

RESEARCH NOTE

Does Pig Production in Arunachal Pradesh Exhibit Efficiency and Profitability? An Empirical Analysis of Its Determinants and Socio-Economic Factors

Rish Makcha and Devegowda S. R.¹

ABSTRACT

Pig farming plays an important role in rural livelihoods in Arunachal Pradesh, and pork is an important component of the local food system. Despite its importance, the efficiency and profitability of pig farming remain inadequately examined. This study has evaluated the socio-economic characteristics, technical efficiency, profitability, and constraints facing pig farmers using primary data from 450 respondents. Stochastic Frontier Analysis (SFA), cost-returns analysis, and Garrett's ranking technique were used. The results indicated a mean technical efficiency of 0.82, suggesting that farmers operate close to the production frontier with scope for improvement. Herd size, feed and labour significantly influenced output, while education and farming experience reduced inefficiency. The economic efficiency analysis demonstrated that piggery is highly profitable with a benefit-cost ratio of 1.63. The constraints identified in piggery include higher feed costs, poor veterinary facilities, and insufficient access to credit facilities. The study highlights the need for improved input support, extension services and institutional credit to enhance productivity and sustainability.

Keywords: Pig Farming, Technical Efficiency, Determinants, Profitability, Constraints

JEL Code: Q12, D24, O13, Q14, R11

I

INTRODUCTION

Pig farming plays a vital role in rural economies and contributes to the global supply of protein for various communities. Due to their high feed conversion capacity, pigs are an effective livestock choice, efficiently transforming various feeds into valuable meat (Gaillard *et al.*, 2020). Several aspects that influence the profitability of pig farming such as feed costs, animal health, management techniques, and market availability. Furthermore, variables such as herd size and production technologies play an important role in determining returns in pig farming (Obayelu *et al.*, 2017). The global demand for pork is stable because global pig meat production has been estimated at around 124.5 million metric tons (MT) for the year 2023. Pig farming is a developing sector, mainly driven by demand in Asia, particularly China, which accounts for 47% of the world's total pig production (FAO, 2024).

Pig farming in India holds great significance in the agricultural sector, particularly within rural and tribal areas. The pig population stands at around 11.1 million, with the bulk of this farming concentrated in the North Eastern states (GoI, 2013). In Assam, Nagaland, and Arunachal Pradesh, pig farming is reportedly high due

¹Department of Agricultural Economics, Rajiv Gandhi University (A Central University), Doimukh, Arunachal Pradesh-791112

to strong cultural preferences for pork and high demand for pig-related products (Chauhan et al., 2016). Most pig farmers come from lower socio-economic backgrounds and often use traditional methods for raising pigs. The production systems in India vary from small backyard farms to larger commercial operations. Generally, pig farmers employ low-input systems, making use of readily available feed such as kitchen scraps and agricultural waste (Das et al., 2005). Women play a critical role in pig farming, managing tasks such as feeding, breeding and health care, thus making substantial contributions to the family's overall income (Singh et al., 2019).

The pig farming sector in Arunachal Pradesh remains underexplored, leaving critical challenges that hinder productivity and profitability unaddressed. Despite the state's vast potential for piggery production, driven by the predominantly non-vegetarian food habits and high demand for pork, the local supply falls short, necessitating imports from Assam. This supply gap underscored the need to understand pig farming in Arunachal Pradesh. The objectives of this study are to analyse the socio-economic characteristics of pig farmers in Arunachal Pradesh, investigate the determinants affecting the technical efficiency of pig production, profitability and identify the constraints faced by the pig farmers.

II

METHODOLOGY

2.1 Study Area, Sampling Techniques and Data Collection

The research was conducted across three districts of Arunachal Pradesh, specifically Papum Pare, Lower Subansiri and Namsai, to gain comprehensive insights into the study (Table 1). The purposive sampling method was used to select the districts, while the villages and 450 pig farmers were chosen using simple random sampling without replacement.

