



Participatory Identification and Assessment of Constraints and Opportunities in Dairy Production among Small Scale Farmers in Kericho County, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Background: Dairy farming is the main source of livelihoods and food security, but milk production is low due to various constraints.

Aims: The aim of the current study was to identify and assess the constraints and opportunities in dairy production among small scale dairy farmers in Kericho County, Kenya.

Study Design: Participatory Action Research design was adopted for the study.

Place and Duration of Study: The study was conducted in Ainamoi, Belgut and Bureti sub counties of Kericho County, Kenya, between November ,2024 and November 2025.

Methodology: All small-scale dairy cattle farmers, keeping 1-5 dairy animals, in the County were targeted. Interview schedule was used to collect quantitative data and focus group discussion guide was used to collect qualitative data from 397 participants in the three sub-counties. Quantitative data were analyzed using

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Statistical Package for Social Sciences (SPSS) version 27. Descriptive statistics were utilized to document the socio-demographic characteristics of the participants based on their frequencies. Qualitative data were analyzed using thematic analysis and constant comparative methods. Qualitative findings were organized into themes, categories and codes and findings presented through narratives. 62.3% of participants were male, while 37.7% were female. 29.2% were aged 40–50 years and 26.5% aged 30–40 years. 43.4% had college/university education, 38.8% secondary education, and 15.3% primary education.

Results: Findings indicated that the main constraints identified were feed and input, financial, market, institutional and governance issues, infrastructure and transport constraints, climatic constraints, and knowledge and extension gaps. opportunities identified were; investment in feed systems, finance, markets, infrastructure, climate resilience, and extension services.

Conclusion: Constraints at the production node are interlinked and reinforcing impacting on low productivity, reduced profitability, and weak sustainability. unlocking production node potential requires integrated investment in feed systems, finance, markets, infrastructure, climate resilience, and extension services.

Keywords: Participatory action research; assessment; constraints; opportunities; small scale dairy farmers; Kericho county.

1. Introduction

1.1 Background Information

In Kenya, the dairy industry contributes 22% of livestock gross market value and about 1.8 million people rely on it for their livelihoods (Auma et al., 2017). For each and every 1000 litres of milk, 77 people get full-time employments and 3-20 jobs are generated in processing and marketing of the product (Nguli & Kyule, 2021). Small-scale dairy producers contribute over 70% of the marketed milk in the country's dairy industry. The industry has been rising at rate of about 3–4% yearly (USAID-KAVES, 2013). 3.2 million out of 6.8 million dairy cows in Kenya produce over 5 million litres of milk yearly (Auma et al., 2017). At the same time, dairy consumption is growing faster than production at the rate of 6% per annum (USAID-KAVES, 2014). The potential drivers of demand are high population growth, urbanization and rising per capita consumption (Perin & Enahoro, 2023, Ngeno and Ngeno, 2018).

On average, small-scale dairy farmers in Kericho County generate 5.46 litres of milk per cow per day, against the expected 15 litres (KIPPRA, 2025), indicating a low level of productivity. (Yegon et al., 2016) noted that smallholder dairy farming in the county is below the expected yield due to lack of quality breeding, feed shortage, inadequate knowledge and skills of the farmers, and pests and diseases. The findings by (Kebebe, and Duncan, 2015) highlight the difficulties faced by small-scale dairy farmers in transporting their milk to cooperative societies due to lack of bargaining power and transportation costs. (Ngeno, 2018) noted that smallholder dairy farmers in the county have inadequate skills in herd management, economic land planning, marketing systems and value addition for improved incomes. (Ngeno, 2018) notes that low adoption of technologies, diseases, and inappropriate cattle breeds for dairy production also contribute to these drawbacks. Market opportunities for small-scale farmers are significant if yields can increase and production costs reduced through interventions that promote improvement of breeds, narrow the management and technology gaps, focus on availability of fodder/feed and water all year round and introduce better animal husbandry practices (USAID-KAVES, 2014). This calls for approaches which encourage involvement of all stakeholders to make improvements along the dairy value chain. Participatory research approaches involve farmers and other stakeholders in identifying problems, generating knowledge, and co-developing locally relevant solutions, thereby improving the relevance, adoption, and sustainability of agricultural innovations (Gómez et al., 2011).

1.2 Statement of the Problem

Despite the importance of dairy farming in improving rural livelihoods, small-scale farmers in Kericho County continue to experience production challenges that limit productivity and profitability. Previous studies have largely focused on other nodes of the dairy value chain in the region, with limited attention given to participatory assessment of constraints and opportunities at the production node in the County. This knowledge

gap limits the development of sustainable interventions capable of upgrading the dairy value chain and improving food security in the county. Therefore, this study sought to identify and assess the constraints and opportunities affecting small-scale dairy farmers in the county, using participatory methods in order to generate information aimed at enhancing milk production and household food security.

1.3 Objectives

The purpose of the current study was to carry out participatory identification and assessment of constraints and opportunities in dairy production among small scale farmers in Kericho County, Kenya. The study was guided by the following objectives:

- i. To describe the socio-demographic characteristics of small-scale dairy farmers in Kericho County.
- ii. To identify and assess, through participatory method, constraints in dairy production among small scale dairy farmers in Kericho County.
- iii. To identify and assess, through participatory method, the opportunities in dairy production among small scale dairy farmers in Kericho County.

