ECONOMIC ANALYSIS OF DAIRY-CROP INTEGRATION IN THE KENYA HIGHLANDS; A CASE STUDY IN ELGEYO-MARAKWET COUNTY, KENYA

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DECLARATION AND APPROVAL

CANDIDATE DECLARATION

I declare that this thesis is wholly my original work and to the best of my knowledge has not been presented for the award of any degree at any other university.

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To my late grandparents, my parents Wilson Karamai and Magrina Kipkosgei, brothers Nixon, Leonard and Obed, sisters Caroline and Jackline as well as all the well wishers.

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ABSTRACT

Dairy-crop integration is a form of mixed farming in which there exist complementarities between dairy and crop enterprises. It occurs where dairy animals serve to add value to crop by-products, to diversify crop rotations and/or help recycle nutrients. Although a number of studies have shown that there are multiple benefits of dairy-crop integration and despite efforts made by agricultural extension officers in Elgeyo-Marakwet County to educate farmers on the practice, many households have not embraced and yet the ecological conditions are favorable. The study characterized integrators and non integrators in terms of socio economic characteristics. The role socio-economic characteristics on the farmers' decision to integrate dairy and crop enterprises was put into focus. A partial budget analysis of farms that practice dairy-crop integration was done to determine the net benefits of integration . A sample of 170 farmers was obtained using multistage sampling. The sample comprised of 85 integrators and 85 non integrators of dairy and crop enterprises. Both descriptive statistics and binary logit were used. The study found that integrators have a low mean in years of schooling and bigger size of land compared to non-integrators. Among the significant socio-economic characteristics that influenced the decision to integrate include gender, household size and awareness of the benefits of dairy-crop integration. Partial budget analysis shows that integration is a superior technology as opposed to non-integration of dairy and crop enterprises.

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LIST OF ABREVIATIONS

CMAAE	**-**	Collaborative Masters in Applied Agricultural Economics
DC	-	Dairy-crop integration
GoK	-	Government of Kenya
HH	-	Households
RSA	-	Republic of South Africa

CHAPTER ONE

INTRODUCTION

1.1 Background information

Dairy-crop integration is a form of mixed farming. Mixed farming occurs where livestock serves to add value to crop products, to diversify crop rotations and/or help recycle nutrients. It combines crops and livestock on different degrees. Most farmers with little access to resources such as capital, land and labour rely on mixed farming systems. On the livestock side, ruminants (cows, sheep, or goats) provide added value by converting fibrous feeds like straws, maize stovers and crop residues. Monogastrics (pigs, donkeys and poultry) also provide cash income by converting by - products like grain to high value foods, and thereby serving as a saving account for subsistence farmers. Donkeys on the other provide traction power in the farm (Hans *et al.,* 2006).

Diversification occurs where components such as crops and animals co-exist rather independently on the farm. Their combination serves to spread risks, but their interactions are minimal. Nutrient flows are rather linear in this case. This form of mixing does not involve recycling of resources to a significant degree. Integration occurs where the components of the farm are interdependent, for example, where animals providing dung while consuming crop residues (Savadogo 2000). Humans developed agricultural systems that combined crop production with animal husbandry about 8 to 10 millennia ago (Smith, 1995). These integrated systems provided a greater variety of products to a farm family than did either enterprise alone and offered a means of utilizing crop residues or non cultivated land to produce meat, milk, and associated products, while generating manure to improve the fertility and quality of cultivated soil. In the past 60 years, however, agriculture in many industrialized countries has become increasingly specialized, resulting in a separation of crop and livestock enterprises (Ray and Schaffer, 2005).

1.2 Co-evolution of farming system in time and space

Mixed crop-livestock systems co-evolve in their context. This is due to the fact that farming systems are not static but they are constantly changing in time and space. When land is relatively abundant, crops and animals exist parallel to each other. In this case, crops and animals are complementary and do not exchange resources among them. As land becomes scarce, as a result of the success of this type of farming, the expanding farmer population is forced to keep animals together with crops. Higher exchange of resources like dung, crop residues and animal draft are then required. This therefore results to a mode of farming which is referred as the Integrated Low External Input Agriculture (ILEIA).Keeping of animals and crops will start to disintegrate as specialization begins to set in. This mode permits economies of scale, labour efficiency, and mechanization as well as inorganic inputs such as the chemical fertilizers. This mode of specialization eventually chocks itself or starves itself due to the negative impacts on the environment as well as the exhaustion of resources .This leads to re-integration of enterprises depending on the mind - set of the farmer (Herman and Schiere, 2008) .

It has been pointed out that several agricultural activities increase greenhouse gas emissions. On the other hand, it is increasingly becoming better appreciated by the public as well as by the producers that selected agricultural practices can greatly increase productivity and incomes while simultaneously reducing the impact of climate change-related economic, social and environmental effects. These include minimizing mechanical soil disturbance and increasing soil organic matter which help reduce effects of dry periods on crop productivity and farm output. Similarly, it is possible to increase biomass in quantity and quality, and thereby increase livestock output in small-scale integrated systems. Therefore, the integration of crop and livestock production systems increases the diversity, along with environmental sustainability, of both sectors. At the same time it provides opportunities for increasing overall production and economics of farming (FAO, 2010).

Although direct consumption of crops provides more protein and energy to humans than when crops are processed by livestock (Spedding, 1988), and although some livestock production systems have contributed to environmental degradation, livestock can utilize crops and residues not suitable as food and fiber for humans. In addition, crop–livestock systems that are appropriately integrated and intensified for the location can provide multiple benefits (Schiere *et al*., 2006).

The importance of manure as a source of recycled nutrients has been recognized for millennia. The economic value of manure, though significant, has not overcome the convenience and relatively low cost of inorganic fertilizers, and the lower confidence farmers have in nutrient supply from manure. Larger, more specialized livestock production operations that import nutrients from distant sources have resulted in greater nutrient concentration in localized areas. These factors have contributed to excessive manure (or total nutrient) application and subsequent degradation of water resources, which in turn has stimulated regulations (Jongbloed,1998 and ; Saam *et al*., 2005).

1.2.1 Advantages and disadvantages of mixed crop- livestock systems

An interaction between crops and livestock production enables sustainability of farm production as well as enhancing intensification of the production activities due to the complementarities of the two enterprises. Therefore, the use of farmyard manure can assist farmers to a great deal to produce essential food crops despite the increase in fertilizer prices. The agricultural sector is constrained by a number of factors such as the high costs of inputs resulting in low application of fertilizer and certified seeds, which thereby affect agricultural productivity (Kenya Vision 2030, First Medium Term plan, 2008-2012). According to Tegemeo (2008), it is necessary for the farmers to integrate the two enterprises to reduce the variability in farm income.

Since the late 1990s, researchers have been exploring the ways in which African households diversify their livelihood strategies, including on-farm (crop, livestock) and off-farm activities, to mitigate risks (Bryceson, 2002). Crop–livestock integration systems are the most important mechanism for producing food across sub-Saharan Africa (SSA). Opportunities for farmers to generate income from livestock production are increasing dramatically as demand for animal products increases across Asia and Africa. Most of this increased demand will be met from mixed cropping-livestock enterprises, in which the majority of tropical livestock are currently raised and where production is usually dependent on low-quality crop residues.

With a total population of approximately 156,471, the population of the people who live in absolute poverty in the former Keiyo district was estimated at 47.82% (GOK, 2008).Even within a small land area, households in the Elgeyo-Marakwet County pursue heterogeneous livelihood diversification strategies. Some depend solely on crops (often only maize and beans), or mostly on livestock, while others grow crops, have goats and dairy cows. Other households have diversified into other activities that generate off farm income. However, despite the existence of several enterprises in their farms, some farmers in Elgeyo-Marakwet County are not integrating the crop and dairy enterprises while others have attempted to integrate. Those farmers that have embarked on dairy- crop integration use crop residues to feed their dairy cattle while the manure from the dairy enterprise is used as a fertilizer not only in the maize enterprises but also in other crop enterprises such as beans and vegetables.

1.3. Statement of the problem

Agricultural extension officers in Elgeyo-Marakwet County have made efforts to educate the famers on dairy-crop integration but many households have not embraced the technology yet the ecological conditions are favourable for this type of farming system. Despite the economic benefits of dairy-crop integration that several studies have shown, there is low uptake of dairy–crop integration in Elgeyo-Marakwet County. It is not clear whether the associated economic benefits are understood by the farmers or not. Some farmers in the county tend to incur high production costs due to non integration yet the positive association of crops and dairy enterprises can help a great deal to reduce the production costs as well as to recycle nutrients within the farm. This study aimed at investigating these issues and by so doing contribute to the existing body of knowledge on the agricultural sector and it's to linkage farm resource utilization especially in the highland areas.

1.4. Objectives

1.4.1 General objective

The general objective of the study was to provide an insight into dairy-crop integration in the Kenyan highlands and to contribute into a better understanding of the economic aspects behind dairy crop-integration.

1.4.2 Specific objectives

1) To characterize dairy-crop integrators and non integrators in Elgeyo-Marakwet county.

2) To determine the important socio-economic factors influencing the decision to integrate dairy and crop enterprises amongst smallholder farmers in Elgeyo-Marakwet County.

3) To comparatively analyze objectives of farmers who practice dairy-crop integration and those who do not.

4) To comparatively analyze the biophysical resource flow among farms that practice dairy-crop integration and that which do not.

5) To compare the partial budget of farms that practice dairy-crop integration and which do not.

1.4.3 Research questions

1) Are there any differences in the characteristics of dairy- crop integrators and non integrators?

2) What are the important Socio-economic factors which influence the decision to integrate dairy and crop enterprises?

3) Do the household who practice dairy-crop integration and those who do not practice dairy crop integration have the same objectives?

4) Are there any differences in the characteristics and direction of flows of biophysical resources in farms that practice dairy-crop integration and those that do not practice dairy crop integration?

5) Does dairy-crop integration have any benefits to the adopters?

1.5. Justification

Agricultural production is an important revenue generating activity to the people of Elgeyo Marakwet County. Cost reduction has been identified as key to the realization of producer's goal to generate higher net income. On the other hand nutrient recycling is paramount in ensuring environmental and production sustainability. An Economic analysis on Dairy-crop integration provides an insight into the different approaches in which extension workers can use to persuade farmers to adopt integration of enterprises. Therefore, this study targeted to generate imperative information that will elucidate economic aspects behind on Dairy-crop integration.

