

Exploring the determinants of smallholder farmer's net farm income from cattle production in Timor-Leste

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ABSTRACT: While farmers in Timor-Leste have long been involved in subsistence cattle production, their economic status and living standards have not seen significant improvement. This study aimed to analyze the annual net farm income from beef cattle production and its determinants among smallholder farmers in Timor-Leste. Data was collected through face-to-face interviews with a sample of 100 small farmers from three Timor-Leste cities: Bobonaro, Ermera, and Viqueque, with 43, 31, and 26 respondents, respectively. The multistage sampling method was used to select the respondents, and multiple regression analysis was employed to investigate the determinants of net farm income from cattle production among smallholder farmers in Timor-Leste. The study found that most farmers were between 41 and 60 years old, illiterate, small land holdings, and a non-commercial objective for raising cattle. Grazing freely was the most common rearing method, and the average herd size was 15.62 heads. An annual total cost of cattle production was USD 2,584.42, consisting of a total variable cost of USD 2,272.77 and a total fixed cost of USD 311.65. The total revenue generated was USD 3,645.09, resulting in a gross margin of USD 1,372.32 and a net farm income of USD 1,060.67. The multiple regression analysis indicated that the number of lands for cattle rearing had a significantly positive effect on smallholder farmer's net farm income from cattle production, while a dummy variable for Bobonaro, total variable cost, and age had a significantly negative effect. The study's findings suggest that increasing cattle rearing land and decreasing the total variable cost by managing feed costs effectively could enhance smallholder farmer's net farm income from cattle production. Furthermore, transferring husbandry technology and management to young farmers who readily adopt new practices can enhance cattle production productivity and net farm income.

Keywords: gross margin; net farm income; cattle production; multiple regression analysis

Introduction

The majority of Timor-Leste's population resides in rural areas, and agriculture constitutes their principal economic activity. The 2019 Timor-Leste Agricultural Census reveals that 141,141 households, equivalent to 66% of the total households, actively participated in agriculture (General Directorate of Statistics, Ministry of Finance, and the Ministry of Agriculture and Fisheries, 2020). The main crops grown include maize, rice, cassava, and sweet potatoes, primarily intended for household consumption. Coffee, coconuts, and vegetables are primarily cultivated for generating household cash income, with only a small portion for household consumption (Fanzo and Bonis-Profumo, 2019). Despite this, Waldron et al. (2015) reported that the majority of rural household cash income is

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derived from livestock. Livestock production is critical to the economy, social structure, and cultural practices of rural households in Timor-Leste, providing cash income, savings, food and nutrition, social status, and traditional ceremonial events. In 2019, livestock activities engaged 134,158 households, representing 95% of all agricultural households. Cattle, predominant among livestock, were raised by 57,637 households, constituting 43% of those engaged in such activities. The country had 285,701 cattle, with an average of 5 cattle raised per household (General Directorate of Statistics, Ministry of Finance, and the Ministry of Agriculture and Fisheries, 2020). This statistic highlights that most cattle farmers in Timor-Leste are smallholders who encounter challenges such as limited market access, high marketing and transportation costs, and a scarcity of human and land resources in their cattle-raising activities.

Small-scale farmers often face limitations in both input and output, which can significantly impact their production activities and reduce net farm incomes. As a result, many small-scale farmers in developing countries continue to rely on subsistence production practices (Fan et al., 2013). However, cattle fattening can play a crucial role in the economy by generating relatively profitable family cash income, food, and nutritional supply, thereby reducing poverty and unemployment, and increasing land productivity among rural smallholder communities (Sarma et al., 2014). Livestock provides an important source of animal protein that is critical for human health and helps to support the body's structural development. In Timor-Leste, the community's health and nutrition status reveals that 46% of children younger than five years are stunted for their age, and almost 24% of children are underweight, indicating signs of malnutrition. Childhood and pregnancy malnutrition can have adverse consequences on child survival and long-term well-being, leading to a broad impact that hinders development. As a solution, increasing livestock production can be considered to improve protein availability (United States Agency for International Development, 2018). In order to improve nutrition, reduce malnutrition, and generate income, it is essential for the government and society to help farmers develop the skills and resources to effectively link their cattle production to the market (Dewi and Yustikaningrum., 2018).

