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Interdependent Effects of Agro-input Node Interventions on the Adoption of Cattle milk Production Technologies among Smallholder 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

Agricultural extension service delivery system is a vital component in agricultural development initiatives of any nation. Several extension approaches are used to achieve these initiatives. Globally, many Governments and development partners in rural agricultural development initiatives have gradually transitioned away from total state control of rural community and agricultural

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extension service delivery into adopting and supporting a more multifaceted system built on holistic participatory approach commonly referred to as Agricultural Value Chain Extension Approach (AVCEA). This AVCEA is relatively new in developing countries, including Kenya, and specifically in Kericho County where exploration on its impact on farm-level technology adoption has yet to be undertaken. The purpose of this study was to investigate the interdependent effects of agro-input node interventions on the adoption of cattle milk production technologies among smallholder farmers in Kericho, Kenya. This study adopted an ex-post-facto research design and systematic random sampling technique to select a sample of 132 farmers who previously exposed to AVCEA. Interviews were conducted for eight (8) dairy production experts and 6 Dairy organization representatives as key informants. The primary data were collected using interview schedules, questionnaires and focus group discussion tools. The data were analyzed for descriptive statistics like frequencies, percentages and inferential statistics like Chi-square tests with the aid of SPSS version 26.0. The results of the study indicated that there was a significant interdependence between some agro-input value chain node interventions and the adoption of cattle milk production technologies. There was also Interdependence between ease of access to farmers 'groups/cooperative societies and the adoption of cattle milk production technologies by the smallholder farmers. Based on findings of this study, Agricultural experts, stakeholders, and other concerned bodies should focus on developing strategies to strengthen interventions at the agro-input node, particularly by fostering cooperation among smallholder farmers to enhance collective actions.

Keywords: Agricultural Value Chain Extension Approach (AVCEA); Agricultural value chain node; dairy cattle milk production technologies; adoption.

1. INTRODUCTION

The agricultural value chain is thought to include all of the interconnected roles of produce, products, services, and processes involved in bringing an agricultural produce/product from the field to the market (agro-input supply and agro-production) through intermediaries (agro-processing, agro-marketing) to the table of the final consumer [1]. This happens in the course of interactive, constructive and active participation of all the actors amongst themselves vertically at micro, meso and macro levels [2]. There is also horizontal interaction at the value-chain nodes. This interaction has been associated with an increase in agricultural productivity in programmes and projects where agricultural value chain extension approach has been used [3]. In contrast to the simplest type of value chain in which producers and buyers share only price information, often in an adversarial mode, agricultural value chains function better when and where all the actors collaborate to create higher quality goods and generate more income for all participants along the entire chain. The object of Agricultural Value Chain Approach in Extension is to integrate traditional agricultural extension services with a focus, not only on the production, but on the entire value chain that does not only target farmers, but also targets other stakeholders involved in the agricultural value chain [4]. According to FAO [5], the development of Sustainable Food Value chains can offer a pathway out of poverty for millions of the poor in developing countries. The value chain approach is viewed as a direct way to boost market-driven agriculture and enhance the income of the smallholder farmers [6]. As argued by [7], improving farmers-adoption of technologies demands comprehensive and inclusive strategies at multiple levels. The emphasis on multiple levels suggests a need for strong integrated value chains.

The Agricultural Value Chain Extension Approach (AVCEA) is relatively new, especially in developing countries [8], including in Kenya. Its full effectiveness has not yet been thoroughly examined or recorded. During the last eleven years, resources have been committed to support and implement agricultural programmes in Kericho County, Kenya. First, there was the Agricultural Sector Development Support Programme (ASDSP) with phase one running from 2013 to 2017 and phase two from 2018 to 2023. Secondly, there was Kenya Climate-Smart-Agriculture Programme (KCSAP) from 2019 to 2023. Both programmes used Agricultural value chain Extension Approach. Their successor programmes; National Agricultural Value Chain Development Programme (NAVCDP), 2023-2027 and Kenya Agri-Business Development Programme, 2024-2028, have similarly deployed the Value chain Extension approach [9]. The use of the value

chain approach is fairly new in the county. It is a new approach to development thinking in agriculture. Its effect on the adoption of new practices and technologies, however, has not been well understood or evaluated for its potential tangible results, despite its continued use in Kericho County programmes. Using the example of the dairy cattle milk production value chain enterprise, this study assessed whether this approach indeed had an effect on the adoption of dairy cattle milk production technologies by the small-holder farmers in Kericho County, Kenya.

