International Journal of Agricultural Economics
2025, Vol. 10, No. 1, pp. 30-45
https://doi.org/10.11648/j.ijae.20251001.14

Research Article

Socio-Economic Factors Affecting Dairy Cow Milk Production Among Small-Scale Farmers in Marakwet East Sub-County, Elgeyo-Marakwet County, Kenya

Richard Kaino Chelanga[1], Elijah Kiplangat Ng'eno[2], Joseph Amesa Omega[3, *]

[1]Department of Agricultural Economics and Rural Development, University of Eldoret, Eldoret City, Kenya
[2]Department of Applied Economics, University of Eldoret, Eldoret City, Kenya
[3]Department of Animal Science and Management, University of Eldoret, Eldoret City, Kenya

Abstract

Milk production in developing has remained lower than 20 litres/cow/day in developed countries. Subsequently the aim of the current study determined the influence of socio-economic factors on dairy cow milk production among small-scale dairy farmers in Marakwet East Sub-County, Kenya. Data was collected using a questionnaire from a sample of 220 small-scale dairy farmers through stratified and systematic random sampling. The descriptive results revealed that small-scale dairy farmers had a mean age of 47.1 ± 8.1 years, with family size of 5 members, farmer experience of 16.8 ± 8.1 years, with average annual income of 900 ± 250 USD. Majority of the small-scale farmers were male (65.8%), married (90.3%), with a primary level of education (53.1%) and were involved in full-time farming activities (63.3%). The multiple linear regression results revealed that socio-economic factors significantly (Adjusted $R^2 = 0.791$, $P < 0.01$) influenced milk production at 79.1% where a unit increase in the level of education, family/household size, farmer's experience and total annual farmer's income had a positive impact of 60.2%, 109.1%, 131.1%, and 112.2% respectively on milk production. Strategies to improve milk production should encourage more women and youth to be proactive in the local dairy sector.

Keywords

Socio-Economic Factors, Small-Scale Dairy Farmers, Livestock, Dairy Cow Milk Production, Marakwet East Sub-County, Kenya

1. Introduction

The dairy industry dominates the livestock sector in several countries due to the rapid increase in demand for milk which stood at 105-110 g/capita/day against a supply of 51.4 g/capita/day in 2020 [1]. In 2021, the dairy sector produced 844 million metric tons (MMT) of cow milk worldwide [2]. In countries such as the United States of America, Western European countries, Russia, the United Kingdom, China, India, and the Scandinavian countries dairy farming is done on a large scale and it is highly mechanized [3, 4]. This is reflected in the milk production by 2020 which was dominated by India (187.95 MMT), the European Union (143.9 MMT), United States of America (USA) (102.4 MMT), Pakistan (45.78

*Corresponding author: joseph.omega@uoeld.ac.ke (Joseph Amesa Omega)

Received: 14 January 2025; **Accepted:** 27 January 2025; **Published:** 17 February 2025

MMT), China (35.6 MMT), Brazil (34.7 MMT), Russia (30.6 MMT), and United Kingdom (UK) (21.4 MMT) [5]. Approximately 150-230 million households around the globe are engaged in raw cow milk production [6]. Among these, over 80% of the raw milk volume produced globally comes from small-scale dairy cattle production systems. Small-scale dairy farmers are estimated at 700 to 950 million (10 to 12%) of the world population [7]. On average, these small-scale farmers rear two milking cows producing about 11 litres per day.

Dairy production in Africa plays a central role in the region's economic and sustainable development. The industry has been growing gradually where traditional systems have dominated milk production accounting for above 90% of the dairy ruminant population in Sub-Saharan Africa [8, 9]. The total volume of milk in the continent stood at 46.62 MMT in 2022 [10]. These values represent only about 5% of the world's milk production. In 2022, quintet African countries led by Kenya (4.92 MMT), Sudan (4.59 MMT), Egypt (4.47 MMT), South Africa (3.75 MMT), South Sudan (3.26 MMT), Algeria (3.06 MMT) and Ethiopia (2.77 MMT), accounted for 70% of the total milk production from small-scale dairy farming [5, 10].

Dairy farming has a significant contribution to Kenya's economy [11]. Kenya has one of the largest dairy industries in sub-Saharan Africa with an improved cattle herd larger than all of the rest of Eastern Africa. Dairy farming is the single largest sub-sector of agriculture in Kenya contributing 14% of Agricultural Gross Domestic Product (GDP) and 3.5% of total GDP [5]. Dairy milk production in Kenya, among 625,590 small-scale dairy farmers, stood at 510.5 million litres (4.92 MMT) in the year 2021 [11], with an average of 10 litres of milk per cow per day. Small-scale dairy farmers dominate the sector (80%) with about 1.8 million farmers involved in the production of milk.

In Elgeyo Marakwet County, dairy production has emerged as a critical player in the local economy, food security, and household employment opportunities for a substantial portion of the population [12]. However, despite the improvement in dairy cow milk production over the years in Marakwet East Sub-County, the average per capita dairy cow milk production is alarmingly low, ranging from 5.52 to 5.75 litres per cow per day. That production rate falls significantly short of Kenya's potential yield of 10 to 12 litres per cow per day achievable under optimal dairy farming conditions [13]. The production is also lower than the world's average of 20 litres/cow/day [5]. Therefore, there could be factors in the study area that could have contributed to the low level of dairy cow milk production among small-scale dairy farmers.

Socio-economic factors have a significant influence on the production of dairy cow milk, particularly among small-scale farmers [14, 15]. These factors include age, gender, marital status, family size, education level, occupation, income level, land size and years of experience [16]. Each of these socio-economic factors may interact with and contribute to the complex landscape of dairy cow milk production among small-scale farmers. Therefore, this study aimed to determine the socio-economic factors affecting dairy cow milk production among small-scale farmers in Marakwet East Sub-County, Elgeyo-Marakwet County, Kenya.

2. Methodology

2.1. Study Area

The study area is Marakwet East Sub-County which is one of the sub-counties of Elgeyo Marakwet County in the former Rift Valley Province (Figure 1). The Sub-County borders West Pokot County to the North, Baringo County to the East, Trans Nzoia County to the West, Uasin Gishu County and Marakwet West Sub County to the South [17]. According to the Kenya Population and Housing Census, Marakwet East Sub-County has four wards namely: Kapyego, Embobut/Embolot, Endo and Sambirir. It covers a total area of 784.3 square kilometers (KM^2) (Kapyego 308.6 KM^2, Embobut/Embolot 151.8 KM^2, Endo 178.6 KM^2 and Sambirir 145.3 KM^2). The Sub-County has approximately 97,041 people (Kapyego 21,268, Embobut/Embolot 19,794, Endo 28,905 and Sambirir 27,709).

The Sub-County is geographically diverse, comprising three distinct agro-ecological zones (AEZ): highlands, escarpments, and the valley floor. The highlands account for 49% of the Marakwet East Sub-County and encompass regions such as Kapyego, Chesoi, and Embobut/Embolot. These areas are characterized by favourable climatic conditions and are suitable for dairy cow rearing, sheep for wool production, as well as the cultivation of crops such as small-holder farmers, maize, peas, and beans. The escarpment covers approximately 11% of the sub-county area and is well-suited for the cultivation of crops like maize, millet, and sorghum. Marakwet East Sub-County is predominantly characterized by small-scale farmers, with an average landholding size of 1 to 6 acres, while a few large-scale farmers possess an average of 17.3 acres. Farmers in the study area practice both livestock production and crop farming. The sub-county consists mostly of small-scale farmers who own land sizes that range from 1 to 6 acres. The main food crops produced in the study area are Irish potatoes, dairy, maize, beans, mangoes, avocadoes, cowpeas, green grams, sorghum, cassava and finger millet. There are also cash crops such as pyrethrum, coffee, macadamia and Napier grass.