1.6 Scope and limitations of the study

The study was geographically confined to the boundaries of Elgeyo-Marakwet County. The study only focused on data pertaining 2010 production year. The study concerned itself on the aspects of production such as costs of fertilizer, animal feeds and farm labour utilization as well as the revenues emanating from crop and dairy enterprises. It emphasized on bringing into focus the factors that influence the farmers' decision to integrate crop and dairy enterprises. On the other hand, the study tried to compare the financial viability of dairy crop integration versus non integration of the two enterprises. The study further compared the differences in the objectives of the households that practice dairy crop integration and those that do not. The study critically examined the influence of the farmers' objectives in the decision to integrate dairy and maize enterprises. The study also analyzed the role of the socio-economic factors such as age, gender, land size, access to credit and distance from the market on the farmers' decision to integrate the two enterprises.

1.7 Definition of terms

1. **Dairy-crop integration**- A form of mixed farming in which the farmer rears dairy cows and plants crops in his farm in such a manner that there is constant interaction and complementarities between the dairy cows and the crops.

2. **Household** – an independent male or female producer and his dependants who must have lived together for a period not less than six months. The members are answerable to one person as the head and share the same eating arrangement.

3. **Socio- economic factors** – factors that influence both the social and economic well being of an individual.

CHAPTER TWO

2.0 LITERATURE REVIEW

Crop-livestock systems play a major role in the dynamics of many agricultural systems. They occur in many forms and they allow more efficient use of resources than specialized systems and spreading of risks. The renewed interest in such systems to mitigate the negative (mainly environmental) impact of highly specialized agricultural systems is highlighted. In these systems crop residues can be used to feed the animals and the excreta from the animals as nutrients for the crops. In addition, inclusion of livestock alters the rate of nutrient turnover; it provides a labour opportunity in slack times for crops and adds value to crop by-products. To some extent, both crop and dairy are essential for the livelihood of the farmer in that they provide income at one hand and food on the other. (Herman *et al*, 2008) Crop-livestock integration is traditionally strong in Africa's mixed farming systems based around subsistence food cultivation. In some situations (such as in the Republic of South Africa), a perceived decline of this integration, particularly in the availability of draft power, has been viewed as compromising the maize production system. This is less significant in East Africa where hand cultivation is much more prevalent (Thorne *et al.,* 2002).

A key to the successful operation of integrated farming systems is the orchestration of the multi-enterprise production calendar in such a co-ordinated manner, that residues from one enterprise are available at the right time and in the right amounts needed as inputs to other enterprises. On the other hand, smallholder farms are usually nutrient-starved and farmers focus their efforts on the successful production of the staple crops. Other elements of the farm, such as unconfined livestock, have to survive on what feed resources they can find (Prein, 2002). Successful integration will often result in a more varied mix of activities—at the regional level of farm enterprises and the vertical level of economic sectors, including new input markets and emerging processing industries. This will reduce community dependency on a narrow range of outputs and, as a result, will reduce vulnerability to shocks from climatic variability and volatility of commodity prices. One of the most common rationales for diversification of farm output mix is to reduce Environmental (climate shocks), ecological (pest and diseases) and economic risk associated with uncertainty and variations of net (aggregate/farm) income (IBRD, 2003).

Concerns are growing over the ability to maintain long-term intensive monoculture agriculture. Currently, there is an increasing shift back toward integrated systems to address the challenges of the 21st Century. Specifically, agriculture in the 21^{st} Century will increasingly be asked to continue providing an abundant supply of safe and wholesome food and fiber at a reasonable cost and that is environmentally benign and assures the future economic and social sustainability of rural areas. The most scientifically sound and objective way to accomplish this will likely be by exploiting the many advantages and benefits of production systems that are well integrated and diverse. The concept of integrated systems must be viewed not only on an individual farming entity basis but also from a landscape perspective where the mosaic of crop and livestock systems contributes to the diversification of the regional system (Allen *et al* 2007).

Dairy animals require 19 elements, and except for cobalt, iodine and selenium, the others are also essential to plants. African farmers and herdsmen have traditionally derived the nutrients, necessary to support dairy-crop systems, from soil reserves, crop residues, animal manures and biological nitrogen fixation (BNF). In recent years, commercial fertilizers have become important, but are far short of the level of usage required by crops to sustainably increase productivity. In the simplest undisturbed systems, plants grow utilizing soil nutrients and when they die, nutrients return to the soil through the litter for reuse. If a herbivore(such as a dairy cow) is introduced into the system only part of the nutrients may return to the soil from the plants directly as litter, and if animals move out of the designated boundaries, there must be a deliberate effort to return the excreta if nutrients are to be recycled. In intensified land-use involving complex food crops, food-forage mixtures and different livestock species, nutrients go in a lengthy path through different trophic levels before they are returned to the soil. Type of animals and methods of management will, to a large extent, determine the amount of nutrients that are ultimately returned to the same land unit. Livestock feeding strategies vary from unrestricted grazing, restricted/seasonal grazing to zero grazing or stall-feeding. As more land is cultivated, grazing lands diminish. The spatial shift from free pastures to fallow uplands or steeper lands has several consequences for feed availability and quality. Not only is there a reduction in the amount of pasture available, but pastures may become seasonally inaccessible because of the fragmented nature of cropping and/or other land-uses. (Mohamed, 2003)

A study done by Devendra, (2002) on the future Perspectives of Animal-crop systems in Asia indicated two possible scenarios for the future of crop-livestock systems in developing countries. One is where market forces and technological requirements force the systems to grow in unit size and to specialize. This would present fewer opportunities for on-farm crop and animal integration. The second possibility, as a result of continuing human population pressures, leads to decreasing farm sizes to the point where the system disintegrates (involution). Large ruminants can no longer be maintained on the farm, the nutrient and farm power balance runs into a widening deficit and disinvestment occurs as natural resources degrade. According to Pengelly *et al*, (2003), without substantial additions in the form of mineral, protein and energy supplements to the diet, both reproductive rates and animal production are almost universally poor within Dairy-crop integration systems. Despite this low level of animal production, dietary supplements including sown forages should be put into consideration when embarking on Dairy-crop integration (Pengelly *et al*, 2003).

According to Ilyama *et al*, (2007), staple crops (mainly maize) and indigenous cattle were positively associated with this component of integration, while fruits were negative. This is because fruits are more likely to be planted on fenced homestead plots thus not awarding livestock an opportunity to interact with the fruits. Households with a higher score of integration and diversification are specialised in extensive production of staple crops and grazing of indigenous cattle.Ordinary least squares (OLS) analysis was used to estimate crop -livestock patterns which were associated with a higher level of household income (Kshs per year) and increased use of organic manure (kg/total land area in hectares used by household). The quantity of manure was estimated for each crop type and aggregated for the total number of hectares a household uses. Five dominant Crop livestock patterns were identified among them, a pattern of improved cattle and fruits was found to be associated with higher household income and more intensive manure use. Education and access to knowledge and skills through participation in farmers' groups and close access to the training centre appear to be crucial factors for households to adopt improved cattle and fruits pattern.

Squires *et al,* (1992) found that improved forages are more likely to be planted in mixed cropping-livestock systems where grazing control is usually practiced, at least for part of the year. Given their restricted resources, smallholder farmers are necessarily cautious about new investments; they would probably invest in new forages only when they have control over the resultant utilization. Consequently, investment in new forages for communally grazed grasslands is unlikely until pastoral communities develop strategies for grazing management.

In a study on location and uptake of technology, by Staal *et al,* (2002) a farmer adopts the new technology if the derived benefits are higher than a certain threshold. Okoruwa *et al.,* (2000), found that a farmer cannot produce crops without losing some income from livestock and *vice versa*, there is always a tradeoff between crops and livestock in the allocation of farm resources. Profitability of crop and livestock enterprises under different systems of management was measured by applying farm budgeting procedures. Among other things, the implication of charging a rent or tax for grazing land was examined. A linear programming model was used to test whether available land, labour and capital resources were efficiently allocated by the different farm groups.

In their seminal review paper, Feder *et al*., (2005) pointed out that individual variables like education, farm size, and experience are significant determinants of agricultural technology adoption in developing countries. Feder and O'Mara (2001), in their study on the adoption agricultural techniques during the Green Revolution, emphasized the importance of proper access to information and credit as facilitating elements in the adoption process. Information and credit constraint where therefore defined as dummy variables. The information constraint variable is founded on self-reported access to information on modern agricultural technologies. The credit constraint variable is based on the farmers' self reported access to a loan from the bank or credit from the input dealer. A probit model was used to analyze the effects of these socio-economic variables on the adoption of agricultural technologies.

In another study carried out by Nyoro, *et al*., (2004) on costs of production between Kenya and Uganda, it was found that application of manure in dairy- crop systems resulted in higher yield and lower production costs; this was found not to be true in intercropping systems. Decomposition of costs of production shows that the largest portion of costs for small-scale farmers is labor, fertilizer and seed costs, while that of large-scale producers is land preparation because of high mechanization.

According to Barlas *et al*., (2001), the key dimensions of the integration of alternative farm enterprises (AFEs) are

a) Technological dependence.
b) Dependence on markets.

c) Dependence on credit.

In a study done by Kiruiro et *al*., (2001), the broad objective was to develop integrated and sustainable feeding system based on the use of maize leaves for smallholder dairy farmers. A participatory rural appraisal (PRA) approach was applied in implementing the project with farmers being actively involved in all stages of the research right from problem identification and setting the research agenda to dissemination of proven technologies. It was found the aspects of removing maize leaves and feeding it to the cattle is practical and gender friendly. The activities did require much of labour or conflict with other activities at the farm during the removal of maize leaves from the field.

2.1 Sustainability indicators for Dairy-crop Systems

System's Farm productivity, in terms of plant and animal output per unit area or time or level of nutrient inputs is a possible measure of sustainability. Nutrient changes in the different pools can be assessed. However, agro- ecosystems that include Dairy animals encompass a mixture of land use systems that cut across farm, landscape and watershed scales. At those different scales, there are no sensitive and easily observable indicators to assess the state of nutrients. The state of the soil, as expressed in its organic matter content, density, cation exchange capacity, pH, available plant nutrients, water absorption capacity, drainage, rate of erosion and soil surface temperatures etc. can be measured, but by themselves they are insufficient to assess the nutrient movements through the agro ecosystem as a whole. Plant biomass could provide more holistic information, but is not a good indicator because it varies seasonally and is very much affected by extraneous factors such as grazing and fire.

