

Full Length Research Paper

Econometric analysis of determinants of land resource allocation to dairy farming in the highlands of Uganda: A case of Kigezi Highlands

Mercy Nimusiima*, Rolland Agaba, Silver Tukamushaba, Andrew Ampaire and Alex Barekye

Kachwekano Zonal Agricultural Research and Development Institute (KAZARDI), National Agricultural Research Organization (NARO), P. O. Box 421 Kabale, Uganda.

Received 23 February, 2024; Accepted 17 October, 2024

Dairy farming is important for income, food and nutritional security globally. The enterprise is traditional to cattle corridor in Uganda but of interest in non-traditional areas of the country such as the southwestern highland agro-ecological zone (SWHAEZ). The study examined dairy production, feeding and management practices and, assessed socio-economic factors that influence land resource allocation to dairy enterprise in the SWHAEZ. Mixed research methods were used for data collection including 60 key informants and 125 structured interviews to randomly selected dairy farmers. Descriptive statistics were used to characterize household demographics, dairy feeding, and management practices while multiple linear regression models was used to assess the effect of socio-economic factors on land resource allocation to dairy production. Results showed land allocation to dairy farming is significantly influenced by number of crossbreeds ($P>0.01$), number of exotic breeds ($P>0.01$), education level ($P>0.05$), and age ($P>0.1$) of respondent. Household income, food and nutritional security accounts for 43% while 32% draw manure and prestige from dairy farming, the rest are interested in both. The farmers practice semi-intensive and natural mating systems at 43% and 92% respectively. Average land (owned, hired & rented) allocated to dairy production is 10 acres. Increasing the number of cross and exotic breeds by one cow raises the size of land allocated to dairy farming by 63.8 and 47.7%. Cross and exotic breeds that are highland acclimatized should be introduced for improved land resource allocation and overall dairy production in the highland areas.

Key words: Dairy farming, land resource allocation, and highland areas of Uganda.

INTRODUCTION

Dairy farming is a crucial component of Uganda's agricultural sector, contributing significantly to the country's economy and social welfare. It plays a key role

in boosting the Gross Domestic Product (GDP), providing regular income, and creating employment opportunities, particularly for resource-poor households. Additionally,

*Corresponding author. E-mail: nimusiimamercy@gmail.com

dairy farming holds cultural importance in some Ugandan traditions, such as being used for dowry in marriage practices. The dairy industry accounts for about 9% of the country's total agricultural GDP and 3% of the overall GDP (Balikowa, 2011). Beyond its economic contributions, dairy farming is vital for food and nutrition security, providing milk and other dairy products to many households.

Manure from dairy cattle also enhances crop production by supplying essential nutrients to smallholder farms (Herrero et al., 2013). In Uganda, dairy production primarily involves *Bos taurus* cattle, but it also includes dairy goats and sheep. Breeds like Saanen, Toggenburg, British Alpine, and Anglo-Nubian have been introduced to East Africa, including Uganda, to diversify and increase milk production (Byaruhanga et al., 2015; Kahi and Wasike, 2019).

Traditionally, dairy farming has been concentrated in the "cattle corridor," a vast zone characterized by pastoral rangelands stretching from mid-western through central to northeastern Uganda. These areas are dominated by semi-arid conditions suitable for extensive cattle rearing (Twagiramaria and Tolo, 2016). However, Uganda has seen a significant expansion of dairy farming beyond these traditional zones due to the growing recognition of its economic, nutritional, environmental, socio-cultural, and security benefits (Kabi et al., 2016). This expansion has led to dairy production spreading into non-traditional cattle-rearing areas, including highland agroecological zones and other regions characterized by small-scale farming systems.

While the expansion of dairy farming into non-traditional areas presents opportunities for increased production and broader economic benefits, it also introduces new challenges. Farmers in these regions face unique constraints, such as limited access to land, inadequate infrastructure, insufficient technical knowledge, and competition with other land uses. Moreover, the socio-economic dynamics and environmental conditions in these non-traditional areas differ significantly from the cattle corridor, affecting the viability and sustainability of dairy enterprises.

Problem statement

The expansion of dairy farming into non-traditional cattle-rearing areas in Uganda presents both opportunities and challenges. However, the status, potential, and constraints of dairy farming in these regions are not well documented. There is a significant knowledge gap regarding the socio-economic status of dairy farming, the factors influencing land resource allocation to dairy enterprises, and the sustainability of these farming systems in non-traditional areas. Without a clear understanding of these aspects, it is difficult to develop targeted policies and interventions that could support

sustainable dairy production and optimize land use in these regions.