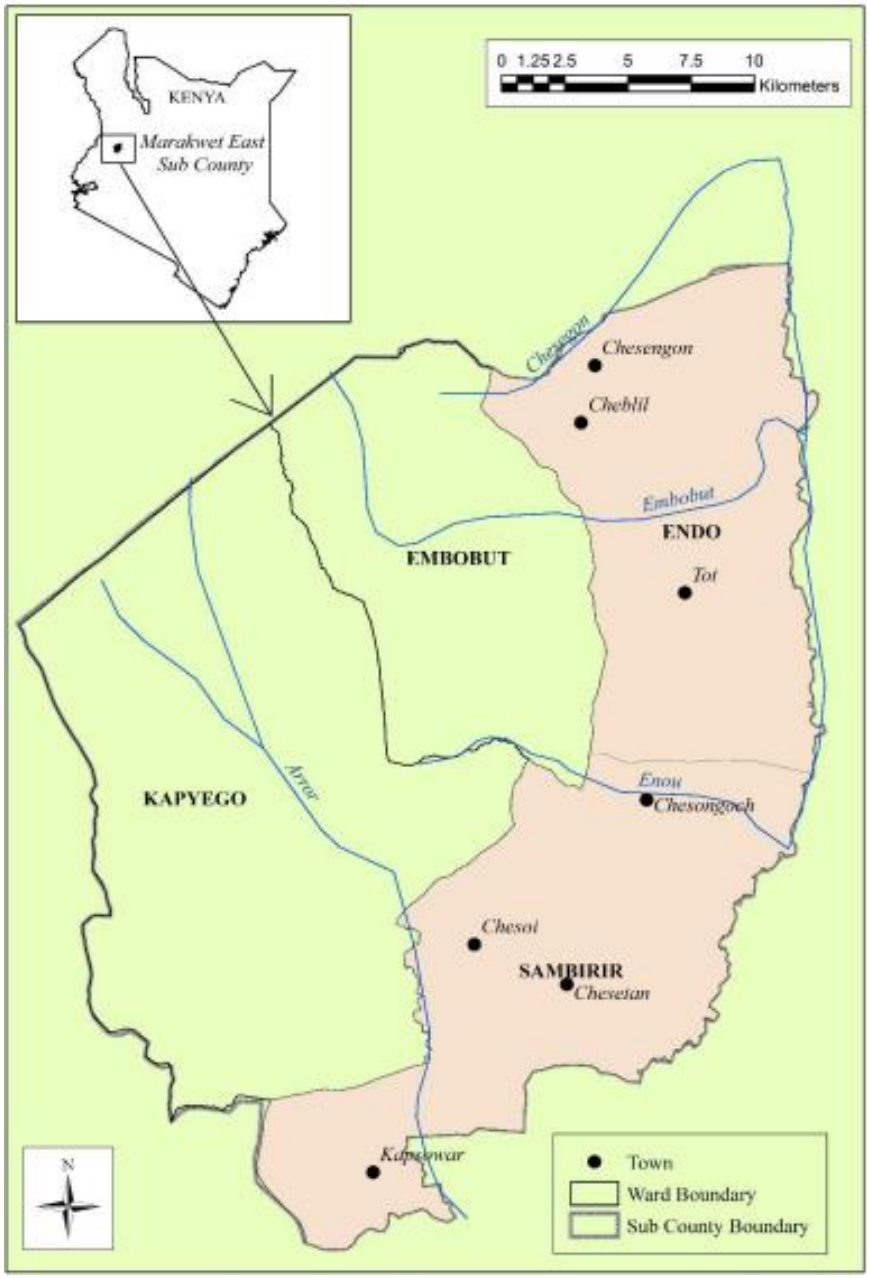

Figure 1. *Map of Marakwet East Sub-County (Source: Murkomen, 2019).*

2.2. Research Design

This study used descriptive and cross-sectional research designs. The descriptive research design provides a comprehensive description of the existing characteristics. Descriptive research design involves enquiring about different kinds of fact findings and then drawing conclusions about a targeted population by describing the data [18]. Cross-sectional research design provides data at a single point in time [19]. This provides a snapshot or a "cross-section" of the small-scale dairy farmers in the study area at a specific moment by allowing them to examine various variables and characteristics within that particular timeframe without studying changes over time. Cross-sectional research design, also known as a cross-sectional survey design, involves the collection of data at a single point in time from a sample of individuals or elements within a population.

2.3. Target Population

The target population encompassed all the small-scale dairy farmers residing in Marakwet East Sub-County. According to the Elgeyo-Marakwet Livestock and Fisheries Annual Report (2022), the total number of small-scale dairy farmers in Marakwet East Sub-County in 2022 were 8,364 and the dairy farmers' population distribution per ward is as shown in Table 1.

Table 1. Target Population of Small-scale Dairy Farmers per Ward.

S. No	Ward	Target Population
1	Kapyego	2,108
2	Sambirir	1,419
3	Endo	2,028
4	Embobut	2,809
Total		8,364

Source: Elgeyo-Marakwet Livestock and Fisheries Annual Report (2022)

2.4. Sample Size Determination

The sample size of a survey refers to the number of units selected from which data are gathered which possesses relatively the same characteristics as that of the population [20]. Larger samples reduce sampling errors but may be expensive and small sample sizes may increase sampling bias and error variance.

The sample size determination, for the small-scale dairy farmers selected in the study area was based on the formula for calculating the minimum sample size required for this study. This formula contends that, in most surveys, a coefficient of variation in the range of 21%≤C≤30% and a standard error in the range of 2%≤e≤5% is acceptable. This study, therefore, used the coefficient of variation of 30% and a standard error of 2%. The higher limit for the coefficient of variation and standard error were selected to ensure low variability in the same and to minimize the error. The coefficient variation formula is presented as shown in the equation.

$$n = \frac{NC^2}{C^2+(N-1)e^2} \quad (1)$$

Where: n = sample size
N = accessible population
C = Coefficient of Variance
e = standard error (error term)

To find the sample size for this study, the variable values were then fitted into the equation as shown below:

$$n = \frac{8364\times0.3^2}{0.3^2+(8364-1)*0.02^2} = 219.13 \approx 220$$

Thus, a total of 220 small-scale dairy farmers were the required sample size for this study.

2.5. Sampling Procedure

Sampling involves a method of choosing a subset of a population that represents the characteristics of the entire population to collect information about the phenomenon of interest [21]. This study employed purposive sampling, stratified and systematic random sampling techniques. Marakwet East Sub County was selected as the study area because it is the least in terms of dairy cow milk production in Elgeyo Marakwet County. In the second stage, a stratified random sampling procedure was used to obtain the sample of small-scale dairy cow milk farmers in the whole Sub-County. This involves subdividing the small-scale dairy farmers into distinct subgroups or strata based on relevant characteristics. In this study, the four wards in Marakwet East Sub-County, namely Kapyego, Sambirir, Endo and Embobut/Embolot served as the strata. Thirdly, in each ward of the study area, a proportionate size sampling procedure was used to pick respondents for the study as shown in Table 2.

In the last stage, a systematic random sampling technique was used. This sampling involved selecting every n^{th} individual from the sampling frame or the list obtained from the sub-county Agricultural, Livestock, and Fisheries Office. This technique ensures that each individual in the population has an equal chance of being selected.

Table 2. Proportionate Size Sample Distribution per Ward.

Ward	Target Population	Proportion	Sample Size
Kapyego	2,108	25.20%	58
Sambirir	1,419	17.00%	39
Endo	2,028	24.20%	56
Embobut	2,809	33.60%	77
Total	8,364	100%	230

Source: Author's Computation from Marakwet East Sub-County Livestock and Fisheries Annual Report (2022).

2.6. Data Collection Instrument, Validity and Reliability

In this study, primary data was collected directly from the small-scale dairy farmers using a questionnaire. The questionnaire was administered to 230 small-scale dairy farmers by the research team that comprised the researcher and nine trained research assistants.

To establish the validity of the research instrument for this study, two measures were used. Firstly, the validity of the instruments was ensured through a comprehensive literature review and expert opinions [22]. Secondly, in this study, validity was achieved by discussion with the two university supervisors on the items in the instrument, which is expert opinion. The two experts have extensive experience in teaching and supervising postgraduate students. They were able to ascertain the validity by the clarity of wording and

whether the respondents were able to interpret all questions similarly. Suggestions were then incorporated into the final instruments.

To ensure the reliability of the questionnaire, several measures were implemented. Firstly, internal consistency reliability is assessed using Cronbach's Alpha technique to measure the inter-item reliability of scales [23]. A pilot scope of between 1% and 10% is considered suitable. For this study, reliability was tested by pretesting the instrument with a sample of 22 (10% of the sample population) small-scale dairy cattle farmers in Marakwet West Sub-County of Elgeyo Marakwet County. Marakwet West Sub-County has similar characteristics to the study sample but was not part of the study. Data from the pilot study was analysed using Cronbach's Alpha coefficient, mathematically expressed as shown in Equation 2 below. A coefficient of 0.7 and above was deemed reliable.

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

Where á 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.