In any event, the information provided by soil and plant variables would be limited to the environment, and would not serve well as indicators of human or economic activities. In Dairy-crop integration systems, crops receive organic manure from the grazing fields. The state of health and productivity of Dairy animals is closely related to natural and cultivated plant biomass produced by the agro ecosystems. It could be therefore, hypothesized that the state of health of dairy animals could provide indicators of the state of environment of agro-ecosystems. This is because dairy animals have a low tolerance for mineral deficiencies. Body mineral deficiencies are expressed in different forms of health disorders, and therefore can also serve as good indicators of the available feed and the environment which supply those feeds. (Mohamed, 2003)

2.2 Theoretical and conceptual framework

2.2.1 Theoretical framework

The decision to integrate crops and dairy can be regarded as a binary choice. This is because of the dichotomous nature of the dependent variables, that is, to integrate or not to integrate. Therefore, the binary choice model is appropriate if the following conditions hold true. (i) The households are faced with only two alternative choices (ii) any choice a household makes depends on its socio-economic characteristics. The binary choice model is based on the foundation of utility maximization, therefore, the net of expected utility that is accrued from integrating or not integrating dairy and crop enterprises is estimated as follows;

$$Eu_iA = f(X_i) + e_i$$
$$Eu_iN = f(W_i) + e_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6)$$

Eu_iA is the expected net utility of household *i* from integrating dairy and crop enterprises. A is a denotation of dairy-crop integration. N denotes non integration of dairy and crop enterprises. X_i and W_i are independent variables which denote farmer characteristics, physical and economic, influencing the decision and e_i is error term. The expected net utility from each of the decisions is then compared such that: $Eu_iA - Eu_iN > 0$, or $Eu_iA - Eu_iN < 0$. Y_i is then used as an indicator of whether household i integrate the two enterprises or not, so that $Y_i=1$ if they integrate and $Y_i=0$ if they do not integrate.

$$Y_i = 1 \, if \, Eu_iA - Eu_iN > 0$$
$$Y_i = 0 \, if \, Eu_iA - Eu_iN < 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

In a study by Caviglia-Harris., (2003), the above equation can be interpreted as probability that the household *i* adopts the new technology which also implies that the probability that the expected net utility derived from dairy -crop integration is greater than the expected net utility derived from not integrating dairy and crops.

2.2.2 The conceptual framework

The conceptual framework of the study was based on a typical farm that has both crops and dairy enterprises integrated together such that there is no distinction between the cost of inputs for the dairy enterprise and crop enterprise. The main areas of interaction between dairy and crop enterprises that was put into focus were manure utilization and crop residue utilization by the animal enterprise as well as farm labour utilization by the both enterprises. The conceptual framework assumed that interaction between crops and dairy lead to a decline in farm production costs, which was accompanied by increase in farm profits thereby culminating into increased farm productivity. Sustained increase in farm productivity contributed to poverty alleviation amongst the Elgeyo-Marakwet community. The farmers' main objective was assumed to be that of profit maximization or constant food and milk supply for the household. The conceptual framework further assumes that socio-economic factors (such as age, education, farm size, gender, infrastructure, market access, attitude towards risk and culture) and the benefits accruing from dairy-crop integration (Improved income, reduced cost of production, sustainable use of soil resources, reduced farming risk etc) influence the farmers decision to integrate the two enterprises. The benefits accruing from integration influence the farmers' household objective thereby deciding to integrate or not to integrate depending on the perception whether the benefits are high or low. If the benefits are perceived by the farmer to be lower than accepted, the farmer will decide not to practice dairy-crop integration. On the other hand, if the benefits are high enough, decision will be made to integrate the two enterprises. These benefits will in turn influence poverty reduction. This conceptual framework is diagrammatically illustrated below.

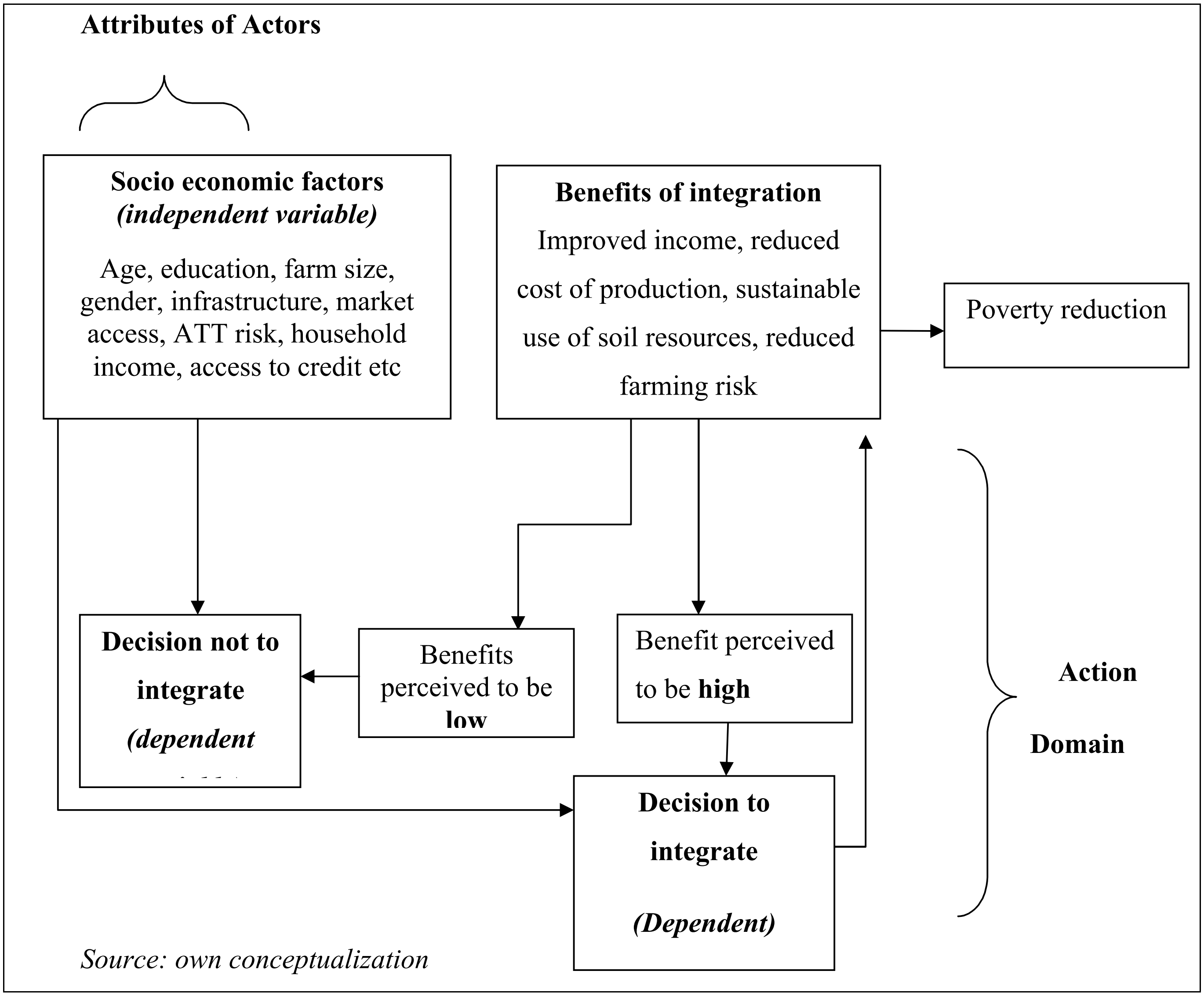

Figure 1: Diagrammatic representation of the conceptual framework

CHAPTER THREE

METHODOLOGY

This chapter presents the methodology used in the study and includes sources of data, the sampling technique and sample size, the models and the methods of data analysis

3.1 The study area

Elgeyo-Marakwet County is one of the counties in the former Rift Valley province. The county is located along the basin of the Kerio River in the Rift Valley Province of Kenya. It borders Uasin Gishu County in the west, Baringo and Pokot Counties in the east, and Turkana County in the north. The county can be divided into three agro-ecological zones: highlands in the west, escarpment in the central parts, and the valley floor. This study focused on the highlands community. The Valley floor is flat and dry with sandy soils, ideal for staple and drought-resistant crops; livestock graze freely in open areas. In the highlands (Upper valley), homesteads are located on relatively flat to moderately sloped land with sandy and clay soils; horticulture is currently practiced in this region. Escarpment is very steep, but staple or drought-resistant crops are cultivated .

The highland areas include; Iten, Kaptarakwa, Kaptagat, Chepkorio, Nyaru, Flax, Metkei and Cherangany. The valley floor forms the low lands. The areas on the valley floor include, Cheptebo and Fluorspar, Kimwarer and Tot (GoK, 2008).