Cattle play an important role in the wellbeing of rural households as one of the cash income sources (Waldron et al., 2015). According to National Statistics Directorate (2011), cattle production was the second-largest source of income from livestock for rural households in Timor-Leste, contributing USD 19.87 per month per household. While Australian Centre for International Agricultural Research (2017) found that the net returns from cattle production in Timor-Leste averaged USD 36.67 per month per household. In addition, cattle are used as a source of meat for household consumption and for traditional ceremonies and festivals such as funerals and wedding parties. Moreover, cattle are used for preparing land in rice fields and producing animal manure to improve soil nutrients (Waldron et al., 2016).

The export of live cattle to Indonesia is an important component of Timor-Leste's export industry, and it is supported by several policies and development programs. Before 2010, the export of live cattle to Indonesia was legal and formal. However, Indonesia later compelled Timor-Leste to comply with the World Trade Organization Agreement on Sanitary and Phytosanitary Measures for cattle exports. Unfortunately, Timor-Leste was unable to meet all of the necessary health certification criteria, and as a result, official cattle exports to Indonesia were shut down at the end of 2010. Despite this, the demand for live cattle in Indonesia has remained strong, and unofficial trade has continued. In 2014, approximately 5,000 cattle were exported across the border, generating USD 4.2 million in revenue (Waldron et al., 2015).

Australian Centre for International Agricultural Research (2017) found that Timor-Leste has experienced growth in domestic demand for beef and has the potential for livestock exports to Indonesia. However, the development of the Timor-Leste beef industry faces major obstacles on the supply side. Most farmers are smallholders who raise cattle in traditional production systems for social and ceremonial purposes, rather than for commercial purposes. As a result, they often lack knowledge, skills, and management in animal husbandry practices, feeding, pastures, diseases, and breeding. The development of the beef industry in Timor-Leste, aimed at meeting the growing domestic demand and potential for exports, requires a shift away from traditional cattle production systems towards a commercialized system (Australian Centre for International Agricultural Research, 2017). Correia et al. (2016) highlighted that across Timor-Leste, the predominant method of cattle production relies on small-scale and traditional systems, particularly through free-range pasture grazing. In contrast, commercialized cattle production is prominent in the western region, featuring densely populated cattle and numerous cropping activities. The cut-and-carry method for grass and crop residues is widely practiced for feeding animals in the region. Timor-Leste, based on governmental administrative, and natural characteristics, is divided into three regions: western, central, and eastern. According to the report from the General Directorate of Statistics, Ministry of Finance, and the Ministry of Agriculture and Fisheries (2020), indicated that in the western region, the municipality of Bobonaro had the highest number of cattle farming households, totaling 8,889. Meanwhile, in the central and eastern regions, Ermera and Viqueque had the highest numbers, with 7,469 and 5,582 households, respectively, as of 2019. These three municipalities are vital and representative areas for studying smallholder cattle production.

However, many smallholders in Timor-Leste encounter obstacles in achieving productivity due to their limited access to financial services and critical resources, including working capital, land, cattle breed, feed, and disease and veterinary services (Correia et al., 2016). Similar to many cattle farmers in developing countries, smallholder farmers face challenges in accessing credit to expand their farms and purchase necessary inputs such as feed, supplements, and drugs, as well as limited relevant knowledge (Fan et al., 2013). Moreover, smallholder cattle farmers in Timor-Leste are impacted by climate change, skills shortages, and lack of resources and credit to expand their herd size. Despite these challenges, cattle are an important source of cash income for rural households and can benefit agricultural crops. The increasing demand for cattle and rising prices motivate Timor-Leste to develop the beef industry and assist smallholder farmers in expanding cattle production and improving productivity to meet market demand in neighboring Indonesia (Australian Centre for International Agricultural Research, 2013). In addition, Waldron et al. (2016) stated that cattle production in Timor-Leste is characterized by low input-low output systems. This means that using low levels of inputs (such as feed, labor, and capital) results in low levels of outputs (measured in live weight of cattle). Although this production system is biologically inefficient or characterized by low productivity, it does not necessarily demonstrate financial inefficiency due to its low production costs. However, Australian Centre for International Agricultural Research (2017) found that the average profit from cattle for surveyed households in Timor-Leste was USD 440 per year, with high variability. In two out of the ten surveyed areas, a negative profit was observed.

