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Profitability and Multi-functionality of Integrated Enterprise Model Cattle Farming in Coastal Region of Bangladesh: A Socio-Economic Analysis

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ABSTRACT

This study aimed to assess the profitability of cattle farming with non-conventional by-product utilization, understand the economic benefits of livestock multi-functionality, and identify challenges in livestock farming in coastal Bangladesh. A quantitative, cross-sectional survey-based research design was employed. The study was conducted in the Khulna, Satkhira, and Bagerhat districts of coastal Bangladesh between November, 2024 and January, 2025. Data were collected from 120 randomly selected cattle farmers across 12 villages through face-to-face interviews using a pre-tested schedule. Data analysis involved descriptive statistics, farm budgeting techniques (Net Farm Income, Management Income), and a Problem Facing Index (PFI) to evaluate constraints. The integration of non-conventional by-products (cow dung stick, vermicompost, biogas) significantly enhanced profitability. Biogas integration yielded the highest Net Farm Income (BDT 316,632.10) and Management Income (BDT 124,132), representing a 47.51% and 76% higher income, respectively, compared to business-as-usual practices (NFI BDT 166,200.85; MI BDT 30,431.75). Farmers strongly perceived livestock's contribution to soil fertility (85% agreement) and food and nutrition (80% agreement). The primary challenges identified were disease occurrence (PFI: 310/360) and high feed prices (PFI: 285/360) in traditional systems, while bad odor (PFI: 260/360) and labor availability (PFI: 250/360) were key issues in integrated models. Multi-functional livestock farming, especially with biogas integration, is a highly profitable enterprise that substantially boosts household income, food security, and environmental sustainability in coastal Bangladesh. It offers a viable pathway for climate change mitigation through the valorization of manure. Policy interventions focused on increasing awareness, providing soft loans for technology adoption, and improving veterinary services are crucial for scaling these benefits.

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Introduction

Livestock is an indispensable component of the agricultural farming system in Bangladesh, with the sector contributing 1.66% to the national Gross Domestic Product (GDP) in the 2015-2016 fiscal years. The importance of livestock extends beyond direct economic outputs of milk, meat, and eggs; it embodies a concept of multi-functionality, providing employment, draft power, and a source of organic manure for crop production. Traditionally, livestock, particularly cattle, serve as a critical support system for the livelihoods of millions of rural poor. Globally, livestock contributes about 40% to the agricultural GDP and is a cornerstone of livelihood for an estimated 1.3 billion people in developing nations (World Bank, 2008, 2009) with a growth rate over 1.27%. In Bangladesh, recent innovations have highlighted the potential of cattle by-products, especially cow dung, as a valuable resource. The use of dung for vermicompost and biogas production presents an opportunity to create alternative income streams, enhance soil fertility, and provide a renewable energy source for rural households. This transition aligns with principles of a circular economy, turning a farm waste product into a valuable asset. Despite the recognized importance of livestock, a significant research gap exists in empirically quantifying the profitability gains from integrating these non-conventional by-product utilization methods into traditional cattle farming systems in coastal areas of Bangladesh. While the multi-functional roles are acknowledged, their specific socio-economic and environmental benefits particularly the potential for climate change mitigation via biogas generation remains under-evaluated. Farmers also face persistent challenges that limit productivity and the adoption of new technologies.

This study builds on existing literature that has explored the multi-functionality of livestock (Moyo and Swanepoel, 2010) and the economics of production systems (Sanpaolo, 2016), but provides specific, empirical data from the vulnerable region like coastal context of Bangladesh. This research, therefore, aims to address the aforementioned gaps. The specific objectives were:

- To assess the profitability of cattle farming via enterprise model after integrating non-conventional by-product utilization in farming systems.
- To understand the economic benefits derived from livestock's multi-functionality.
- To identify the primary challenges and obstacles faced by farmers in livestock farming.

Materials and Methods

Study Area and Sampling

The study was conducted in the coastal region of Bangladesh, encompassing three districts: Khulna, Satkhira, and Bagerhat. These areas were selected purposively due to their significant engagement in cattle farming and their relevance to climate change discourse. From these districts, a total of 12 villages were selected for the survey. A comprehensive list of all households engaged in cattle farming was prepared for each village. Using a simple random sampling technique, 10 farmers were selected from each village, resulting in a total sample size of 120 respondents for the study.