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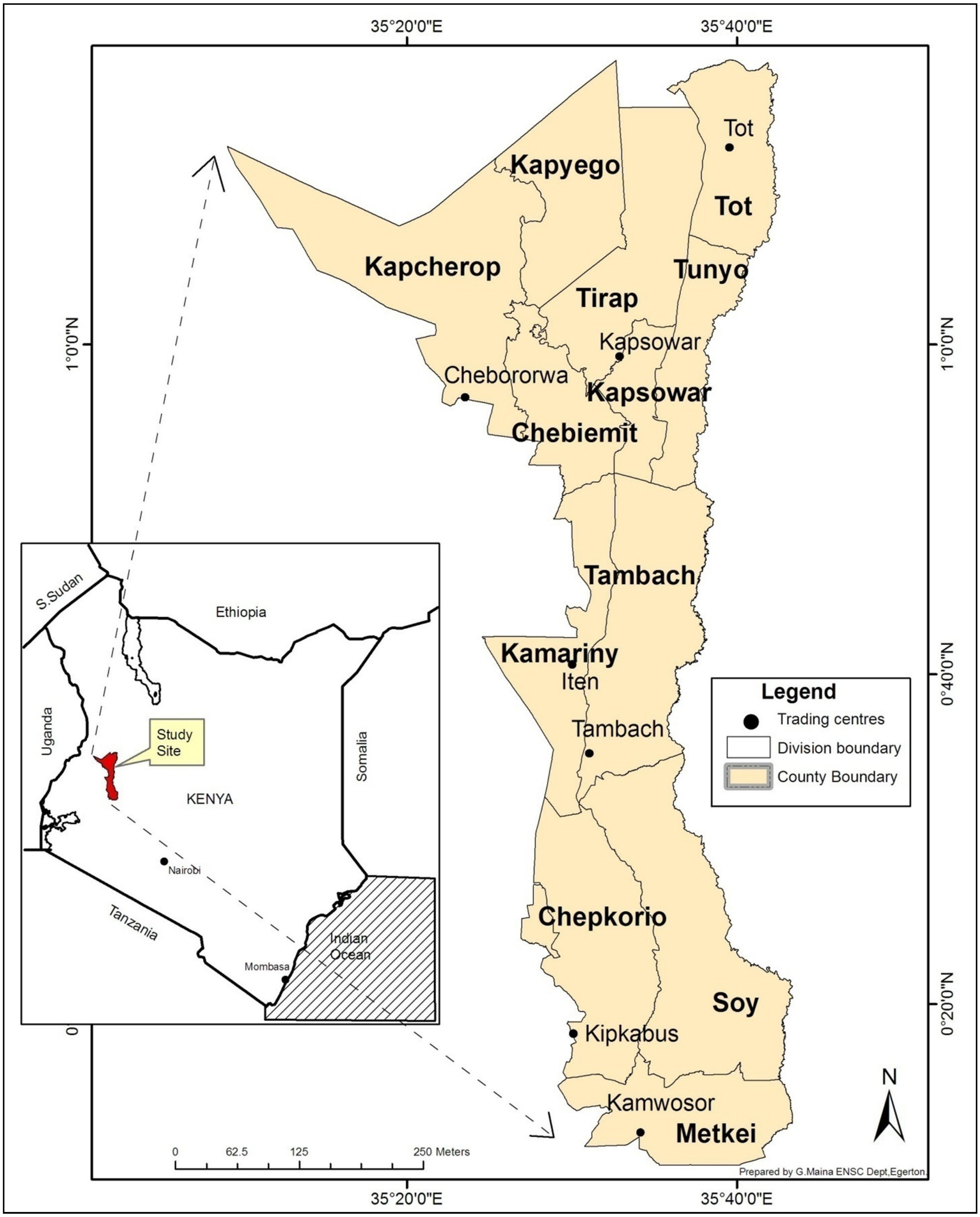

Source: Regional Centre for Mapping of Resources for Development (RCMRD)

Figure 2: Map of Elgeyo-Marakwet County

3.2 The population

The target population of the study was smallholder farmers who have integrated their activities farm into dairy farming and crop production and those who have not integrated the two enterprises. The target population for this study was 170.This included 85 adopters and 85 non adopters.

3.3 Sampling procedure

Multistage sampling procedure was used in the study. First, simple random sampling was used to select the two former divisions (Chepkorio and Kamariny) among the ten former divisions in the county. The required sample size was then determined by proportionate to size sampling methodology (Anderson *et al.,* 2007).

$$n = \frac{pqZ^2}{E^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

Where; n = Sample size; Z= confidence level (α=0.05); p = proportion of the population containing the major interest q = 1-p E= allowable error. Since the proportion of the population was not known with certainty, p= 0.5, q= 1-0.5=0.5, Z= 1.96 and E = 0.075. This resulted to a sample of 170 respondents. Since the study was interested in both integrators and non integrators, the sample size was divided into two to yield a sample of 85 integrators and 85 non integrators.

3.3 Data and data analysis

Primary data used in this study was obtained using a semi-structured questionnaire administered to the households that were sampled. The questionnaires were completed through schedules with the household head. The primary data comprised of the costs of production both in dairy and crop enterprises. The costs were measured in terms of Kenya shillings. Data on physical, institutional and socio-economic factors that enhance poverty reduction through dairy crop integration were also collected. In addition to, data on labour utilization, fertilizer utilization and land use in both enterprises was brought into focus. Furthermore, secondary data was also be used in the study. The data collected was first cleaned, sorted arranged and thereafter entered into STATA and SPSS computer software for analysis.

3.4 Analytical framework

3.4.1 Hard system methodologies (HSM) versus the Soft System Methodologies (SSM)

There are three strongly related and complementary approaches that are used in farm system thinking and analysis; hard, soft and complex system thinking. HSM is predominant among technically oriented people .This system focuses on quantifications while at the same time assuming clear and strict boundaries of interaction among enterprises in the farm. SSM focuses on the issues of motivation, learning, relations, mind-set and empowerment. SSM stresses on multiple inputs, perceptions, outputs and relation to the environment. In this system, most if not all problems can be perceived differently by different stakeholders. The soft SSM assumes the following:

a) Different vague and qualitative but real human interactions play a role in the farming process.

b) The opinion of one individual affects the opinion of someone else.

c) Different perceptions occur.

Goals and opinions change continuously. A combination of HSM and SSM yields Complex System Methodology (CSM) whose focus is on variation and uncertainty. (Schiere *et al.,* 2002). Therefore this study employed the complex system thinking.

3.4.2 Analytical methods

Data pertaining the objectives outlined in chapter one were analyzed as follows:

Characterization of dairy-crop integrators and non integrators

To characterize dairy-crop integrators and non integrators, descriptive statistics such as means and percentages were used.

Socio- economic characteristics influencing the decision to integrate dairy and crop enterprises

In studies where the dependent variable (Yi) is dichotomous in nature, there are different regression models that can be used like the Linear probability model, logit and probit. According to Mohammed and Ortmann (2005), the logit model is based on the logistic cumulative distribution function and its results are thus not sensitive to the distribution sample attributes when estimated by maximum likelihood. The study assumed a logistic distribution of the error term. Therefore, this study used the logit model to analyze objective 2 in that it provides the advantage of predicting the probability of a farmer integrating dairy and crop enterprises or not. This is opposed to the probit model which assumes a normal distribution of the error term.

The dependent variable is the decision to integrate dairy and crop enterprises. The dependent variable is binary thus, 1=integrating and 0= not integrating. Therefore, the logit model is presented as

$$p_t = \frac{1}{1+e^{-z_i}} = \frac{1}{1+e^{-(\alpha+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_n x_n)}}$$

Where p_t denotes the probability that a farmer integrates dairy and crop enterprises. z_i is the weighted sum of household socio economic characteristics ($\mathbf{X}_i$).

Table 1 shows a description of the logit model variables and their expected signs for integration.

Table 1: Description of the variables an expected signs for integration

Variable	Definition	Description of the variables	Expected Sign
MANUTI	Manure utilization	Whether a household uses manure in the crop enterprise. Yes=1 No=2	**None**
AWERENES	Knowledge and awareness	Whether the farmer is aware of the benefits of dairy-crop integration Yes=1 No=2	+
OBJ	Household objective	Motivation behind the farming activities	**None**
BUDGET	Net difference	Net difference in the partial Budget.	**None**
Z	Integration	Dummy variable. If a farmer integrates dairy and crops =1 and if not =0	**None**
EDU	Education	Level of education	**-**
GNDER	Gender (male)	Whether the decision integrate or not was made by male or female	+
LSIZE	Land size	Total size of land in hectares a farmer has. (Dummy)	+
AGE	Age	The age of the farmer in years	+
LBOR	Labor	Includes both family and hired-in labor in hours	+
LDOWN	Land ownership	Type of land tenure system (individual/private, communal or rented from outside)	**None**
OFFCME	Off-farm income	Refers to availability and source of off-farm income	_
AREA	Part of the district	Dummy: Chepkorio division, Yes=1 and No=0 Kamariny division, Yes=1 and No=0	**None**
CRED	Credit access	Dummy: Yes=1 and No=0)	+
HSIZE	Household size	Total number of household members	+

Comparison of household objectives

Comparison of household objectives of farmers who practice dairy-crop integration and those who do not practice dairy crop integration in Elgeyo-Marakwet County involved calculation of means and percentages. Thereafter, the results and findings were presented using descriptive statistics such as graphs and tables.

Biophysical resource flow among farms

Means, mode and percentages were used to describe the biophysical resource flow among farms that practice dairy crop integration. Flow charts were used to present the findings.

The partial budget

The partial budget is a way of analyzing the differences in costs and benefits of two or more competing enterprises or technologies. The partial budget is concerned only with those elements that change from the existing technology to the proposed one. It involves organizing data and information about the costs and benefits from some changes in technologies being used on the farm. Partial budgeting is a useful tool in analyzing small changes in farming systems and requires fewer changes than a whole farm budget or an enterprise budget. It measures changes in incomes and returns to limited resources. The goal here is to estimate the difference in benefits or losses expected from the technologies being considered. Partial budget that was used for the study appears in table 2.

Table 2: Partial budget for integration

Additional benefits of integration/non integration	Monetary value (Kshs/hectare)	Reduced benefits due to integration/non integration	Monetary value (Kshs/hectare)
1.Increased milk yields		1.Reduced milk yields	
2. Increased crop yields		2.Reduced crop yields	
Reduced costs		**Additional cost of integration**	
1. Labour		1.Labour	
2 .Animal feeds		2. Land rent	
3. Transport costs			
4 Land preparation			
5.Fertilizer costs			
SUB TOTAL INCREASES		**SUBTOTAL DECREASES**	
DIFFERENCE = (SUB TOTAL INCREASE **minus** SUBTOTAL DECREASES)			

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Characterization of dairy-crop integrators and non integrators

The major characteristics of interest that were put into focus in this objective include the years of schooling of both integrators and non integrators as well as their ability to access credit facilities from both formal and informal organizations. The formal organizations that provide credit to both dairy-crop Integrators and non integrators included banks and micro- finance organizations. Co-operative organizations also formed an important source of formal credit. In addition to, the size of land of land owned by the famer was used to characterize dairy-crop integrators and non integrators.

Table 3: Years of schooling of dairy- crop integrators and non integrators

Type of farmer	Mean yrs of schooling	No. of observations	Std. Deviation
Dairy-crop integrator	8.87	85	3.851
Non integrator of Dairy and crops	10.00	85	4.132
Total	9.44	170	4.022

The mean years of schooling for both dairy-crop integrators and non integrators were not the same (table 3). The integrators had a lower mean in years of schooling of 8.87 as compared to that of non integrators who had a higher mean of 10 years of schooling

Table 4: Independent sample t- tests for the level of education of farmers

	t-test for Equality of Means						
	T	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
						Lower	Upper
Education level of farmer	-1.844	168	**0.067**	-1.13	0.613	-2.339	0.080

The two tailed t -test in table 4 shows that the significance level (0.067) is greater than confidence interval (0.05). This reinforces the fact that there is a significant difference in the mean number of years of schooling of integrators and non-integrators.