As the substantial variability in net returns from cattle production mentioned in previous literature, it is imperative to investigate the factors influencing net farm income from cattle production among smallholder farmers in Timor-Leste. This study aims to fill gaps in prior research, providing valuable insights and recommendations on

cattle production strategies. Farmers can benefit from adjusting their production practices and resource allocation based on profitability determinants. Additionally, policymakers can use these insights to formulate policies that support and incentivize practices leading to stable and profitable cattle production.

Methodology

Area of study

Timor-Leste is a small island state in Southeast Asia, situated between 8.1° to 9.5° south latitude and 125.0° to 127.3° east longitude. It has a land area of approximately 15,007 square kilometers and is bordered by the Indonesian archipelago to the north, west, and east, and the continent of Australia to the south. The study was conducted in three municipalities representing the western, central, and eastern regions of the country. The municipality with the highest number of cattle-raising farmer households in each region was selected as the representative. Bobonaro municipality represented the western region, Ermera represented the central region, and Viqueque municipality represented the eastern region (see Figure 1).



Figure 1 Map of study areas

Source: Australia Timor-Leste Friendship Network (2018)

Data collection

The study population focused on farmer households involved in cattle production in Timor-Leste, which had a total of 57,637 households in 2019 (General Directorate of Statistics, Ministry of Finance, and the Ministry of Agriculture and Fisheries, 2020). To determine an appropriate sample size, the guideline proposed by Hair et al. (2014) was followed, which recommended a sample size of at least 10 times the number of predictors in a regression

model. With 10 independent variables in this study, a sample size of 100 cattle farmer households was considered adequate.

A multi-stage sampling technique was employed to select the sample for the study. The three municipalities with the highest number of cattle farming households in each region, namely Bobonaro, Ermera, and Viqueque, were selected as the representatives. The sample was distributed proportionally to the population of cattle farming households in each municipality, and further divided into sub-districts and villages with high cattle production. The total sample of 100 respondents was obtained, including 43 farmers from Bobonaro municipality in the western region, 31 farmers from Ermera municipality in the central region, and 26 farmers from Viqueque municipality in the eastern region (see Table 1). Data were collected through face-to-face interviews using a structured questionnaire.

Table 1 Proportional distribution of population and sample size of cattle farmer households in each representative municipality

Region	Municipality	Number of cattle farming households*	Proportion	Distribution of sample size
Western	Bobonaro	8,889	0.41	41
Central	Ermera	7,469	0.34	34
Eastern	Viqueque	5,582	0.25	25
Total		21,940	1.00	100

Sources: * General Directorate of Statistics, Ministry of Finance, and the Ministry of Agriculture and Fisheries (2020)

Data analysis

The analysis of costs and revenues is a commonly used method for measuring the profitability of a business, production activity, or service. In beef cattle production, the total costs refer to the sum of all expenses incurred in raising beef cattle, including both fixed and variable costs. Fixed costs in beef cattle production are expenses that do not change regardless of the level of output, such as land rent and depreciation of buildings and equipment. On the other hand, variable costs are expenses that vary with the level of output, such as the cost of feed, labor, veterinary care, transportation, and other inputs. The amount of these costs will vary depending on the number of beef cattle being raised and the specific requirements of each animal (North Dakota State University Extension, 2018; United States Department of Agriculture, 2022).

Cattle production revenues refer to the income generated by farmers from selling their beef cattle as well as other sources of revenue, such as breeding stock sales or rental of land for grazing (North Dakota State University Extension, 2018; United States Department of Agriculture, 2022).

For determining the profitability of smallholder cattle production, gross margin (GM) and net farm income (NFI) were employed in this study. Gross margin is the difference between the total revenue earned from selling cattle and the total variable costs incurred to produce cattle as expressed in Equation 1. Net farm income (NFI), which implies farm profit, is the difference between the total revenue earned from selling cattle and the total costs,

including both variable and fixed costs, incurred in producing cattle as expressed in Equation 2 (North Dakota State University Extension, 2018; United States Department of Agriculture, 2022).

$$GM = GFI - TVC \quad (1)$$

$$NFI = GFI - TVC - TFC \quad \text{or} \quad NFI = GM - TFC \quad (2)$$

Where:

GM = Gross margin

GFI = Gross farm income or total revenue

TVC = Total variable cost

NFI = Net farm income

TFC = Total fixed cost

In previous studies, the estimation of factors influencing the profitability of agricultural production employed the Ordinary Least Squares (OLS) multiple regression model, with profitability treated as the continuous dependent variable. For example, the study of Jobirov et al. (2022) investigated the determinants of beef cattle farming profitability among smallholder farmers in the Baljovan District of Khatlon region, Tajikistan. Similarly, Oke et al. (2022) analyzed the factors influencing catfish farming profitability in the Ijebu-Ode zone of the Agricultural Development Programme in Ogun State. Therefore, the OLS multiple regression model was used to analyze the determinants of smallholder farmer's net farm income from beef cattle production in Timor-Leste. The dependent variable in the model was net farm income from beef cattle production, while the independent variables were age, education, number of household members, number of lands for cattle rearing, rearing method, rearing experience, total variable costs, herd size, a dummy variable for Bobonaro, and a dummy variable for Ermera. The OLS multiple regression model was expressed in linear function as Equation 3.

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + e \quad (3)$$

Where:

Y = Net farm income from beef cattle production (USD)

b_0 = Intercept

$b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9, b_{10}$ = Estimated coefficients of independent variables

X_1 = Age (years)

X_2 = Education (0= illiterate, 1 = educated)

X_3 = Number of household members (persons)

X_4 = Number of lands for cattle rearing (hectares)

X_5 = Rearing method (0= grazing freely, 1 = tethering in cattle stall)

X_6 = Cattle rearing experience (years)

X_7 = Total variable costs (USD)

X_8 = Herd size (0= small herd size, 1 = medium or large herd size)

X_9 = A dummy variable for Bobonaro (0= no, 1 = yes)

X_{10} = A dummy variable for Ermera (0= no, 1 = yes)

e = Error term

The OLS multiple regression analysis provided estimated regression coefficients, standard errors, t-values, F-value, and adjusted R^2 for presenting the model's goodness of fit. Furthermore, various assumptions, including normality, multicollinearity, homoscedasticity, and autocorrelation, were considered to ensure the validity of the model (Gujarati, 2003).

The expected effects of independent variables on net farm income from cattle production would be varied, with both positive and negative effects possible depending on the specific variables considered. The age of the farmer would have a positive impact on net farm income or profits of livestock production, as older livestock farmers had higher profits than younger farmers, which was attributed to their greater experience, knowledge, and social capital (Hennessy and Miranowski, 1995; Marley and Ward, 2009; Kassie et al., 2017; Mawejje et al., 2018). While, Key and McBride (2009); McSweeney et al. (2016) found that older farmers were less likely to adopt new technologies and management practices, which led to lower productivity and profitability.

The net farm income of cattle production would have a positive relationship with education (Bekele et al., 2019), number of household members (Asmare et al., 2021; Maharjan et al., 2021), number of lands for cattle rearing (Sanni et al., 2019; Hailemariam et al., 2021; Maharjan et al., 2021), rearing method with a tethering in cattle stall or a zero-grazing system (Kiptot et al., 2011; Nyikahadzoi et al., 2014; Abegaz et al., 2018), and cattle rearing experience (Alemu et al., 2015; Abdulmalik et al., 2018). On the other hand, the net farm income of cattle production would have a negative relationship with total variable costs (Fausti et al., 2005; Hofmeyr et al., 2015; Cavalieri et al., 2017; Martinez et al., 2018).

Herd size would have both a negative and positive relationship with net farm income from cattle production. Larger farm sizes had a positive effect on the productivity and profitability of cattle production due to economies of scale (Borges et al., 2020). However, Njuki et al., 2020 found that small-scale farms that engaged in mixed crop-livestock systems were able to diversify their income and manage risks effectively, resulting in higher incomes compared to larger-scale cattle farms.

A dummy variable for farm location was used to capture the variations in profitability between different geographic locations in cattle production. Cattle farms located in regions with greater access to grazing land, water resources, veterinary services, and markets are more likely to achieve profitability in cattle production (Olayemi et al., 2013; Alemu et al., 2018; Ouma et al., 2018).

Results and discussions

Socio-economic characteristics and farming management of smallholder cattle farmers in Timor-Leste

The socio-economic characteristics and farming management practices of smallholder cattle farmers in Timor-Leste were presented in **Table 2**. The results showed that the majority of the farmers (97%) were between 41 and 60 years old, with a mean age of 50.78 years, and over half of them were illiterate (58%). The farmers had a household size of between 5-8 persons (89%) and had limited land for cattle rearing, with 97% of them owning

only 0.01-0.20 hectares of land. The mean herd size of the farmers was 15.62 heads, with 43% having a small herd size of 10 heads or less. Grazing freely, also known as an extensive grazing system was the most common rearing method, accounting for 69% of the farmers, while tethering in cattle stall accounts for 31%. The objective of rearing cattle for 90% of the farmers was for non-commercial purposes, such as family consumption, asset saving, traditional celebrations, and draught animal power. Only 10% of the farmers reared their cattle for sale. The mean experience in rearing cattle was 10.29 years, with 65% having less than 10 years of experience. Most farmers reared cattle with corn farming (37%), followed by coffee plantation (27%) and mixed rice and corn farming (24%).