Study objective

This study targeted to fill the knowledge gap by assessing the socio-economic status of dairy farming in non-traditional areas, specifically in the southwestern highland agroecological zone (SWHAEZ) of Uganda. The study assessed the social demographic characteristics of dairy farmers in the zone. It further examined the factors influencing land resource allocation to dairy enterprises in the zone. The study hypothesized that the age of the household head, education level, and the number of different breeds (Indigenous, cross, and exotic) had a positive significant effect on land resource allocation to dairy production in high land (non-traditional cattle rearing) areas. The findings would guide research and inform policy decisions that promote sustainable dairy production and optimal land resource allocation for dairy enterprises, not only in traditional cattle-rearing areas but also in non-traditional regions.

LITERATURE REVIEW

While there is a substantial body of literature on dairy farming in Uganda's traditional cattle-rearing areas, research on dairy farming in non-traditional regions remains sparse. Studies by Kabi et al. (2016) and Mweya (1993) have primarily focused on the economic and environmental benefits of dairy farming in the cattle corridor, with limited attention to the emerging dairy sectors in highland agroecological zones and other non-traditional areas. Research has shown that small-scale farmers in these non-traditional areas face unique challenges, such as limited access to land, inadequate infrastructure, lack of technical knowledge, and competition with other land uses (Byaruhanga et al., 2015; Kahi and Wasike, 2019). These constraints, coupled with different socio-economic dynamics and environmental conditions, affect the viability and sustainability of dairy enterprises outside the traditional cattle-rearing regions.

Despite the challenges, there is a growing interest in expanding dairy production into non-traditional areas to enhance economic opportunities and food security. However, the factors influencing land resource allocation to dairy enterprises in these regions, the socio-economic status of dairy farmers, and the sustainability of dairy farming systems remain inadequately explored. Existing studies do not provide comprehensive data on these aspects, which limits the formulation of effective policies and interventions that could support sustainable dairy production and land use planning in these non-traditional regions.

Table 1. Social economic variables are hypothesized to influence land allocation to dairy farming.

Independent Variable	Hypothetical effect
X1-Gender of household head (Male=1, Female=2)	+
X2-Breed (Number of Local, Number of Cross, Number of Exotic)	+, +, +
X3-Education level	+
X4-Age of household head	+/-
X5-Experience (Years) in dairy production	+
X6-Annual household income	+

MATERIALS AND METHODS

Location of study

The study was conducted in SWHAEZ which is referred to as the Kigezi region. It is a highland geographical area comprising 6 districts which include Kabale, Kanungu, Kisoro, Rubanda, Rukiga, and Rukungiri. The area receives bi-model rainfall with the short rains received between March and May and the long rains received between August and December ranging from 1000 to 1500 mm per annum. The mean temperature ranges between 10.9 and 24.4°C and the relative humidity rises between 90 - 100% at dawn and decreases to 42 - 75% in the afternoons throughout the year (Twagiramaria and Tolo, 2016). The soils are generally volcanic, and inherently fertile, with terraced hilly fields giving this part of Uganda a distinctive geographical characteristic (Mugisha and Aloba, 2012). The area was traditionally known as the Switzerland of Africa due to its geographical location and physical features. The land sits at the Latitude and Longitude of 01 13 20S, and 29 53 20E coordinates respectively with an altitude of 1500 - 2700 masl (Mugisha and Aloba, 2012). The region borders the Republic of Rwanda to the southwest and the democratic republic of Congo to the west. According to the national census of 2014 and the Uganda Bureau of Statistics Report (UBOS, 2014), the region has a population of 1.6 million people.

Data collection and sampling

Using Cocran's sampling formula for small samples,

$$n = \frac{no}{1 + \frac{(no-1)}{N}}$$

where $no = z^2 pq / e^2$ such that $z = 1.96$, $p = 0.5$, $q = 1 - p$, $e = 0.05$ and taking $N = 200$, a sample of $n = 130$ dairy farmers was targeted. A semi-structured questionnaire was used to obtain primary quantitative data. A sample of 125 randomly selected dairy farmers¹ were interviewed in September 2021. The focus was on household socio-economic characteristics, dairy production, feeding, and management practices. Complementary qualitative data was collected from 3 Focus Group Discussions (FGDs) with at least 10 participants per FGD. The FGD participants include the district production and marketing officer (DPMO), district veterinary officer (DVO), 2 processors, 2 representatives of the dairy cooperative marketing association, operation wealth creation (OWC) officer, 2

progressive dairy farmers, 2 artificial insemination technicians, 2 animal husbandry officers, 2 veterinary/agro-vet in put dealers/suppliers, 2 representatives of non-governmental organizations and 2 representatives of dairy product consumers.

