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PROFITABILITY OF DAIRY CATTLE PRODUCTION AMONG SMALLHOLDER DAIRY CATTLE FARMERS IN CHEPALUNGU SUB-COUNTY, BOMET COUNTY, KENYA

[1]*JOSPHAT SIELE, [2]ELIJAH K. NG'ENO, [3]NOAH KIBET

[1]Department of Agricultural Biosystems, Economics and Horticulture, University of Kabianga

[2]Department of Applied Economics, University of Eldoret, Kenya

[3]Department of Agricultural Biosystems and Economics, University of Kabianga

*University of Kabianga, P.O Box 2030-20200, Kericho, Kenya

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ABSTRACT

Smallholder farmers in Kenya are the majority players in the dairy sector, contributing to the country's economic performance. However, smallholder dairy cattle performance in the country is still low despite concerted efforts for improvement in recent decades. In Chepalungu Sub-County, Bomet County, dairy farming has remained a major concern for the smallholders who experience low milk production and prices. Smallholder dairy farmers produced an average of 4.3 litres of milk per cow per day, which is way below the potential national average of 8-10 litres. Besides the low milk production, smallholder dairy farmers in the study area also receive very low milk prices of about Kenya Shillings 25 to 30 per litre. Therefore, this study's objective was to estimate the profitability of smallholder dairy cattle enterprises in Chepalungu Sub-County, Bomet County, Kenya. The study was guided by the theory of the firm, and descriptive and cross-sectional research designs were used. A sample of 155 smallholder dairy cattle farmers was selected using purposive, stratified, and simple random sampling techniques. A pretested questionnaire was used to collect primary data, while secondary data was collected through a literature review. Data were analysed using Gross Margin Analysis with the help of Statistical Package for Social Sciences (SPSS) version 26 software. Analysed data was presented using tables, graphs, charts, and figures. Gross Margin results showed that smallholder dairy enterprises were profitable with an average monthly gross margin of Ksh 2,192.40 per cow. To enhance dairy profitability, the study recommends that policymakers advance policies and strategic dairy production investments significantly reduce dairy production costs. Moreover, the study recommends the development and implementation of policies and programs that facilitate skill improvement and those that will stimulate and bolster the performance of dairy cattle production among dairy farmers. Additionally, the study recommends investments in relevant dairy infrastructure that can help reduce transaction costs and streamline the market for farm inputs and outputs.

Keywords: Profitability, Smallholder farmer, Dairy Performance.

1.0 INTRODUCTION

The dairy industry is a major employer in the world, supporting the economies of both developed and developing countries. Livestock production contributes significantly to national economies worldwide; the value of livestock production in 2014 stood at 40% and 20% of total agricultural output in developed and developing nations respectively (FAO, 2019). According

to Knechtges (2011), approximately 900 million people in the world are poor and live in rural areas, most of whom depend on agricultural activities for food and income. The global demand for milk is rising as the World's population continues to grow to over 7 billion. However, the milk production pace is lower than the rate of population growth; world total milk production has increased by 35%, whereas per capita world milk production has dropped by 10% (Cheruiyot & Otieno, 2017).

A report by FAO (2010) shows considerable discrepancies in global dairy production. The study shows that Asia owned 25.7% of the world's dairy cattle and produced around 14.9% of the world's milk, while North America, with 5.0% of the global dairy cattle population, accounted for 16.3% of the world's milk. The study shows that the lowest dairy production exists in Africa, where despite the continent being home to 14.2% of the world's dairy cattle, their dairy production was only 4.7%.

According to the same report by FAO (2010), a dairy cow in North America can produce over 5000 kilograms of milk per annum compared to 500 kilograms per cow per annum in Africa. While in Israel, total milk production per cow increased from 4,000 litres annually in the 1950s to more than 12,000 litres in 2006. The same report further revealed that the advancement of the Israeli dairy industry resulted from more than 60 years of Research and Development (R&D). Key components include the field of precise nutrition (daily ration design), fertility management, veterinary services and dedicated dairy farmers. Per capita milk consumption is also high in Israel, averaging 175 litres annually (FAO, 2010).

The dairy industry in New Zealand demonstrates how industrial restructuring, state regulations, and transnational corporations shape patterns of economic globalization (Le Heron et al., 2010). The New Zealand Dairy Board became the world's largest dedicated dairy marketing network (Le Heron et al., 2010). Most farming countries are in the Mediterranean and Near East, the Indian sub-continent, the savannah regions of West Africa, the highlands of East Africa and parts of South and Central America. Countries without a long tradition of dairy production are in Southeast Asia (including China) and tropical regions with high ambient temperatures and/or humidity (Faye & Konuspayeva, 2012).