2. Literature Review

2.1 The Role of Dairy Cow Ownership in Enhancing Family Well-Being

A dairy cow contributes to multiple interconnected components that sustain both farm productivity and household livelihoods. A dairy cow produces three main outputs; milk, manure, and offspring, each playing a distinct yet interrelated role within the farming system. Milk serves both economic and nutritional functions. When sold, it generates income for the household, which can be reinvested into farm and non-farm activities. When consumed at home, it contributes to improved household nutrition, thereby enhancing food security and overall wellbeing. Manure is utilized as an input in crop production, where it improves soil fertility and enhances crop yields. The crops produced are, in turn, used as feed for the dairy cow, creating a continuous feedback loop that reduces reliance on external inputs and lowers production costs. This form of crop livestock integration enhances nutrient recycling, improves resource use efficiency, and contributes to sustainable agricultural production systems. Income generated from dairy activities supports investment in farm improvements such as better feeds, veterinary services, and infrastructure, as well as off-farm activities that diversify household income sources. Some of this income is also reinvested into crop production and feed resources, further strengthening the system. Studies show that integrated farming systems enhance both on-farm productivity and livelihood diversification, thereby improving household economic resilience (Kurgat et al,2019). This integrated perspective is relevant in the context of Kenya, where food security remains a significant concern. In the 2016 Global Food Security Index, Kenya was ranked 87th out of 113 countries, with a score of 42.7%, indicating persistent challenges in food availability, accessibility, quality, and safety (Florence et al., 2017). Within this context, dairy farming emerges as a key agricultural value chain with strong potential for commercialization and livelihood improvement (Makoni et al., 2014). The sector contributes approximately 4% to the Gross Domestic Product (GDP) and provides a primary source of livelihood for over one million people.

2.2 Production Activities of Small-Scale Dairy Farmers

Small-scale dairy farmers carry out several important production activities that support milk production and household livelihoods. One major activity is feeding and nutrition management, where farmers provide fodder, pasture, crop residues, and commercial feeds to dairy cattle to ensure adequate milk production and animal health (Murui, 2011). Some farmers also practice fodder cultivation and silage making to ensure feed availability during dry seasons.

Another key activity is breeding and reproduction management. Farmers select suitable dairy breeds and use methods such as artificial insemination or natural mating to improve milk productivity and maintain healthy herds (Bebe et al., 2008). Proper breeding practices help improve genetic quality and milk yields. Small-scale dairy farmers also engage in animal health management through vaccination, disease control, deworming, and regular veterinary care to prevent diseases and reduce livestock losses (Ochieng et al,2024, FAO, 2024). Good health management contributes to improved productivity and milk quality. Milking and milk handling are

important daily activities carried out by dairy farmers. Farmers milk cows, store milk hygienically, and transport it to collection centers, cooperatives, or local markets for sale (Kenya Dairy Board, 2022). Proper milk handling helps maintain milk safety and quality standards. In addition, dairy farmers participate in record keeping and farm management activities such as monitoring milk yields, tracking breeding cycles, managing farm inputs, and budgeting farm expenses (Ojango et al., 2017). These activities help farmers make informed production and marketing decisions. Small-scale dairy farmers also market milk and dairy products either individually or through cooperatives and farmer groups. Marketing activities enable farmers to generate income and access better market opportunities and support services (Ojango et al., 2017).

2.3 Constraints and Opportunities at the Production Node of the Dairy Value Chain

The production node of the dairy value chain faces several constraints that limit productivity and profitability among small-scale dairy farmers. One major constraint is inadequate access to quality feed and fodder, especially during dry seasons, which leads to low milk production and poor animal health (Ojango et al., 2017). High costs of commercial feeds and limited land for fodder production further worsen the problem. Another significant challenge is the prevalence of livestock diseases and limited access to veterinary services. Diseases such as mastitis, East Coast fever, and foot-and-mouth disease reduce milk yields and increase production costs for farmers (FAO, 2023, Surve et al., 2023). Inadequate extension services and limited farmer training also constrain the adoption of improved dairy farming technologies and practices.

Limited access to credit and financial services is another major constraint affecting small-scale dairy producers. Many farmers lack sufficient capital to invest in improved breeds, feeds, housing, and equipment, leading to low productivity (Bebe et al., 2008). In addition, fluctuating milk prices and poor market access reduce farmers' income and discourage investment in dairy farming. Poor breeding practices and limited access to high-quality dairy breeds also affect milk productivity at the production level (Kenya Dairy Board, 2022). Some farmers rely on low-yielding breeds due to the high cost of artificial insemination and breeding services.

Despite these constraints, the production node of the dairy value chain presents several opportunities. One important opportunity is the growing demand for milk and dairy products due to increasing population, urbanization, and changing consumer preferences (FAO, 2023). This creates market potential for dairy farmers to increase production and income. The availability of improved dairy technologies such as artificial insemination, fodder conservation techniques, and improved animal health services provides opportunities for enhancing productivity and milk quality (Ojango et al., 2017). Farmer cooperatives and producer groups also offer opportunities for collective marketing, access to training, credit facilities, and better bargaining power. Government support and partnerships with development organizations further create opportunities through extension services, subsidized inputs, and dairy development programs aimed at improving smallholder dairy farming (Kenya Dairy Board, 2022). Additionally, value addition activities such as milk cooling, processing, and yogurt production can help farmers increase profitability and reduce post-harvest losses.

2.4 Participatory Action Research

Participatory Action Research (PAR) is a collaborative research approach that actively involves community members, stakeholders, and researchers in identifying problems, generating knowledge, and implementing solutions to address social or developmental challenges (Kemmis et al., 2014). PAR emphasizes participation, empowerment, reflection, and collective action, allowing participants to contribute to decision-making throughout the research process (Stringer, 2014). Unlike conventional research approaches where participants are only sources of data, PAR treats them as co-researchers who help in problem analysis and solution development. It promotes active participation and empowerment of local communities and stakeholders in the research process (Benjamin-Thomas et al., 2018). This increases ownership of the findings and improves the chances of implementing sustainable solutions.