Data management and analysis

Qualitative data was synthesized by thematic content analysis to yield meaningful information. Using SPSS and Stata statistical packages, descriptive statistics including frequencies, proportions, and percentages were used to summarize household socio-economic characteristics, dairy production, and management practices. A multiple linear regression model (MLRM) was employed to assess the socio-economic factors (Table 1) that influence land resource allocation to dairy production and management. The MLRM was as specified in Equation 1 (Greene, 2003):

$$Y_i = \beta + \alpha_i DE_i + \delta_i X_i + \dots + \epsilon_i \quad (1)$$

where Y_i is the outcome variable (total land allocated to dairy production), DE_i is the explanatory dummy variable (gender and education level), X_i represents other explanatory count variables, and α_i and δ_i are parameters to be estimated. Linearity and normal distribution were assumed between dependent and independent variables. The explanatory variables were tested for multi-collinearity using variable inflating factors (VIF) and the variables were assumed to be homoscedastic.

RESULTS

Multiple linear regression estimates of socio-economic factors affecting land allocation to dairy enterprise

The F-value was 72.09, with a p-value of 0.000, indicating that the model was statistically significant and adequate. The coefficient of determination (R^2) was 0.8327, such that approximately 83.3% of the variability of the dependent variable (land allocated to dairy) was accounted for by the explanatory variables in the model. While determining model adequacy, some broad features of the results, such as the R^2 value and F-value should be considered (Gujarati, 2004). The broad features were both statistically significant in this study. Results indicate that land allocated to dairy farming is significantly influenced by the total number of crossbreeds ($P > 0.01$), total number of exotic breeds ($P > 0.01$), education level of

¹ A respondent was selected as a dairy farmer if s/he possessed at least a milking cow

Table 2. Household socio-economic characteristics.

Variable Category	Frequency (n=125)	Percentage	
Gender			
Male	110	88.0	
Female	15	12.0	
Marital status			
Single	8	6.4	
Married	104	83.2	
Separated	0	0.0	
Widowed	13	10.4	
Level of education			
No formal education	9	7.2	
Primary	40	32.0	
Secondary (O' level)	18	14.4	
Secondary (A' level)	16	12.8	
Vocational/College	22	17.6	
University	20	16.0	
Age category (years)			
15-30	4	3.2	
31-50	53	45.6	
51-70	48	38.4	
Above 70	20	16.0	
Main Occupation			
Agriculture (Animal production)	57	45.6	
Agriculture (Crop production)	46	36.8	
Employment	11	8.8	
Casual labor	0	0.0	
Business	9	7.2	
Others	2	1.6	
Prior Knowledge of dairy farming			
Yes	111	88.8	
No	14	11.2	
Reason for starting dairy farming			
Income	40	32	
Food and nutritional security	9	7.2	
Manure	7	5.6	
Income, food, and nutritional security	54	43.2	
Income and manure	2	1.6	
Income and prestige	1	0.8	
Food, nutritional security, and manure	1	0.8	
Food, nutritional security, and prestige	1	0.8	
Income, food, nutritional security, and manure	8	6.4	
Income, food, nutritional security, and prestige	2	1.6	
Land resource variability (acres)			
	Mean	Standard Error	[95% Conf. Interval]
Total Land accessed (land owned+ land hired + land rented)	15.928	2.898	10.193, 21.663
Total Land for dairy production	10.104	2.363	5.426, 14.781
Total land for crop production	5.809	0.746	4.333, 7.285

respondent ($P>0.05$), and age of respondent ($P>0.1$) as shown in Table 4.

DISCUSSION

Table 2 shows male farmers dominated the sample which was largely attributed to the position of males being household heads and hence having control and knowledge of most household resources. This finding agrees with Belay et al. (2012) who argue that household heads are normally equipped with traditional knowledge and background of farming activities concerning succession from ancestors. The males were also mentioned as the major owners of the dairy cattle due to their high chances of land tenure and access, advanced skills in dairy management, and enthusiasm about dairy farming compared to their female counterparts. In addition, women traditionally have an important role in milk production, but their labor is usually non-monetized hence their involvement in dairying generally declines towards males as the activity becomes more important for household economic benefit (OECD-FAO, 2022).