In Africa, the industry has been growing gradually, where traditional systems have dominated milk production for several years and still supply considerable amounts of milk today, around 85% of livestock keepers are found in Sub-Saharan African countries (Erdaw, 2023). Due to population growth, land shortage and increasing interest in production and consumption, market-oriented dairy systems are evolving, using high-performing graded animals and/or higher inputs (Ndambi et al., 2007). Several international bodies, such as Heifer Project International, Land O' Lakes, and Send a Cow, among others, have developed strategies to promote milk production in African countries (IFAD & RoK, 2006; EADD & Land O' Lakes, 2008). The growth of the African population and per capita milk consumption at 2.8% and 0.8% per annum, respectively, between 1990 and 2004 led to increased demand for milk and dairy products at an average rate of 4.0% per annum. However, milk production only grew at 3.1% (FAO & Hemme et al., 2006).

Eastern Africa is the leading milk-producing region in Africa, representing 68% of the continent's milk output (FAO, 2011). East Africans are relatively important consumers of milk and dairy products compared to other African countries. Generally, milk consumption is rising

although there are disparities among eastern African countries. The dairy sector is one of the fastest-growing agricultural sub-sectors in Eastern African countries, which has generated significant economic returns and employment opportunities along dairy value chains (FAO, 2011). From a heavily state-managed industry, with the objective of satisfying domestic food consumption and nutrition needs, to the reforms that led to a private-sector-driven industry, especially in the processing sector, the eastern African dairy production and marketing has gone through a broad-ranging transformation, especially over the past decade (FAO, 2011). At the same time, the range of products offered in the market has expanded. Recent data show that intra-regional trade in dairy products is slowly rising (World Bank, 2010). Uganda has become the region's first exporter of dairy products, with its dairy exports valued at USD 24.6 in 2013 (World Bank, 2010). Overall, a gap between supply and demand for dairy products is met by imports from outside the East African Community (EAC) region. Imports come from Europe, Australia, New Zealand, South Africa and the USA (FAO, 2011). In Ethiopia, Kenya and Rwanda, dairy farming is common in the highland areas because of the favourable agro-climatic conditions characterized by a cool and humid climate, which entails slight fluctuation in milk production during the year (FAO, 2011). In these areas, the agro-pastoral (crops and livestock) production system is predominant (RoK, 2010). In Rwanda, according to the National Dairy Strategy (NDS), milk production has been rising rapidly from 51.5 million litres in the year 2000 to 445 million litres in 2012, and continued rapid growth is expected (MINAGRI, 2013). Besides important investments by the government and development partners, the rise has been attributed to a favourable policy and institutional environment. The government of Tanzania has adopted different agricultural development projects to enhance animal productivity and improve the livelihood of the rural population by supporting farmers and providing them with the necessary livestock production services (IFAD, 2017).

In Kenya, the dairy sector is a rapidly expanding sector and one of the largest dairy industries within Sub-Saharan Africa (SSA) and is leading in East Africa with an estimated growth rate of 5% per year (GOK, 2019). The Kenya Vision 2030 recognized the dairy industry as one of the fundamental avenues contributing significantly to food security, rural livelihoods, and employment creation (GoK, 2008). Dairy farming is the single largest sub-sector of agriculture. The agricultural sector accounts for 33% of the GDP and another 27% indirectly through linkages with other sectors (FAO, 2019). The dairy sub-sector is the second largest contributor to Kenya's agricultural GDP (FAO, 2011). Smallholder dairy farming is the most popular, owning 80% of dairy cattle, producing around 56% of the total milk in the Country, and supplying 80% of Kenya's milk marketed (KDB & Tegemeo, 2016). Nganga et al. (2010) posit that smallholder dairy farmers' production ranges between (5-50) litres of milk and own between (5-10) cows. The dairy cattle population accounts for approximately 27% of total livestock and comprises 14.1 million indigenous and 3.4 million exotics, totalling 17.5 million (KNBS, 2018). The major breeds kept by the dairy farmers are Friesian, Ayrshire, Jersey, Guernsey, and their crosses (Kibiego, 2015). Improved breeds, such as Holstein-Friesian, Ayrshire, and Jersey, are preferred due to their higher milk yields, which can range from 5 to 20 litres per day depending on breed and management practices (Lukuyu et al., 2019). With an annual total milk production estimated at 4.6 Billion litres, the dairy sub-sector plays a significant role in the economy, providing a means of livelihood to about 2 million Kenyan households employing an estimated 750,000 persons directly and 500,000 indirectly (KDB & Tegemeo, 2016; KDB, 2024). According to a study by FAO (2011), every 1,000 litres of milk produced creates 77 jobs. SDP (2005) reported total milk consumption in Kenya at 145 litres

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per person per year, which is more than five times the milk consumed in other East African countries. The demand for milk in Kenya is expected to rise considering the intercensal growth rate of 1.69% where the population is projected to rise to about 57.8 million people by the year 2030 (GoK, 2019).