Additionally, PAR enhances the relevance and practicality of research outcomes because the study focuses on real-life problems identified by participants themselves (Stringer, 2014). The collaborative nature of PAR encourages the sharing of local knowledge and experiences, leading to context-specific solutions. PAR also promotes learning and capacity building among participants. Through reflection, discussion, and action, participants acquire new skills, knowledge, and confidence to address future challenges independently (Kemmis et al., 2014). Additionally, PAR is flexible and adaptive, allowing researchers and participants to modify

strategies based on emerging findings and changing situations during the research process. However, P A R approach is time-consuming because it requires continuous participation, consultation, reflection, and collaboration among stakeholders (Benjamin-Thomas et al., 2018). Organizing meetings and achieving consensus among participants may delay the research process. PAR may also face challenges related to power imbalances among participants. Some individuals or groups may dominate discussions and decision-making, limiting equal participation by others (Stringer, 2014). Findings from PAR may have limited generalizability because the research is often conducted within specific communities or contexts. The solutions developed may not easily apply to other settings. In addition, PAR requires strong facilitation and communication skills from researchers to manage conflicts, encourage participation, and maintain collaboration throughout the study process.

2.5 Scope of the Study

The study focused on small-scale dairy cattle farmers of Ainamoi, Belgut and Bureti sub counties in Kericho County, Kenya. It employed stakeholder participatory forums to identify and assess constraints and opportunities at the production node of the dairy value chain in the three sub counties. The forums brought together all the milk producers from the three sub counties. It adopted a Participatory Action Research design and collected both quantitative and qualitative data through interview schedules and focus group discussions. Quantitative data were analyzed using SPSS version 27 while qualitative data were analyzed using thematic analysis and constant comparative methods to identify and synthesize emerging themes. The study was limited geographically to Kericho County and thematically to the production node of dairy cattle value chain among small-scale farmers.

2.6 Justification of the Study

The study was justified by the need to address persistent milk insufficiency and food insecurity in Kericho County through participatory approach. Its findings contribute to broader development goals, particularly United Nations Sustainable Development Goals 1 and 2, which emphasize poverty reduction, food security, improved nutrition, and sustainable agriculture. By strengthening stakeholder collaboration, the study supports efforts to enhance milk production and household resilience. The results are valuable to farmers and research organizations by informing decision-making. Policymakers may also use the findings to improve extension delivery methodologies. Additionally, the study provides a reference point for future researchers interested in participatory approaches and food security in agricultural system.

3. Methodology

3.1 Study Area

Kericho County occupies an area of 2,479 km². It is divided into six sub-counties; Kipkelion West, Bureti, Ainamoi, Sigowet/Soin, Belgut and Kipkelion East. The County's altitude ranges between 1800m to 3000 m above sea level. The central part of the County receives 2125 mm of rainfall while the lower belts receive 1400 mm of rainfall per annum. It is characterized by volcanic as well as igneous and metamorphic complexes. The County receives relief rainfall, with moderate temperatures of 17°C and low evaporation rates. It has four agro-ecological zones; Lower Midland, Lower Highland, Upper Highland and Upper Midland zones. Upper Highland and Lower Highland zones are suitable for dairy, tea, maize, horticultural crops and wheat farming. Bureti, Belgut and Ainamoi Sub Counties are found in Upper and Lower Highland zones. The three sub-counties were chosen due to differences in both their geographical locations and the number of dairy farmers. Bureti has the highest concentration of dairy farmers; Belgut represents a moderate level, while Ainamoi has the lowest number of dairy farmers among the selected areas. Fig. (1) shows the study areas in Kericho County.

3.2 Target Population and Sampling Procedures

At the production level, the target population used in this study were all smallholder dairy farmers keeping pure or improved breeds/crosses of cattle in the County. The target population was 53565. The sampled household of the milk-producing small-scale dairy farmer was determined using Yamane formula, which yielded 397 dairy farmers.