The purpose of this study was to investigate interdependence betweenagro-input node interventions with the adoption of dairy cattle production technologies. The specific objective of the study was to assess the interdependent effects between the agro-input node interventions with the adoption of dairy cattle production technologies among small-holder farmers in Kericho County, Kenya.

2. METHODOLOGY

2.1 Study Design

This study adopted *an Ex post facto* research design to assess the potential interdependent effects of value chain node interventions on the adoption of dairy production technologies by the smallholder dairy farmers in Kericho County. An *Ex post facto* research study is a form of study in which the investigation begins after the event has occurred and without the intervention of the researcher [10]. It is an 'after the fact' design in which qualities that pre-existed in a group of participants before the research are compared on a dependent variable, without the researcher randomly assigning them. It is a form of quasi experimental research since there is no random assignment of respondents.

2.2 Study Location

This study was carried out in Kericho County, Kenya. The county has a total area of 2,479 square kilometers and is divided into six sub-counties: Ainamoi (Kericho East), Belgut (Kericho West), Bureti, Kipkelion East, Kipkelion West and Soin/Sigowet. It has 30 administrative Wards, 85 Locations, and 209 Sub-Locations [11]. Kericho County is surrounded by Nakuru to the East, Kisumu to the West, Bomet to the South, Homa Bay &Nyamira to the South-West, Nandi to the North-West, Uasin Gishu to the North, and Baringo to the North-East. The county has a population of 901,777 persons, consisting of 450,741 males, 451,008 females and 28 intersex individuals with a population density of 370 persons per square kilometer [12]. The number of Households/farm families is 206,036 with an average Household size of 4.4 people, and an average farm size of 0.7 Ha for smallholders and 12 Ha for large scale farmers [12]. According to County Government of Kericho [11] report, Kericho County has four Agro-Ecological Zones: Upper Highlands (UH) covering an area of 26 Km^2 (1%), Lower Highlands (LH) with an area of 726 Km^2 (31%), Upper Midlands (UM) 830 Km^2 (35%) and Lower Midlands (LM), 186 Km^2 (8%). These agro-ecological zones have implications on the dairy sub-sector as it contributes to the dairy cows comfort and productivity [13].

2.3 Sampling Techniques

The study covered all the six Sub-Counties of Kericho county spread as shown in Table 1. Stratified random sampling techniques were used to obtain 10 wards to participate in the study. The strata were based on Sub-county and Agro-ecological zones. This study targeted all the 500 dairy farmers who had been exposed to the AVCEA in Kericho County [14]. A sample of 132 smallholder farmers was selected through systematic random sampling from the list of farmers who had previously been exposed to the AVCEA. All the fourteen key informants (eight dairy extension agents and six dairy organizations' representatives) were purposively picked to provide key information as experts in the dairy sub-sector. Table 1 shows the sample size per category.

2.4 Data Collection Tools

Data were collected from individual smallholder farmers using questionnaires. Structured Likert-scale type of questions sought to establish the extent to which respondents used specific production technologies and management practices (adoption) and the extent to which they had been exposed to specific agro-input interventions. A score of 1 and 2 on the 5-point scale was treated to imply non-adoption, while a score of 3 to 5 was treated as adoption. A score of 1 represented an opinion of *not at all,* 2 *minimal extent*, 3 *some extent,* 4 *great extent* and 5 *very great extent*. Interview schedules and focus group discussion guides were also used to gather data from key informants; the dairy

experts and Dairy organization representatives. The data collection instruments were tested through a pilot survey before the main data collection. The pilot data was analyzed to determine whether the tools were free from ambiguities and the final tools were adjusted as informed by this pilot result.

For this study, the agro-input interventions considered were: availability and accessibility of agro-inputs' stores, ease of accessing affordable credit facilities from the agro-input stores/suppliers, availability and accessibility of farmers' groups/cooperative societies, and the ease of accessing affordable credit facilities from the farmers' groups/cooperative societies as illustrated in the conceptual framework in Fig. 1. These variables were measured on a 5-point scale from the lowest 1 (none at all) to the highest 5 (very high extent). The scores on adoption were summed and averaged. Individuals with a score below the average were treated as non-adopters and those with an average score and above as adopters of the selected dairy technologies.