According to KDB & Tegemeo (2016), the average daily cow milk production in Kenya is 8-10 litres per cow, whereas it is approximately 12.7 litres in South Africa (Theron & Mostert, 2008). The sector has continued to witness increasing milk production, processing capacity, per capita milk consumption, and export potential (Rademaker et al., 2016). Due to the fluctuations in milk prices and delayed payment by some processors, farmers sell a large amount of milk through the informal milk market (Machira, 2014). In addition, the dairy sub-sector, as shown in Figure 1.1 (annual milk production trend in Kenya from the year 2010 to 2019), is dominated by cow milk, which in 2019 accounted for 72% of all the milk output in the country (KDB, 2021). Camel, goat, and sheep milk closely follow this at 21%, 5%, and 2% respectively (KDB, 2021). These estimates are based on the most current comprehensive data set that is available regarding trends in milk production in Kenya.

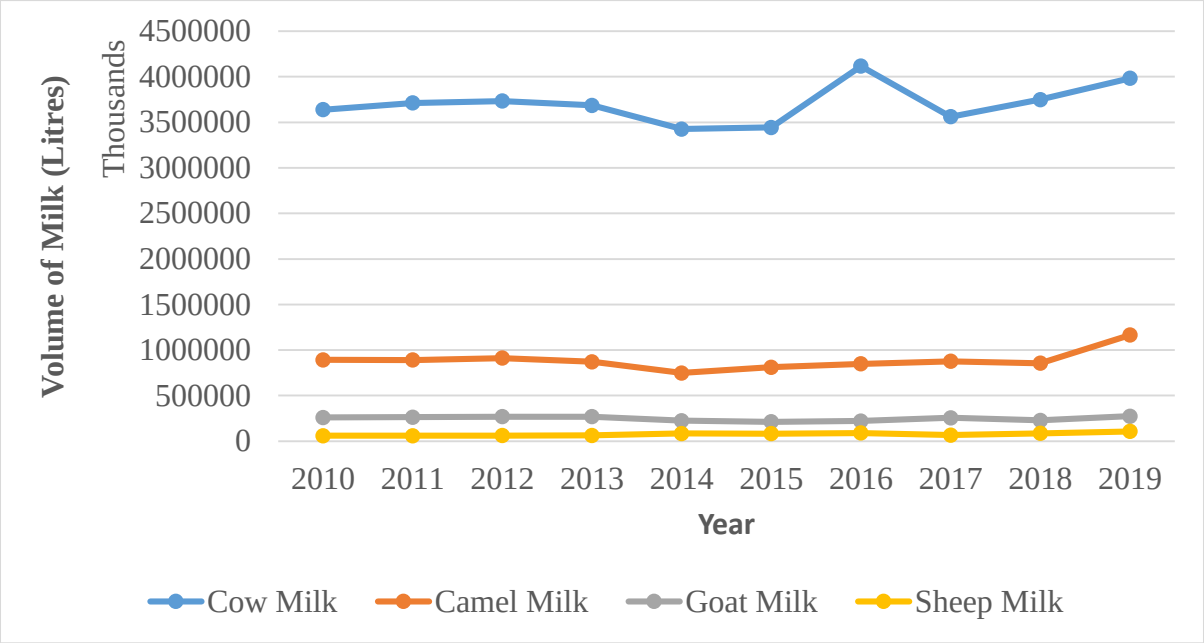

Figure 1.1: Annual Milk Production Trends in Kenya, 2010 - 2019

Source: Kenya Dairy Board (2021)

There are four major dairy production systems practiced in Kenya namely zero grazing, semi-zero grazing, tethering, and open grazing (Wambugu et al., 2011). The dairy production system is majorly dependent on an area's agro-ecological characteristics, human population density, land productivity potential, and prevalence of animal diseases (Wambugu et al., 2011). The zero grazing system is a more intensively managed system and cows are fed on rations that are relatively high in concentrates and stored forages. Tethering and open grazing are more pasture-based systems, which are the primary production systems in several dairy-producing units in the country.