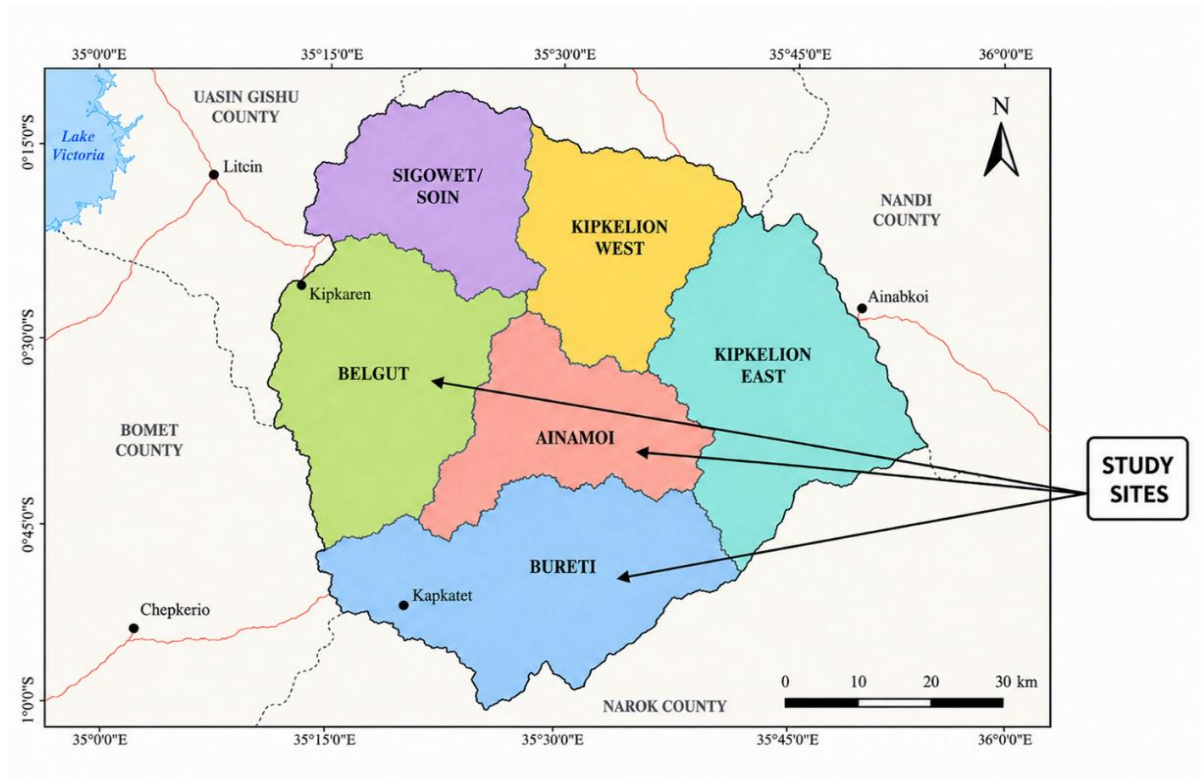


Fig. 1. Map of Kericho County showing Study Sites.

This study employed a multistage sampling procedure to obtain participants from the production node of the dairy value chain. The approach was appropriate due to the hierarchical nature of the study area, which is organized into sub-counties, wards, and villages.

In the first stage, three sub-counties, namely Bureti, Belgut, and Ainamoi, were purposively selected based on their prominence in dairy production and their relevance to the study objectives. The sampled population from these sub-counties comprised of 210 respondents from Bureti, 127 from Belgut, and 60 from Ainamoi.

In the second stage, wards were selected from each of the three sub-counties using simple random sampling. A list of all wards within each sub-county was obtained, and the lottery method was used to ensure that each ward had an equal chance of being selected.

In the third stage, villages were selected from the sampled wards. A sampling frame consisting of all villages within each selected ward was compiled, from which villages were randomly selected using simple random sampling techniques.

In the final stage, participants were selected from the chosen villages. The number of respondents drawn from each village was determined using proportionate sampling to ensure that villages with larger populations contributed more respondents than those with smaller populations. A sampling frame of eligible participants was developed with the assistance of local leaders and extension officers. From this list, respondents were selected using simple random sampling to eliminate bias and ensure representativeness.

3.3 Data Collection

Interview schedules were used to collect quantitative data, mainly on socio demographic characteristics of the participants.

Focus group discussions were conducted separately with small-scale dairy farmers from different sub-counties to ensure representation of diverse production systems and experiences. Focus group discussion guides were

developed to explore constraints and opportunities at the production node of the dairy value chain. Participants were asked to list constraints and opportunities and rank them in terms of severity or importance.

Participants collaboratively identified and assessed constraints and opportunities at the production node of the dairy value chain and recorded on flip charts and audios. Brainstorming, group discussion, and consensus building techniques were used to capture collective insights and validate findings from focus group discussions.

3.4 Data Analysis

Data collected through interview schedules were analyzed using SPSS version 27 to get descriptive statistics.

Data collected through Focus Group Discussions (FGDs), were analyzed using thematic analysis and constant comparative methods to assess constraints and opportunities at the production node of the small-scale dairy value chain.

Audio recordings, flipcharts, and field notes were transcribed and organized according to the constraints and opportunities identified. The transcribed data were grouped into recurring themes, sub-themes, and patterns. Identified constraints and opportunities were classified by type; such as financial, infrastructural, institutional, or technical and further assessed based on their perceived severity or impact as reported by participants.

Group consensus generated during workshops and FGDs was used to validate and refine the identified constraints and opportunities. Facilitators employed iterative questioning to ensure that key constraints and opportunities were fully explored and accurately captured. Opportunities were evaluated in terms of feasibility and scalability.

The results were presented using tables drawn on flip charts to depict constraints and opportunities. Verbatim responses further clarified the constraints and opportunities at the production node of the dairy value chain in the three sub counties.

4. Results and Discussion

4.1 Socio-Demographic Characteristics

The study had 393 participants, and their socio-demographic data were analyzed to better understand the survey population's gender, age, and education level. These traits are critical for giving contextual insights into participant behaviors and reactions, particularly in agricultural and value chain research where demographic factors impact production, access, and decision-making (Holmes & Jones, 2013, Tamang et al.,2024).

4.2 Gender of the Participants

Participants were asked to indicate their gender, that is, either male or female. The data was analyzed by calculating frequencies and percentages. Results are displayed in Fig. (2). The figure shows that males made up 62.3% of participants, while females made up 37.7% of household heads. Male dominance in family leadership and agricultural decision-making is prevalent in rural agrarian contexts, as seen by this gender distribution (FAO, 2019). Nonetheless, the large proportion of families led by women suggests that women are becoming more involved in agricultural and rural development activities, which might be due to male altering family obligations. The relatively high proportion of female-headed households (37.7%) aligns with emerging evidence that women are increasingly taking up more visible and active roles across dairy value chains. Recent studies highlight that woman are central actors in dairy production, particularly in milking, feeding, animal care, and value addition activities such as milk processing (Nagasha et al., 2024). Furthermore, women contribute significantly to the agri-food sector, accounting for nearly half of the workforce in Sub-Saharan Africa, with growing participation across production, processing, and marketing segments (FAO, 2023). This trend may be attributed to socio-economic factors such as male outmigration, diversification of livelihoods, and changing household responsibilities, which have increased women's involvement in agricultural production and household management. In the Kenyan dairy sector, women play a critical role in daily dairy operations, although their participation is often under-recognized (Wafula, 2014).

However, some studies caution that increased participation does not necessarily translate into empowerment. Evidence from dairy value chains shows that women are often concentrated in low-value nodes, while men dominate higher-value segments such as marketing and income control (Tamang et al.,2024). Additionally, structural barriers, including limited access to land, credit, extension services, and cooperative membership, continue to restrict women's effective participation and benefits from dairy value chains (Bitange et al., 2025).