The native Bali breed was the most common species of cattle breed with 99% and native grass was the most common type of roughage feed with 37%, followed by leaves (32%) and rice straw (26%). Most farmers relied on veterinarians for cattle health treatment and disease cure with almost 80%. Cattle were mostly sold to middlemen (66%) and some were sold to other farmers (6%). The main cattle production problems were lack of feeds and forages, high production cost, and lack of knowledge. While the main cattle marketing problems were lack of marketing information, high transportation cost, and seasonal demand for cattle.

Table 2 Socio-economic characteristics and farming management of cattle farmers in Timor-Leste

Socio-economic characteristics and farming management	Frequency	Percentage (%)
Age	100.00	100.00
- 21 – 40 years old	2.00	2.00
- 41 – 60 years old	97.00	97.00
- More than 60 years old	1.00	1.00
Max = 68 years old, Min = 40 years old, Mean = 50.78 years old, S.D. = 4.48 years old		
Education	100.00	100.00
- Illiterate	58.00	58.00
- Educated	42.00	42.00
Number of household members	100.00	100.00
- 1 – 4 persons	8.00	8.00
- 5 – 8 persons	89.00	89.00
- 9 – 12 persons	3.00	3.00
Max = 10 persons, Min = 4 persons, Mean = 6.01 persons, S.D. = 1.27 persons		
Number of lands for cattle rearing	100.00	100.00
- 0.01 – 0.20 hectare	97.00	97.00
- 0.21 – 0.40 hectare	2.00	2.00
- 0.41 – 0.60 hectare	1.00	1.00
Max = 0.50 hectare, Min = 0.01 hectare, Mean = 0.10 hectare, S.D. = 0.07 hectare		
Herd size	100.00	100.00
- Small herd size (equal or less than 10 heads of cattle)	43.00	43.00
- Medium or large herd size (more than 10 heads of cattle)	57.00	57.00
Max = 68 heads, Min = 3 heads, Mean = 15.62 heads, S.D. = 10.92 heads		
Rearing method	100.00	100.00
- Grazing freely	69.00	69.00
- Tethering in cattle stall	31.00	31.00

Table 2 Socio-economic characteristics and farming management of cattle farmers in Timor-Leste (Continued)

Socio-economic characteristics and farming management	Frequency	Percentage (%)
Objectives of rearing cattle	230.00	100.00
- Other purposes	90.00	90.00
- For sale	10.00	10.00
Experience in rearing cattle	100.00	100.00
- Less than 10 years	65.00	65.00
- 10 years above	35.00	35.00
Max = 20 years, Min = 5 years, Mean = 10.29 years, S.D. = 2.88 years		
Farming system	100.00	100.00
- Rearing cattle only	3.00	3.00
- Rearing cattle with rice farming	9.00	9.00
- Rearing cattle with corn farming	37.00	37.00
- Rearing cattle with coffee plantation	27.00	27.00
- Rearing cattle with mixed rice and corn farming	24.00	24.00
Species of cattle breed	100.00	100.00
- Native Bali	99.00	99.00
- Brahman	1.00	1.00
Type of roughage feed*	269.00	100.00
- Native grass	100.00	37.17
- Legume/ bush legume	13.00	4.84
- Rice straw	69.00	25.65
- Leaves	87.00	32.34
Cattle health treatment and disease curative*	108.00	100.00
- Never done by anyone	1.00	0.92
- Done by farmer self	19.00	17.59
- Done by neighboring farmers	2.00	1.86
- Done by veterinarians	86.00	79.63
Cattle selling channel*	101.00	100.00
- Not selling	28.00	27.72
- Selling to middlemen	67.00	66.34
- Selling to other farmers	6.00	5.94
Cattle production problems*	143.00	100.00
- Lack of feeds and forages	56.00	39.16
- High production cost	44.00	30.78
- Lack of knowledge	43.00	30.06
Cattle marketing problems*	189.00	100.00
- Lack of marketing information	89.00	47.09
- High transportation cost	56.00	29.63
- Seasonal demand for cattle	44.00	23.28