TABLE 1. DISTRIBUTION OF SAMPLE RESPONDENTS ACROSS DISTRICTS AND VILLAGES

Papum pare		Lower Subansiri		Namsai	
Village name	Pig farmers (No.)	Village name	Pig farmers (No.)	Village name	Pig farmers (No.)
Midpu	6	Hong	13	Namsai	14
Dobum	8	Hari	9	Chongkham	12
Kharsingsa	14	Bulla	8	Chowkham	10
Kimin	11	Hija	13	Lathao	9
Mengio	8	Dutta	8	Piyong	4
Nyorch	6	Mudang Tage	6	Manmow	8
Tarajuli	7	Old Ziro	9	Old Mohong	9
Sonajuli	8	Hapoli	8	Kumari	8
Hollongi	8	Joram	9	Helam	9

Contd...

Balijan	9	Pistana	8	Embong	8
Tengabari	8	Deed	6	Lekang	10
Lenka	8	Siiro	12	Mahadevpur	9
Sagalee	11	Joram	8	Jaipur	7
Leporiang	9	Tallo	9	Jona-I	6
Gumto	8	Kardo	6	Pankhao	5
Mani	6	Reru	8	Alubari	7
Chiputa	6	Rubdi Amban	4	Deobeel	6
Nirjuli village	9	Kiile Pakho	6	Wengko	9
Total	150	Total	150	Total	150

Primary data were collected from pig farmers using a structured survey schedule exclusively made for this study by face-to-face interviews. The study data for this research were collected from pig farmers for the year 2023-2024.

2.2 Descriptive Statistics

The socio-economic status of the respondents was assessed through descriptive statistics involving the use of frequency distribution, mean and percentages. The socio-economic factors used for analysis were family size, age, gender, landholding, farming experience, literacy level and annual income.

2.3 The Stochastic Frontier Analysis (SFA)

The stochastic frontier analysis was used to specify the production of the pig farms. The empirical stochastic frontier model for this study was given as:

$$Y_{ij} = \beta_0 + \beta_1 \ln X_{1ij} + \beta_2 \ln X_{2ij} + \beta_3 \ln X_{3ij} + \beta_4 \ln X_{4ij} + V_{ij} - U_{ij}$$

Where,

Y_{ij} = Pig weight (kg) for the i^{th} farmer in the j^{th} location

X_{1ij} = Herd size (number of pigs)

X_{2ij} = Labour (man-days)

X_{3ij} = Cost of medication (₹)

X_{4ij} = Quantity of feed (kg)

$V_{ij} \sim N(0, \sigma_v^2)$ = Random error

$U_{ij} \sim |N(0, \sigma_u^2)|$ = Non-negative technical inefficiency term.

2.4 Technical Efficiency Estimation

The technical efficiency of pig production for the i^{th} farmer is determined as:

$$\text{Technical Efficiency} = \frac{Y_i}{Y_i^*}$$

$$\text{Technical Efficiency} = \frac{f(X_i, \beta) \exp(V_i - U_i)}{f(X_i; \beta) \exp(V_i)}$$

Variance Parameters

$$\sigma^2 = \sigma_V^2 + \sigma_U^2 \quad \text{and} \quad \gamma = \frac{\sigma_U^2}{\sigma^2}$$

Where,

Y_i^* = potential output

Y_i = actual output

σ^2, β, γ are unknown parameters

Technical efficiency ranges between 0 and 1, where values closer to 1 indicate higher efficiency and lower inefficiency.

The inefficiency model is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4$$

Where

U_i = Technical inefficiency of the i^{th} farmer.

Z_1 = Household size.

Z_2 = Farmer's education (years).

Z_3 = Farmer's age (years).

Z_4 = Farmer's experience.

Where $\delta_1, \delta_2, \delta_3$ and δ_4 are unknown parameters to be estimated.

2.5 Profitability and Cost of Pig Production

Average Cost and Returns: To examine the profitability of pig farming in the study area, the following variables were considered:

Cost of Pig Stocks (₹): The total expenses on purchasing pig stock during the initial phase by the farmers were measured in rupees per kg of pig weight.

The Total Cost incurred in Pig Farming (₹): The total input costs, including feed, medicine, transportation and other costs, used by farmers for pig rearing.

Total Fixed Cost (₹): The amount of money invested in making the pig shed and maintenance expenses, with pig shed cost treated as an annualised fixed cost.

Cost of Labour (₹): The cost includes both hired and family labour involved in pig-rearing activities.