2.7. Data Collection Procedure

Before commencing data collection, a research permit was obtained from the National Commission for Science Technology and Innovation (NACOSTI) number (NACOSTI/P/24/33043). Additional mandatory legal authorization permits were obtained from Elgeyo Marakwet County Commissioner and the Ministry of Education. Subsequently, the researcher contacted and scheduled appointments with small-scale dairy cow farmers in Marakwet East Sub-County. Household heads served as the primary respondents during interviews, with spouses or knowledgeable individuals within the household being interviewed in cases where the household head is unavailable. These procedures were designed to facilitate legal, ethical, and efficient data collection while obtaining the necessary approvals and participant cooperation.

2.8. Data Analysis and Presentation

The initial data screening upon completion of the questionnaires was done by sorting, coding, and cleaning. The data sources were then numbered and coded using a coding frame in readiness for entry and analysis. The collected data were analysed using both descriptive and inferential statistics. Descriptive statistics were used to summarize the characteristics of the variables, including measures of central tendency (mean) and variability (standard deviation). Frequency distributions and percentages were used for categorical variables. Inferential analysis was done for each specific objective with the help of IBM Statistical Packages for Social Sciences (SPSS) version 28.0.1.1 software as specified for each of the specific objectives as follows.

To assess the effects of farm-specific socioeconomic factors affecting milk production among small-scale dairy farmers in Marakwet East Sub-County, Kenya, a multiple linear regression model was employed as shown in Equation 3.3 below. This model is suitable because it allows us to analyse how various socio-economic variables jointly influence milk production. The use of multiple linear regression is also appropriate because it accommodates several independent variables simultaneously and helps identify the strength and direction of their relationships with the dependent variable.

$$Y_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon_i \quad (3)$$

Where:
Yi= Milk production (Milk yield)
X_1= Age of household head
X_2= Gender of household head
X_3= Marital status
X_4= Education level
X_5= Family/household size
X_6= Farmer's occupation
X_7= Farmer's years of experience
X_8= Total farmer income
$\beta_1, \beta_2, \ldots, \beta_8$ are the regression coefficients estimated.
ε = is the error term that is normally distributed with a mean of zero and constant variance of epsilon squared (ϵ^2), and included in the model to account for other factors that are not included in the model but affected the performance.

Diagnostic tests were conducted on the regression results obtained from the analytical approach, specifically the SPSS output. These tests aimed to assess the assumptions underlying the chosen analytical model, which in this study was multiple linear regression using Ordinary Least Squares. The main diagnostic test was multicollinearity, which refers to the correlation between independent variables and was assessed using the Variance Inflation Factor (VIF). The VIF measures the extent to which the variance of an estimated regression coefficient is inflated due to multicollinearity. A VIF of 1 indicates no correlation, while values between 1 and 5 suggest a moderate correlation that does not require corrective measures. VIFs greater than 5 indicate severe multicollinearity, which can lead to unreliable coefficient estimates and questionable p-values [24].

$$\text{VIF} = \frac{1}{1-R^2} \quad (4)$$

3. Results and Discussion

This section presents the major findings of the study and discusses it in comparison with the results of other studies. Both descriptive and econometric methods were used to analyze the primary data. Descriptive statistics was employed to describe the general socio-economic characteristics of sample respondents. Econometric analysis was further used to identify socio-economic factors affecting dairy cow milk production in the study areas.

3.1. Response Rate and Reliability of Questionnaire

For this study, a sample size of 220 small-scale dairy farmer households was selected to take part in the study. From the sampled small-scale dairy farmer households, only a total of 196 questionnaires were duly filled by the farmers' and returned for data analysis. The duly filled and returned questionnaires represented a response rate of 89.0%. The overall return rate was suitable for data analysis. A response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and over is excellent [25]. Therefore, for this study, the response rate of 89% was excellent for analysis and reporting.

The overall reliability of the questionnaire was 0.79. A reliability value above 0.6 is adequate to accept the research instrument's internal consistency [26]. Therefore the high reliability value above 0.6 showed that the questionnaires were good for analysis.

3.2. Descriptive Statistics for Socio-Economic Characteristics of Sampled Households

A summary of statistics results on the continuous socio-economic characteristics of small-scale dairy farmers is shown in Table 3.

Table 3. *Socio-Economic Characteristics of the Sampled Small-Scale Dairy Farmers for Continuous Variables.*

Variable	Mean	Std. Dev.	Min.
Age of the household heads (Years)	47	8.1	28
Family size (Number)	5	2	3
Farmer experience (Years)	16.8	8.1	3
Total farm income [50]†	900	250	100

Source: Author's computation from Survey Data (2024)
†Converted from Kenya Shillings (KSH) to USD at the rate of 1 KSH = 0.0078 USD.

The mean age of the household heads of the small-scale dairy farmers in the study area was 47 years, with a minimum of 28 years and a maximum of 60 years. The current findings indicate that a higher proportion of farmers were old due to the possible migration of the youths to towns to look for better opportunities at the expense of livestock farming [27]. The high number of older farmers population in the dairy industry production may also be related to the fact that land ownership is quite hard for young people to acquire. The current results are in convergence with other study findings such as those of [28] who found that the mean age among livestock farmers in Tigania East Sub-County in Meru County was 46 years. Further, the mean ages of livestock farmers were 44.8 years and 45.4 years in Kajiado and Makueni Counties, respectively [29]. The current results also converge with the mean age of 46 years for ruminant farmers in Northern Ghana [30], and 47 years for dairy farmers in Mekelle, South Africa [31] as well as 45 years age among livestock farmers in the West Region of Cameroon [32].

The result on family/household size indicates that there were 5 members in each family, where the minimum number was 3 and a maximum of 10 members. The number of members in the family is an important source of labour for the farms. Few members of the households therefore imply inadequate and unreliable farm labour supply thus negatively impacting milk production. The current result concurs with the provincial and national average family size of 5 members in Kenya [17]. This result also compares well with a study finding [33] conducted in Kiganjo Sub-location in Kiambu and found the mean size to be 5 members, small-scale farmers in Western Kenya which reported 5 members per household [34]. Elsewhere, the current study compares well with the mean number of 5 members among small-scale livestock farmers in Dodoma and Morogoro located in Tanzania [35], as well as the mean age of 5 members among livestock farmers in three regions of Mayange in Rwanda, Mwandama in Malawi and Ruhiira in Uganda [36]. Nevertheless, the current results of 5 members in a household are lower than the 12 household members reported among pastoral farmers adopting artificial insemination in Narok and Kajiado counties of Kenya [37]. The current household size is also much lower than the 10 reported in a research study on pastoral households in Ghana [38].

From the results, the overall farmer's years of experience in livestock production in the study area was 16.8 years, which ranged from a minimum of 3 years to a maximum of 30 years. The current results suggest that the small-scale farmers had attained enough experience that positively influenced their levels of dairy production. The current results show similarity with a study of farmers' experience in other regions of Kenya. Such previous research studies include that of Job and others [14], who found the mean years of farmers' experience to be 16.76 years for dairy farmers in Mosop Sub County, Nandi County. Likewise, in Central Kenya, a study on factors influencing economic efficiency of milk production among

small-scale dairy farms in Mukurweini, Nyeri County, the mean years of farmers' experience was 16.7 years [39]. The current years of farmer experience compared to the 16.8 years of communal livestock farmers in Ga-Matlala, Limpopo Province, South Africa [40], 17 years of experience among farmers participating in traditional and modern livestock markets in the Republic of Benin [41], and 16.3 years farmer experience of small-holder cattle farmers in South-Kivu Province, Eastern Democratic Republic of Congo [42].

The results for the mean annual farmer income of the small-scale dairy farmers was 900 USD, with a minimum of 100 USD and a maximum of 2000 USD. Low mean annual farmer income makes many farmers remain vulnerable and experience shocks that have a significant impact on their households since many lack appropriate coping strategies. Although it is often difficult to compare the income of farmers across different countries due to constant fluctuation of the rate of exchange, and cost of living, the current average annual income level of 900 USD which translates to ~75 USD per month in the household and compares well with farmer income in several regions in Nakuru and Nyandarua Counties [43]. The current farmers' income levels were however, lower than in other studies done in Kenya where the income level among small-scale livestock farmers was 1918 during a KIPPRA household survey [44], 2580 USD in Kangema, Murang'a County during a study of the uptake of modern reproductive technologies in dairy cattle [45]. The per capita farmer income in the study area was estimated at 0.40 USD per day, which is indeed low earning compared to a world recommended standard per capita of ~5.50 USD per day for upper-middle-income countries, as well as ~3.20 USD per day in lower-middle-income countries that reported a mean per capita of ~2 USD per day. The country's results confirm previous findings of low income among livestock farmers including dairy farmers in Sub-Saharan Africa [46].