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Given its enormous contribution, the sector has been prioritized for investment in the Agricultural Sector Transformation & Growth Strategy (GOK, 2019). Consequently, the dairy sub-sector has helped to hasten the achievement of poverty reduction and food security under Sustainable Development Goals (SDGs) and in line with the country's economic pillar of Vision 2030 in the sub-county, county and the entire country through increased food production. Despite the apparent significance of the sub-sector to Kenya's economy, smallholder dairy cattle farming has been characterized by poor performance (Lukuyu et al., 2011). Further, the sector is plagued with many challenges such as poor breeding techniques, poor feeding regime, poor marketing systems, poor access to credit facilities and the high cost of artificial insemination (Bebe et al., 2003; TechnoServe, 2008; Odero-Waitituh, 2017; Godde et al., 2021). Low milk productivity further derails the sector's performance compared to the best performers in the African region. For instance, primary marketing faces infrastructure bottlenecks caused by poor road networks and the lack of appropriate cooling and storage facilities, consequently increasing transactional costs (SDP, 2005). This may be attributed to the high cost of production and other challenges such as feed shortage, diseases and parasites, poor dairy farming practices, and poor access to extension and veterinary services (Odero-Waitituh, 2017). To combat these challenges, various initiatives including training programs on best management practices, increased access to markets, and efforts to promote value addition through processing and packaging are being implemented to improve dairy farming practices (GoK, 2023). Such measures aim to enhance productivity and profitability for farmers, ultimately supporting rural development (GoK, 2023).

Bomet County, which borders the Mau Forest, has a developing dairy sector in Kenya and experiences suitable agro-climatic conditions favourable for improved dairy livelihoods (GoK, 2014). In the year 2018, the county had 306,269 dairy cows. In 2019, the number increased to 310,867 dairy cows and in 2020, the number increased to 315,532 (KDB & Tegemeo, 2021). However, the average milk production per cow per day in the year 2020 was 5.75 litres, compared to the national average of 8-10 litres (KDB & Tegemeo, 2021).

The dairy subsector in Chepalungu Sub-County continues to develop and significantly contributes to the Sub-County economy, food security, and household incomes (CIDP, 2013). It is a primary economic activity that employs thousands of people and produces high-quality milk for consumption (CIDP, 2013). Because of the favourable agro-climatic conditions, Chepalungu Sub-County is a high-potential dairy production zone comprising many well-established farmers-owned dairy cooperative societies. According to the County Department of Cooperative report (2020), there are 12 registered dairy cooperative societies and 19,638 smallholder dairy farmers. Despite the suitable climatic conditions and improved dairy cattle breeds, the average milk production in the sub-county is still low at 4.3 litres per cow per day. The same report further revealed farm-gate milk price per litre at Kenya Shillings (KSh) 25 to 30. This is lower than the set minimum farm gate milk price range of between Ksh 33 and 35 per litre, recommended by the Kenya Dairy Board (KDB & Tegemeo, 2021). However, the dairy sector in the study area has been plagued with low milk production coupled with declining land sizes due to the increasing population (KDB & Tegemeo, 2021). Poor dairy performance has also been attributed to poor access to breeding services, poor access to credit, poor

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marketing systems, and inadequate and poor-quality feeds (SDP, 2005). Additionally, there are challenges of transportation and perishability as milk collection routes are prone to erosion, especially during rainy seasons when production is at its peak (EADD, 2008).

As demonstrated above, several constraints ail the dairy sub-sector weakening the ability of the sector to participate and compete in the domestic and regional markets (Wambugu et al., 2011). According to RoK (2010), over 1.8 million households are involved in milk-based enterprises, but despite this significant role, the sector experiences low productivity, low profitability and slow enterprise growth (GoK, 2010). The sub-county's dairy sector has the potential to generate growth. Although the average production is known, the sector's performance is not known. Therefore, this study aims to analyse the economic factors affecting the performance of smallholder dairy cattle production among smallholder dairy cattle farmers in Chepalungu Sub-County, Bomet County, Kenya. The findings of this study may provide key production insights to the smallholder dairy cattle farmers and other stakeholders in the study area on ways of enhancing the performance of dairy cattle farming.

1.1 The Problem Statement

The dairy sub-sector is the second largest contributor to Kenya's agricultural Gross Domestic Product (GDP). Over the years, the sector has witnessed tremendous investments, including increased intensification through the adoption of zero grazing, expansion of markets for dairy products, and increased commercialization. Despite these developments, smallholder dairy cattle farming has been characterized by poor performance. For instance, notwithstanding an increase in dairy cow population in the study area from 78,374 in the year 2018 to 81,744 in the year 2020, smallholder dairy cattle farmers still recorded an average daily production of 4.3 litres per cow in 2017-2020, which is way below the potential national average of 8-10 litres per cow per day. Coupled with the low milk production that is below production potential, smallholder dairy cattle farmers in the study area also received very low farm gate milk prices of about Kenya Shillings (Ksh) 25 to 30 per litre in the year 2020. This is lower than the set minimum farm gate milk price range of between Ksh 33 and 35 per litre, recommended by the Kenya Dairy Board. Consequently, low farm gate milk price per litre would result in a narrow gross margin that the smallholder dairy cattle farmers would receive. Even though the average production per cow is known, the performance of smallholder dairy production in the study area is not known. Therefore, this study intends to fill this research gap by analysing the economic factors affecting the performance of smallholder dairy cattle production in Chepalungu Sub-County, Bomet County, Kenya.