Table 1. Sample size per strata based on population

Sub-County	Category	Population N	Sample Size n
Total	Wards	30	10
	Smallholders	500	132
Ainamoi	Wards	5	2
	Smallholders	100	26
Belgut	Wards	6	2
	Smallholders	100	26
Bureti	Wards	7	3
	Smallholders	150	40
Kipkelion East	Wards	4	1
	Smallholders	50	14
Kipkelion West	Wards	4	1
	Smallholders	50	13
Soin/Sigowet	Wards	4	1
	Smallholders	50	13

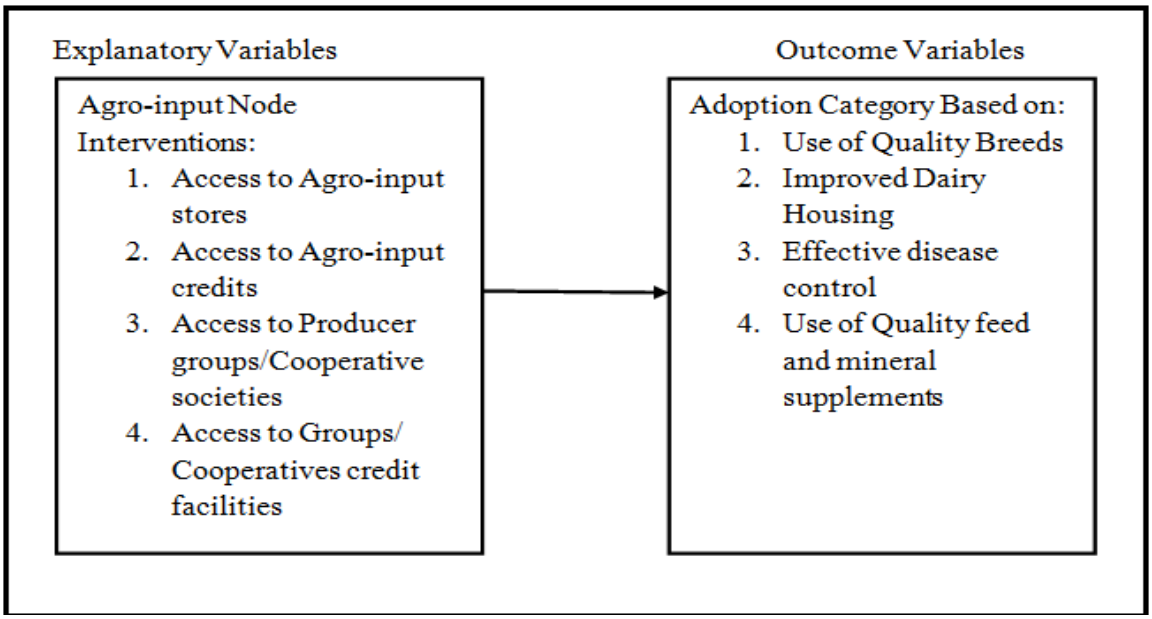

Fig. 1. Conceptual framework on potential interdependence between agro-input node interventions and adoption of selected dairy technologies

Table 2. Summary of data analysis as per research hypothesis

Hypothesis	Independent variables	Dependent variable	Statistical test
Ho There is no statistically significant interdependence between agro-input node interventions with the adoption of cattle milk production technologies by the smallholder farmers in Kericho County.	Agro-input interventions	Adoption of dairy cattle production technologies	*Chi-square*

2.5 Data Analysis

The data collected were organized and analyzed to generate descriptive statistics such as frequencies and percentages and are presented in tables and figures. Chi-square statistic was used to test for interdependence between the agro-input node interventions and the adoption of dairy production technologies as captured in Table 2. The chi-square test was used to assess potential associations between value chain extension interventions and adoption of dairy production technologies since both variables were measured on a categorical scale. Additionally, Cramers' *V* coefficient was employed to estimate the strength of association between these attributes [15]. The data collected through interview schedules and questionnaires were reviewed for completeness and accuracy before analysis. Incomplete and inaccurate data were discarded. The data were analyzed using SPSS, version 26.0.