Source: Author's survey (2018)

Noted: * is multiple responses

Gross margin and net farm income from beef cattle production of smallholder farmers in Timor-Leste

The cost and return analysis results are presented in **Table 3**. Variable costs, including labor, fodder, medicine, veterinary services, transportation, and other miscellaneous items, were evaluated. Fixed costs, such as land rent and depreciation of assets like cattle shelter, stalls, hand tractors, trucks, and motorbikes, were also considered. Some costs were assessed in terms of non-cash costs, like labor, fodder, land rent, and depreciation. Smallholder farmers in Timor-Leste practiced subsistence cattle rearing with free-grazing cattle in fields. The cost of fodder was calculated by multiplying rough feed consumption (estimated total digestible dry matter: DDM) with the local grass price. According to Mukhtar (2019), the estimated DDM of rough feeds was 1,140 kilograms per head per year, while the livestock unit (LU) for beef cow aged 12-23 months was 0.7 (Chilonda and Otte, 2005). From the survey, the average herd size of was 15.62 cattle per farm. Therefore, the estimated consumption of native grass was 12,464.76 kilograms, which was multiplied by the price of USD 0.10 per kilogram to obtain a total non-cash cost of USD 1,246.48 per year. While total costs accounted for USD 770.47 consisting of non-cash cost of labor of USD 695.15, calculated at a daily wage rate of USD 5.50 for 126.39 man-days worked by family members, and hired labor cost of USD 75.32. Land rent or land opportunity cost was USD 150, estimated by multiplying the land used for cattle rearing (0.10 hectares) by the rent value of USD 1,500 per hectare per year.

The total variable cost of smallholder cattle production was USD 2,272.77 per year, representing 87.94% of the total cost. The main contributors to the variable costs were fodder, which accounted for 48.23%, and labor, which accounted for 29.81%. The findings aligned with Priyanti et al. (2012); Domingos et al. (2019); Muñoz et al. (2018), who emphasized the significance of feed and labor costs as crucial expenses in beef cattle fattening production. On the other hand, the total fixed cost was USD 311.65 per year, making up 12.06% of the total cost. The primary fixed costs were the depreciation of assets, which accounted for 6.25%, and land rent, which represented 5.8% of the total cost.

Overall, the total cost of smallholder cattle production was USD 2,584.42 per year. The total revenue generated was USD 3,645.09. This resulted in a gross margin of USD 1,372.32 and a net farm income of USD 1,060.67. These findings suggested that smallholder cattle production can be a profitable enterprise. Notably, previous studies reported different net income levels for smallholder cattle production in Timor-Leste. For instance, Domingos et al. (2019) documented an average annual net income of around USD 529 per household, whereas Muñoz et al. (2018) recorded a higher figure of USD 2,550 per household. The net farm income generated by this study was within the range of these two previous studies. However, smallholder cattle production in Timor-Leste was generally profitable when farmers had access to land, water resources, and credit, as well as technical assistance and veterinary services.

Table 3 Cost, revenue, and net farm income of beef cattle production of smallholder farmers in Timor-Leste in 2017

Items	Amount (USD per year)	Percentage (%)
1) Variable Cost	2,272.77	87.94
1.1) Labor	770.47	29.81
1.2) Fodder	1,246.48	48.23
1.3) Medicine and veterinary cost	74.69	2.89
1.4) Transportation	121.25	4.69
1.5) Others (rope, knife, and bucket)	59.88	2.32
2) Fixed Cost	311.65	12.06
2.1) Land rent	150.00	5.80
2.2) Depreciation of assets	161.65	6.25
3) Total Cost	2,584.42	100.00
4) Total Revenue	3,645.09	
5) Gross Margin	1,372.32	
6) Net Farm Income	1,060.67	

Source: Author's calculation

Determinants of smallholder farmer's net farm income from beef cattle production in Timor-Leste