Total cost was calculated as the sum of the variable cost (VC) and fixed cost (FC)

Total Cost was given as (Total variable cost + Total fixed cost)

Net revenue (NR) was calculated by total revenue (TR) less the total cost (TC);

NR was given as (Total revenue – Total Cost)

Gross margin (GM) was calculated as (Total revenue – Total variable cost or Direct cost)

$$\text{Return on Investment (ROI)} = \frac{\text{Net Revenue}}{\text{Total Cost}}$$

$$\text{Benefit-Cost Ratio (BCR)} = \frac{\text{Total Revenue}}{\text{Total Cost}}$$

2.6 Garrett's Ranking Technique

Garrett's ranking technique was adopted to identify the constraints faced by pig farmers in the selected districts of Arunachal Pradesh. The respondents were asked to rank fifteen sets of constraints that were related to pig production faced by pig farmers.

The order of merit that was given by the respondents was converted into ranks using the following formula:

$$\text{Percentage Position} = \frac{100(R_{ij} - 0.50)}{N_j}$$

Where

R_{ij} = The rank marked for the i^{th} constraint by the j^{th} farmer.

N_j = The number of constraints ranked by the j^{th} farmer.

Garrett's table was used to convert each rank's percentage position into points. Individual respondent scores were totalled for each constraint, and the sum was then divided by the total number of respondents. Accordingly, each constraint's mean score was ranked by placing them in descending order (Garrett and Woodworth, 1969).

III

RESULTS AND DISCUSSION

3.1 Socio-economic Profile of Pig Farmers

Socio-economic characteristics of the sampled pig farmers are presented in Table 2. The study data showed that out of 450 respondents, 180 farmers (40%) were

under the young (ages <35) category, 150 farmers (33.3%) were under the middle (ages 35-50) category and 120 farmers (26.7%) were under the old (age above 50) category. The study showed that most farmers were under the young age category, suggesting that the group under study was mostly young. Younger farmers are generally more adaptable to the labour-intensive nature of pig farming (Kumar *et al.*, 2007; Ume *et al.*, 2020). The findings indicated that 57.8% of the farmers were women and 42.2% of the farmers were men in the study area. This suggests that in the research region, women were more active in the production of pigs than men. Women also helped with minor agricultural tasks like cleaning the pig pen and delivering feed and water (Fualefac *et al.*, 2014; Aminu *et al.*, 2017; Omoregie and Osabuohien, 2021). Contrasting findings have been reported by Ahmed *et al.* (2017). A total of 110 small (24.5%), 140 medium (31.1%) and 200 large (44.4%) families were found in the study area. The majority of the pig farmers in Arunachal Pradesh are in large households. The small family size category had the least representation, with only 24.5% of the total pig farmers. Larger family units are more involved in pig farming, possibly due to the labour efficiency and resources required for pig farming getting easier in families with more members (Patra *et al.*, 2014; Singh *et al.*, 2019). The findings indicated that among the 450 pig farmers surveyed, 70 respondents (12.5%) possessed no formal education, 130 (28.9%) pig farmers had completed primary education, 185 (41.1%) had achieved secondary education and 65 (14.4%) had obtained collegiate education. The education level distribution of pig farmers in the study area showed a trend towards higher educational groups, mainly primary and secondary education. These results reflected the positive effect of higher education on pig farmers, influencing their understanding of practices and productivity of pig farming (Singh *et al.*, 2019). Contrasting results with low literacy among pig farmers were reported in the research of Sivakumar *et al.* (2006). The study showed that out of 450 respondents, 260 pig farmers (57.8%) belonged to the marginal category with land holdings of less than 1 hectare, 90 respondents (20%) in the small group had a land holding of 1 ha to 1.99 ha, 70 respondents (15.6%) under the semi-medium had 2 ha to 3.99 ha and 30 respondents (6.6%) under the medium group had a land holding of 4 ha to 9.99 ha. The studies revealed that most farmers had land holdings under the marginal group in pig production (Kumar *et al.*, 2007; Tudu *et al.*, 2015). Data showed the distribution of the respondents according to their annual income, with high annual income pig farmers occupying 38.9% with income above ₹ 1 lakh, the medium annual income category occupying 33.3% with income of ₹ 50,000-100000 and the low annual income category occupying 27.8% with income of less than ₹ 50,000. The study revealed that 100 (22.2%) pig farmers belonged to the low experience category of fewer than 8 years. In contrast, the majority of 180 (40%) pig farmers had experience ranging from 8 to 15 years under the medium category, and 170 (37.8%) of the pig farmers were doing pig farming for 15 years or more.