2.0 LITERATURE REVIEW

A study on the estimation of technical and cost efficiencies of smallholder dairy farms in Embu and Meru Counties of Kenya by Kimenchu et al. (2014) concluded that dairy cows were underfed and produced milk less than their genetic potential (9.3kg against 20kg). The amount of milk produced by a cow depended on the number of cows milked and the quantities of roughage, mineral supplements, and concentrates fed. The study shows that if inputs were doubled, total milk production would increase more than double. This study, however, failed to analyse other factors apart from the cost of production that may affect farms' performance.

Studies that have used gross margin analysis in estimating the performance of smallholder dairy enterprises in Kenya include the studies by Kibiego et al. (2015) and Mburu et al. (2007). For instance, in a study of the competitiveness of small-scale milk production systems in Uasin Gishu County of Kenya, Kibiego et al. (2015) showed that the level of intensification significantly influenced the gross margin and net margin in small-scale milk production. The authors indicate that the gross margin and profit per litre of milk reduced with an increase in the level of intensification. The free-grazing system had higher gross margins and profits than the zero-grazing system. Nonetheless, the study failed to analyse other factors that might have contributed to the variations in performance.

In a study by Wambugu et al. (2011) on the productivity trends and performance of dairy farming in Kenya, the gross margin analysis results showed that dairying is an economically viable enterprise in the short run with non-zero grazers having higher gross margins than zero grazers and therefore a financial advantage. Both variable costs and milk produced by lactating cows per month were higher in zero grazing. The high variable cost explains the lower margins. However, other than the cost of inputs, the study failed to assess other factors that may have affected the performance of dairy farming. A study by Mawa (2013), on the profit efficiency of dairy farmers in Kenya: a case study of smallholder farmers in the Rift Valley and Central province, found that small-scale farmers on average received gross margins of Kshs. 17 having deducted total costs from unit revenue. Similarly, this study failed to look at the factors that influenced the performance. Another study on the characterization and profitability assessment of dairy farms in Central Kenya by Kimenchu et al. (2015) found that the average production cost was higher than the revenue per unit. The resultant gross margins were negative, with only a few farmers making profits. This was attributed to high input prices. In conclusion, the authors noted the need to assess other factors that might have contributed to the negative profitability.

Somda et al. (2005) analysed the economic viability of milk production in smallholder farming systems in Gambia. In a study involving 90 smallholder dairy farms, the gross margin analysis was used to assess the profitability and viability of smallholder dairy production. The results showed that smallholder dairy farming in Gambia was indeed viable. The study also established that profitability varies across groups based on the scale, that is, medium-resource group and resource-poor farmers. Viability was higher in the resource-medium group than in the resource-poor group. This implies that smallholder dairy farmers have different resource endowments which affect profitability. Overall, a dairy technology that requires more resources is likely to be less preferred by resource-poor farmers.

Mwale et al. (1999) assessed the economic feasibility of smallholder dairy farmers using Malawi Zebu and its crosses for dairy in the Mzuzu Milk Shed Area. The results suggested interlinkages between genotype and management level under the prevailing smallholder conditions in Malawi. In addition, when no labour costs were included, gross margin analysis showed that the Malawi Zebu was the most efficient genotype in a low-input, low-output system. Therefore, this implies that the genotype of the dairy cow, management practice and labour costs (family and hired labour) significantly influence smallholder dairy returns. Chindime (2007) applied the gross margin analysis to estimate returns from smallholder dairy

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among borrowers and non-borrowers of in-kind credit in central and northern milk shed areas of Malawi. The results revealed that smallholder dairy farming was profitable for borrowers and non-borrowers, with borrowers reporting higher gross margins than non-borrowers.

A study by Wanjala et al. (2014) on herd characteristics (type of breeds, herd composition, performance and feeding system) in small-scale dairy farms in Western Kenya found that farmers kept on average 2.5 cows. Lactating cows accounted for 36.0%, and heifers accounted for 15.0% of the total number of cows kept. The mean yield per cow per day was 6.5 litres and 89.3% of the farms were producing less than 10 litres of milk per day per cow. There was a significant difference in the means of the total milk produced by the exotic breeds and the total milk produced by the crosses. The majority of the farms used Napier as the main fodder. The study concluded that one of the contributors to low performance is a type of breed. The study recommended support to enable farmers to keep commercial dairy stock.