A summary of statistics results on the nominal socio-economic characteristics of small-scale dairy farmers is in Table 4.

Table 4. *Socio-Economic Variables of Sampled Small-Scale Dairy Farmers for Nominal Variables.*

Variable	Frequency (n=196)	Percent
Gender		
Male	129	65.8
Female	67	34.2
Marital status		
Single	7	3.6
Married	177	90.3
Widowed shown	12	6.1
Level of education		
Primary	104	53.1
Secondary	83	42.3
College	9	4.6
Farmer occupation		
Full-time farmer	124	63.3
Part-time farmer	18	9.2
Fully employed	42	21.4
Trader	12	6.1

Source: Author's computation from Survey Data (2024)

The summary statistic results on the gender of the household head of the small-scale dairy farmers show that 65.8% were males while 34.2% were females. The results show that smallholder dairy cattle farming in Marakwet East Sub-County is male-dominated, as more men are involved than women. This was not surprising since in African society, most of the households are headed by males who are in charge of the land and livestock resources. The result of the current study compares well with gender differences in Eastern and Western regions of Kenya where 77% of the households are male-headed compared to female-headed households [47]. The current study agrees also with several other studies on the gender composition of the livestock farming communities in Sub-Saharan Africa. In Free State South Africa, [48], males were 87.6% and females were 12.4% in a study on socioeconomic factors influencing livestock production among smallholder farmers. In three Regions of Nigeria, a study on socio-economic characteristics of subsistent small ruminant farmers [49], males were 71.5% and females were 28.5%, which is almost in convergence with the current study finding.

Statistics results on marital status indicate that 90.3% of small-scale dairy cow milk-producing farmers were married, 6.1% were widowed and 3.6% were single. The high number of married small-scale dairy farmers in Marakwet East Sub County is not surprising since most of the household heads are mature and belong to the elderly category in a region where marriage is appreciated. Many African men at the age above 26 years are often married. These results converge with others on the marital status of household heads in Africa. A study on factors influencing milk production among small-scale dairy farmers in Bomet County, Kenya [50], also found that 90% of the dairy farmers were married, which is in convergence with the current study findings.

The result on the level of education of the small-scale dairy farmers showed that a large number of the small-scale farmers had primary levels of education (53.1%) followed by sec-

ondary levels of education (42.3%) and the least being college level of education (4.6%). These results imply that the low levels of literacy among farmers hinder their economic and commercial engagement in dairy production in the study area. Low levels of education and literacy among small-scale farmers lead to poor animal feed production practices, conservation, and utilization which negatively impact milk production. Kenya has a literacy level of 78% where 54% have secondary education [17]. Education is significant in enhancing productivity among farming households. This was likely because household heads with education are more likely to adopt new technologies and innovations that are vital for productivity enhancement. Generally, the more educated people are, the more efficient producers they become [51]. The high proportion of primary-level education in the current study converges with other studies that have determined that the majority of Kenyan farmers often drop out of primary or secondary schools to concentrate on farming activities as reported in a study on factors influencing smallholder dairy cattle productivity in Tigania East sub-county, Meru County [28]. In three Regions of Northern Ghana, 64% of males had no formal education, 13% had primary education and 15% had secondary education [30]. However, in a study on determinants of smallholder dairy farmers' access to credit in Uasin Gishu County, Kenya [52], 43.8% of the farmers had attained post-secondary education, which is in divergence from the current study finding.

The results on the main occupation of the farmers show that 63.3% of the farmers were full-time farmers, 21.4%, 9.2% and 6.1% were fully employed, part-time and traders respectively. The current results indicate that most of the small-scale farmers are more involved in dairy production by being full-time farmers which may positively impact dairy production if they make the right investments in terms of quality dairy breeds, housing and feeds. This result agrees with the study by [43] among dairy farmers in Nakuru and Nyandarua counties who found that 81.1% of farmers in the study area depend on farming as their main source of occupation. The current results converge with the study by [48] among farmers in Free State in South Africa who found that 77.2% of the respondents' main occupation was farming, while 12.8% were employed and 10% were doing business. In Boditti, South Ethiopia, 48.5% of the small-scale farmers' occupations were farming activities, 25% were government workers and 16.7% were traders [53]. The current result is dissimilar from the finding in a study on fodder production on smallholder farmers' household income in Homa Bay County, Kenya, where it was found that 40% of livestock farmers had formal employment while 18.3% indicated that livestock farming was their main occupation [54].

3.3. Descriptive Results for Dairy Cow Milk Production

Table 5 shows the average annual milk production per household, the average annual milk production per cow, the average daily milk production per cow, the average daily average per household, the average number of dairy cows per household, and the average number of lactating cows per household.

Table 5. *Milk Production Statistics in Marakwet East Sub County.*

Milk production (litres)	Mean	Std. Dev
Average annual milk production per household	2,925	211
Average annual milk production per cow	975	101
Average daily milk production per cow	4.5	0.4

Source: Author's computation from Survey Data (2024)

The result in Table 5 of the results shows that the total average annual milk production per household is 2,925.2 litres in Marakwet East Sub County. The current milk production per household is lower than the per household milk production values reported in developed countries such as those found in a study on the analysis of milk production and failure data using unit exponentiated half logistic power series class of distributions where 12,450 litres were reported in the USA [55]. In another study on the organic milk production and dairy farming constraints and prospects under the laws of the European Union [56], results revealed that an average total of 8,675 litres of milk per household annually was produced in the European Union. The current annual milk production per household is also lower than in another study on household dairy production, dairy intake, and anthropometric outcomes in rural Bangladesh which reported that milk production per household was 5,150 litres [57]. A dissimilar result was also found in the study on the economic efficiency of milk production among smallscale dairy farmers in Mukurweini, Nyeri County, Kenya [58], which found that the annual milk production per household was 4,500 litres.

Results also show that the average household annual milk production per cow was 975 litres which was similar among the wards of Marakwet East Sub-County. The current milk

production per cow per annum was lower than the national milk production average of 2,359 litres reported in a study on the impact of ICT-based extension services on dairy production and household welfare: the case of iCow service in Kenya [59]. The milk production per cow in the current study was lower than values reported in Kenya during a study on the effects of *Calliandra* and *Sesbania* on daily milk production where a total annual cow milk production was 1,300 litres per cow per year [60]. In a milk symposium review on the sustainability of dairy production and consumption in low-income countries, the production values for the USA were reported as 24,630 litres per cow per year [61]. In addition, in a study on a multi-scale framework for advancing national dairy sector mitigation in Israel, it was reported that the average milk production was 13,043 litres per cow per year [62]. Furthermore, in a study on the factors shaping cow's milk production in the European Union, milk production was reported as 7,960 litres per cow per year [63]. According to the study on the Australian cattle herd: A New Perspective on Structure, performance and Production, the total milk production was 5,782 litres per cow per year [64], while in China, in a study on heat stress taking a toll on milk production, the findings indicated that milk production was 5695 litres per cow annually [65]. However, the current production level per year per cow is higher than one values reported in a study on modelling and forecasting of milk production in Chhattisgarh and India which indicate that milk production was 766 litres per cow per year [9].

Further, results revealed that the household average daily milk production per cow was 4.5 litres. The current milk production in the study area is lower than the 10 to 12 litres per cow per day achievable under optimal dairy farming conditions in Kenya [66]. This shows that cows in the study area produced less milk per day due to several challenges faced by farmers. The current milk production per cow was also lower than milk production per cow found in a study on the determinants of utilization of agricultural technologies among smallholder dairy farmers in Kenya where 14.3 litres/cow/day was reported in Murang'a [67]. The current results on milk production were also lower than milk production per cow found in a study on smallholder dairy production in high altitude Nyandarua milk shed in Kenya where 8.42 ± 3.29 litres/cow/day was reported [29]. A study on the assessment of the performance of small-scale dairy farming in Meru County, Kenya [68], found that the average daily milk production per cow among small-scale farmers in Tigania was 21 litres per day which is higher than the current study values. The current study results are also lower than the results found in a study on the household characteristics, production and quality of bovine milk from crossbred dairy stock in the rural dairy production system of Ethiopia, which reported that milk production per cow per day was 6.3 to 6.7 litres [69]. Higher milk production of 10 litres per day was also reported in the study on socioeconomic characteristics of dairy production in selected areas of the Central Highlands of Ethiopia [70].