TABLE 2. SOCIO-ECONOMIC CHARACTERISTICS OF PIG FARMERS OF ARUNACHAL PRADESH

Grouping variable	Parameter	Respondents (N=450)
Age	<35	180 (40)
	35-50	150 (33.3)
	>50	120 (26.7)
Sex	Male	190 (42.2)
	Female	260 (57.8)
Marital status	Married	400 (88.9)
	Unmarried	50 (11.1)
Family size	Small-sized family (up to 4 members)	110 (24.5)
	Medium-sized family (5-8 members)	140 (31.1)
	Large-sized family (>8 members)	200 (44.4)
Education level	Illiterate (No education)	70 (15.6)
	Primary level (up to 7 th)	130 (28.9)
	Secondary level (8 th - 12 th)	185 (41.1)
	College and above (Grad & PG)	65 (14.4)
Landholding	Less than 0.50 ha	110 (24.5)
	0.50 ha-1 ha	150 (33.3)
	1.00 ha-2 ha	90 (20)
	2 ha-4 ha	70 (15.6)
	4 ha-10 ha	30 (6.6)
	10 ha-above	0 (0)
Annual Income	Low annual income	125 (27.8)
	Medium annual income	150 (33.3)
	High annual income	175 (38.9)
Farming experience	Low	100 (22.2)
	Medium	180 (40)
	High	170 (37.8)

Source: Authors' estimate based on primary data

Figures in parentheses indicate the percentage of total respondents.

3.2 Integrated Analysis of Production Efficiency and Its Determinants

The empirical assessment of Arunachal Pradesh pig production systems revealed significant input elasticities and efficiency determinants. Production function estimates showed statistically significant positive coefficients for herd size ($\beta_1 = 0.080$; $p < 0.05$), indicating that a 1% increase in herd size leads to a 0.08% increase in output. Feed quantity ($\beta_4 = 0.435$; $p < 0.01$), confirming concentrates' productivity impact, and labour ($\beta_2 = 0.431$; $p < 0.05$), reflecting labour-intensive operations, while medication costs were insignificant. Simultaneously, technical efficiency determinants analysis identified: education ($\delta_2 = -0.177$; $p < 0.01$), farming experience ($\delta_4 = -0.011$; $p < 0.05$), age ($\delta_3 = -0.014$; $p < 0.05$) and household size ($\delta_1 = -0.017$; $p < 0.01$) as significant inefficiency reducers, highlighting human capital's critical role, whereas extension

contacts showed no effect. Model diagnostics confirmed substantial random noise ($\sigma^2 = 0.75$; $p < 0.05$) and technical inefficiency dominance ($\gamma = 0.663$; $p < 0.01$), indicating that 66.3% of the total variance in the composite error term is attributable to inefficiency effects rather than random noise.

TABLE 3. ESTIMATION OF PARAMETERS FOR THE STOCHASTIC PRODUCTION FRONTIER AND INEFFICIENCY MODEL

Variable	Variables	Parameters	Coefficients	t-Ratio
Stochastic Production Frontier	Constant	β_0	5.021	7.456***
	Herd size	β_1	0.08	2.373**
	Labour	β_2	0.431	1.977**
	Medicine cost	β_3	0.068	0.811
	Feed quantity	β_4	0.435	2.879***
Inefficiency Model	Constant	δ_0	0.343	1.861*
	Household size	δ_1	-0.017	-6.081***
	Education	δ_2	-0.177	-4.283***
	Age	δ_3	-0.014	-2.338**
	Farming experience	δ_4	-0.011	-2.069**
	Extension contacts	δ_5	0.016	0.202
	Sigma-squared	σ_2	0.75	1.771**
	Gamma	Γ	0.663	2.724***

***Significant ($p < 0.01$), **Significant ($p < 0.05$), *Significant ($p < 0.1$), NS-insignificant ($p \geq 0.1$)

Source: Authors' estimate based on primary data

Technical efficiency ranged from 0.60 to 0.95, revealing an 18% average output gap, with 72.4% of farmers exceeding 80% efficiency. Farmers at minimum efficiency could increase output by 35% through the adoption of best practices, while mean-efficiency operators could achieve 13% gains, demonstrating scalable productivity

TABLE 4. PERCENTAGE DISTRIBUTION OF RESPONDENTS BY TECHNICAL EFFICIENCY ESTIMATES

Efficiency level	Total respondents
0.60 - 0.69	75 (16.67)
0.70 - 0.79	49 (10.89)
0.80 - 0.89	242 (53.77)
0.90 - 0.99	84 (18.67)
Total	450 (100)
Minimum Efficiency	0.6
Mean Efficiency	0.82
Maximum Efficiency	0.95

Figures in parentheses indicate the percentage of total respondents.