A study by Musalia et al. (2007) on small-scale dairy farms in Butere, Mumias sub-region of Kakamega County of Western Kenya on dairy production, practices, and constraints revealed low milk production. The study further revealed that the average herd size was 4.2, those in milking produced 8.0 kg/ animal per day, and the average land size was 8 acres. The number of dairy animals in the area was limited by diminishing land size and scarcity of pasture and fodder crops. Although over 90% of the milk was consumed locally, the local demand was above the supply (Musalia et al., 2007).

3.0 RESEARCH METHODOLOGY

3.1 Research Design

Research design refers to the method used to carry out research. It is a framework that assists the researcher in structuring the data collection, analysis, and interpretation. This study will employ descriptive and cross-sectional survey designs. According to Oso & Onen (2005), descriptive design involves enquiring about different kinds of fact findings and then drawing conclusions about a targeted population by describing the data. The data collected will then be analysed with the help of descriptive statistics (frequency distribution, percentages, mean scores, and standard deviations) and inferential statistics (multiple regression analysis and correlations).

3.2 Location of Study

The study was done in Chepalungu Sub-County, Bomet County, Kenya, as shown in Figure 3.1. The sub-county is located at 0°47'00.0" S 35°21'00.0"E and is one of the largest sub-county in Bomet County. The sub-county covers an area of 539.8 km2 and comprises five wards: Kongasis, Siongiroi, Chebunyo, Sigor, and Nyangores (County Integrated Development Plan, 2013). The Sub-County borders Narok County to the South, Bomet East Sub-County to the East, Bomet Central Sub-County to the North, and Sotik Sub-County to the West (CIDP, 2013). The total land under agriculture is 34,562 ha. of which 33,737 are subsistence while 741 ha. is under commercial farming.

3.3 The Target Population

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According to Alvi (2016), the target population for a survey is the entire set of units for which the survey data are to be used to make inferences. Thus, the target population for this study was 19,638 smallholder dairy cattle farmers. According to the Department of Agriculture, Livestock and Fisheries (2020), 19,638 smallholder dairy farmers are in the study area, as shown in Table 1.

Table 1: Population of Smallholder Dairy Cattle Farmers per Ward

S. No.	Ward	The target population of dairy farmers
1	Kongasis	1,874
2	Siongiroi	10, 578
3	Chebunyo	5,234
4	Sigor	1,256
5	Nyangores	696
	Total	**19,638**

Source: Department of Agriculture, Livestock, Fisheries and Cooperatives (2020)

3.3.1 Sample Size and Sampling Procedure

Sample Size Determination

A sample size is a sub-population with relatively the same characteristics as the population (Singh, 2014). This study used Yamane's (1967) simplified formula to determine the sample size at a 95% confidence level, as shown in Equation 1.

$$\alpha = \frac{N\bar{c}}{\bar{v}+(n-1)\bar{c}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Where;

n = Sample size of dairy farmers,

N = Population of dairy farmers (target population),

e = precision level (error term) of 8%, and

1 = designates the probability of an event occurring

To find the sample size, the variable values are then fitted into Equation 3.1 as shown below.

$$n = \frac{19,638}{1+19,638(0.08)^2} = 155$$

Therefore, the sample size for this study was 155 smallholder dairy farmers.

3.3.2 Sampling Procedure

According to Orodho (2002), sampling is the process of selecting the required individuals for the study. Some individuals are selected from a population such that the selected group has

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elements representative of the characteristics found in the entire population. Therefore, this study employed purposive, stratified, and simple random sampling techniques. In the first stage, purposive sampling was used to select Chepalungu Sub-County since the sub-county is leading in milk production in Bomet County. In the second stage, a stratified random sampling procedure was used to obtain the sample of smallholder dairy farmers in the whole sub-county. Chepalungu Sub-County has five administrative wards, forming the study's five strata. In each ward, a proportionate size sampling procedure was used to pick respondents for the study. In the last stage, a simple random sampling technique was used. A list of smallholder dairy farmer households from each ward was obtained from the sub-county Livestock Office. The names of the farmers in the lists were first serially numbered and then randomly ordered and picked using a simple random sampling technique. This technique gave each farmer an equal opportunity to be selected, increasing the chances of obtaining an appropriate and representative sample size. This was advantageous because the sample frame was already available in the form of a list (Kothari, 2004). The sample size distribution is shown in Table 2.