More non integrators (43.5%) as opposed to integrators (41.2%), reported to have off farm income from business activities such as such as shops, flour mills, transport business or other employments in the public and private sectors of the economy. This further underpins the argument that non integrators had more years of schooling than integrators and this could have exposed them to additional business skills. It seems therefore that because non integrators do not have other skills, they have attempted to concentrate the knowledge they have on farming by embracing such activities as integration.

Table 5: Household size of integrators and non integrators

Type of farmer	Mean HH size	No. of observations	Std. Deviation
Dairy-crop integrator	6.49	85	2.693
Non integrator of Dairy and crops	4.98	85	1.566
Total	5.74	170	2.324

Integrators had a higher household mean unlike the non integrators .The mean size of households for dairy-crop integrators was 6.49 persons as opposed to 4.98 for non integrators (table 5). The higher household mean for integrators can be translated to mean integrators have a higher supply of family labour and will tend to put it into enterprise integration given that integration is a labour intensive activity. The opposite is true to non integrators.

Table 6: Independent sample t- test for the household size among integrators and non integrators

	t-test for Equality of Means						
	T	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
						Lower	Upper
Household size	4.491	168	0.07	-1.52	0.338	0.851	2.185

The two tailed t-test results shows that there is significant difference (p=0.05) in the mean household size of integrators and non integrators (table 6).

Table 7 Procurement of credits by integrators and non integrators

	INTEGRATORS		**NON INTEGRATORS**	
	Frequency	**Percent**	**Frequency**	**Percent**
Credit seekers	29	34.1	34	40.0
Non Credit seekers	56	65.9	51	60.0
Total	85	100.0	85	100.0

Results in Table 7 show that only 34.1 % of dairy-crop integrators in Elgeyo Marakwet County seek credit for agricultural purposes .On the other hand, 40% of non-integrators strive to seek credit Therefore; more non-integrators are credit seekers as opposed to integrators. The high number of credit seeking by non integrators can be attributed to the higher mean in years of schooling, meaning that they have access to more information on matters relating to credit as opposed to integrators. Access to information gives the non integrators the ability to haggle for and solicit credit from diverse sources while their counterparts may be suffering from fear of the unknown. But in order to improve and even modernize integration, the integrating households must embrace the use of agricultural credit.

Table 8: Credit providing organization for dairy crop integrators

	Integrators	Non-integrators
Credit providing organization	Percent	Percent
Banks	17	38
Co-operative organizations	17	26.5
Micro-finance institutions	38	26.5
Informal organizations	28	9
Total	100	100

The trend depicted by results in Table 8 reinforces the level of exposure of the two groups. Integrators are more inclined towards micro-finance (38%) and informal institutions (28%). This is probably because of their proximity and the less formal nature of these providers. They seemed not to prefer bank credit possibly because of the distance and the stringent bank procedures unfamiliar to them. The non integrators on the other hand, as a result of more exposure, utilized credit from banks, co-operatives and microfinance but not from informal sources.

Results presented in table 9 show that integrators had a larger size of land (2.12 hectares) on average as compared to non integrators (1.44 hectares)

Table 9: Mean size of land owned by integrators and non integrators of dairy and crops

	Integrators	Non-integrators
Mean size of land owned	2.12 (hectares)	1.44(hectares)

Table 10: Independent sample t-test for land size owned by integrators and non integrators

	t-test for Equality of Means						
	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Hectares of land owned	2.76	168	0.06	1.71	0.62	0.48	2.93

The independent t-test results in table 10 give a clear indication that there is a significant difference in the mean land size owned by both integrators and non-integrators. It can, therefore, be implied that farmers with smaller land sizes do not integrate dairy and crop enterprises. This finding is surprising because it was expected that as farms become smaller, they should tend towards integration, which is a form of diversification. This finding is inconsistent with the findings of Devendra, (2002) who found that as the land resource becomes scarce, involution occurs and farmers tend to integrate enterprises instead of specializing.

Therefore, there is significant difference in the characteristics of dairy- crop integrators and non integrators as depicted by findings of the study because integrators have a lower mean in the years of schooling as opposed to non integrators. Furthermore, the non integrators had smaller households and land sizes as compared to the integrators. In addition more non integrators were credit seekers unlike the integrators.

4.2. Socio-economic characteristics Influencing the Decision to Integrate Dairy and Crop Enterprises

The socioeconomic characteristics that were significant in influencing the decision to integrate dairy and crop enterprises are presented in table 11 and these were: gender of the household head, occupation of the household head, years of schooling of the household head, household size, hectares of land owned by the farmer, source of labour in the farm, perception of the farmer whether dairy-crop integration leads to maximum labour utilization, presence of off farm income, presence of extension services, distance to the nearest market, awareness of the benefits of dairy-crop integration, attitude towards risk, objectives of the farmer and net benefits resulting from adopting dairy-crop integration technology.

If the gender of the household head is male, integration of dairy and crop enterprises increases by 0.134 (p=0.01). This can deduce the fact that male decision makers tend to be receptive to integration technology as opposed to female decision makers. However, an increase in the household size by one person increases integration by 0.018 at 99% confidence level. This is probably due to the fact that bigger households have a higher supply of labour and this labour will tend to be channeled towards integrating the two enterprises since integration is labour demanding. Interesting to note also was that a positive change in the perception of the farmer that dairy crop integration leads to maximum labour utilization by one unit increases integration by 0.065 at 99% confidence level. Increased access to extension services by the farmer leads to an increase in the decision to integrate by 0.023 (p=0.05). This is owed to the fact that extension services educate the farmers on various farm aspects such as crop residue utilization, manure utilization, labour utilization and other farm practices which then prompts the famer to integrate.

Nonetheless, an increase in the farmer's awareness of the benefits of integration by one unit increases integration of the two enterprises by 0.093 at 99% confidence level. This is because knowledge and awareness of a new technology prompts the farmer to adopt the technology. The farm objectives decrease integration by 0.022 at 99% confidence level. This is due to fact that those farmers with a profit objective will tend to specialize their activities therefore not integrating while those with the objective of ensuring a constant supply of food and milk will tend to integrate the enterprises so as to reduce the risks associated with non-integration.

Table 11 Socio-economic characteristics Influencing the Decision to Integrate Dairy and Crop Enterprises

Variable	dy/dx	Std. Err.	Z	P>|z|	[95%C.I.]		X
Gender of household head*	0.1345	0.0938	1.43	0.151	-0.0493	0.31848	**0.38824**
Occupation of household head	-0.0022	0.0080	-0.28	0.78	-0.0179	0.01346	**0.51177**
Education of household head	0.0014	0.0019	0.72	0.472	-0.0024	0.00528	**9.43529**
Household size*	0.0186	0.0173	-1.08	0.282	-0.0527	0.01532	**5.73529**
Access to credit	0.0209	0.0233	0.9	0.37	-0.0248	0.0667	**0.62941**
Land tenure	-0.0171	0.0171	-1	0.317	-0.0508	0.01644	**0.42941**
Land size	0.0013	0.0019	0.69	0.489	-0.0024	0.0051	**4.40588**
Source of labour	0.0359	0.0517	0.7	0.487	-0.0655	0.13744	**0.32353**
Maximum utilization of labour*	0.0645	0.0641	1.01	0.315	-0.0613	0.19034	**0.5**
Access to off farm income*	-0.0366	0.0337	-1.09	0.277	-0.1027	0.02941	**0.58235**
Extension services*	0.0238	0.0252	0.94	0.346	-0.0257	0.07341	**0.62941**
Distance to market	-0.0004	0.0006	-0.75	0.451	-0.0017	0.00077	**8.31765**
Awareness on the benefits of integration*	0.0939	0.0760	1.24	0.217	0.0551	0.24299	**0.48824**
Attitude towards risk	0.0094	0.0112	0.84	0.4	-0.0126	0.03149	**1.34118**
Farm objective*	-0.0218	0.0218	-1	0.317	-0.0646	0.02092	**0.51765**
Net benefits on the partial budget*	-0.0001	0.0001	-1.07	0.287	-3E-05	0	**6.12**

** Indicates the variables that are significant in influencing the farmer's decision to integrate dairy and crop enterprises **dy/dx** is for discrete change of dummy variable from 0 to 1*

4.3 Comparison of household objectives of Dairy-crop integrators and non integrators

Three farm objective options were presented and the results shown in Table 12. "Yes" indicates the percentage of farmers who sufficiently met their objective while "No" indicates the percentage of farmers who did not sufficiently meet their objective.

Table 12 Comparison of households' objectives

Farm objective	Dairy-crop integrators (%)		Non dairy-crop integrators (%)	
First objective **Profit objective**	50.58	Yes = 79.06 No = 20.93	57.64	**Yes =63.26** **No =36.73**
Second objective **Ensuring sustained supply of food and milk**	42.35	Yes =75.00 No=25	36.47	**Yes=70.96** **No=20.03**
Third objective **Combined (both ensuring profit maximization and ensuring sustained supply of food and milk)**	7.06	Yes=66.66 No= 33.33	5.88	**Yes =60** **No = 40.00**
Total	100		**100**	

Results in table 12 show that majority of the farmers (50.58%) had the sole objective of profit maximization followed by ensuring a sustained supply of food and milk (42.35%) and both objectives 7.06%. Among the dairy-crop integrators, about 21% did not meet the first objective, 25% the second and about 33% the third objective. Comparatively, about 37%, 20%, and 40% of non dairy-crop integrators did not meet the first, second and third objectives respectively. It is instructive to note that on average, dairy-crop integrators are better achievers of the three objectives than non integrators. It would imply that in order to enhance rural development and alleviate poverty in the study area, dairy-crop integration would be an option. This is owed to the fact that integration leads to reduction in costs of production as well as increased yields for both dairy and crop enterprises (Ilyama *et al* 2006).

Therefore, objectives of farmers who practice dairy-crop integration and those who do not practice dairy crop integration are not the same is accepted given the fact that the percentages of famers pursing the three different objectives are not equal.

4.4 Flow of biophysical resources.

About 91 % of integrators used manure in their crop enterprises. Among these, 30% use the manure on vegetable gardens while 14.3% use it to plant beans. Nonetheless, 8.6% of the farmers use the manure on their fruit orchards due to the perception that manure is a slow releasing fertilizer as opposed to chemical fertilizers which are highly soluble. Maize is a staple crop in the county and 31.4% of the farmers use manure in their maize fields. About 3% of the famers used manure on potato gardens and 4% on other crop enterprises.