Source: Authors' estimate based on primary data

improvements through optimised input allocation and efficient management of determinant factors (Table 4). The herd size coefficients (0.08%) align with Aminu et

al. (2017), while the feed impact (0.435) confirms Etim et al. (2014) findings. Human capital effects mirror Etim and Udoh (2014), with education reducing inefficiency as in Ogundari (2014). The 18% efficiency gap matches Bravo-Ureta et al. (2007) smallholder range, while Arunachal Pradesh's 35% maximum gain exceeds Binam et al. (2004) and the West African estimate, revealing significant attainable reserves (Kumbhakar and Lovell, 2000).

3.3 Profitability of Pig Production in Arunachal Pradesh

The profitability of pig farming was assessed using the average costs and returns, as detailed in Table 5 for the selected study areas. The variable costs in pig production, which made up 76.54% of the total expenses (₹1,41,200), included costs that varied depending on production levels. Among these expenses, the cost of stocking was the largest component, representing 42.78% of the total variable costs (₹60,400). This expense reflected the initial capital invested in pigs' stock and was crucial to the overall production process. Labour expenses, the second most significant cost component, covered 32.08% of the total variable costs (₹45,300), underscoring the vital role of labour in feeding, cleaning and managing the pigs. The cost of feed, which is essential for the pigs' growth and health, comprised 13.09% (₹18,500) of the variable costs. Other expenses included a medical cost of 4.25% (₹6,000), which ensured the health and well-being of the animals and transportation and other costs, each contributing ₹5,500 (3.90%). These costs demonstrated the significant operational investments required for successful pig production.

TABLE 5. AVERAGE COST AND RETURNS OF PIG PRODUCTION IN ARUNACHAL PRADESH

Variable Cost	Amount (₹)	% TVC
Feed cost	18500 (10.04)	13.09
Labour cost	45300 (24.55)	32.08
Medicine cost	6000 (3.25)	4.25
Cost of stocking	60400 (32.73)	42.78
Transportation cost	5500 (2.98)	3.90
other costs	5500 (2.98)	3.90
Total variable cost (TVC)	141200 (76.54)	
Fixed Cost	Amount (₹)	% TFC
Maintenance cost	6500 (3.52)	15.05
Pig shed cost	36800 (19.94)	84.95
Total fixed cost (TFC)	43320 (23.47)	
Total Cost (TC) = TFC + TVC	184520	
Returns	Amount (₹)	% TR
GM = TR – TVC	158800	52.93
NR = TR – TC	115480	38.49
ROI = NR/TC	0.63	
BCR = TR/TC	1.63	
Total Revenue (TR)	300000	

Figures in parentheses indicate percentages of total costs or returns.

Source: Authors' estimate based on primary data

The fixed costs in pig farming were ₹43,320, covering 23.47% of the overall costs. These costs did not change with the level of production and included the pig shed expenses of ₹36,800 (84.95%) of the fixed costs. The cost of the pig shed represented the investment in the construction of pig sheds, providing adequate shelter and management for the pigs. Maintenance expenses, which covered regular repairs and upkeep, totalled ₹6,500 annually, representing 15.05% of fixed costs.

The pig production activity generated substantial returns, with a total revenue (TR) of ₹3,00,000. After deducting variable costs, the gross margin (GM) stood at ₹1,58,800, which was 52.93% of the total revenue. The net return (NR) amounted to ₹1,15,480, representing 38.49% of the revenue. The profitability of the enterprise was evident from the return on investment (ROI) of 0.63, which indicates a 63% return on investment, while the BCR of 1.63 implies that each rupee invested generates ₹1.63 in total returns. The ratio indicated that the benefit (or return) is 63% greater than the cost, reflecting the economic viability and high returns on investment in pig production in Arunachal Pradesh. Pig farming in India offers profitability, emphasising efficiency, resource optimisation and economic sustainability, contributing to growth and expanding rural livelihoods (Raja *et al.*, 2022).

