivity and consequently affect profitability. Chah *et al.* (2018) and Taiwo *et al.* (1999) reported that disease outbreaks in rabbits, such as mange, caused a great loss in the rabbit production enterprise.

The coefficient of labour availability had a positive effect on rabbit production profitability ($P<0.05$). This indicates that availability of the workforce needed is required to increase profitability of rabbit production. This is because availability of labour, especially skilled labour, will improve rabbit production management and consequently enhance productivity, which is necessary to enhance profitability. Thus, rabbit farmers with the labour needed will have a higher profitability than those with no labour availability. In the same vein, the coefficient of share of family labour to total labour units had positive influence on rabbit production profitability ($P<0.05$). This implies that family labour plays an important role in rabbit production and profitability. This is because labour is an important factor of production and family workers are considered unpaid labour in Nigeria; thus, operating on the farm free of charge (Falola *et al.*, 2022a).

The coefficient of membership in an association also had a positive influence on rabbit production profitability ($P<0.05$). This implies that being a member of an association increases the profitability of rabbit production. Thus, rabbit farmers who are members of the association had a higher profitability than those who are non-members of the association. This could be due to several advantages of being a member of an association, such as getting credit and relevant information, and enjoying economies of scale (Akanbi *et al.*, 2020; Falola *et al.*, 2022b).

The coefficient of rabbit rearing experience had a positive effect in relation to rabbit production profitability ($P<0.1$). This indicates that the profitability of rabbit production rises as the year spent in the enterprise increase. Years of farming experience determine farmers' knowledge about the business, adoption of innovation, and influence farmers' decision-making positively (Akanbi *et al.*, 2020). Therefore, rabbit farmers with greater farming experience will have a higher profitability in their business.

The coefficient of education had a positive influence on rabbit production profitability among farmers ($P<0.01$). This indicates that an increase in educational level will result in an increase in the profitability of rabbit production. Thus, education was an enhancing factor in the profitability of rabbit production among the farmers. This is because education paves the way to efficient information on better production methods, which consequently increases the profitability of the enterprise. Aminu *et al.* (2020) also found that education influenced income from rabbit production positively.

The stock size was positively related to rabbit production profitability among the rabbit farmers ($P<0.05$). This implies that the profitability of rabbit production increases along with stock size. Therefore, rabbit stock size was an enhancing

Table 5: Factors influencing the profitability of rabbit production.

	Coefficient	Standard error	T	*P*-value>t
Mortality	–0.2230083[a]	0.0425002	–5.25	0.000
Disease outbreak	-8.59×10^{-06} [b]	3.48×10^{-06}	–2.47	0.015
Labour availability	0.0178203[b]	0.0089971	1.98	0.049
Share of family labour	0.0527388[b]	0.0211802	2.49	0.014
Access to extension services	0.0277375	0.0555270	0.50	0.618
Membership of association	0.1128219[b]	0.0459746	2.45	0.015
Rearing experience	0.0208502[c]	0.0115213	1.81	0.072
Education qualification	0.0775528[a]	0.0263394	2.94	0.004
Access to credit	-4.10×10^{-08}	2.08×10^{-07}	–0.20	0.844
Stock size	0.0008625[b]	0.0003339	2.58	0.011
Access to market	0.0183392	0.0432349	0.42	0.672
Cost of feeding	-3.05×10^{-06} [a]	1.05×10^{-06}	–2.90	0.004
Constant	0.0545724	0.1264314	0.43	0.667
Sigma	0.2074828	0.0121932		
Pseudo R^2=0.7539				
Likeihood ratio $chi^2(11)$=76.25				
Prob>chi^2=0.0000				
Log likelihood=11.1061				

[a]$P<0.01$, [b]$P<0.05$, [c]$P<0.1$.

factor for the profitability of rabbit production. This is because stock size determines the number of kits produced in the rabbit production enterprise. The kits are raised into matured rabbits ready for sale, and their sales will increase the rabbit enterprise's revenue and will, in turn, increase its profitability.

The cost of feeding rabbits influenced rabbit production profitability negatively ($P<0.01$). This is not surprising, as the cost of feeding is an important outlay in rabbit rearing (Cartuche *et al.*, 2014; Coutelet *et al.*, 2015). Therefore, an increase in the cost of feeding rabbits will increase the cost incurred in rabbit farms and consequently reduce the profitability of the enterprise.

Barriers to profitable rabbit production

The constraints faced in the rabbit production enterprise are presented in Table 6. The Garret ranking indicated that disease and mortality ranked first and second among the barriers encountered by rabbit farmers, respectively. Disease results in high mortality in rabbit production (Rosell and de la Fuente, 2016). This consequently resulted in low revenue generated and profitability of the rabbit production enterprise. El-Ashram *et al.* (2020) and Taiwo *et al.* (1999) also found that pest and disease greatly affected rabbit production. Poor financial assistance (credit) was the third most severe barrier to rabbit farming. Most rabbit farmers were unable to access credit, which could be the reason for their small-scale production level. Credit facilities increase the capital needed to expand agribusiness enterprises (Falola *et al.*, 2022b).