3.4. Diagnostic Test Results

The diagnostic results were tested for multicollinearity using tolerance and Variance Inflation Factors (VIF) as shown in Table 6 of the results. The results in Table 6 show that all the variables under study had a VIF ranging between 1.061 and 2.365 and also tolerance values ranging from 0.423 to 0.943, which show that there were no potential multicollinearity symptoms among the predictors and hence found to have no potential influence on the estimates from the model. These were the indicators that there was a low correlation among the variables under consideration.

Table 6. *Estimates of Multicollinearity Statistics.*

Variables	Multicollinearity statistics	
	Tolerance	VIF
Age of the household head	0.739	1.354
Gender of the household head	0.677	1.477
Marital status	0.734	1.362
Levels of education	0.733	1.364
Family/Household size	0.631	1.585
Farmer's occupation	0.731	1.367
Farmer's experience	0.535	1.871
Total farmer income	0.631	1.584

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

3.5. Econometric Model Analytical Results

The estimated results on the effects of socio-economic factors on dairy cow milk production are shown in Table 7 of results. The results, the value of R-Square indicate the goodness of fit of the linear regression. R-square and Adjusted R Square values are 0.800 and 0.791 respectively, which means that 79.1% of the total variation in the dependent variable (milk yield) is attributed to the socio-economic factors and the remaining 20.9% lies within the error term in the regression model for this study.

Analysis of Variance (ANOVA) test was conducted to test the significance of the relationship between the independent variables (socio-economic factors) and dependent variable (milk production) by predicting the power of the model with that of an intercept-only model [71]. The results established from the ANOVA test results show that the *P*-value is <0.01. This indicates a statistically significant relationship between milk production and socioeconomic factors, which implies that socioeconomic factors affect milk production to a large extent.

Table 7. Estimated Results on Effects of Socio-Economic Factors on Dairy Cow Milk Production.

Regression Statistics	
Model summary	
Multiple R	0.894
R Square	0.8
Adjusted R Square	0.791
Observations	196
Standard Error	1.083

ANOVA	**SS**	**df**	**MS**	**F**	**P-value**
Regression	877.925	8	109.741	93.414	<0.01
Residual	219.683	188	1.175		
Total	1,097.61	196			

	Unstandardized Coefficients		**Standardized Coefficients**	**t Stat**	**P-value**
	Beta	**Std. Error**	**Beta**		
(Constant)	4.899	0.666		7.356	0
Age of household head	0.009	0.011	0.033	0.871	0.385
Gender of household head	0.212	0.198	0.043	1.069	0.286
Marital status	-0.107	0.173	-0.024	-0.617	0.538
Education level	0.602	0.088	0.27	7.054	0.000**
Family/household size	1.091	0.155	0.28	6.811	0.000**
Farmer's occupation	0.188	0.09	0.072	2.187	0.061
Farmer's experience	1.311	0.015	0.332	7.414	0.000**
Total farmer income	1.122	0.034	0.312	7.58	0.000**

** = significant at $\alpha = 0.01\%$
Source: Author's Computation from Survey Data (2024)

The results of the multiple linear regression analysis, the level of education, family/household size, farmer's experience and total farmer income were all statistically significant at a 1% level and influenced dairy cow milk production. The rest of the socio-economic factors were insignificant in dairy cow milk production among the small-scale dairy farmers.

The education level of the household head was statistically significant at a 1% level with a positive coefficient of 0.602. This implies that, as the level of education of the household head increases by one unit, there is a probable increase in milk production among small-scale farmers by 60.2% when other factors are kept constant. This implies that as the farmer attains a higher level of education, he has a better understanding of dairy farming and increases milk production from their dairy cows. Likewise, household heads with education are more likely to adopt new technologies, innovations, and best husbandry practices pivotal for improving dairy cow milk production. The current findings on the level of education of the household head are in convergence with a study in Zimbabwe on factors affecting milk production in the smallholder dairy sector [72] who found that the education level of the farmers facilitated a positive attitude toward appreciating new dairy technologies and hence increased milk production. Education improves knowledge, management skills and absorptive capacity of new ideas which are important to drive milk production [73]. Farmers who acquire higher levels of

education are more inclined to practice and benefit from livestock production technologies such as improved dairy breeds, better breeding technologies, and improved feed technologies compared to the ones who have no formal education due to their higher levels of technical knowledge concerning livestock husbandry. The literacy level of farmers may also determine the rate of adoption of improved livestock production technology and directly affect their capacity to absorb new ideas that could affect milk production [74].

The household size of the smallholder dairy farmer was statistically significant at a 1% level with a positive coefficient of 1.091. This implies that as the family/household size increases by one additional member, there is a probable increase in milk production among small-scale farmers by 109% when other factors are kept constant. In Kenya, dairy production is largely subsistence, and off-farm income opportunities are limited in rural areas of Kenya, the positive association between household size and increased milk production is indeed not surprising. This could be attributed to the fact that a large household size acts as a source of cheap family labour thereby increasing the family's chances of more milk production. Relatively larger households would mean increased labour supply and also an incentive for increased farm productivity [75]. The current result is in agreement with a study on the economic efficiency of milk production among small-scale dairy farmers in Mukurweini Sub-county, Nyeri Kenya [76] which found that the size of the household positively affected milk production efficiency. In a study on the determinants of market participation among smallholder farmers in Southwest Ethiopia [77], family size was statistically significant where a one-person increase in family size decreased the level of participation by 3.6% which is in divergence with the current study. In a study, the household size was positive (0.044) and statistically significant on access to credit among smallholder dairy farmers in Bomet County, Kenya [50] which is also in divergence from the current study finding.

Farmer's years of experience in dairy production was statistically significant at a 1% level with a positive coefficient of 1.311. This implies that an increase of one year of farmers' experience increases the probability of milk production among small-scale farmers by 131% when other factors are kept constant. Many years in dairy farming imply that farmers are experienced in managing their dairy cattle better for improved milk productivity. The current study findings were in convergence that farmers with experience utilized their long-term acquired knowledge and skills to reduce risks related to dairying and the management of diseases. Further, the current study agrees with another study [78], which showed that experience assists in making decisions and allocation of resources which means that the more experience one has, the wiser decisions are being made in terms of allocating resources to new technologies such as artificial insemination, improving the breeds and breeding that may enhance milk production. This result is in line with previous in Mukurweini, Nyeri County, Kenya which have shown that a high farming experience would be related to high milk production [79].

Total farmer's income was statistically significant at a 1% level with a positive coefficient of 1.122. This implies that as the household income increases by one unit, there would be a probable increase in milk production among small-scale farmers by 112% when other factors are kept constant. This implies that farmers with high income can have a high probability of purchasing required machinery, feeds, and requirement health management facilities that may increase dairy production.

4. Conclusion and Policy Implications

The results of socio-economic factors indicated that small-scale dairy farmers were dominated by married males, aged 47.1 years, with a primary level of education, family size of 5 members, farmer experience of 16.8 years, doing full-time farming, with an income level of 900 USD. The multiple linear regression results show that 79.1% of the total variation in the dependent variable (dairy cow milk production) is accounted for by the socio-economic factors while the remaining 20.9% is attributed to other factors not specified in this study model. To increase dairy cow milk production in Marakwet East Sub-County, small-scale farmers need to increase the levels of education of the household heads, the family/household size, the years of dairying experience and the total farmer's income.

The study showed that smallholder dairy cattle production factors such as level of education, family/household size, farmer's experience and total farmer income increase the dairy cow milk production in the study area. Therefore, strategies such as promotion to pursue further education, increase in family, farmer's experience and total income are aimed at improving milk production among small-scale farmers and should be encouraged. More women and youth to be proactive in dairy husbandry, more single people to take up milk production activities and encouraging farmers in other occupations to give more time to milk production.

Abbreviations

AEZ	Agricultural Ecological Zone
ANOVA	Analysis of Variance
GDP	Gross Domestic Product
ICT	Information and Communication Technology
KM^2	Square Kilometres
KSH	Kenya Shillings
MMT	Million Metric Tons
NACOSTI	National Commission for Science Technology & Innovation
PA	Per Annum
UK	United Kingdom
USA	United Sates of America

USD	United States Dollar
SPSS	Statistical Package for Social Sciences
VIF	Variance Inflation Factor

Acknowledgments

The authors sincerely thank Mr. Joseph Kibor, Barnabas Kimutai, Joseph Kitum and Robert Yego for assistance in field data collection among the small-scale dairy farmers of Marakwet East Sub County, Kenya. The authors also thank the respondents who willingly responded to the administered questionnaire. This study was granted by the University of Eldoret.