Data Collection

Primary data were gathered through face-to-face interviews with the selected farmers using a pre-tested, semi-structured interview schedule. The schedule was designed to capture detailed information on:

- Socio-economic and demographic characteristics of the farmers.
- Costs and returns associated with cattle rearing, including both business-as-usual (BaU) practices and integrated systems utilizing by-products (biogas, vermicompost, cow-dung stick).
- Farmers' perceptions regarding the multi-functional contributions of livestock.
- Challenges and constraints faced in livestock production.

The interview schedule was pre-tested with non-sample farmers and modified to ensure clarity and relevance. The data collection was performed by the researcher to ensure accuracy and consistency.

Analytical Techniques

The collected data were coded, tabulated, and analyzed using Microsoft Excel and appropriate statistical tools. The following analytical methods were employed:

- **Descriptive Statistics:** Frequencies, percentages, and means were used to summarize the socio-economic characteristics of the sample farmers.
- **Profitability Analysis:** Farm budgeting and cost-return analysis were used to assess profitability. Key indicators were calculated as follows:
    - **Gross Output:** The total value of all products and services from the enterprise, including milk, change in animal inventory, and the value of by-products (manure, biogas, etc.).
    - **Net Farm Income (NFI):** Calculated by subtracting total costs (variable and fixed) from the Gross Output.
    - **Management Income (MI):** Calculated by subtracting the opportunity cost of family labor and operating capital from the Net Farm Income to determine the return to management.
    - **Problem Facing Index (PFI):** To assess the severity of problems faced by cattle farmers, a Problem Facing Index (PFI) was computed. Farmers were asked to indicate the extent of each problem on a four-point Likert scale: "very high" (4), "high" (3), "medium" (2), and "low" (1). The PFI for each problem was then calculated using the following formula:

$$PFI = \sum_{i=1}^{4} (S_i \times N_i)$$

Where:

S_i = Score given to the i-th response (4 for very high, 3 for high, 2 for medium, 1 for low).

N_i = Number of farmers giving the i-th response.

The calculated PFI values allowed for a ranking of the problems from most to least severe.

The index for each problem was computed using the simplified formula:

$$PFI = (P_s \times 3) + (P_m \times 2) + (P_l \times 1) + (P_n \times 0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

P_s = Number of the respondents with severe problem;

P_m = Number of the respondents with moderate problem;

P_l = Number of the respondents with low problem; and

P_n = Number of respondents having no problem.

Results

Socio-economic Profile of Farmers

The majority of cattle farmers (43.33%) were in the most active age group of 30-40 years. The average family size was 5.4 persons, with most households (56.67%) having 2-4 members. In terms of education, 40% of farmers had completed primary education, while 6.67% were illiterate. Agriculture was the primary occupation for the majority (51.67%), while all 120 respondents engaged in livestock farming as a crucial subsidiary occupation.

Financial & Economic Profitability of Integrated Cattle Farming Systems

The integration of non-conventional by-product utilization significantly enhanced the financial performance of cattle farming compared to the business-as-usual (BaU) model. As detailed in Table-1, the biogas integration model yielded the highest returns. The Net Farm Income (NFI) for the biogas model was BDT 316,632.10, which is 47.51% higher than the NFI of the BaU model (BDT 166,200.85). The Management Income (MI) showed an even more substantial increase, rising from BDT 30,431.75 in the BaU model to BDT 124,132 in the biogas model—a 76% increase. The integration of cow dung stick production and vermicomposting also resulted in higher profitability than the BaU model, though to a lesser extent than biogas.

Financial Profitability of Integrated Cattle Farming Systems

After calculating the gross output; the total value was determined**.** All the calculations are based on yearly output of five cattle. From table 1, it is observed that the value of animals in the opening stocks is BDT 239,280.9 and closing stock was BDT 383,797.35. The value of product mainly from the milk sold was BDT 400750. The value of milk which used for farmers own consumption was BDT 12775. From the cow dung sold, the yearly income of the farmer is BDT 8000 and for the own consumption, it’s valued for BDT 4000. For its closing stock the value was about BDT 5800. Now from the integration of business purpose, the cow-dung stick sold for BDT 18000. Beside this, the own consumption of the farmer for stick preparation is BDT 14500 per year. The calculated amount for vermi-compost sell is about BDT 32500; and for the farmers own need for composting; the amount is BDT 9500. In the integration of business model; the bio-gas production and sell amount was BDT 8400. It becomes very beneficial when the opportunity cost of the bio-gas is about BDT 18000; which means this amount for fuel purchase are being saved by this bio-gas generation in every farm household for cooking.