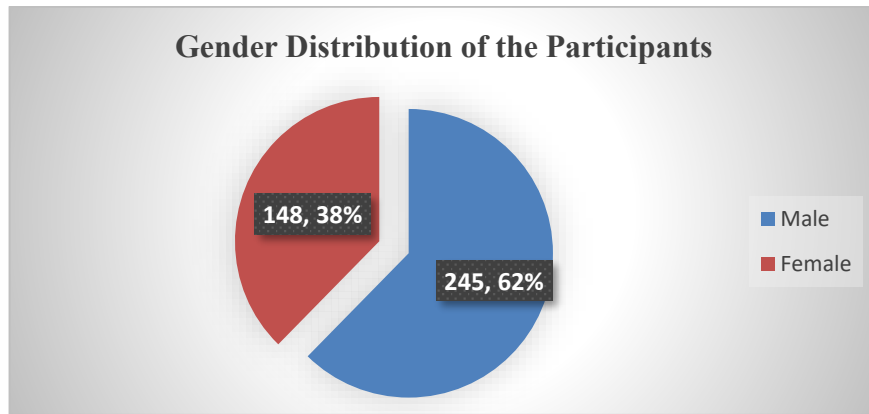


Fig. 2. Gender Distribution of the Participants

4.3 Age of the Participants

Each participant was presented with five age groups and asked to indicate the age group they fell in. The age groups were; below 20 years,21-30 years,31-40 years,41-50 years and above 50 years. Data were analysed by calculating frequencies and percentages. The results are displayed in Fig. (3). According to the age profile, the majority of participants were of active working age. For instance, 29.2% were between the ages of 40 and 50, with 26.5% falling between 30 and 40. Of the participants, 23.9% were over 50, while 19.4% were between the ages of 20 and 30. The proportion of persons under 20 years old was the lowest (1.1%). According to this distribution, the majority of respondents were in their peak productive years, which is critical for labour-intensive farming enterprises. Middle-aged farmers are more likely than older farmers to accept new technologies; hence age is an important determinant in productivity and innovation adoption (Kalungu and Leal Filho, 2018). The age distribution indicates that the majority of participants fall within the active and economically productive age groups, particularly between 30 and 50 years, which supports the labour demands of smallholder dairy farming. This finding aligns with existing literature showing that agriculture in Sub-Saharan Africa is largely driven by middle-aged farmers who possess both the physical capacity and farming experience necessary for labour-intensive enterprises such as dairy production (Odero-Waitituh, 2017). Individuals within this age bracket are often considered to be in their peak productive years, enabling them to effectively manage demanding activities such as feeding, milking, and herd management, which are central to dairy value chains.

Furthermore, the relatively high proportion of farmers aged 30–50 supports studies suggesting that this group is more responsive to innovation and more likely to adopt improved agricultural technologies compared to older farmers (Kalungu and Leal Filho, 2018, Wainaina et al., 2016). Their ability to balance experience with openness to new ideas enhances productivity and facilitates the uptake of improved breeds, feeding practices, and market oriented dairy strategies. In the Kenyan dairy context, middle aged farmers have been found to play a key role in transitioning from subsistence to more commercialized dairy systems (Wangu et al,2021).

However, the lower representation of youth (particularly those below 30 years) reflects a widely documented challenge in African agriculture, declining youth participation. Many young people tend to migrate to urban areas in search of alternative employment, leaving agriculture dominated by older generations (Odero-Waitituh, 2017, FAO, 2023). This trend may negatively affect the long-term sustainability and innovation potential of the dairy sector, as youth are often more receptive to digital technologies and modern farming practices.

On the other hand, the presence of farmers above 50 years (23.9%) suggests the continued importance of experience and indigenous knowledge in dairy farming. Some studies argue that older farmers may be less likely

to adopt new technologies due to risk aversion and shorter planning horizons (Kalungu and Leal Filho, 2018), which could limit productivity improvements. However, contrasting evidence shows that older farmers often possess valuable farming knowledge and social capital that can support decision making and resilience in agricultural systems (Wainaina et al., 2016).

In conclusion, the findings suggest a relatively balanced age structure dominated by middle aged farmers, which is advantageous for labour availability and productivity in dairy farming. Nonetheless, the low youth involvement presents a potential risk to future sector growth, while the presence of older farmers highlights the need to integrate experience with innovation through targeted extension and capacity building programs.

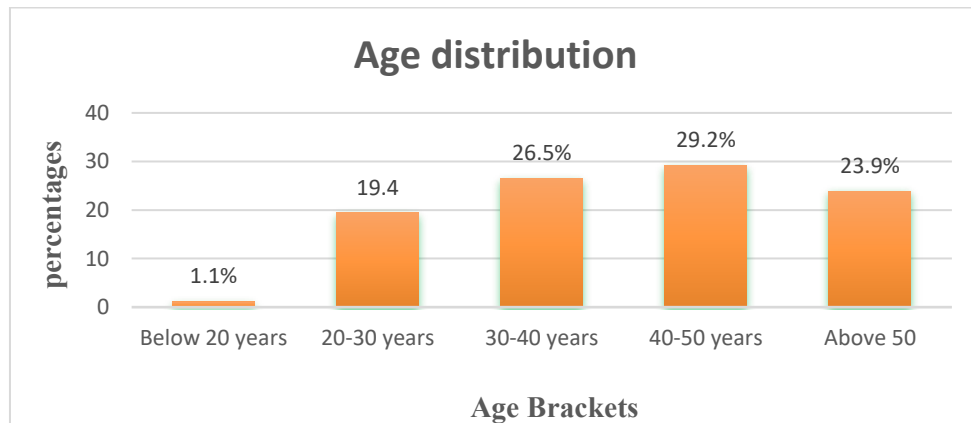


Fig. 3. Age distribution of the participants

4.4 Education Level of the Participants

Participants were asked to indicate their education level under the following categories; primary, secondary, college/university and others (specify). Data was analyzed by calculating frequencies and percentages. Results are displayed in Fig. (4).