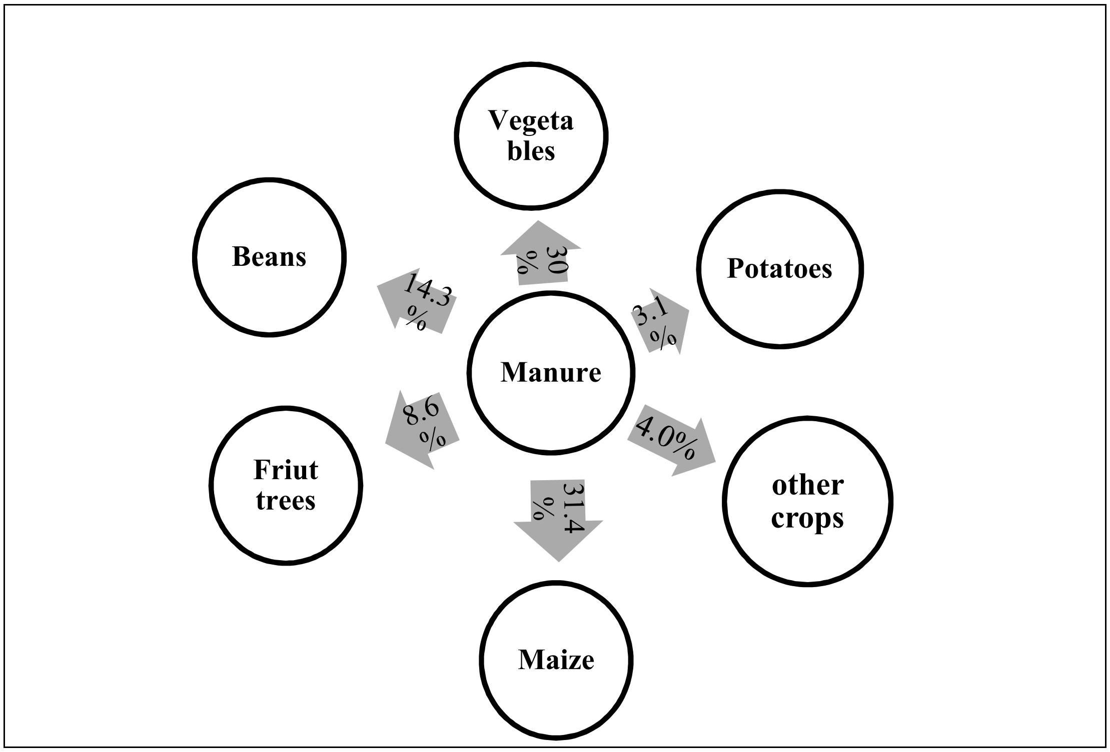

Figure 2: Flow of Manure resource amongst integrators

All the integrators interviewed attested to the fact that farm yard manure reduces the cost of production and is environmentally friendly as opposed to chemical fertilizers. One limitation that was observed amongst farms that used farm yard manure was that, use of farm yard manure is labour intensive as opposed to chemical fertilizers.

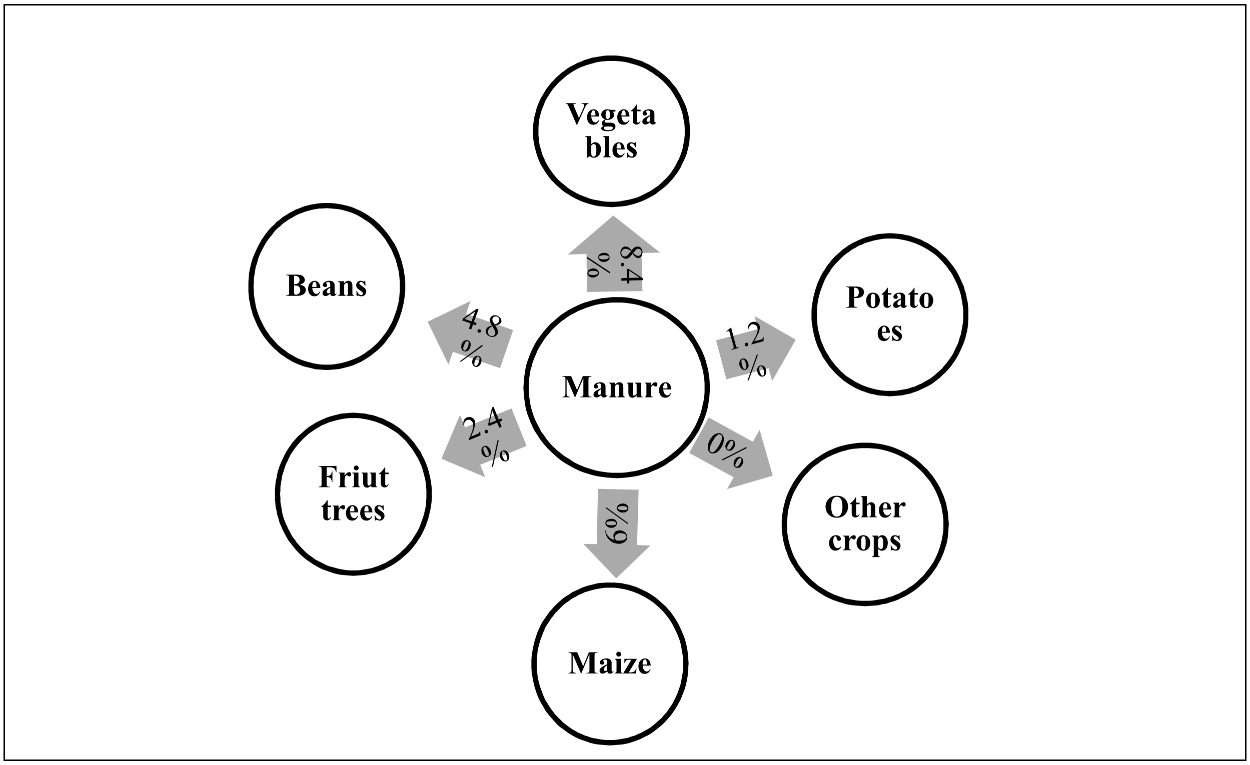

Figure 3: Flow of manure resource amongst non integrators

Some non integrators sourced their manure from external sources for their crop enterprises. Their use of manure was minimal and non consistent. About 8.4% of these famers sometimes used farmyard manure in their vegetable enterprises while 4.8% use in the bean enterprises. Furthermore, 2.4% intermittently used it in their fruit orchards while 6% used it to grow maize which is a staple crop in the county.

Therefore, flow of farm yard manure amongst farms that integrate dairy and crops is not the same. Integrators source their manure from within the farm while non integrators source their manure from external sources.

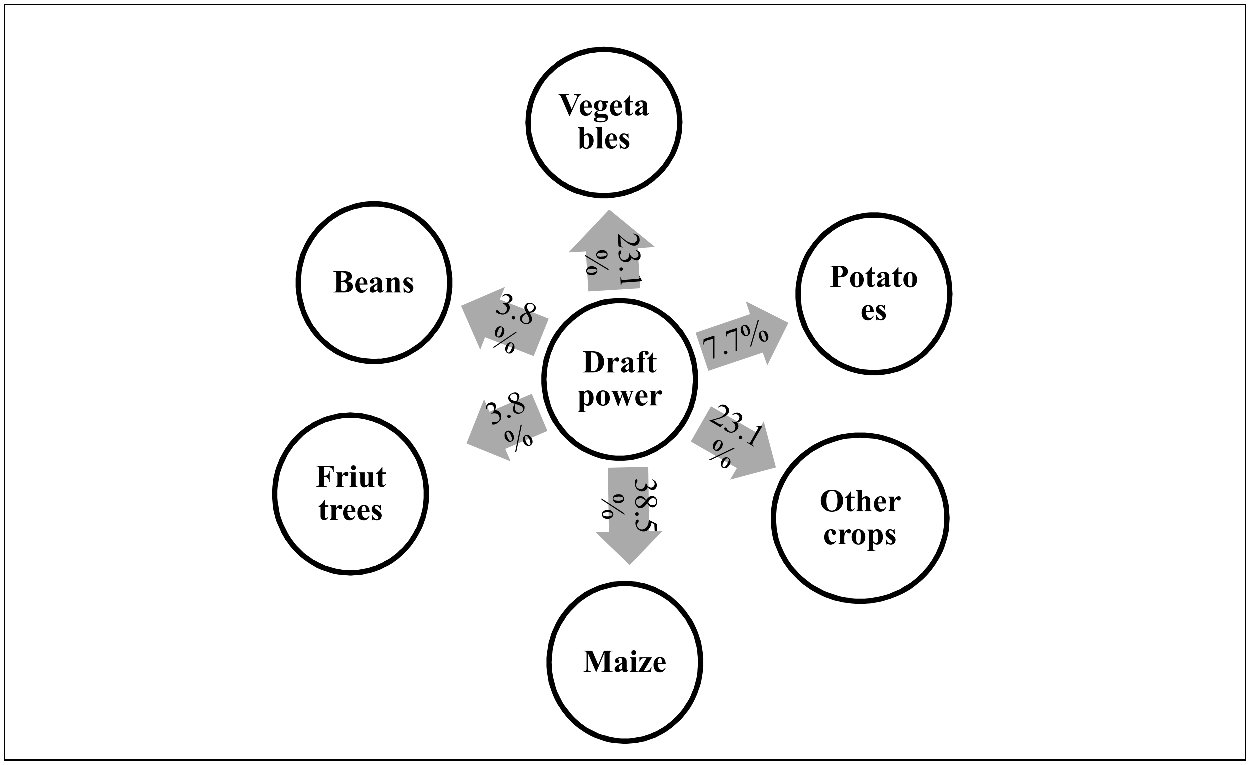

Figure 4: Flow of animal draft power amongst integrators

Animal draft power that was predominant in the area with oxen and bulls being the main sources. They were utilized for land preparation practices such as ploughing, harrowing as well as weeding, depending on the type of crop grown by the farmer. However at the end of the harvesting period, the oxen and bulls were used to transport the farm produce to the stores. About 30.6% of the integrators used draft power while 23.1% of these used in vegetable enterprises as shown in figure 4. Farmers who grew beans and fruit trees and at the same time utilized draft power from their dairy enterprises amounted to 3.8% of the integrators, while that of maize culminated to 38.5%. Potatoes on the other hand had 7.7% of the farmers utilizing draft power from the dairy enterprise on it. The fact that most integrators used draft power on maize fields was because maize crops allowed mechanization compared to other crops grown in the area. On the other hand, maize is bulky compared to crops such as fruits and beans thereby tending to require draft power as opposed to manpower.