Calculation of Total Net Change in Inventory = (Value of closing stock + Sales value+ Consumed value) - (Bought + Opening Stock);

By using this formula; Total Net Change in Inventory comes to BDT 144516.45. Estimated gross output is BDT 144516.45; as the value of animals is BDT 413525; the value of milk product and lastly the value of cow-dung is BDT 17800 yearly/farm for 5-cattle together. Hence, Total Gross Output in the Business-as-Usual practice model is BDT 575841.45; whereas it comes to BDT 676741.45 in the Business Integration Model; thus, value addition amount is BDT 100900.00

Table 1. Gross Output from Livestock Farming in Different Models

Items	Business-as-Usual Practice			Business Integration Model		
	Value of Animals BDT	Value of Product (Milk)	Cow dung (Tk/Year)	Cow dung Stick (Tk/Year)	Vermi-compost	Biogas
Opening Stocks	239280.9	0		0	0	0
Bought	0	0	0	0	0	0
Sold	0	400750	8000	18000	32500	8400
Consumed	0	12775	4000	14500	9500	18000
Closing Stock	383797.35		5800	0	0	
Total Net Change in Inventory	144516.45					
Gross Output of Livestock	144516.45	413525	17800	32500	42000	26400
Output from Business-as-Usual Practice: 575841.45				Value added by Business Integration Model: 100900		
Total Gross Output (575841.45+100900) =						676741.45

Source: Farm survey, 2024

Estimation of Gross Margin from Cattle Farming

The formula used: GM= TR -VC

Where,

GM= Gross margin;

TR= Total return

VC= Variable cost

From table 1, it got gross output as BDT 575841.45 in the Business-as-Usual (BaU) model and the variable cost of five cows per year was found 353086.692. As a result, the gross margin is amounted to BDT 222754.758 in BaU model (table-2). The gross Margin per five cow in cow-dung stick integration model is BDT 318217.258. In vermi-compost integration model, gross margin per five cows is BDT 309467.26; and the gross margin in bio-gas integration model is BDT 309467.25 as shown in Table 2:

Table 2. Gross Margin Analysis of Various Models of Livestock Farming

Livestock Farming Model	Business-as- Usual Model	Business Integration Model		
		Cow-dung stick Integration	Vermi- compost Integration	Bio-gas Integration
Gross Output of Livestock	575841.45	676741.45	676741.45	676741.45
Variable Costs of five cows (BDT)	353086.69	358524.19	367274.19	248055.44
Gross Margin	222754.75	318217.25	309467.25	428686.00

Source: Farm survey, 2024

Estimation of Fixed Cost or Overhead Cost

Fixed cost of the farming system was estimated considering land rent on grazing land & farm shed, interest on capitalized value of animals, permanent labour, depreciation cost & interest on borrowed capital. For calculating the interest on capitalized value of animal; the following formula is used:

Interest on capitalized value of animals
= [10% on {(Value of opening stock + value of closing stock) ÷ 2}]

The Interest on capitalized value of animals is BDT 31153.9125; Depreciation (10% on Cowshed and Machinery) and interest on borrowed capital is calculated respectively as BDT 15000 and 5000. Total fixed cost is BDT 56553.9125 for all models without the bio-gas integration model. Overhead cost of BaU model is BDT 56553.9125; cow-dung integration model is BDT 56553.91; in the vermi-compost integration model BDT 81553.91 have been estimated.