Author Contributions

Richard Kaino Chelanga: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing

Elijah Kiplangat Ng'eno: Supervision, Validation, Visualization, Writing – review & editing

Joseph Amesa Omega: Supervision, Validation, Visualization, Writing – review & editing

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Henchion, M., A. Moloney, J. Hyland, J. Zimmermann, and S. McCarthy, Trends for meat, milk and egg consumption for the next decades and the role played by livestock systems in the global production of proteins. Animal, 2021. 15: p. 100287. https://doi.org/10.1016/j.animal.2021.100287

[2] Bojovic, M. and A. McGregor, A review of megatrends in the global dairy sector: what are the socioecological implications? Agriculture and Human Values, 2023. 40(1): p. 373-394. https://doi.org/10.1007/s10460-022-10338-x

[3] Duan, Y., Q. Lai, S. Li, Z. Liu, and C. Yang. Analysis of the Development of the Dairy Industry During COVID-19. in 2022 7th International Conference on Social Sciences and Economic Development (ICSSED 2022). 2022. Atlantis Press. https://doi.org/10.2991/aebmr.k.220405.064

[4] Owusu-Apenten, R. and E. Vieira, Dairy Products, in Elementary Food Science. 2022, Springer. p. 399-431. https://doi.org/10.1007/978-3-030-65433-7

[5] FAO, Dairy market review: Emerging trends and outlook. 2022: Rome, Italy.

[6] Van Heerden, B., A changing dairy world: 2000–2020–2040 Special types of milk. The Dairy Mail, 2019. 26(9): p. 10-13. https://hdl.handle.net/10520/EJC-17f825fcd6

[7] Lema, Z., L. A. Lobry de Bruyn, G. R. Marshall, R. Roschinsky, M. Gebreyes, and A. J. Duncan, The influence of multilevel innovation platforms on continuing utilization of smallholders' livestock feeding practices. Innovation and Development, 2023: p. 1-26. https://doi.org/10.1080/2157930X.2023.2178877

[8] Monica, K., Influence of dairy farming practices on milk production. A critical literature review. Animal Health Journal, 2022. 3(1): p. 1-15. https://doi.org/10.47941/ahj.771

[9] Mishra, P., C. Fatih, H. Niranjan, S. Tiwari, M. Devi, and A. Dubey, Modelling and forecasting of milk production in Chhattisgarh and India. Indian Journal of Animal Research, 2020. 54(7): p. 912-917. https://doi.org/10.18805/ijar.B-3918

[10] Merem, E., Y. Twumasi, J. Wesley, D. Olagbegi, M. Crisler, C. Romorno, M. Alsarari, P. Isokpehi, A. Hines, and G. Hirse, The Analysis of Dairy Production and Milk Use in Africa Using GIS. Food and Public Health, 2022. 12(1): p. 14-28. https://doi.org/10.5923/j.fph.20221201.03

[11] Nyokabi, S. N., Bridging the gap: improving milk quality on smallholder dairy systems in Kenya. 2023, Wageningen University. https://doi.org/10.18174/579689

[12] County Government of Elgeyo Marakwet, County Integrated Development Plan (CIPD II) 2018-2022: The Popular Version. 2018: Iten, Elgeyo Marakewet. p. 1-52.

[13] Oloo, R. D., R. Mrode, J. Bennewitz, C. C. Ekine-Dzivenu, J. M. Ojango, G. Gebreyohanes, O. A. Mwai, and M. G. Chagunda, Potential for quantifying general environmental resilience of dairy cattle in sub-Saharan Africa using deviations in milk yield. Frontiers in Genetics, 2023. 14: p. 1208158. https://doi.org/10.3389/fgene.2023.1208158

[14] Job, K. K., K. Elijah, and K. K. Joash, Factors affecting adoption of dairy cattle milk production technologies in Mosop Sub County, Nandi County, Kenya. African Journal of Agricultural Research, 2020. 15(1): p. 140-148. https://doi.org/10.5897/AJAR2019.14432

[15] Kipaya, K. G., P. Nguhiu, and L. Munga, Socio-economic factors influencing the adoption of improved livestock farming practices among members of livestock cooperatives in Kajiado County, Kenya. World J. Innov. Res, 2020. 8: p. 1-9.

[16] Khalangre, K. D. and M. Suryawanshi, Socio-Economic Profile of Dairy Farmers in Maharashtra: A Case Study of Latur District. ICRRD Journal, 2024. 5(1): p. 109-115. https://doi.org/10.53272/icrrd

[17] Kenya National Bureau of Statistics, The 2019 Kenya population and housing census. Nairobi: Kenya National Bureau of Statistics, 2019.

[18] Siedlecki, S. L., Understanding descriptive research designs and methods. Clinical Nurse Specialist, 2020. 34(1): p. 8-12. https://doi.org/10.1097/NUR.0000000000000493

[19] Maier, C., J. B. Thatcher, V. Grover, and Y. K. Dwivedi, Cross-sectional research: A critical perspective, use cases, and recommendations for IS research. 2023, Elsevier. p. 102625. https://doi.org/10.1016/j.ijinfomgt.2023.10262

[20] Kaplan, R., D. Chambers, and R. Glasgow, Big data and large sample size: A cautionary note on the potential for bias. Clin Transl Sci. 2014; 7: 342–346. https://doi.org/10.1111/cts.12178

[21] Mweshi, G. K. and K. Sakyi, Application of sampling methods for the research design. Archives of Business Review–Vol, 2020. 8(11): p. 180-193. https://doi.org/10.14738/abr.811.9042

[22] Sürücü, L. and A. Maslakci, Validity and reliability in quantitative research. Business & Management Studies: An International Journal, 2020. 8(3): p. 2694-2726. https://doi.org/10.15295/bmij.v8i3.1540

[23] Izah, S. C., L. Sylva, and M. Hait, Cronbach's Alpha: A Cornerstone in Ensuring Reliability and Validity in Environmental Health Assessment. ES Energy & Environment, 2023. 23: p. 1057. https://dx.doi.org/10.30919/esee1057

[24] Bayman, E. O. and F. Dexter, Multicollinearity in logistic regression models. 2021, LWW. p. 362-365. https://doi.org/10.1213/ANE.0000000000005593

[25] Nulty, D. D., The adequacy of response rates to online and paper surveys: what can be done? Assessment & evaluation in higher education, 2008. 33(3): p. 301-314. https://doi.org/10.1080/02602930701293231

[26] Murphy, J. J., M. H. Murphy, C. MacDonncha, N. Murphy, A. M. Nevill, and C. B. Woods, Validity and reliability of three self-report instruments for assessing attainment of physical activity guidelines in university students. Measurement in Physical Education and Exercise Science, 2017. 21(3): p. 134-141. https://doi.org/10.1080/1091367X.2017.1297711

[27] Mueller, V., C. Doss, and A. Quisumbing, Youth migration and labour constraints in African agrarian households, in The Transformation of Rural Africa. 2020, Routledge. p. 101-128. https://doi.org/10.1080/00220388.2018.1430770

[28] Kirea, J. A., Factors influencing smallholder dairy cattle productivity in Tigania East sub-county, Meru County. 2023. http://repository.seku.ac.ke/handle/123456789/7346

[29] Muia, J., J. Kariuki, P. Mbugua, C. Gachuiri, L. Lukibisi, W. Ayako, and W. Ngunjiri, Smallholder dairy production in high altitude Nyandarua milk-shed in Kenya: Status, challenges and opportunities. Livestock Research for Rural Development, 2011. 23(5): p. 2011.