3. RESULTS AND DISCUSSION

3.1 Socioeconomic Profiles of the Smallholder Farmers

To understand the socio-economic profiles of the smallholder dairy farmers sampled, key characteristics such as gender, age, marital status, highest level of education of the respondent plus land size and the main source of income for family were captured and analyzed.

3.1.1 Gender

The result on gender distribution of the smallholder farmers as captured in Table 3 showed that 71.8% of the respondents were males while 28.2% were females. Similar surveys on gender distribution of smallholder farmers' participation in livestock production enterprises as conducted by Agricultural Sector Development Support Programme II (ASDSP II) in Kericho County under their baseline survey (2019), showed that there was a higher percentage of men (55.3%) than women (44.7%) engaged in livestock rearing [14].

3.1.2 Age

The respondents were asked to state their ages under three age bands and the results revealed that 42.7% of the respondents were of above 50 years of age while 35.9% and 21.4% were categorized under the age bands 36–50 and 18–35 years respectively (Table 3). The average age for the smallholder farmers' respondents was found to be 43 years while that of the key informants was found to be 55 years. Age, especially for farmers has been, and is still being considered to be an important factor that affects or may affect the probability of an individual to adopt or not adopt agricultural technologies as it is a primary latent characteristic in adoption process [16]. Similar studies by [17] opined that in community context, elderly persons are deemed to have higher community status, persons who have gained many experiences in farming and could foresee potential gains in participating in extension interventions. A similar baseline study in the same county estimated the average age of dairy farmers at 46 years [14], similar to that reported by [17], but slightly higher than that in the current study. A study by [18] similarly found a higher average of 48.4 years. The current lower level maybe attributed to the weaknesses of interval data in the computation of means as compared to continuous data.

3.1.3 Level of education

In this study, the respondents were also asked to indicate their highest level of Education. The result for the question on the level of education of the respondents showed that 45.3% of the respondents had attained secondary level as their highest level of education while 36.8% and 17.9% of the respondents had attained tertiary and primary levels of education respectively (Table 3). The Level of education of the individual smallholder farmer participating in agricultural farming was viewed to have a

potential effect on the process of engaging oneself in a given agricultural enterprise. Further, the data gathered during focus group discussions revealed that some of the farmers were retirees with tertiary level of education. Some of them came on board for the AVCEA with anticipations for funding from the Agricultural Sector Development Support Programme (ASDSP I) that was implemented in the county between 2013 and 2017.Others were retirees who upon retirement decided to venture into dairy cattle milk production as their fallback activity. While others still in the tertiary level of education were smallholder educated agricultural entrepreneurs who chose to do dairy cattle production as their farm business. ASDSP [14] reported similar, though slightly different findings; 38.6%, 28.7% and 26.3% of respondents had secondary, tertiary and primary levels of education respectively.

3.1.4 Major sources of family income

Among the targeted smallholder farmers 88.0% indicated that dairy-cattle farming were their major source of income. This was followed by employment at 6%, horticulture at 3.4% and business at 2.6% (Table 3). The finding gave an indicative picture and affirmation that our sampled population was the right target population of dairy producers for this research work.

3.1.5 Land size under dairy cattle

The data gathered revealed that 14.5% of the respondents had approximately 0.808 Ha (≈ 2.00 Acres) of land size under dairy cattle milk production. Similar surveys on the approximate land size under dairy cattle milk production as carried out byASDSP [14] in Kericho County in their baseline survey, revealed a value of 0.9 Ha (≈ 2.23 Acres) for the majority of the respondents. Their baseline survey compared very closely with our findings. This current finding is in contrast to the 4.1 acres reported by [18].

3.1.6 Net-income from dairy farming

Respondents were also asked to state what they perceived as their net-income from dairy farming and the results are depicted in Fig. 2. Findings revealed that Kshs. 120,000 per annum was the most frequent value indicated as net income from dairy farming. The mean value was Kshs. 84,017 with a high range of 397,000. Similar findings were reported in ASDSP [14] report.