Table 3. Fixed Cost or Overhead Cost of Business-as-Usual Model

Particulars	**Cost (BDT)**
Rent	
a. On Grazing Land (Average) 33 Decimal / year	2400
b. On Farm shed Area 15 Decimal	3000
Interest on capitalized value of animals	31153.91
Permanent labour	0
Depreciation (10% on Cowshed and Machinery)	15000
Interest on borrowed capital	5000
Total Overhead Cost	56553.91

Source: Farm survey 2024

Estimation of Net Farm Income

It considered fixed cost; cost of land rent, interest on operating capital, etc. Net income was calculated by deducting all costs (variable and fixed) from gross return. It is denoted as under:

Net Farm Income = Total Gross Margin - Overhead Cost

In the table4; total gross margin is BDT 222754.75 and the overhead cost is BDT 166200.84; after necessary subtractions - the Net farm income from BaU, cow-dung stick integration, vermi-compost integration and bio-gas integration models were BDT 166200.84; BDT 261663.3455; BDT 227913.34; and BDT 316632.0955 respectively. These values of Net farm income showed that the profitability of other three integration models is higher than the Business-as-Usual model in practice.

Table 4. Net Farm Income from Livestock Farms of Various Models

Livestock Farming Models	**Business as usual model**	**Integration of Models**		
		Cow dung stick Integration	**Vermi-compost Integration**	**Bio-gas Integration**
Total Gross Margin	222754.75	318217.25	309467.25	428686.00
Overhead Cost	56553.91	56553.91	81553.91	112053.91
Net Farm Income	166200.84	261663.34	227913.34	316632.09

Source: Farm survey 2024

Comparison among Livestock Farming Models in terms of their Net Farm Income

Table 5 showed that the business as usual model's net farm income is BDT 16620.8455; where it is BDT 261663.34; BDT 227913.34 and BDT 316632.09 respectively in the integration of cow-dung stick, vermicompost and bio-gas models. So, the value addition in the net income from cow-dung stick integration, vermi-compost integration and bio-gas integration model are BDT 95462.49; BDT 61712.50; and BDT 150431.25 respectively. This is a rise above the Business-as-usual model by 63.51%, 72.92%, and 52.49% of net farm income, respectively. Therefore, the percentage of more income over the very common business-as-usual model by the cow-dung stick integration, vermi-compost integration; and bio-gas integration model are 36.49%, 27.08%, and 47.51% respectively. So, it can be concluded that the Business Integration Models have significantly increased the financial profitability of cattle farming.

Table 5. Various Model's Net Farm Income Comparison of Livestock Farming

Livestock Farming Models	Business-as-Usual in Model (BaU)	Integration model		
		Cow dung stick Integration	Vermi-compost Integration	Bio-gas Integration
Net Farm Income	166200.84	261663.34	227913.34	316632.09
Excess Income Over BaU Model	---	95462.49	61712.50	150431.25
Changes in Percentage	---	63.51%	72.92%	52.49%
Excess Income in Percentage	---	36.49%	27.08%	47.51%

Source: Farm Survey, 2024

Economic Profitability of Integrated Cattle Farming Systems

Operators Income

An operator income is the income which is considered as the actual operating return. To calculate it, the following formula is used;

Operator's Income = Net Farm Income - Opportunity cost of family labour

The opportunity cost of family labour is estimated as BDT 70000. So, the operator's income is calculated as BDT 96200.8455 in the table-6 in business-as-usual model. Besides in three models i.e in the cow-dung stick, vermi-compost and bio-gas integration model; the operator's income is BDT 191663.34, 157913.34 and 246632.09, respectively.

Table 6. Operators Income from Livestock farming

Livestock Farming Models	Business-as-usual model	Integration model		
		Cow-dung stick Integration	Vermi-compost Integration	Bio-gas Integration
Net Farm Income	166200.84	261663.34	227913.34	316632.09
Opportunity cost of family labour	70000	70000	70000	70000
Operators Income	96200.84	191663.34	157913.34	246632.09

Source: Farm survey, 2024

Operator’s Labor and Management Income

Mean value of the operator’s income is BDT 168870.65 and the value of Opportunity cost of family’s operating capital is BDT11769.10; hence the value of ‘Operator’s labour and Management Income’=

[Operators labour and Management Income =
(Operators Income - Opportunity cost of family operating capital)]

and it has been calculated as 84431.74 BDT. Besides, in the three models i.e. the cow-dung stick, vermi-compost and bio-gas integration model; the operator’s income is BDT 179894.24, 144913.34 and 232132 respectively (Table 7).