Table 2: Proportionate Size Sample Distribution of Smallholder Dairy Cattle Farmers

S/No.	Ward	Target Population	Proportion (%)	Sample Size
1.	Kongasis	1,874	9.54	15
2.	Siongiroi	10, 578	53.86	83
3.	Chebunyo	5,234	26.65	41
4.	Sigor	1,256	6.40	10
5.	Nyangores	696	3.55	6
TOTAL		**19638**	**100**	**155**

Source: Author's Computation, (2021)

3.3.3 Data Collection Instrument

In this study, primary data was collected directly from the respondents using a structured questionnaire. Mugenda and Mugenda (2003) defined a questionnaire as a list of questions a researcher prepares to fit a certain inquiry. The attached questionnaire was used to collect data from smallholder dairy cattle farmers. This study collected data from the sampled smallholder dairy cattle farmers in Chepalungu Sub-County. The items in the questionnaire were derived from the five objectives of the study.

3.3.4 Validity of Research Instruments

According to Mugenda and Mugenda (2003), validity alludes to the accuracy and meaning of realities and proof drawn from the research results. It is the extent to which results acquired from the investigation of the information represent the subject under study. They argue that an instrument is valid when it can measure what it purports to measure. According to Orodho (2009), before using a research instrument, the researcher should determine content validity by discussing the items in the instrument with the supervisor and colleagues. Therefore, the validity of the research instrument for this study was determined by presenting the instrument

to two experts at the University of Kabianga to determine both content and face validity. The experts have wide experience in teaching and supervising postgraduate students. Their comments were incorporated into the final instrument.

3.3.5 Reliability of Research Instruments

Kothari (2008) refers to reliability as the degree to which scores obtained with an instrument are consistent. The instrument should return the same measurements when used at different times. According to Mugenda and Mugenda (2003), a pilot scope of between 1% and 10% is considered suitable. The instrument's reliability was determined by pre-testing the instrument with a sample of 16 smallholder dairy cattle farmers in Sotik Sub-County of Bomet County. Sotik Sub-County has similar characteristics to the study sample but was not part of the study. Data from the pilot study were analysed using Cronbach's Alpha coefficient, mathematically expressed as shown in Equation 3.2. A coefficient of 0.7 and above was deemed reliable.

$$\alpha = \frac{N\bar{c}}{\bar{v} + (n-1)\bar{c}} \quad \text{.......................................} (2)$$

Where α is the Cronbach's Alpha coefficient, $\bar{c}$ is the average inter-item covariance among the items, $\bar{v}$ is the average variance, and N is equal to the number of items/observations.

The reliability of the questionnaire was determined using Cronbach's Alpha coefficient as shown in Table 3. After calculating the Cronbach's Alpha coefficient for this study, a coefficient of 0.777 was found, which showed that the data collection instrument was reliable.

Table 3: Reliability Statistics

Cronbach's Alpha	No. of items
0.777	6

Source: Author's Computation from Survey Data, (2024)

3.3.6 Data Collection Procedures

A research authorization letter (permit) as shown in Appendix 3 was sought from the National Commission for Science Technology and Innovation (NACOSTI) through an introduction letter from the Board of Graduate Studies, University of Kabianga. The permit was presented to the Sub-County Commissioner, Chepalungu Sub-County, and the Sub-County Agriculture Officer for permission to collect data from the dairy farmers. After that, an appointment with the farmers was sought by the researcher before the commencement of data collection. Household heads were interviewed, and a spouse or knowledgeable person was interviewed where the household was unavailable.

3.3.7 Data Analysis and Presentation

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The initial data screening upon completion of the questionnaires was done by sorting, coding, and cleaning. All the data sources were complete. They were then numbered and coded using a coding frame ready for entry and analysis. For the determination and description of elements of independent variables, descriptive statistics were used for the dependent variable. Editing, organizing, and analysis of data collected was done using SPSS version 26 software. Distribution tables, bar charts, graphs, and figures were used to present the analysed data.

3.3.8 Profitability Estimates of Smallholder Dairy Cattle Enterprises

Farm gross margin analysis was used to estimate dairy cattle enterprises' profitability (performance) in Chepalungu Sub-County. An enterprise's performance (dairy cattle production) is the foundation for its profitability, and the profitability, in turn, reflects the enterprise's performance. For instance, if an enterprise has a high-performance level, it will likely generate higher profits. On the other hand, if an enterprise does not perform well, it will reflect in the profitability of the enterprise. The difference between the value of an enterprise's gross output and variable costs is defined as the gross margin (Ergano & Nurfeta, 2006). In dairy production, gross output is those products that routinely become available through the production process. Examples of these products include milk and breeding stock. In Kenya's highlands, the livestock production system deals with products that do not have a clear market value, e.g., calves reared at different intensity levels to be used for breeding later and, to a certain extent, heifer (Staal et al., 2003) hence not included in gross margins of the study.

The fodder and labour cost values were estimated based on the cost of fodder bought and labour payments, respectively. Fixed costs were ignored because they are not related to higher milk production and do not affect the optimal combination of variable inputs used and outputs obtained, whether sold or consumed by the household (Mburu et al., 2007).