The findings indicate that a large proportion of participants had attained secondary (38.8%) and tertiary education (43.4%), while a smaller proportion had only primary education (15.3%) and very few (2.6%) had other forms of education. This distribution suggests a relatively well-educated farming population, which is advantageous for engagement in modern and market oriented dairy value chains. Literature shows that education enhances farmers' ability to access, interpret, and utilize agricultural information, thereby improving decision-making, productivity, and participation in value chain activities (Reimers & Klasen., 2013, Wainaina et al., 2016). In dairy systems, educated farmers are more likely to adopt improved technologies such as artificial insemination, improved feeding practices, and record-keeping, and are better positioned to engage in formal markets and cooperative structures (Wairimu et al., 2022, FAO,2023).

The high level of formal education also implies that farmers are more receptive to extension services and innovation platforms, as education improves their capacity to evaluate risks and benefits associated with new technologies (Swanson et al., 2010). In the Kenyan dairy context, higher education levels have been associated with increased commercialization, value addition, and income diversification, all of which contribute to improved livelihoods and food security (Wangu et al.,2021).

However, the very small proportion (2.6%) of participants with other forms of education highlights limited engagement with non-formal and vocational training pathways such as farmer field schools, extension-based training, and technical short courses. This is significant because, although formal education provides foundational knowledge, agriculture, particularly dairy farming, relies heavily on practical, hands-on skills that are often acquired through experiential learning and extension services (Davis et al., 2021). The low uptake of such alternative education may therefore indicate gaps in access to or awareness of specialized agricultural training, which could limit farmers' technical capacity in areas such as animal health management, feed formulation, and milk quality control.

While the findings generally support the positive role of education in agricultural development, some studies offer a contrasting perspective by emphasizing that education alone does not guarantee technology adoption or improved productivity. Structural factors such as access to credit, land, markets, and institutional support often play a more decisive role in determining whether farmers can apply the knowledge they possess (Muiruri et al.,2012; Khan et al.,2024). Additionally, highly educated individuals may diversify into non-farm employment, potentially reducing their direct involvement in agriculture (Davis et al.,2021).

The study concludes that the study area has a relatively knowledgeable and capable farming population, which is well-positioned to benefit from extension programs and dairy value chain upgrading initiatives. However, the limited engagement with non-formal education highlights the need to strengthen vocational and extension-based training to complement formal education. Integrating practical skill development with formal knowledge will be critical in enhancing productivity, innovation adoption, and overall performance within the dairy value chain.

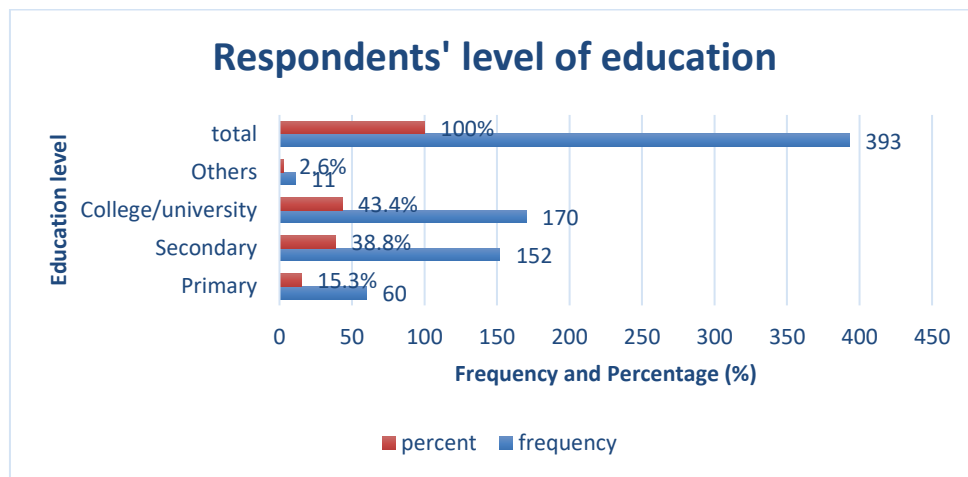


Fig. 4. Education level of the participants

4.5 Constraints and Opportunities at the Production Node of the Dairy Value Chain

Participants at the production node of the dairy value chain from the three sub counties were asked to identify and assess the constraints and opportunities at the production node. Their responses were documented using flip charts and audio recordings. The collected data were organized into categories, themes, and codes, while verbatim responses were also captured.

4.6 Constraints at the Production Node of the Dairy Value Chain

The findings revealed that feed and input constraints were among the most significant challenges affecting smallholder dairy farmers. Farmers reported inadequate and unreliable feed supply, with one farmer noting, *"Feeds are not always available, and when they are, the prices are too high for small farmers like us."* This suggests that feed insecurity remains a major barrier to sustainable dairy production among smallholder farmers. High costs of veterinary drugs and other farm inputs further reduced profits from milk production, as another farmer stated, *"The cost of inputs such as feeds and veterinary drugs has gone up so much that profits from milk are very low."* This aligns with studies showing that feed scarcity and high input costs are among the most significant constraints in smallholder dairy production, often accounting for up to 60–70% of total production costs (Muriuki, 2011, FAO, 2018). Such cost pressures limit farmers' ability to reinvest in productivity enhancing technologies. Verbatim responses further demonstrate the financial burden experienced by farmers in accessing quality feed and animal health inputs.