Table 7. Operator’s Labour and Management Income from Livestock farming

Livestock Farming Models	Business-as-usual model	Business Integration Models		
		Cow-dung stick Integration	Vermi-compost Integration	Bio-gas Integration
Operator’s Income	168870.65	191663.34	157913.3455	246632.0955
Opportunity cost of family operating capital	11769.1	11769.1	13000	14500
Operator’s Labour and Management Income	84431.7455	179894.24	144913.3455	232132

Source: Farm survey, 2024

We got that opportunity cost of operator’s labour (9000/months X Six months/yr): BDT 54000

Estimation of Management Income

Management income is the Total Managerial Income from the farm. Yearly, the Operator’s Labour and Management Income of the farm are calculated previously as BDT 84431.74. Besides, the Opportunity cost of operators’ labour of the farm is calculated as the value of BDT 54000. For calculating the management income; we used the following formula:

[Management Income = (Operator’s labour & Management Income - Opportunity cost of operators labour)]

The management income is calculated in the table-8 as BDT 30431.7455 in the business-as-usual model. Besides, in the three models i.e. cow-dung stick, vermi-compost and bio-gas integration model; the operator’s income is BDT 71894.24, 39913.34 and 124132.00 (table-8)

Table 8. Management Income from Livestock Farming Models

Livestock Farming Models	Business as usual model	Business Integration Models		
		Cow-dung stick Integration	Vermi-compost Integration	Bio-gas Integration
Operators labor and Management Income	84431.74	179894.24	144913.34	232132

Opportunity cost of operators labor	54000	108000	108000	108000
Management Income	30431.74	71894.24	39913.34	124132

Source: Farm survey, 2024

Comparison of Management Income among various models of Livestock Farming

Table 9 showed that the Management Income from business-as-usual model is BDT 30431.74; Whereas, it is BDT 71894.24, 39913.34, 124132 respectively in the integration of cow-dung stick, vermi-compost and bio-gas model. Over management income, the net value addition from the cow-dung stick integration, vermi-compost integration and bio-gas integration models are BDT 41462.49, 9481.59; 93700.25 respectively -- which is excess by 42%, 76%, 24% of Management income of business-as-usual model. Thus, it can be said that the Integration of business model can significantly increase the economic profitability of cattle farming.

Table 9. Comparison of Management Income among various models of Livestock Farming

Livestock Farming Models	Business-as-usual model	Business Integration Models		
		Cow-dung stick Integration	Vermi-compost Integration	Bio-gas Integration
Management Income	30431.74	71894.24	39913.34	124132
Difference of Income more than the BaU Model	---	41462.49	9481.59	93700.25
Changes of percentage	---	42%	76%	24%
More income in percentage	---	58%	24%	76%

Source: Farm survey 2018

Farmers' Perception of Livestock Multi-functionality

Farmers demonstrated a strong appreciation for the diverse roles of livestock. At the farm level, soil fertility was the most highly recognized contribution, with 85% of farmers either agreeing (50%) or strongly agreeing (35%) with its importance. Its function as a risk buffer was also highly valued, with 60% agreement (30% agree, 30% strongly agree). At the societal level, food and nutrition security were a paramount contribution, with 80% of farmers agreeing or strongly agreeing. Again, soil fertility was perceived as a major societal benefit, with 80% agreement (55% strongly agree, 25% agree). These perceptions underscore that farmers view livestock as an integral component of their livelihood and the broader community's well-being, far beyond a simple commodity.

Challenges Faced by Cattle Farmers

The study identified distinct challenges for BaU and integrated farming systems, as ranked by the Problem Facing Index (PFI) in Table 10. For farmers practicing the BaU model, disease occurrence was the most severe constraint (PFI: 310), followed by the high price of feeds (PFI: 285). In contrast, farmers who had adopted integrated models reported different primary challenges. Bad odor from manure management was the top-ranked problem (PFI: 260), with the non-availability of skilled labor being the second most significant obstacle (PFI: 250).