[30] Adams, F. and K. Ohene-Yankyera, Socio-economic characteristics of subsistent small ruminant farmers in three regions of northern Ghana. Asian Journal of applied science and engineering, 2014. 3(3): p. 351-364. https://doi.org/10.15590/ajase/2014/v3i8/54489

[31] Elum, Z. A., D. M. Modise, and A. Marr, Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. Climate Risk Management, 2017. 16: p. 246-257. https://doi.org/10.1016/j.crm.2016.11.001

[32] Oben, E. E. E., H. N. Ndi, and L. B. Tchuikoua, Livestock farmers' willingness to pay for farming insurance in four divisions of the West Region of Cameroon. Asian Journal of Geographical Research, 2024. 7(1): p. 24-38. https://doi.org/10.9734/ajgr/2024/v7i1211

[33] Wanjala, C. N., Impact of Land Size and Land Use Change on Rural Livelihood in Dairy Farming Zones in Kenya: the Case of Kiganjo Sublocation in Kiambu-Kenya. 2023, University of Nairobi. http://erepository.uonbi.ac.ke/handle/11295/163899

[34] Musafiri, C. M., M. Kiboi, J. Macharia, O. K. Ng'etich, D. K. Kosgei, B. Mulianga, M. Okoti, and F. K. Ngetich, Adoption of climate-smart agricultural practices among smallholder farmers in Western Kenya: do socioeconomic, institutional, and biophysical factors matter? Heliyon, 2022. 8(1). https://doi.org/10.1016/j.heliyon.2021.e08677

[35] Bundala, N., J. Kinabo, T. Jumbe, C. Rybak, and S. Sieber, Does homestead livestock production and ownership contribute to consumption of animal source foods? A pre-intervention assessment of rural farming communities in Tanzania. Scientific African, 2020. 7: p. e00252. https://doi.org/10.1016/j.sciaf.2019.e00252

[36] Hetherington, J. B., A. K. Wiethoelter, J. Negin, and S. M. Mor, Livestock ownership, animal source foods and child nutritional outcomes in seven rural village clusters in Sub-Saharan Africa. Agriculture & Food Security, 2017. 6: p. 1-11. https://doi.org/10.1186/s40066-016-0079-z

[37] Khainga, D., G. Obare, and A. Murage, Ex-ante perceptions and knowledge of artificial insemination among pastoralists in Kenya. Livestock Research for Rural Development, 2015. 27(4): p. 1-11.

[38] Nuvey, F. S., K. Kreppel, P. A. Nortey, A. Addo-Lartey, B. Sarfo, G. Fokou, D. K. Ameme, E. Kenu, S. Sackey, and K. K. Addo, Poor mental health of livestock farmers in Africa: a mixed methods case study from Ghana. BMC public health, 2020. 20: p. 1-12. https://doi.org/10.1186/s12889-020-08949-2

[39] Kimenchu, M. D., M. Mwangi, W. S. Kairu, and G. A. Macharia, Characterization and profitability assessment of dairy farms in Central Kenya. International Journal of Innovative Research and Development, 2014. 3(9): p. 82-90.

[40] Monkwe, T., M. Gxasheka, and B. Gunya, Challenges and perception of communal farmers on cattle production in Ga-Matlala, Limpopo Province, South Africa. Heliyon, 2023. 9(3). https://doi.org/10.1016/j.heliyon.2023.e14190

[41] Akouegnonhou, O. and N. Demirbaş, Factors affecting the income of farmers participating in traditional and modern livestock markets: case study from Benin Republic. Selcuk Journal of Agriculture and Food Sciences, 2021. 35(3): p. 210-217. http://sjafs.selcuk.edu.tr/sjafs/index

[42] Mugumaarhahama, Y., R. B. B. Ayagirwe, V. B. Mutwedu, N. C. Cirezi, D. S. Wasso, P. C. Azine, and K. Karume, Characterization of smallholder cattle production systems in South-Kivu province, eastern Democratic Republic of Congo. Pastoralism, 2021. 11: p. 1-15. https://doi.org/10.1186/s13570-020-00187-w

[43] Otieno, G., K. Muendo, and R. Mbeche, Smallholder dairy farming characterisation, typologies and determinants in Nakuru and Nyandarua counties, Kenya. Journal of Agriculture, Science and Technology, 2021. 20(1): p. 1-23.

[44] Karlyn, A., Comparative analysis of smallholder farmers in Kenya, Zambia and Tanzania, in Comparing results from FinScope Tanzania 2017 and AFA benchmark studies in Kenya and Zambia, R. S. Africa, Editor. 2017, Welcome.

[45] Susan, K., E. L. Chimoita, J. Mburu, and T. Wanjala, The effectiveness of communication channels for the uptake of modern reproductive technologies in dairy cattle: The case of Kangema, Murang'a County, Republic of Kenya. International Journal, 2019. 5(2): p. 242-249. http://erepository.uonbi.ac.ke/handle/11295/153234

[46] Erdaw, M. M., Contribution, prospects and trends of livestock production in sub-Saharan Africa: a review. International Journal of Agricultural Sustainability, 2023. 21(1): p. 2247776. https://doi.org/10.1080/14735903.2023.2247776

[47] Maina, K. W., C. Ritho, B. A. Lukuyu, and E. Rao, Socio-economic determinants and impact of adopting climate-smart *Brachiaria* grass among dairy farmers in Eastern and Western regions of Kenya. Heliyon, 2020. 6(6). https://doi.org/10.1016/j.heliyon.2020.e04335

[48] Nkonki-Mandleni, B., F. T. Ogunkoya, and A. O. Omotayo, Socioeconomic factors influencing livestock production among smallholder farmers in the free state province of south Africa. International Journal of Entrepreneurship, 2019. 23(1): p. 1-17.

[49] Adisa, R. S. and O. A. Adekunle, Farmer-herdsmen conflicts: A factor analysis of socio-economic conflict variables among arable crop farmers in North Central Nigeria. Journal of Human Ecology, 2010. 30(1): p. 1-9. https://doi.org/10.1080/09709274.2010.11906266

[50] Cheruiyot, M. K. and M. Otieno, Factors influencing milk production project among small scale dairy farmers in Bomet East Sub County, Bomet County, Kenya. Int J Latest Res Engineer Technology (IJLRET), 2017. 3(09): p. 01-23.

[51] Paltasingh, K. R. and P. Goyari, Impact of farmer education on farm productivity under varying technologies: case of paddy growers in India. Agricultural and Food Economics, 2018. 6(1): p. 1-19. https://doi.org/10.1186/s40100-018-0101-9

[52] Mabonga, G., D. Tarus, Y. Kibet, N. Rop, and O. Otieno, Determinants of Smallholder Dairy Farmers Access to Credit: A Case of Uasin Gishu County. African Journal of Education, Science and Technology, 2013. 1(2): p. 53-59. https://doi.org/10.2022/ajest.v1i2.160

[53] Ayza, A., Z. Yilma, and A. Nurfeta, Characterization of milk production systems in and around Boditti, South Ethiopia. Livestock Research for Rural Development, 2013. 25(10).

[54] Ayuko, M. S., J. K. Lagat, M. Hauser, K. O. Ouko, and D. C. Midamba, Effects of fodder production on smallholder farmers' household income in Homa Bay County, Kenya: An application of propensity score matching. Cogent Food & Agriculture, 2024. 10(1): p. 2292868. https://doi.org/10.1080/23311932.2023.2292868

[55] Alghamdi, S. M., M. Shrahili, A. S. Hassan, R. E. Mohamed, I. Elbatal, and M. Elgarhy, Analysis of milk production and failure data: Using unit exponentiated half logistic power series class of distributions. Symmetry, 2023. 15(3): p. 714. https://doi.org/10.3390/sym15030714

[56] Grodkowski, G., M. Gołębiewski, J. Slósarz, K. Grodkowska, P. Kostusiak, T. Sakowski, and K. Puppel, Organic milk production and dairy farming constraints and prospects under the laws of the European Union. Animals, 2023. 13(9): p. 1457. doi: 10.3390/ani13091457

[57] Bakhtiar, M. M. and J. Hoddinott, Household dairy production, dairy intake, and anthropometric outcomes in rural Bangladesh. Food Policy, 2023. 121: p. 102567. https://doi.org/10.1016/j.foodpol.2023.102567

[58] Maina, F., J. Mburu, G. Gitau, J. VanLeeuwen, and Y. Negusse, Economic efficiency of milk production among smallscale dairy farmers in Mukurweini, Nyeri County, Kenya. Journal of Development and Agricultural Economics, 2018. 10(5): p. 152-158. https://doi.org/10.5897/JDAE2017.0915

[59] Marwa, M. E., J. Mburu, R. E. J. Oburu, O. Mwai, and S. Kahumbu, Impact of ICT based extension services on dairy production and household welfare: the case of iCow service in Kenya. Journal of Agricultural Science, 2020. 12(3): p. 1-12. https://doi.org/10.5539/jas.v12n3p141