Table 2 shows that many respondents (83.2%) were married hence married couples were presumed to be socially stable compared to respondents from single, separated, or widowed households. Most farmers were literate with at least a primary level of education and 53% were in the age category of 31-50 years. This age category is considered more active and productive. The highest percentage (57%) of the farmers spent most of their time in animal production than crop production and other occupations. It was revealed that 88.8% of the dairy farmers had prior knowledge of dairy farming before starting the dairy project. Whereas the highest percentage (43.3%) of farmers had a combined interest in "income, food, and nutritional security" when they started dairy farming, a reasonable number of farmers (32%) had a primary motive of main income while other benefits like source of manure and prestige were considered secondary. The average land accessed (owned, rented, and borrowed) by a household was approximately 15.9 acres with at least 63.5 and 36.5% allocated to dairy and crop production respectively. This observation concurs with the study by (Yegon et al., 2016) which highlights that among dairy farmers, dairy production was allocated the largest proportion of the land compared to other enterprises.

From the results shown in Table 3, a semi-intensive system is the most common method of grazing cattle in the zone followed by extensive and intensive (zero grazing). Semi-intensive grazing average yields between 5 to 20 L of milk per day per cow especially for cross and exotic breeds which is in agreement with the observation by Balikowa (2011). Semi-intensive grazing system is characterized by having one or more pens and paddocks in which the calves and cows forage on natural pastures

and are supplemented on fodder and other feed resources including concentrates and minerals. Similar to traditional cattle corridor areas, the common sources of forages are grasses, shrubs, fodder trees, and legumes where grasses include *Hyparrhenia rufa*, *Chloris gayana*, *Brachiaria decumbens*, *Cynodon dactylon*, *Themeda triandra*, *Digitaria* species, *Hyparrhenia filipendula*, *Panicum maximum* and *Paspalum dilatatum* (Balikowa, 2011). The legumes include lab, *Centrosema*, glycine, *alfa alfa*, and *Desmodium* species while shrubs and fodder trees include *Calliandra*, ficus, *Sesbania*, and mukuna. Intensive grazing also known as zero grazing or stall feeding involves total confinement of cattle and the use of a lot of inputs to maximize the productivity of a small piece of land associated with land fragmentation, a norm to the highlands. Feed and water were regularly provided in troughs and keen attention was paid to vaccination against common internal and external infections. Conversely, extensive grazing is practiced over large swathes of land including communal land strips, with little or no inputs of labor, fertilizers, and capital, relative to the land area being farmed which was associated with less productivity. Extensive farming was characterized by indigenous breeds with low growth rates and productivity in terms of milk yield while semi-intensive and stall feeding was mostly practiced with hybrids and exotic cows. Farmers asserted that local breeds are resistant to diseases and parasites and thus do not need intensive management while exotic breeds are prone to diseases and parasites which are therefore managed under an intensive system. Key informants asserted that an intensive system helps to minimize energy wastage while moving long distances for pastures and water and thus results in increased productivity. Hybrids were mostly associated with semi-intensive systems under relatively large pieces of land where cows fed on both natural pastures and supplements leading to increased milk yields.

Most farmers did not make silage to supplement normal feeding regimes while 71.2% of the farmers who supplemented feeding used cheap non-commendable feed resources². Many farmers (92.0%) used the natural mating mechanism of breeding (Table 3). The low use of AI was attributed to the limited access to the service providers, lack of knowledge of the benefits of the technology, and transaction costs associated with the service. The few farmers who used AI did it just to avoid inbreeding and reproductive infections such as fibrosis and brucellosis. The most common cattle breed kept was cross (a hybrid of local and exotic) which also recorded the highest average milk production per day (15.5 L) compared to the local (1.2 L) and exotic (12.6 L) breeds. Whereas exotic breeds were expected to produce more

²Though some farmers supplemented with mash (concentrates) and mineral salt licks, most of them (90%) fed cows on non-commendable feed resources especially banana suckers and poorly preserved kitchen refuse.

Table 3. Dairy production, feeding, and management practices.