3.2 Interdependence between Agro-input Node interventions and Technology Adoption

The categorical data on Agro-input node interventions were tested for interdependence with the adoption of cattle milk technologies at the production node. The extent to which the technologies were used at the production node was used as a measure of adoption. The extent of use was also measured on a 5-point scale. Low scores of 1 and 2 were treated as non-adoption, while high scores of 3 to 5 were treated as adoption. Tests for interdependence between the variables were tested by Chi-square analysis and the related Cramers' *V* coefficient.

Table 3. Demographic and socio-economic profiles of the sample

		Frequency F	Percent %
Gender	Male	84	71.8
	Female	33	28.2
Age	18-35 years	25	21.4
	36-50 years	42	35.9
	Above 50 years	50	42.7
Education	Primary level	21	17.9
	Secondary level	53	45.3
	Tertiary level	43	36.8
Major source of income	Dairy cattle farming	103	88.0
	Employment	7	6.0
	Business	3	2.6
	Horticulture	4	3.4

(Source: Study Data, 2023)

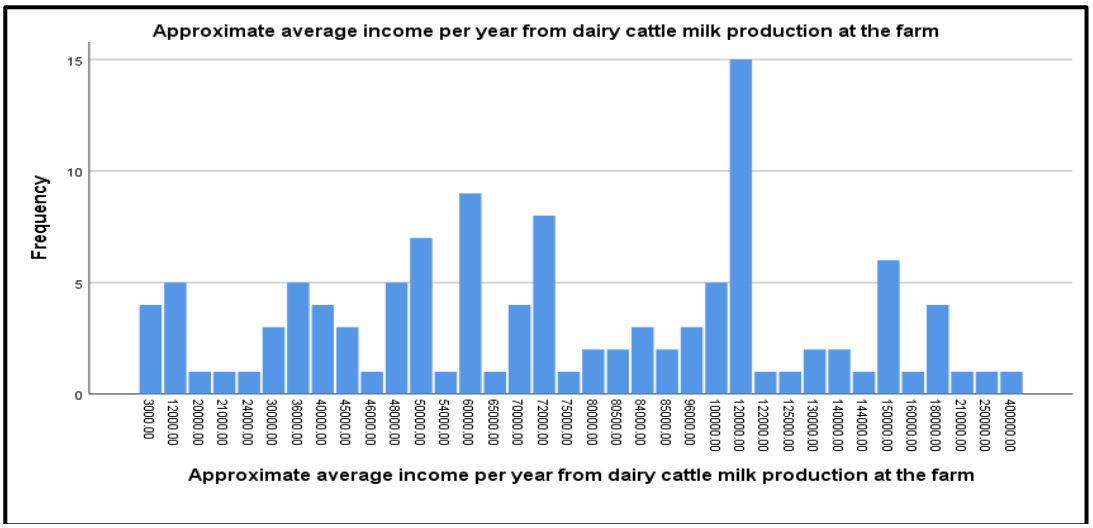

Fig. 2. Annual Net income from cattle-milk in Kenyan shillings as reported by respondents

3.2.1 Ease of access to agro-input stores and decision to adopt technologies

The findings showed that 54.7% of the respondents agreed to some extent that the availability and ease of accessing agro-input stores as envisaged by agricultural value chain extension approach intervention had affected their decision to adopt dairy cattle milk production technologies in their respective administrative wards, with 37.6% and 7.7% agreeing to a great and to a very great extent' respectively. Majority (54.7%) of the respondents agreed to some extent that the availability and ease of accessing agro-input stores had affected their decision to adopt dairy cattle milk production technologies. Similar studies by Ng'eno [17] opined that farm-input suppliers or agro-input stores in a value chain extension service delivery approach forms part of the extension service delivery notch as enabler of the farmer decision to, or not to adopt the agricultural technologies. Their findings are consistent with the current study-findings.

3.2.1.1 Interdependence

There was a weak interdependence between ease of access to agro-input stores by the dairy farmers with the adoption of production technologies; χ^2 (2) = 4.928, *P*= .085, *V* = .205 as captured in Table 4. The 20.5% strength of linkage between the two aspects indicates a moderate strength of interdependence between the two variables [19]. The observed interdependence indicates that access to agro-inputs has some profound implications in the adoption of technologies such as the use of superior quality feeds and superior breeding techniques. The results indicate that the potential to adopt is partly attributed to the ease of access of agro-inputs. This finding has implications for the value chain extension approach as it suggests a need for continued interventions that foster ease of access to superior quality inputs among smallholder dairy farmers.