3.4 Constraints faced by pig farmers in Arunachal Pradesh

Table 6 ranked the constraints faced by pig farmers in Arunachal Pradesh across four categories: Financial, Extension, Input and General. Financial constraints were the most critical, with the high cost of pig feed ranked first (71.45), followed by the lack

TABLE 6. CONSTRAINTS FACED BY PIG FARMERS IN ARUNACHAL PRADESH

Constraint	Constraints in Pig Farming	Score	Rank
Financial constraints	Lack of operating capital and inadequate access to a credit facility	68.73	2
	Higher cost of hired labour	61.88	4
	Higher cost of Pig feed	71.45	1
	Maintenance costs are higher	64.6	3
Extension constraints	Lack of access to extension service	37.04	11
	Lack of knowledge and training in pig rearing	35.68	12
	Inadequate research and extension support	53.21	7
	Inadequate veterinary services	57.48	5
Input constraints	Lack of knowledge of feeding balanced feed	37.4	10
	Preparation/ management of pig feed	52.51	8
General constraints	Lack of an organised marketing facility	33.38	14
	Disposal of piggery wastes	35.43	13
	Seasonal demand	31.98	15
	Diseases and infections	53.54	6
	Lack of quality breed pig	52.45	9

Source: Authors' estimate based on primary data

of operating capital and credit access (68.73). Maintenance costs (64.6) and high labour costs (61.88) also posed challenges. Extension constraints highlighted inadequate veterinary services (57.48) and insufficient knowledge and training (37.4). Input constraints focused on pig feed management (52.51) and knowledge gaps in balanced feeding (37.4). General constraints included diseases (53.54), poor-quality breeds (52.45), waste disposal issues (35.43), lack of marketing facilities (33.38) and seasonal demand (31.98). The high feed costs, veterinary services and extension support were identified as key areas to improve productivity and sustainability in pig farming (Mbuthia et al., 2015).

IV

CONCLUSIONS

The study examined the socio-economic characteristics, technical efficiency, profitability, and constraints of pig farming in Arunachal Pradesh. The findings reveal that pig farming is a viable and profitable livelihood activity, with a mean technical efficiency of 0.82 and a benefit-cost ratio of 1.63. However, significant efficiency gaps and structural constraints persist. Based on the findings, targeted policy interventions are required. Given the high contribution of feed costs to total production costs, there is a need to promote the development of local feed resources and strengthen feed supply systems. Labour and human capital were found to reduce inefficiency, indicating that greater emphasis should be placed on farmer training programmes and skill development initiatives. The prevalence of inadequate veterinary services highlights the need to expand veterinary infrastructure and mobile animal health services in remote areas of Arunachal Pradesh. Improving access to institutional credit helps farmers overcome capital constraints and invest in improved production practices. Strengthening input delivery systems, veterinary infrastructure, and institutional credit access will be critical for enhancing productivity, reducing inefficiency, and ensuring the sustainable growth of pig farming in Arunachal Pradesh.

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REFERENCES

- Ahmed, N., Doley, S., Ahmed, K., & Das, B. B. (2017). Socio-economic status of small-scale pig farmers in rural communities of Tripura. *International Journal of Chemical Studies*, 5(3), 102-104.
- Aminu, F. O., & Akhigbe-Ahonkhah, C. E. (2017). Profitability and technical efficiency of pig production in Nigeria: The case of Ekiti State. *Agriculture Tropica et Subtropica*, 50(1), 27-35.
- Binam, J. N., Sylla, K., Diarra, I., & Nyambi, G. (2003). Factors affecting technical efficiency among coffee farmers in Côte d'Ivoire: Evidence from the Centre West region. *African Development Review*, 15(1), 66-76.