Table 10. Ranking of Major Challenges Faced by Cattle Farmers (PFI Score)

Challenges and Obstacles	Severe problem	Moderate problem	Low problem	No problem
Grazing land	60	30	20	10
Disease occurrence	90	15	10	0
High price feed	70	30	15	5
Price fluctuation	65	35	10	20
Cow dung management	65	35	15	5
Non availability of labour	50	40	20	10
Bad odor	60	35	15	10
Uncontrollable rainy season	40	40	20	0
Low percent of bio-gas	40	30	20	10

Source: Calculated from Field Survey, 2024. Maximum possible score = 360 (120 respondents * 3)

Hence, the major challenge is the disease occurrence and minor problem is the availability of grazing land; these two major and minor problems have scored of 310 and 260 out of 480.

Discussion

The study's findings reveal that integrating non-conventional by-product utilization transforms cattle farming from a traditional subsistence activity into a significantly more profitable enterprise. The remarkable increase in Net Farm Income (47.51%) and Management Income (76%) through biogas integration confirms that valorizing "waste" such as manure provides a powerful economic incentive for farmers (Talukder & Taj Uddin, 2000). This aligns with circular economy principles and demonstrates a practical, market-driven approach to sustainable agriculture. The additional income can enhance household resilience, enabling farmers to invest in better nutrition, education, and farm inputs.

Farmers' strong perception of livestock's multi-functional roles, particularly in enhancing soil fertility, is a critical finding. This indigenous knowledge aligns with scientific evidence on the benefits of organic manure for improving soil structure and nutrient content. This shared understanding provides a solid foundation for agricultural extension services to promote integrated systems not just for economic gain, but also for their ecological benefits, such as reducing the reliance on costly and environmentally damaging chemical fertilizers (Pell et al., 2010). The recognition of livestock as a risk buffer further highlights its role in the livelihood security of poor households, acting as a living asset that can be liquidated during emergencies.

The challenges identified point to the need for tailored support strategies. For traditional systems, the high PFI scores for disease and feed costs highlight deep-seated systemic issues that constrain the entire livestock sector in Bangladesh (Rahman and Rahman, 1991). Strengthening veterinary services, improving access to vaccines, and promoting the cultivation of local, high-quality fodder are essential interventions. For the more innovative integrated systems, the emergence of challenges like bad odor and labor shortages suggests that technology adoption must be accompanied by technical training on proper management (e.g., biogas plant maintenance to control odor) and the development of labor-saving tools. These "second-generation" problems are common during the scaling of new technologies and must be addressed to ensure their long-term success and adoption (Vandamme et al., 2010).

Conclusion and Recommendations

This study concludes that multi-functional livestock farming, when integrated with non-conventional by-product utilization, is a highly profitable and sustainable pathway for rural development in coastal Bangladesh. The valorization of cow dung through biogas, vermicompost, and fuel stick production significantly boosts household income, enhances food and nutrition security, and contributes to environmental objectives like improved soil health and climate change mitigation.

Despite the clear benefits, adoption is hindered by both traditional constraints (disease, feed costs) and emerging challenges related to new technologies (odor, labor). Based on these findings, the following policy recommendations are proposed:

- Promote Awareness and Training: Launch extension programs to increase mass consciousness about the economic and environmental benefits of livestock multi-functionality, with a focus on by-product management.
- Enhance Access to Finance: Provide soft loans and financial incentives through government and non-government channels to help smallholders invest in technologies like biogas plants and vermicomposting units.
- Strengthen Veterinary and Support Services: Improve the delivery of veterinary services, including mobile clinics, to combat disease outbreaks. Support should also be provided for the promotion of local fodder cultivation and unconventional feed resources to reduce costs.
- Develop Market Linkages: Improve marketing facilities for both primary livestock products (milk) and value-added by-products to ensure farmers receive fair prices.
- Addressing these areas will help unlock the full potential of the livestock sector, making it a more resilient, profitable, and environmentally sustainable cornerstone of the rural economy in Bangladesh.

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Competing Interests

The authors have declared that no competing interests exist.

Authors' Contributions

Salim Ahmed designed the study, managed the data collection, performed the data analysis, and wrote the first draft of the manuscript. Other Author, Mohammad Fakhrul Alam managed the literature searches and contributed to the discussion section and socio-economic analysis. Prof. Dr. Fakir Azmal Huda contributed to the methodology and critically reviewed the manuscript. All authors read and approved the final manuscript.

Consent

All authors declare that written informed consent was obtained from all participating farmers for their participation in this study and for the publication of aggregated data.

Ethical Approval

All authors hereby declare that all procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

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