The OLS regression analysis results of the factors influencing smallholder farmer's net farm income from beef cattle production in Timor-Leste was shown in **Table 4**. The adjusted R^2 value of 0.617 indicated that 61.7% of the variation in smallholder farmer's net farm income from beef cattle production could be explained by the independent variables in the model. The F-value of 16.940 was significant at $P < 0.01$, indicating that the model was a good fit for the data. The Durbin-Watson statistic of 1.990 fell within the range of 1.5 to 2.5, suggesting that there was no significant autocorrelation in the residuals of the model (Gujarati, 2003; Field, 2009; Wooldridge, 2015; Hill et al., 2018). The independent variables had correlation coefficients ranging from -0.500 to 0.652 (**Table 5**) and VIF values ranging from 1.329 to 2.222 (**Table 4**). These values indicated no multicollinearity in the regression model, as the correlation coefficients were below 0.80 and the VIF values were below 10 (Hair et al., 2010). The Breusch-Pagan-Godfrey (BPG) value of 18.50 and Koenker-Bassett (KB) value of 4.80 for the model's heteroscedasticity was lower than the critical value at $P < 0.01$ of 23.21, indicating no significant evidence of heteroscedasticity (Gujarati, 2003; Wooldridge, 2015).

The results revealed that four out of ten independent variables had a statistically significant effect on smallholder farmer's net farm income from cattle production in Timor-Leste, namely number of lands for cattle rearing, a dummy variable for Bobonaro, total variable cost, and age. While education, number of household members, rearing method, cattle rearing experience, herd size, and a dummy variable for Ermera had no significant effect.

Number of lands for cattle rearing was found to have a significantly positive effect on net farm income from cattle production at $P < 0.01$. The coefficient for the number of lands for cattle rearing was 2,003.38, representing that an increase of one hectare of land resulted in an increase in net farm income from cattle production by 2,003.38 USD. This finding was consistent with previous studies (Sanni et al., 2019; Hailemariam et al., 2021; Maharjan et al., 2021) indicating more grazing and rearing land allowed for better nutrition and health for the cattle, which in turn led to higher productivity and income.

A dummy variable for Bobonaro had a negative effect on net farm income from cattle production at a significance level of $P < 0.01$, with a coefficient of -375.51. This finding implied that, on average, cattle farms located in Bobonaro municipality had a net farm income from cattle production that was USD 375.51 lower than those located in Viqueque municipality. The Bobonaro municipality is situated on the northern coastline and comprises of a valley, flatland, and hills that experience a long dry season (Tofa et al., 2021). On the other hand, the Viqueque municipality is located on the southern coastline and has a flat terrain that extends from the coastline to the mountains, with a long rainy season. The rainy season provides abundant animal feed such as green native grasses and crop by-products, which enables farmers to practice more intensive grazing and raise improved cattle breeds for higher productivity and profitability (Soares et al., 2013; Tofa et al., 2021).

Total variable cost had a negative effect on net farm income from cattle production at a significance level of $P < 0.01$, with a coefficient of -0.46. This implied that a decrease in total variable cost by one USD resulted in an increase in net farm income from cattle production by 0.46 USD. This was consistent with the findings of Fausti et al. (2005), who found that total variable costs had a significant negative impact on the net income of beef cattle operations in the United States. The study also found that feed costs were the largest contributor to total variable costs, and effective management of feed costs was critical for profitability. Similarly, a study conducted in South Africa found that variable costs, particularly feed costs, were a major determinant of the profitability of beef cattle production. Farmers who effectively managed their feed costs were more likely to achieve profitability in their beef cattle operations (Hofmeyr et al., 2015).

Lastly, the study found a significantly negative effect of farmer's age on net farm income from cattle production at $P < 0.05$. The coefficient for farmer's age was -27.02, indicating that a decrease in farmer's age by one year led to an increase in net farm income from cattle production by 27.02 USD. This result contradicted previous studies that showed older livestock farmers had higher profits, which was attributed to their greater experience, knowledge, and social capital (Hennessy and Miranowski, 1995; Marley and Ward, 2009; Kassie et al., 2017; Mawejje et al., 2018). However, this finding aligned with the results of Key and McBride (2009) and McSweeney et al. (2016), who found that younger farmers were more likely to adopt new technologies and management practices, leading to higher productivity and profitability.