- Bravo-Ureta, B. E., Solís, D., Moreira López, V., Maripani, J., Thiam, A., & Rivas, T. (2007). Technical efficiency in farming: A meta-regression analysis. *Journal of Productivity Analysis*, 27(1), 57–72.
- Das, A., & Bujarbariah, K. M. (2005). Pig for meat production. *Indian Journal of Animal Science*, 75(12), 1448-1452.
- Etim, N. A., & Udoh, E. J. (2014). Identifying sources of efficiency among resource-poor indigenous vegetable farmers in Uyo, Nigeria. *International Journal of Food and Agricultural Economics*, 2(1), 33-39.
- Etim, N. A., Etim, N. N., & Offiong, E. E. (2014). Estimation of efficiency in small-scale pig production. *European International Journal of Science and Technology*, 3(6), 111-118.
- FAO. (2024). *Meat market review: Overview of global market developments in 2023*. FAO. <https://openknowledge.fao.org>
- Fualefac, D. H., Raphae, K. J., Bime, M. J., Ndebi, G., Yemele, F., Zoli, P. A., Manjeli, Y., Tegua, A., & Tchoumboue, J. (2014). Socioeconomic and technical characteristics of pig farming in the urban and peri-urban zone of Dschang-West region of Cameroon. *Discourse Journal of Agriculture and Food Sciences*, 2(1), 11–20.
- Gaillard, C., Brossard, L., & Dourmad, J. Y. (2020). Improvement of feed and nutrient efficiency in pig production through precision feeding. *Animal Feed Science and Technology*, 268, 114611. <https://doi.org/10.1016/j.anifeedsci.2020.114611>
- Garrett, H. E., & Woodworth, R. S. (1969). *Statistics in psychology and education*. Vakils, Feffer and Simons Pvt. Ltd.
- GoI (2013). *Annual report 2012-13*. Ministry of Agriculture, Government of India. https://agritech.tnau.ac.in/fishery/pdf/Annual_Report_12_13.pdf
- Kumar, A., Staal, S. J., Elumalai, K., & Singh, D. K. (2007). The livestock sector in the north-eastern region of India: An appraisal of performance. *Agricultural Economics Research Review*, 20(2), 255-272.
- Kumbhakar, S. C., & Lovell, C. A. K. (2000). *Stochastic Frontier Analysis*. Cambridge University Press. (Online publication June 5, 2012). <https://doi.org/10.1017/CBO9781139174411>
- Mbuthia, J. M., Rewe, T. O., & Kahi, A. K. (2015). Evaluation of pig production practices, constraints and opportunities for improvement in smallholder production systems in Kenya. *Tropical Animal Health and Production*, 47(3), 369-376.
- Obayelu, A. E., Ogunmola, O. O., & Sowande, O. K. (2017). Economic analysis and the determinants of pig production in Ogun State, Nigeria. *Agriculture Tropica et Subtropica*, 50, 61-70.
- Osagie, O., & Osabuohien, J. I. (2021). Problems of pig farming as correlates of socio-economic status among pig farmers in Ovia North East and Ovia South West Local Government Areas of Edo State, Nigeria. *African Journal of Sustainable Agriculture and Development*, 2(4), 1-13.
- Patra, M. K., Begum, S., & Deka, B. (2014). Problems and prospects of traditional pig farming for tribal livelihood in Nagaland. *Indian Research Journal of Extension Education*, 14(4), 6-11.
- Raja, M. B., Selvakumar, K. N., Pandian, A. S. S., Sundaram, S. M., Anbukkani, P., & Jayanthi, R. (2022). Profitability and efficiency of pig production in Tamil Nadu. *Indian Journal of Animal Sciences*, 92(3), 365-369.
- Singh, N. M., Singh, S. B., & Singh, S. K. (2019). Small scale pig farming in Manipur, India: A study on socio-personal and socio-economic status of the small-scale tribal farming community. *International Journal of Current Microbiology and Applied Sciences*, 8(8), 1158-1168.
- Sivakumar, T., Gopi, H., & Senthilkumar, S. (2006). Strategies for enhancing the economic status of pig farmers in Kancheepuram district of Tamil Nadu. *Indian Journal of Animal Research*, 40(1), 42-45.
- Tudu, N. K., Pyne, S. K., Goswami, K. K., Ghosh, N., & Roy, D. C. (2015). Socio-economic status of pig farmers in Nadia District of West Bengal. *International Journal of Bioresource and Environmental Agricultural Sciences*, 1(1), 1-4.
- Ume, I., Onwujiariri, E. B., & Ako, N. (2020). Pig farmers' socioeconomic characteristics as a determinant of pig production and profitability in the tropics. *International Journal of Research*, 7(4), 394-405.