3.2.2 Ease of access to credits from Agro-input stores and adoption of technologies

An analysis on the opinions in regard to ease of access to credits from agro-input stores shows that 50.4% of the respondents responded to '*not at all'*, while 41.9% and 7.7% agreed to a '*minimal extent'* and to *'some extent'* respectively. None of the respondents indicated that ease of access to agro-input credits contributed to adoption to a *great* or *very great* extent. This observation indicates that a large.

Table 4. Chi-square tests for Interdependence between agro-inputs access and adoption

	Value	df	P-value
Pearson Chi-Square	4.928	2	.085
Likelihood Ratio	4.595	2	.101
Linear-by-Linear Association	2.692	1	.101

proportion of the respondents did not benefit from credit facilities from agro-input stores. The 50.4% reporting *not at all*, plus the 41.9% reporting *minimal,* implies that 92.3% of the respondents probably had not benefited from the agro-input credits.

3.2.2.1 Interdependence

There was no statistically significant interdependent effect between the ease of accessing affordable credit facilities from agro-inputs stores and the adoption of dairy cattle production technologies as tested by Chi-square analysis; χ^2 (2) = .279, P = .870, V = .049. The small *V*-value of less than 10% implies that the degree of interdependence between the two attributes is negligible [19].

The expectations from the agricultural value chain extension approach program that was implemented in the area of study was that the extension agents would use their influence and links in the organization to enable smallholder farmers obtain farm inputs and or financial support from input dealers to procure farm inputs on credit. Farmers would later pay the loan upon harvest or pay back in instalments on check-off basis spread over the growing season. This was to be done on agreed friendly and affordable terms [14]. Credit facility was therefore seen as the ability to access goods, services and or physical money from agro-input stores in advance; with the understanding that the beneficiary (borrower) will be honest enough to honour the set obligations to borrow, use and later, upon harvest, pay the loan back. This arrangement was intended to assist in promoting the decision of smallholder dairy farmers to adopt the dairy cattle production technologies in their respective localities. The current findings suggest a non-significant effect.

A Comparative study by [20] found in their research among the smallholder indigenous chicken producers in Makueni County, Kenya that access to credit would only lead to higher profits if and when stringent and punitive demands on credit provision were removed. They asserted that credit facilities from financial institutions were tied with stringent and punitive demands, making it almost impossible to access it. This assertion meant that an alternative source of credit such as through agro-input suppliers may have a better effect on adoption. The current study, however, did not provide evidence to support the same; the strength of interdependence was trivially small [19].

3.2.3 Ease of access to farmers' groups/cooperative societies and adoption of technologies

A descriptive analysis of the data shows that 64.1% of the respondents agreed *'to some extent'* that the availability and ease of accessing farmers' groups/cooperative societies had affected their decision to adopt dairy cattle milk production technologies in their respective administrative wards while 26.5% and 9.4% agreed to a '*great extent'* and 'to a *minimal extent*' respectively. On further probing of the respondents, the analysis of the results showed that the availability and ease of accessing farmers' groups or cooperative societies by smallholder farmers enabled members to get better access to agricultural extension services, achieved better production factors such as better leadership experience, participate in off-farm activities such as cattle milk bulking and transportation services among others. The agricultural value chain extension approach implemented earlier in the locality envisaged that farmers' groups/and or cooperative societies may assist in promoting the decision by smallholder dairy farmers to adopt dairy cattle production technologies in their respective administrative areas.

3.2.3.1 Interdependence

There was a statistically significant interdependence (*P* < .05) between the ease ofaccess to farmers 'groups/cooperative societies and the adoption of dairy cattle production

Table 5. Chi-square test values for interdependence between access to groups/Cooperatives and adoption

	Value		*P*-Value
Pearson Chi-Square	5.506	1	.019
Likelihood Ratio	5.330	1	.021
Linear-by-Linear Association	5.459	1	.019

Table 6. Chi-square test values for interdependence between access to groups/Cooperatives' credits and adoption

	Value	df	*P* value
Pearson Chi-Square	1.142	2	.565
Likelihood Ratio	1.118	2	.572
Linear-by-Linear Association	.123	1	.726

technologies by the smallholder farmers (Table 5). There was a moderate strength of interdependence between the two aspects; χ^2 (1) = 5.506, *P* = .019, *V* = .217.