Lack of government and research institute support was ranked fourth among the barriers faced in rabbit production. Rabbit farmers complain about not receiving government and research institution support like other agricultural enterprises. Furthermore, poor extension services were also a major constraint on rabbit production. This could contribute to the high mortality and disease outbreaks experienced on the farm. This is because extension services would have served as a means of relating modern management information to farmers and linking rabbit farmers to research institutes.

Table 6: Barriers to profitable rabbit production.

s/n	Factors	Garret's score for each rank											Total score	Mean	Rank
		1	2	3	4	5	6	7	8	9	10	11			
1	Disease	6142	2664	195	240	165	250	765	164	315	84	17	11001	68.8	1
2	High mortality rate	3071	1008	325	840	165	100	90	2911	245	112	17	8884	55.5	2
3	Poor access to credit	249	1224	4875	300	330	300	90	123	560	672	51	8774	54.8	3
4	Lack of government and research institutes support	249	2376	130	2580	165	850	135	1886	70	140	51	8632	54	4
5	Poor extension services	1992	504	1105	2100	330	150	45	697	1085	84	272	8364	52.3	5
6	Climate change	166	144	195	120	3135	2050	1575	123	105	168	102	7883	49.3	6
7	High cost of modern housing	166	144	130	960	165	3700	2025	82	140	168	68	7748	48.4	7
8	High cost of feeding	249	144	130	180	3905	350	2115	123	175	140	204	7715	48.2	8
9	Marketing	415	3024	195	120	220	150	180	287	1330	1428	17	7366	46	9
10	Pilfering	249	216	2145	180	110	0	45	123	2100	476	595	6239	39	10
11	High cost of labour	332	72	975	1980	110	100	135	82	35	1008	1037	5866	36.7	11

Climate change also affected rabbit production enterprises, as some farmers complained of unfavourable weather conditions. The cost of modern housing, which could have reduced the effect of harsh weather conditions, is high. Farmers could not afford to construct modern houses for the rabbits. This was linked to their inability to access credit facilities and get government support. In addition, the high cost of feeding rabbits was identified as a barrier to rabbit production, which is consistent with Cherwon *et al.* (2020). In descending order, marketing, pilfering and the high cost of labour were the least important barriers to rabbit production enterprise.

CONCLUSION

This study examined the economic performance of rabbit production to serve as empirical evidence on the profitability of rabbit production, which is needed to enhance participation in the enterprise and increase animal source protein, and consequently reduce malnutrition and poverty. The study shows that rabbit production was productive, viable and profitable with a high profit ratio, return on capital invested and BCR. In addition, the rabbit farmers spent a small percentage of the gross income to run the business effectively. Thus, rabbit production could serve as an excellent means of policy intervention towards achieving food and nutrition security and zero poverty, which are at the frontline of the United Nations' Sustainable Development Goals. The factors that enhanced rabbit production profitability are education, stock size, labour availability, membership of an association and rearing experience. In contrast, disease outbreaks, mortality and feeding costs are deterrents to rabbit production profitability. Furthermore, rabbit farmers' major barriers are disease, high mortality rate, poor credit facilities, lack of support from government and research institutes and poor extension services.

This study suggests that rabbit farmers should be supported by the government, financial institutions and research institutions. This could be through the provision of credits and subsidising production inputs such as high-quality rabbit breeds, stronger and safer housing, biosecurity, feeds and vaccines against disease to maximise profits. This would encourage more participation in rabbit production, which is a good source of white meat and consequently increases the protein availability needed to solve the problem of malnutrition. There is a need for more extension agents who will train the rabbit farmers on disease control, vaccination and proper management.

Author contribution: Mukaila R.: conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – original draft and writing – review & editing.

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APPENDIX

Appendix 1: Result of percentage position and Garret table scores.

Rank	Percentage		Garret score/value
1	100(1–0.5)/11	4.6	83
2	100(2–0.5)/11	13.6	72
3	100(3–0.5)/11	22.7	65
4	100(4–0.5)/11	31.8	60
5	100(5–0.5)/11	40.9	55
6	100(6–0.5)/11	50	50
7	100(7–0.5)/11	59.1	45
8	100(8–0.5)/11	68.2	41
9	100(9–0.5)/11	77.3	35
10	100(10–0.5)/11	86.4	28
11	100(11–0.5)/11	95.5	17

Appendix 2: Frequency distribution of barriers to rabbit production.

		Frequency of rank by the rabbit farmers										
s/n	Factors	1	2	3	4	5	6	7	8	9	10	11
1	Disease	74	37	3	4	3	5	17	4	9	3	1
2	High mortality rate	37	14	5	14	3	2	2	71	7	4	1
3	Poor access to credit	3	17	75	5	6	6	2	3	16	24	3
4	Lack of government and research institutes support	3	33	2	43	3	17	3	46	2	5	3
5	Poor extension services	24	7	17	35	6	3	1	17	31	3	16
6	Climate change	2	2	3	2	57	41	35	3	3	6	6
7	High cost of modern housing	2	2	2	16	3	74	45	2	4	6	4
8	High cost of feeding	3	2	2	3	71	7	47	3	5	5	12
9	Marketing	5	42	3	2	4	3	4	7	38	51	1
10	Pilfering	3	3	33	3	2	0	1	3	60	17	35
11	High cost of labour	4	1	15	33	2	2	3	2	1	36	61