The study also established that limited access to affordable credit and low financial literacy constrained dairy farming operations. Farmers indicated difficulties in accessing loans due to lack of collateral and high interest rates, with one participant explaining, *"Accessing loans is very difficult because we lack collateral and the interest rates are too high."* Low financial literacy also affected farm management, as farmers admitted, *"Many*

farmers do not know how to manage money or calculate profits, so even when they earn, it is not well planned." This finding implies that financial exclusion limits farmers' ability to invest in improved breeds, feeds, and infrastructure. This finding corroborates earlier studies which argue that limited access to financial services restricts farmers' capacity to invest in improved inputs, breeds, and infrastructure (World Bank, 2017). In addition, low levels of financial literacy, further exacerbate inefficiencies in resource utilization. According to (Davis et al., 2021), financial management skills are critical for enhancing farm level decision making and profitability.

Market-related challenges emerged prominently, particularly unstable milk prices and delayed payments. Farmers noted that fluctuating prices often fail to cover production costs, thereby discouraging investment in dairy farming, with one respondent reporting, *"Milk prices keep changing, and sometimes the price is too low to even cover production costs."* Delayed payments also constrained operations, as another farmer explained, *"Payments for delivered milk delay for months, making it hard to buy feeds or drugs on time."* These findings indicate inefficiencies within dairy marketing systems and weak bargaining power among smallholder farmers. Similar observations have been reported in dairy value chain studies in Kenya, where price instability and delayed payments reduce farmer motivation and profitability. This is consistent with findings by (Davis et al., 2021), who observed that weak market structures and lack of price regulation often expose smallholder farmers to exploitation and income uncertainty. Such inefficiencies in dairy marketing systems have been widely reported in East Africa (FAO, 2018).

The findings showed that weak cooperative governance and unfair market competition negatively affected dairy farmers. Farmers expressed concerns regarding poor management with one farmer stating, *"Some cooperatives are poorly managed, and farmers are not informed how their money is used."* Farmers also complained about unfair market competition, noting that *"Cooperatives compete with individual farmers by setting prices that favor themselves."* This suggests that governance challenges undermine trust and participation in cooperative societies. This finding is supported by research indicating that ineffective cooperative management reduces farmer trust and participation, ultimately weakening collective marketing systems (Wangu et al., 2021). Additionally, perceptions of unfair competition from cooperatives suggest power imbalances within the value chain, which can disadvantage small-scale producers.

Poor infrastructure and transport systems were identified as major constraints affecting milk delivery and quality. Farmers reported poor road networks and milk spoilage due to transportation delays and inadequate cooling facilities, particularly in rural areas, with one farmer explaining, *"The roads are very bad, especially in rural areas, making it hard to transport milk to collection centers."* Post-harvest milk losses were also common, as another participant stated, *"By the time milk reaches the market, some of it has already spoiled due to delays and lack of cooling."* These findings imply that infrastructural deficiencies contribute significantly to post-harvest losses and reduced milk quality. Infrastructure and transport constraints observed in the current study are also consistent with findings by (USAID-KAVES,2014), which highlight the critical role of rural infrastructure in reducing losses and improving market efficiency.

The study established that climatic conditions, particularly during the rainy season, disrupted milk transportation and market access. Poor road accessibility during adverse weather conditions affected timely milk delivery and increased spoilage risks, with one respondent observing, *"During the rainy season, roads become impassable and milk delivery becomes very difficult."* These findings indicate that climate variability continues to threaten dairy value chain operations, thereby increasing vulnerability among smallholder farmers (Herrero et al., 2010; USAID-KAVES,2014).

The findings further revealed that inadequate farmer training and limited extension support constrained the adoption of modern dairy practices. Farmers indicated that extension officers rarely visited farms, limiting access to technical knowledge and advisory services. One farmer reported, *"Most farmers have not been trained on modern dairy practices, so productivity remains low."* Inadequate extension support was also highlighted, with farmers noting, *"Extension officers are very few, and they rarely visit farms to advise farmers."* This suggests that insufficient extension services contribute to low productivity and slow adoption of innovations. This finding supports existing literature emphasizing the importance of extension services in enhancing productivity and technology adoption among smallholder farmers (Davis et al., 2021). Without adequate technical support, farmers are less likely to adopt improved practices that could increase efficiency and resilience.

In conclusion, smallholder dairy systems in developing countries are constrained by input, financial, institutional, and infrastructural challenges that are often interlinked (FAO, 2018, Davis et al., 2021).

4.7 Opportunities for Improving Smallholder Dairy Farming

Despite the challenges, the study identified several opportunities for improving productivity and profitability among smallholder dairy farmers.

4.8 Feed Related Opportunities

Farmers identified opportunities such as on-farm fodder production, feed conservation, and bulk purchasing through cooperatives as effective strategies to reduce costs. This is reflected in the response, *“If we were trained and supported to grow our own fodder, we would not struggle with expensive feeds every dry season,”* which highlights the importance of capacity building and self-reliance. Similarly, *“Through the cooperative, we can buy feeds in bulk at a lower price.”* underscores the role of collective action in improving affordability and access to inputs. Technologies such as silage and hay making are widely recognized as cost effective strategies for stabilizing dairy production (FAO, 2018, Sakwa et al., 2020). Additionally, collective purchasing of inputs through cooperatives was seen as a viable solution. Some farmers reported using locally available feeds like maize stalks to feed their animals especially during dry seasons.