However, none of the non integrators utilized draft power (Figure 5). Therefore, draft power that flow into the crop enterprises were nonexistent. The flows to the various crop enterprises were thus 0%.

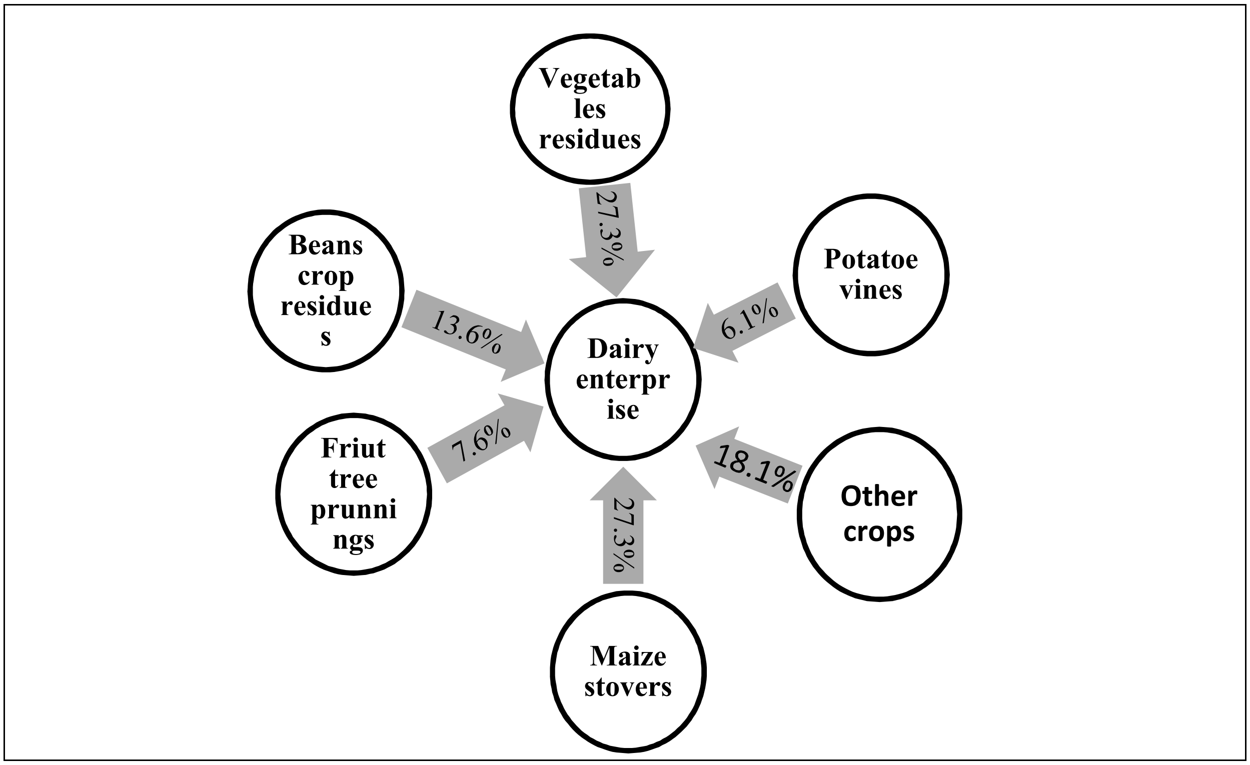

Figure 5: Flow of crop residues amongst integrators

Figure 5 shows the flow of crop residues amongst integrators of dairy and crop enterprises. About 62.4% of integrators use crop residues to feed their dairy animals. Out of these, 27.3% of the integrators used maize stovers while another 27.3% used vegetable leaves (mainly cabbage leaves) to feed their dairy animals. Those who utilized potato vines as animal feed added up to make 6.1% of integrators who utilize crop residues. Only 13.6% of these famers use bean as feed in the dairy enterprise. This indicates a closed system with good nutrient recycling resulting in sound environmental conservation. This interrelationship also leads economic stability of the farm inherent in cost minimization and farm labour utilization (Allen *et al*, 2007).

Unlike the integrators, there was no flow of crop residues from the crop enterprise to the dairy crop enterprises for non integrators. This indicates loss of nutrients through mining. In the long run, their soil will be impoverished. They spend much importing nutrients but lose it through mining. This culminates into a loss of income in the long run thereby spiraling into an increase in poverty levels. (Pengelly *et al*, 2003).

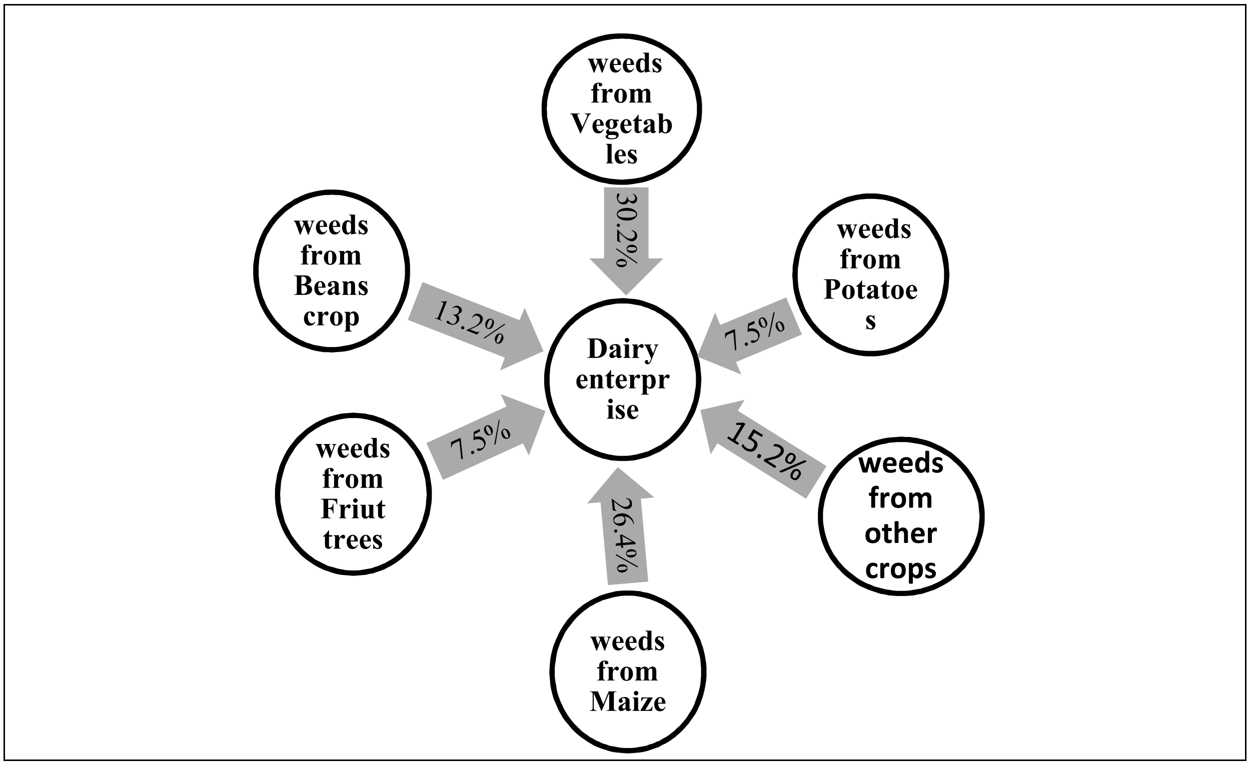

Figure 6: Flow of weeds amongst integrators

Figure 6 above shows the utilization of weeds from different crop enterprises by integrators. Majority of the farmers (30.2%) utilize weeds from the vegetable gardens in their dairy enterprises as animal feed while 26.7% use weeds from the maize fields. However, 13.2% of integrators feed their dairy animals with weeds from bean garden while 15.2% come from other crop enterprises. Non integrators on the other hand do not feed their dairy animals with weeds emanating from the crop enterprises. This is therefore is a clear indication that integrators display a closed system where nutrients are not lost through leakages in the system as opposed to non integrators.

Therefore, the there is a general observation that there are differences in the characteristics and direction of flows of biophysical resources in farms that practice dairy-crop integration and those that do not practice dairy crop integration.

4.5 Partial budget for dairy-crop integration and non integration

Table 13: Partial budget for integrators

Additional benefits due to integration	**Monetary value (Kshs/hectare /yr)**	**Reduced benefits due to integration**	**Monetary value (Kshs/hectare/yr)**
1.Increased milk yields	5,763.08	1.Reduced milk yields	1,282
2. Increased crop yields	8,700	2.Reduced crop yields	2,300
Reduced costs		**Additional cost of integration**	
1. Labour	2,350.1	1.Labour	10,000
2 .Animal feeds	8,200	2. Land rent	1,500
3. Transport costs	1,600	3.Others	387.72
4 Land preparation	3,500		
5.Fertilizer costs	3,109.36		
SUB TOTAL INCREASES	**33,222.54**	**SUBTOTAL DECREASES**	**15,469.72**
NET = (SUB TOTAL INCREASE minus SUBTOTAL DECREASES)	**{ 33,222.54 - 15,469.72 }** = **17,752.82**		

The partial budget (table 13) shows the net benefits emanating from adopting dairy-crop integration technology. The net benefits amount to about Kshs 17,752 per hactre per annum. This contrasts the partial budget of farmers who do not practice dairy-crop integration in table 14 (about Kshs 639.42 per hactre per annum). The high mean of the net benefits in the partial budget shows that dairy-crop integration is a superior technology compared to non integration of dairy and crops. The findings are consistent with those of Nyoro, *et al*., (2004) who found out that integration practices such as application of farm yard to cop fields as well as utilization of crop residues manure in dairy- crop systems result in higher yield and lower production costs particularly in intercropping systems.

Table 14: Partial budget for non integrators

Additional benefits due to non integration	**Mean Monetary value (Kshs/hectare/yr)**	**Reduced benefits due to non integration**	**Mean Monetary value (Kshs/hectare/yr)**
1.Increased milk yields		1.Reduced milk yields	2,000
2. Increased crop yields	11,500	2.Reduced crop yields	2,118.2
Reduced costs		**Additional cost of non integration**	
1. Labour	5,500	1.Labour	2,150
2 .Animal feeds	1,059.1	2. Land rent	3,000
3. Transport costs		3.Transport costs	951.4
4.Land preparation		4.Land preparation	4,000
5.Fertilizer costs		5.Fertilizer costs	3,200
SUB TOTAL INCREASES	**18059.1**	**SUBTOTAL DECREASES**	**17419.6**
NET = (SUB TOTAL INCREASE **minus** SUBTOTAL DECREASES)	**{ 18059.1 - 17419.68**	**} = 639.4**	

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Farm and farmer characteristics were found to be important in influencing the decision to adopt integration technology. These characteristics were age, education, household size, and off farm employment. The results revealed that profit maximization may not be the only objective pursued by farmers. Others objective like ensuring sustained supply of food and milk were important.