[60] Makau, D., J. VanLeeuwen, G. Gitau, S. McKenna, C. Walton, J. Muraya, and J. Wichtel, Effects of *Calliandra* and *Sesbania* on daily milk production in dairy cows on commercial smallholder farms in Kenya. Veterinary medicine international, 2020. 2020(1): p. 3262370. https://doi.org/10.1155/2020/3262370

[61] Tricarico, J., E. Kebreab, and M. Wattiaux, MILK Symposium review: Sustainability of dairy production and consumption in low-income countries with emphasis on productivity and environmental impact. Journal of dairy science, 2020. 103(11): p. 9791-9802. https://doi.org/10.3168/jds.2020-18269

[62] Kissinger, M., S. Triky, T. Grinhut, H. Malka, S. Zaban, T. Schcolnik, and G. Adin, A multi-scale framework for advancing national dairy sector GHG mitigation in Israel. Science of the Total Environment, 2024. 926: p. 171705. https://doi.org/10.1016/j.scitotenv.2024.171705

[63] Bórawski, P., A. Pawlewicz, A. Parzonko, J. Harper, K, and L. Holden, Factors shaping cow's milk production in the EU. Sustainability, 2020. 12(1): p. 420. https://doi.org/10.3390/su12010420

[64] Fordyce, G., R. Shephard, T. Moravek, and M. R. McGowan, Australian cattle herd: a new perspective on structure, performance and production. Animal Production Science, 2021. https://doi.org/10.1071/AN20342

[65] Ranjitkar, S., D. Bu, M. Van Wijk, Y. Ma, L. Ma, L. Zhao, J. Shi, C. Liu, and J. Xu, Will heat stress take its toll on milk production in China? Climatic Change, 2020. 161: p. 637-652. https://doi.org/10.1007/s10584-020-02688-4

[66] Odero-Waitituh, J., Smallholder dairy production in Kenya; a review. Livestock Research for Rural Development, 2017. 29(7): p. 139.

[67] Okello, D., G. Owuor, C. Larochelle, E. Gathungu, and P. Mshenga, Determinants of utilization of agricultural technologies among smallholder dairy farmers in Kenya. Journal of Agriculture and Food Research, 2021. 6: p. 100213. https://doi.org/10.1016/j.jafr.2021.100213

[68] Kainda, S., Assessment of the performance of small-scale dairy farming in Meru county, Kenya. 2019, Kenyatta University. http://ir-library.ku.ac.ke/handle/123456789/20134

[69] Yoseph, D., H. L. Didanna, and A. Ayza, Household characteristics, production and quality of bovine milk from crossbred dairy stock in the rural dairy production system of Ethiopia. Journal of Agriculture and Food Research, 2022. 10: p. 100453. https://doi.org/10.1016/j.jafr.2022.100453

[70] Bereda, A., Z. Yilma, M. Eshetu, M. Yousuf, and G. Assefa, Socio-economic characteristics of dairy production in the selected areas of Ethiopian central highlands. Journal of Veterinary Medicine and Animal Health, 2017. 9(8): p. 193-203. https://doi.org/10.5897/JVMAH2017.0588

[71] Stoker, P., G. Tian, and J. Y. Kim, Analysis of variance (ANOVA), in Basic Quantitative Research Methods for Urban Planners. 2020, Routledge. p. 197-219. https://doi.org/10.4324/9780429325021

[72] Paraffin, A. S., T. J. Zindove, and M. Chimonyo, Perceptions of factors affecting milk quality and safety among large-and small-scale dairy farmers in Zimbabwe. Journal of Food Quality, 2018. 2018: p. 1-7. https://doi.org/10.1155/2018/5345874

[73] Nuthall, P. L., Farm business management: the human factor. 2018: CABI.

[74] Mdoda, L. and L. Mdiya, Factors affecting the using information and communication technologies (ICTs) by livestock farmers in the Eastern Cape province. Cogent Social Sciences, 2022. 8(1): p. 2026017. https://doi.org/10.1080/23311886.2022.2026017

[75] Ramos, M. P., E. Custodio, S. Jiménez, M. Sartori, and E. Ferrari, Enhancing labour productivity by improving nutrition in Kenya: micro-econometric estimates for dynamic CGE model calibration. 2022. https://ageconsearch.umn.edu/record/333426

[76] Maina, F., J. Mburu, G. Gitau, and J. VanLeeuwen, Factors influencing economic efficiency of milk production among small-scale dairy farms in Mukurweini, Nyeri County, Kenya. Tropical animal health and production, 2020. 52: p. 533-539. https://doi.org/10.1007/s11250-019-02039-1

[77] Haile, K., E. Gebre, and A. Workye, Determinants of market participation among smallholder farmers in Southwest Ethiopia: double-hurdle model approach. Agriculture & Food Security, 2022. 11(1): p. 18. https://doi.org/10.1186/s40066-022-00358-5

[78] Nyokabi, S., P. A. Luning, I. J. de Boer, L. Korir, E. Muunda, B. O. Bebe, J. Lindahl, B. Bett, and S. J. Oosting, Milk quality and hygiene: Knowledge, attitudes and practices of smallholder dairy farmers in central Kenya. Food Control, 2021. 130: p. 108303. https://doi.org/10.1016/j.foodcont.2021.108303

[79] Maina, F. W., J. Mburu, G. K. Gitau, and J. Van Leeuwen, Assessing the economic efficiency of milk production among small-scale dairy farmers in Mukurweini sub-county, Nyeri County, Kenya. 2018. http://hdl.handle.net/11295/105711

Biography

Richard Kaino Chelanga is a Master of Science (Agricultural Economics) student at the University of Eldoret (Kenya). He attained his Bachelor's Degree in Agribusiness Management at Egerton University (Kenya) in 2016. He currently works at Elgeyo Marakwet County Government, Kenya as County Project Coordinator in charge of Kenya Agricultural Business Development Project co-funded by the County Government, the Kenya Government and the Government of Sweden. Formerly served as Business Development & Commercialization Officer under Agriculture Sector Development Support Programme II (ASDSP II) under the same funding model. He has immense contribution in livestock sub sector specifically in development of training manuals for frontline service providers on livestock productivity, entrepreneurship skills, capacity building & innovation concepts, strategic & integrated value chain action plans for dairy and indigenous chicken value chains in ASDSP II. In addition, he holds a certificate in Senior Management Course from the Kenya School of Government.

Elijah Kiplangat Ng'eno is a Lecturer at the University of Eldoret, Kenya, Department of Applied Economics. He completed his PhD in Agricultural Economics and Resource Management from Moi University in 2018, and his Master of Agricultural Economics and Resource Management from the same institution in 2010. Recognized for his exceptional contributions, Dr. Ng'eno has been the head of the Department of Applied Economics and a Lecturer for over ten (10) years. He has also been honoured with the Information Security Management System (ISMS) Based on ISO/IEC 27001: 2013. In addition, he holds a Diploma in Project Management. He has participated in interdisciplinary regional and international research collaboration projects in recent years. He currently serves on numerous university and community committees and boards and is affiliated with some professional societies. He has also been invited as a Technical Committee Member and co-session chair of an international conference.

Joseph Amesa Omega is a Lecturer at the University of Eldoret, Kenya, Department of Animal Science and Management. He completed his PhD in Animal Science from Chuka University (Kenya) in 2019, and his Master of Science in Veterinary Pathology and Microbiology from the University of Nairobi, Kenya in 1997. He also obtained a post graduate Diploma in Immunity to Infection (Obihiro University of Agriculture and Veterinary Medicine, Japan) in 2003 and a Bachelor of Veterinary Medicine degree from University of Nairobi in 1988. He is the Chairman of Kenya Veterinary Association, Rift Valley Branch, Chairman of Kenya Veterinary Board, and Farm Manager, University of Eldoret Farm. He is registered by the Kenya Veterinary Board and a member of the Kenya Veterinary Association. He has published numerous papers in refereed journal advancing Animal Science. He has also supervised several Msc and PhD students.

Research Field

Richard Kaino Chelanga: Agricultural Economics, Agribusiness Management, Farm Management, Agricultural Marketing, Agricultural Extension, Agricultural Value Chain Development, Climate Smart Agriculture, Agricultural Project Management.

Elijah Kiplangat Ng'eno: Agricultural Economics, Sustainable Development, Resource Economics and climate change and Agricultural Project Management.

Joseph Amesa Omega: Veterinary Pathology, Veterinary Microbiology, Veterinary Parasitology, Veterinary Immunology, Disease Diagnosis, Animal Production, Anti-Microbial Resistance, One Health Policy.