4.9 Financial Related Opportunities

Farmers identified dairy friendly loan products, SACCOs, and mobile-based microfinance services. As opportunities which could be exploited. A participant explained, *“With affordable loans designed for dairy farmers, we could improve our herds and invest in better feeding,”* while another added, *“Saving through the SACCO has helped us access small loans for farm improvements.”* These findings are consistent with studies showing that access to tailored financial services enhances adoption of improved dairy technologies and productivity (Ndah et al., 2022). Other financial improvement opportunities identified were capacity building in financial management, bookkeeping, budgeting, and use of mobile banking platforms which could further strengthen farmers’ financial planning and resource management. This suggest that strengthening financial inclusion and literacy could improve decision-making and enhance dairy enterprise sustainability. These findings are consistent with studies showing that access to tailored financial services enhances adoption of improved dairy technologies and productivity (World Bank, 2017, Ndah et al., 2022).

4.10 Market Related Opportunities

Collective marketing and contractual arrangements with processors were identified as key opportunities. One respondent noted, *“When we sell milk as a group, we get better prices compared to selling individually,”* while another emphasized market assurance, stating, *“Having a contract with a processor assures us of a ready market for our milk.”* These observations reinforce the role of cooperatives in improving market access, price stability, and farmer bargaining power, as documented in dairy value chain studies across East Africa (FAO, 2023). Digital payment platforms and cooperative managed revolving funds were also identified as solution to payment delays and improvement of farmers’ cash flow. One farmer reported *‘I receive my money through ‘m-pesa’ twice a month for my milk and am able to plough back to my dairy operations.* This implies that the farmer has the ability to sustain his dairy operations through timely reinvestment.

4.11 Institutional and Governance Opportunities

Strengthening farmer organizations and institutional linkages was viewed by farmers as a pathway to improved governance. As one farmer remarked, *“If institutions worked closely with us, many of our challenges would be addressed early,”* while another stated, *“Strong cooperatives would protect us from unfair practices by brokers.”*. Promoting fair trade policies and strengthening farmers’ bargaining power would also help address unfair market competition and enhance accountability and cooperative performance These findings align with literature emphasizing the importance of inclusive institutions and effective governance frameworks in supporting smallholder dairy development (Kebebe et al., 2015).

4.12 Infrastructure Related Opportunities

Infrastructure and transport constraints, particularly poor rural roads and inadequate milk collection facilities, were reported to contribute to post-harvest losses and reduced milk quality. Farmers highlighted long distances

to collection centers increase spoilage and transport costs. One participant observed, “*Better roads would reduce milk spoilage and help us reach markets on time,*” while another noted, “*Having a collection center nearby would save us transport costs and losses.*” This implies that Investment in rural infrastructure and decentralized milk collection systems presents a significant opportunity to enhance efficiency at the production node. The participants also suggested expansion of milk cooling facilities and promotion of on-farm or cooperative-level milk processing to reduce post-harvest losses and encourage value addition. These investments present a significant opportunity to enhance efficiency at the production node, consistent with findings by (Gachango et al.,2014; Mbaya,2023). Some participants identified an opportunity for local value addition through the small-scale production of ‘*Mursik*’ (fermented milk), although the activity was carried out informally and without the necessary licenses (Kariuki & Iravo,2018).

4.13 Climatic and Environmental Related Opportunities

Farmers demonstrated awareness of climate-smart practices such as planting drought-tolerant fodder and water harvesting. A respondent explained, “*Planting drought-resistant fodder has helped us cope with unpredictable rainfall.*” The farmers in the study area had been introduced to new Napier varieties which are drought resistant. Another farmer emphasized the need for information, stating, “*If we had access to climate information, we could plan feeding, feed storage strategies, and breeding better.*” This could strengthen resilience and improve continuity in milk supply. These insights support existing evidence that climate-smart dairy interventions improve resilience to climate variability (Shikuku et al., 2017).

4.14 Knowledge Related Opportunities

Farmers identified several important sources of knowledge, including farmer field schools, extension officers, peer learning, digital advisory platforms and private companies. These sources were perceived to enhance the adoption of modern dairy farming practices and improve dairy productivity. This finding underscores the critical role of extension services and capacity building in promoting technology adoption and productivity at the production node (Davis et al., 2021). One participant stated, “*Training on animal health and feeding would greatly improve our milk production,*” while another added, “*Learning from fellow farmers who are doing well motivates us to adopt new practices.*” In addition, one participant reported relying on the internet as the main source of information, although he lamented the unreliable electricity supply in rural areas, which limited consistent access to digital advisory services. In one study site, participants commended private firms such as One Acre Fund and Brookside Dairies for providing extension services related to the products and services they offered.

5. Conclusion

The findings from the production node of the dairy value chain demonstrate that 62.3% of participants were male, while 37.7% were female. 29.2% were aged 40–50 years and 26.5% aged 30–40 years. 43.4% had college/university education, 38.8% secondary education, and 15.3% primary education. Additionally, the findings demonstrate that smallholder dairy farmers face multiple and interconnected constraints that negatively affect milk productivity, profitability, and household livelihoods. Key constraints identified include high feed and input costs, limited access to affordable finance, unstable milk markets, weak institutional coordination, poor infrastructure, climate variability, and inadequate extension services. These constraints collectively reduce farmers’ ability to adopt improved dairy practices and participate effectively in the dairy value chain.

Despite these challenges, the study revealed significant opportunities that can transform the production node into a more productive, resilient, and sustainable system. Farmers identified on farm fodder production, feed conservation, cooperative based input purchasing, affordable dairy friendly credit, collective marketing, strengthened cooperatives, climate smart farming practices, improved rural infrastructure, and enhanced extension services as practical and achievable solutions. The findings further demonstrate that farmer organizations and stakeholder collaboration play a critical role in improving access to inputs, markets, information, and financial services.

The study concludes that improving the production node of the dairy value chain requires integrated and participatory interventions that address both technical and institutional barriers. Empowering farmers through training, financial inclusion, climate adaptation strategies, and stronger cooperative systems can significantly

enhance milk production, reduce losses, improve market access, and strengthen the resilience of smallholder dairy farming systems.

Consent

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

Authors have declared that no competing interests exist.

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