Table 4 Ordinary least square regression analysis of the factors affecting smallholder farmer's net farm income from beef cattle production in Timor-Leste

Variables	Estimated Coefficients	Std. Error	t-value	p-value	Collinearity Statistics	
					Tolerance	VIF
Constant	2,718.865	670.249	4.057	<0.001**		
Age (X ₁)	-27.017	11.641	-2.321	0.023*	0.610	1.640
Education (X ₂)	54.116	98.103	0.552	0.583	0.702	1.425
Number of household members (X ₃)	54.744	37.083	1.476	0.143	0.752	1.329
Number of lands for cattle rearing (X ₄)	2,003.382	656.840	3.050	0.003**	0.738	1.356
Rearing method (X ₅)	2.190	107.614	0.020	0.984	0.664	1.506
Cattle rearing experience (X ₆)	-5.633	17.288	-0.326	0.745	0.672	1.487
Total variable cost (X ₇)	-0.464	0.054	-8.640	<0.001**	0.450	2.222
Herd size (X ₈)	32.801	111.998	0.293	0.770	0.535	1.869
A dummy variable for Bobonaro (X ₉)	-375.508	110.773	-3.390	0.001**	0.536	1.865
A dummy variable for Ermera (X ₁₀)	-89.596	129.231	-0.693	0.490	0.616	1.624

Adjusted R² = 0.617, Standard error of the estimate = 405.597, F-value = 16.940**, Durbin-Watson = 1.990, N = 100
 Breusch-Pagan-Godfrey (BPG) = 18.50, Koenker-Bassett (KB) = 4.80

Source: Author's calculation

Noted: ** is statistical significance at P<0.01, * is statistical significance at P<0.05

Table 5 Pearson correlation coefficient matrix for independent variables of the regression model

Independent Variables	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀
X ₁	1.000	-0.349	0.258	0.355	0.004	-0.016	0.046	-0.029	-0.063	-0.194
X ₂	-0.349	1.000	0.041	-0.007	-0.045	0.041	0.317	0.289	-0.081	0.081
X ₃	0.258	0.041	1.000	0.352	-0.160	0.163	0.235	0.167	0.198	-0.222
X ₄	0.355	-0.007	0.352	1.000	-0.117	0.080	0.247	0.151	0.174	-0.087
X ₅	0.004	-0.045	-0.16	-0.117	1.000	-0.484	-0.355	-0.335	0.151	-0.227
X ₆	-0.016	0.041	0.163	0.08	-0.484	1.000	0.246	0.229	-0.276	0.133
X ₇	0.046	0.317	0.235	0.247	-0.355	0.246	1.000	0.652	0.097	0.105
X ₈	-0.029	0.289	0.167	0.151	-0.335	0.229	0.652	1.000	-0.061	0.081
X ₉	-0.063	-0.081	0.198	0.174	0.151	-0.276	0.097	-0.061	1.000	-0.500
X ₁₀	-0.194	0.081	-0.222	-0.087	-0.227	0.133	0.105	0.081	-0.500	1.000

Source: Author's calculation

Conclusion

The study found that most smallholder cattle farmers in Timor-Leste were between 41 and 60 years old, with over half of them being illiterate, had a household size of between 5-8 persons, and limited land for cattle rearing, with most owning only 0.01-0.20 hectares of land. Grazing freely was the most common rearing method,

and the objective of rearing cattle for 90% of the farmers was for non-commercial purposes. The farmers had an average herd size of 15.62 heads. The total variable cost of smallholder beef cattle production in Timor-Leste was USD 2,272.77 per year, with fodder and labor being the main contributors. The total fixed cost was USD 311.65 per year, with depreciation of assets and land rent being the primary costs. The total cost of production was USD 2,584.42 per year, while the total revenue generated was USD 3,645.09, resulting in a gross margin of USD 1,372.32 and a net farm income of USD 1,060.67.

The OLS regression analysis results found that four out of ten independent variables had a statistically significant effect on smallholder farmer's net farm income from beef cattle production in Timor-Leste, namely number of lands for cattle rearing, a dummy variable for Bobonaro, total variable cost, and age. The study's findings suggest that increasing the number of lands for cattle rearing and decreasing the total variable cost by managing feed costs effectively could enhance net farm income of beef cattle production. Policymakers should improve smallholder beef cattle farmers' access to land, facilitating the expansion of pasture areas for livestock feed. Additionally, the implementation of targeted training programs for empowering young, tech-savvy farmers is crucial. These programs should focus on refining their skills in cattle rearing, modern husbandry practices, and cost-effective management strategies. Trained farmers who have adopted technology can serve as exemplars, providing guidance to their neighboring counterparts. Consequently, these efforts will lead to enhanced production efficiency, greater profits, and an improvement in the quality of life for small-scale beef cattle farmers in Timor-Leste.

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