The farm gross margin model is a simple method of comparing the performance of enterprises with similar capital and labour requirements. It provides information with an additional planning tool to help evaluate options between different farm activities. A t-test was used to test differences in gross margins. The following formula based on Benard and Nix (1979) was used to calculate the gross margins as shown in Equations 3, 4, and 5:

Total cost (TC) = TVC + TFC ……. (3)

Gross Margin (GM) = TR –TVC ……..... (4)

π = GM – TFC……..…….. (5)

Where,

GM = The performance of smallholder dairy cattle production (Monthly Gross Margin per cow in Kenya Shillings (denoted as Y). It is the dependent variable for the estimation of the objectives of the study.

TC = The summation of annual TVCs and TFCs. TFCs are not included since they are not related to milk output, hence, TC=TVCs.

TFC = Summation of all fixed costs. This was ignored since they are unrelated to milk output

and remain fixed whether milk production increases or reduces.

TVC = Total Variable Cost (Summation of all variable costs (Ksh) per month). These include the

cost of feeds, labour, drugs, and veterinary services.

TR = Total Revenue (Total amount (Ksh) realized from the sale of milk). TR is given by the

average price per litre of milk multiplied by the average milk output per year.

π = Gross profit (Ksh) per month.

4.0 RESEARCH FINDINGS AND DISCUSSIONS

The objective of this study was to estimate the profitability of dairy cattle production among smallholder dairy cattle farmers in the study area. The Gross Margin analysis model was used to determine the performance of smallholder dairy cattle production since fixed costs were not expected to vary with the output level. This is because fixed costs are unrelated to higher milk production in the short run and do not affect the optimal combination of variable inputs used and outputs obtained, whether sold or consumed by the household (Mburu et al., 2007). Nevertheless, gross margins are still useful in assessing enterprise profitability and are widely used in farm management economics (Dijkhuizen & Huirne, 1997). The estimated results of the profitability of smallholder dairy cattle production in the study are shown in Table 4 of results.

Table 4: Farm Gross Margin Analysis for Smallholder Dairy Farming

Variable		Unit	Observations (N)	Minimum	Maximum	Mean	Std Deviation
(i)	Milk/cow/month	Litres	155	30.00	645.00	131.90	104.86
(ii)	Milk price per litre	Ksh.	155	25.00	58.00	32.40	6.40
Monthly Total Revenue/Cow		**Ksh.**	**155**	**750.00**	**23865.00**	**4247.90**	**3463.90**
(i)	Monthly cost of labour/ cow	Ksh.	155	0.00	3000.00	543.40	669.00
(ii)	Monthly cost of feeds/ cow	Ksh.	155	83.30	8000.00	1037.60	956.80
(iii)	Monthly cost of veterinary care/cow	Ksh.	155	66.70	4000.00	474.50	448.40
Monthly Total Variable Cost/Cow		Ksh.	155	230.80	14000.00	2055.50	1704.00
Monthly GM/ Cow		Ksh.	155	-2495.00	11960.00	2192.40	2722.30

Source: Author's Computation from Survey Data, (2024)

Table 4 of results on farm gross margin analysis shows that the average monthly gross margin per cow was positive at Ksh. 2192.40 and ranged from Ksh. -2495.00 to Ksh. 11960.00. The mean monthly total revenue and total variable cost per cow were Ksh. 4,247.90 and Ksh. 2055.50, respectively. This means that smallholder dairy cattle production was profitable in Chepalungu Sub-County. Similar studies that discovered positive gross margin per cow include Wambugu et al. (2011), Mbilu (2015), and Alam et al. (2022) which are convergent with the study findings. A study by Wambugu et al. (2011) on productivity trends and performance of dairy farming in Kenya discovered a positive monthly gross margin of Ksh. 1262.00 per cow which is in convergence with the current study finding. Similarly, a study by Mbilu (2015) on smallholder dairy farmers' technical efficiency in milk production in Tanzania, found that the monthly gross margin per cow was TZS 27,817 (Approx. Ksh. 1342.70) which is also in convergence with the current study. Further, a study by Alam et al. (2022) on financial profitability analysis of dairy milk production in some selected areas of Bangladesh revealed that the daily gross margin per cow was positive (TK. 660) which is also in convergence with the current study findings. However, in a study by Wambugu et al. (2011) on productivity trends and performance of dairy farming in Kenya, GM per cow was Ksh. 376 among the zero-grazers in Nyeri, which is in divergence from the current study result.

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

The first objective was to estimate the profitability of dairy cattle production among smallholder dairy cattle farmers in the study area. The study used the gross margin analysis model to estimate the profitability of smallholder dairy cattle enterprises. Results revealed that the average monthly gross margin per cow was Ksh. 2192.40.

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CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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