This finding compares well with those of [21], who in their similar study in Uganda found that farmers who had access to or who were members of farmer groups had significantly higher maize and banana yields compared to non-group members. Author [22] also in a similar study in Western Kenya reported that there were positive and significant adoptions of agricultural technologies leading to higher and better yields by dairy farmers who had access to, or belonged to farmers groups or farmers cooperative societies compared to those farmers who had no access or were non-members. Other similar studies by [23], while studying formal conditions that affected agricultural credit supply to small-scale farmers in rural Kenya, found out that structures such as farmers' organizations like farmer groups and famers' cooperative societies acted as enablers in adoption of agricultural technologies. Author [24], in their exploration of social capital, found a significant link between membership in farmer producer organizations and collective actions, such as joint learning and joint acquisition of farm-inputs that foster adoption of technologies. In another study conducted by [25] in a rural highland in Kenya, the authors reported that membership to farmer organizations had a positive impact on fertilizer use technology and maize productivity. The current findings are in agreement with these findings on the interdependence between access to farmers' groups/farmers' cooperative societies and the adoption of agricultural technologies by smallholder famers. The smallholder farmers in producer organizations such as cooperatives are expected to benefit from collective actions that reduce the cost of transactions and increase the possibilities of reciprocal learning as reported by [24]. Reciprocal learning of new technologies is expected to foster technology adoption.

3.2.4 Access to credits from farmers' groups/cooperative societies and adoption

This study finds that 52.1% of the respondents agreed that the ease of accessing affordable credit from the farmers' groups/cooperative societies in their respective administrative wards had affected their decision to adopt cattle milk production technologies *'to some extent'* while 44.4% and 3.4% 'agreed that it had affected their decision to a *minimal extent'* and 'to a '*great extent'* respectively. None of the respondents indicated that it had not influenced them at all.

3.2.4.1 Interdependence

There was no statistically significant interdependence between the ease of accessing credit facilities from farmers 'groups/cooperative societies with the adoption of cattle milk production technologies by the smallholder farmers (Table 6). The interdependence was negligible [19] based on the observed Cramers' *V* coefficient; χ^2 (2) = 1.142. *P* = .565, *V* = .099. This observation indicates that the potential role of cooperative credits in increasing technology adoption is yet to be realized in the study area. A study conducted elsewhere in China revealed that small commercial farms tended to benefit more from cooperatives in improving credit access than large farms [26]. The current study suggests that the existing cooperatives may not have been impactful in regard to supplying the needed credit facilities for technology adoption by smallholder farmers. USAID [27] report on the dairy value chain in Kenya recognized the dire need for improved access to credit facilities among the smallholder dairy farmers.

4. CONCLUSION AND RECOMMENDATIONS

The results of this study revealed that a majority of the dairy cattle value chain producers were males, at nearly 72%, with a majority of about 43% aged over 50 years. Majority of the farmers, at about 45% had attained secondary level of education. The objective of the current study was to assess the interdependent effects between the agro-input node interventions with the adoption of cattle-milk production technologies among smallholder farmers. Selected interventions were investigated for their potential interdependence with adoption of the technologies. In conclusion, a moderate level of interdependence was

observed between access to agro-inputs and the adoption of selected dairy technologies. In contrast, interventions on ease of access to credit did not show any significant relationship with adoption. However, group or cooperative membership had a significant impact on the adoption of dairy technologies among smallholder farmers. Overall, certain interventions at the agro-input node had notable influence on the adoption of dairy technologies by smallholder farmers. This study recommends developing strategies to strengthen interventions at the agro-input node, by experts and stakeholders, particularly by fostering cooperation among smallholder farmers to enhance collective actions. This study further recommends future evaluation of dairy value chains in similar socio-economic contexts, for their impact on adoption of technologies that enhance productivity. Such studies would foster understanding of the weak links in the Agricultural value-chain extension approach.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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