Integrators recycle nutrients among enterprises using farm yard manure in crops and crop residues flow back to the dairy enterprise as animal feeds. The partial budget resulting from dairy-crop integration and non integration depicts that integrators have higher net benefits compared to non integrators.

5.2 Recommendations

Farmers in the low education category were found to be engaging dairy-crop integration. Low education status has a negative implication on the effectiveness and innovations on integration activities. There is therefore need for policies to address the limitation of such a category, through targeted training programs that will enhance the knowledge gap of such farmers on better integration activities. The non-integrators should be sensitized on the benefits of integration in order to encourage them to adopt the integration technology. Few integrators were credit seekers as opposed to non integrators, therefore the integrators should be encouraged to solicit credit from credible financial institutions such as banks and micro finance institutions.

Increased attention need to be paid to negative environmental externalities from agriculture; though these negative externalities might be modest now, they could grow very rapidly in the absence of an appropriate policy framework, as input use grows rapidly with increased agricultural specialization. Therefore, policies that encourage dairy-crop integration should be encouraged in order to improve the farmers' welfare since it a form of farm diversification as well as way adding value to farm by-products such as animal droppings, crop residues and weeds from the crop fields. This is further depicted by the high net benefits resulting from integration.

5.3 Suggestions for Further Research

The study only focused on short run analysis of dairy-crop integration therefore it is not able to capture longer-run benefits of soil fertility/structure improvements that are possible with such interventions. In future, studies should incorporate an assessment of the value of increases in soil nutrient stocks, together with the value of the animals themselves (to capture the social/cultural value of the livestock), rather than just the income flows they produce.

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APPENDIX 1

RESEARCH QUESTIONNAIRE

This research is conducted so as to undertake an Economic Analysis of Dairy-crop Integration in Elgeyo-Marakwet County. You are requested to be our informant. The information provided will be used purely for research purposes. The information will be treated with strict confidentiality.

SECTION A: GENERAL INFORMATION

Questionnaire serial number [………]

A. Division […………………………………………………]
B. Location […………………………………………………]
C. Enumerator name […………………………………………]
D. Date of interview […………………………………………]
E. Name of the household head……………………………………Age …….

Type of farmer *(Tick)*

a) Dairy-crop integrator =1 ☐
b) Non integrator of dairy and crops =2 ☐

SECTION B: HOUSEHOLD INVENTORY, INSTITUTIONAL AND FARMER SSOCIO –ECONOMIC CHARACTERISTICS

1.0 Farmers' background information

Gender: (*Tick where appropriate*)

a) Male=1 ☐
b) Female=2 ☐

1.2 Relation to head (*Tick where appropriate*)

a) Head=1 ☐
b) Wife=2 ☐
c) Sibling=3 ☐
d) Other (specify)=4 ______________________

1.3 Occupation (*Tick where appropriate*)

a) Farmer=1 ☐
b) Business man=2 ☐
c) Employed =3 ☐
d) Others (*specify*) =4_________________________

1.4 Age (in years) ______________

1.5 Education level (*Tick where appropriate*)

a) None =1 ☐
b) Primary school=2 ☐
c) Secondary school=3 ☐
d) University=4 ☐
e) Others (*specify*) =5 _________________

1.6 Household size (*number of people living together in one homestead*) __________________

2.0 Access to credit

i) Do you **seek credit** for your farming business? *(tick where appropriate)*

a) Yes=1 ☐

b) No=2 ☐

If yes, which organization do you solicit your credit? *(tick where appropriate)*

a) Banks =1 ☐

b) Co-operative organizations=2 ☐

c) Micro finance institution =3 ☐

d) Informal organizations =4 ☐

3.0 Land tenure and land use

3.1 Land tenure: *(tick where appropriate)*

a) Individual=1 ☐
b) Leasehold=2 ☐
c) Communal=3 ☐
d) Other *(Specify)*=4____________________

i) How much hectares of land do you have?___________*hectares*
ii) How much land is under the following?

a) Crops ______________________

b) Dairy_______________________

c) Homestead___________________

d) Other enterprises_______________

The enumerator to calculate the proportion of land allocated to both dairy and crops.

Proportion $= \frac{total\ land\ under\ both\ dairy\ and\ crops}{total\ \ land\ \ owned\ by\ the\ farmer} =$ ____________

4.0 Labor

What is the source of your labour? *(tick where appropriate)*

a) Family=1 ☐

b) Hired =2 ☐

i.How do you pay your hired labour?

a) Daily =1 ☐
b) Hourly=2 ☐
c) Monthly=3 ☐

ii. Does integration of maize and crops lead to maximum labour utilization?

a) Yes=1 ☐

b) No=2 ☐

4.0 Off farm income

i) Do you have any other source of income apart from farming i.e. **off-farm income**?*(tick where appropriate)*

a) Yes=1 ☐

b) No=2 ☐

ii) If yes, it falls in what range?

a) 1= Less than 5,000=1 ☐

b) 2= 5,001-10,000 =2 ☐

c) 3= 10,001-15,000 =3 ☐

d) 4=15'001-20,000 =4 ☐

e) 5= >20001=5 ☐

6.0 Extension services;

i) Do you get extension services?

a) Yes=1 ☐
b) No =2 ☐

ii) If yes, have they influenced you integrate maize and crops?

a) Yes=1 ☐
b) No =2 ☐

iii) If yes in (ii) above, what information have they givens you that influenced you to integrate maize and crops

a) ______________________________
b) ______________________________
c) ______________________________
d) ______________________________

7.0 Pests and diseases.

In the last five years, how many times have your dairy cattle been affected by a severe diseases outbreak? *(tick where appropriate)*

i) ☐

a) None =1
b) Once =2 ☐
c) Twice =3 ☐
d) Thrice =4 ☐
e) More than thrice =5 ☐

ii) How did the disease affect your dairy herd?

a) Reduction in yield =1 ☐
b) Increased cost of production=2 ☐
c) Others specify______________________________

iii) In the last five years, how many times have your crop fields been affected by a severe pest and diseases outbreak?

a) None =1 ☐
b) Once =2 ☐
c) Twice =3 ☐
d) Thrice =4 ☐
e) More than thrice=5 ☐

iv) How did the disease affect your crop enterprise?

a) Reduction in yield =1 ☐
b) Increased cost of production =2 ☐
c) Others *(specify)*=3______________________________________

8.0 Market distance

i) What is the **name of the nearest** market for your produce______________

ii) What is the distance to the above market? _________*Kms*

9.0 Knowledge and awareness about the benefits of Dairy-crop integration

i) Are you aware of the benefits of dairy-crop integration?

a) Yes=1 ☐
b) No=2 ☐

ii) If yes, name these **benefits**

a) ____
b) ____
c) ____
d) ____
e) ____

7. Attitude towards risk: which of the following situations will you choose in your farming operations?

Enterprise A will give you a profit of Ksh 100,000 in two out of the ten years and in the other eight years Ksh0 (High profit, high Risk)	1
Enterprise B will give you a profit of Ksh 30,000 in six out of the ten years and in the other four years Ksh0 (Medium profit, medium Risk)	2
Enterprise C will give you a profit of Ksh 20,000 in eight out of the ten years and in the other two years Ksh0 (Low profit, low Risk)	3

SECTION C: COMPARISON HOUSEHOLD OBJECTIVES

7.0 Farm Objectives

i) What are the objectives of your household in farming?

a) Profit objective =1 ☐

b) Ensuring sustained supply of food and milk=2 ☐

c) Other (*specify*) =3____________________

ii) Do you sufficiently meet your objectives?

a) Yes=1 ☐

b) No=2 ☐

iii) If no in (ii) above, what are the factors that hinder you from sufficiently meeting your objective?

a) ________________________________

b) ________________________________

c) ________________________________

d) ________________________________

SECTION D: FLOW AND CHARACTERISTICS OF FLOWS OF BIOPHYSICAL RESOURCES

2.2 Flow of Biophysical resources

(tick where appropriate)

i) Do you use Farm yard manure in crop fields?

a) yes=1 ☐

b) no=2 ☐

ii) If yes in (i) above, what is the source of your farm yard manure?

a) Dairy shed=1 ☐

b) Sheep shed=2 ☐

c) Poultry house=3 ☐

d) Others (*Specify)* =4_________________

iii) Do you feed your Dairy animals with crop residues?

a) yes=1 ☐

b) no=2 ☐

iv) Do you use some weeds from the crop fields to feed your dairy cattle?

a) yes=1 ☐

b) no=2 ☐

v) Do you graze your dairy animals?

a) yes=1 ☐

b) no=2 ☐

iv) If no in (v) above what forages do you mainly use in your dairy enterprise?

a) Napier grass=1 ☐

b) Crop residues=2 ☐

c) Hay=3 ☐

d) Others=4 _________________ *(specify)*

vi) Where do you graze your dairy animals?

a) Forest land=1 ☐

b) Your own land=2 ☐

c) Rented land=3 ☐

d) By the Road side=4 ☐

vii) Do you use draft power from your dairy animals in your crop enterprise?

a) yes=1 ☐

b) no=2 ☐

SECTION E: PARTIAL BUDGET ANALYSIS FOR DAIRY-CROP INTEGRATION

1.7 Partial budget for dairy-crop integration. *(to be filled by integrators only)*

i. Please fill the table below to indicate the monetary increases and decreases per acre as result of dairy-maize integration.

Additional benefits of integration	**Monetary value (Kshs/Hectare)**	**Reduced benefits due to integration**	**Monetary value (Kshs/Hectare)**
1.Increased milk yields		1.Reduced milk yields	
2. Increased crop yields		2.Reduced crop yields	
Reduced costs		**Additional cost of integration**	
1. Labour		1.Labour	
2 .Animal feeds		2. Land rent	
3. Transport costs			
4 Land preparation			
5.Fertilizer costs			
SUB TOTAL INCREASES		**SUBTOTAL DECREASES**	
DIFFERENCE = (SUB TOTAL INCREASE minus SUBTOTAL DECREASES)	______________________________		

The End.

Thank you for your cooperation!