Practices and Production		Frequency (n=125)		Percentage	
Grazing type					
Extensive		39		31.2	
Semi-intensive		54		43.2	
Stall feeding/Zero grazing		32		25.6	
Common feed resources					
Both natural and cultivated fodder		81		64.8	
Natural pastures ¹		26		20.8	
Cultivated fodder ²		18		14.4	
Make silage					
Yes		19		15.2	
No		106		84.8	
Supplementary feeding ³					
Yes		89		71.2	
No		36		28.8	
Breeding method					
Artificial insemination (AI)		10		8.0	
Natural mating		115		92.0	
Breeds	Obs.	Mean	Std. Dev.	Min	Max
Local/Indigenous	125	1	3.86	0	29
Cross (Hybrid)	125	9	33.07	0	355
Exotic	125	7	19.55	0	137
Milk production (Liters/day)					
Milk production of Indigenous	125	1.156	3.006992	0	18
Milk production of cross	125	15.54	50.82249	0	550
Milk production of exotic	125	12.58	33.33461	0	200
Reproduction scores	Mean	Std. Err.	[95% Conf. Interval]		
Age at First Service (Years)	2.56	0.235	2.096016	3.027184	
Age at first calving (Years)	3.35	0.266	2.823175	3.876025	
Birth weight (Kg)	28.62	1.35	25.93609	31.29591	
Age at weaning(months)	5.23	0.245	4.741018	5.710182	
Calving interval (Years)	1.47	0.141	1.18892	1.74548	
Mortality incidences		Frequency (n=125)		Percentage	
Yes		63		50.4	
No		62		49.6	
Mortality by age category (n=63)					
Adult		29		46.0	
Calf		24		38.1	
Both		10		15.9	
Mortality by sex (n=63)					
Bull		40		63.5	
Cow		14		22.2	
Both		9		14.3	

Table 3. Contd.

Mortality by breed (n=63)		
Cross	38	60.3
Exotic ⁴	19	30.2
Local	6	9.5
Main causes of mortality		
Tick born infections	7	11.1
East Coast Fever	20	31.7
Birth complications	6	9.5
Accidents and fighting vice	4	6.3
Ingesting foreign bodies	5	7.9
Pneumonia	2	3.2
Others ⁵	19	30.2

¹Major natural pastures were star grass, Kikuyu grass, couch grass, desmodium, Nandi, and Chloris Gayana. ²Cultivated fodder included napier, calliandra, alfalfa, brachiaria, lucener, couch grass, lemongrass, Kikuyu, Chloris-gayana, guatamala, setalia, legumes/lablab, cornflower, nut grass, and star grass. ³Supplementary feeds included Mineral salts block licks, plantain suckers and peels, sweet potato vines, raw maize stovers, concentrates of maize bran, and silverfish. ⁴Common Exotic breeds were Friesian(n=10), Jersey (n=6) and Guernsey (n=3). ⁵Other minor causes of mortality are foot and mouth disease, over and under dose during disease treatment, bloat, anaplasmosis, brucella, fever, malnutrition, and other unknown causes.

Table 4. Multiple linear regression estimates of determinants of land resource allocation to dairy production.

Variable	Coefficient	[95% Conf. Interval]	
Gender	-2.960 (3.279)	-9.455	3.535
Age	-0.143* (0.082)	-0.019	0.306
Education level	1.417** (0.635)	0.159	2.675
Annual income	0.000 (0.000)	0.000	0.000
Experience (Years) in dairy production	0.101 (0.104)	-0.105	0.306
Number of local breeds	0.099 (0.271)	-0.437	0.636
Number of crossbreeds	0.638*** (0.036)	0.567	0.710
Number of exotic breeds	0.477*** (0.057)	0.365	0.589
cons	-8.355 (5.328)	-18.908	2.197

The dependent variable, acreage of land allocated to dairy production, number of obs. = 125, R-squared=0.8327, F (10, 114) = 56.75, ***Significant at 1%, **Significant at 5%, *Significant at 10%, Standard errors in parentheses

characteristic of exotic breeds and the various unique characteristics of Indigenous breeds such as the presence of unique genetic variation in the HSP70 gene family, a 'thermometer gene', and the presence of A2 allelic variant in cow milk. This suits their (especially the Bos taurine cattle) adaptability to the varying tropical and temperate climatic conditions in the area (Srivastava et al., 2019). Like in traditional areas, Indigenous (local breeds) had very low milk production due to low input use and low response capability for milk production traits to increased increments in production inputs (Gregory et al., 1985). The study also reveals that although 90% of the farmers receive extension services from different personnel (AI technicians, government and private veterinary officers), it is mostly done on call especially when there is a disease outbreak or individual-specific

inquiries. When it comes to marketing milk and milk products, 62.4% of farmers depend on farm gate and vending channels (open market) the remaining few depend on both open and cooperative marketing opportunities. This observation coincides with the finding by Balikowa (2011) that most milk in Uganda is sold in the informal markets.

Table 4 shows that increasing the number of cross and exotic breeds by one cow increases the size of land allocated to dairy farming by 63.8 and 47.7%, respectively. This was explained by the fact that cross and exotic breeds are normally given much attention under semi-intensive and intensive systems respectively. Under a semi-intensive system, a relatively large piece of land is required for grazing besides supplementary feeding while under an intensive system; more land is

required for cultivated fodder to provide enough forage for regular feeding. On the other hand, local breeds are normally left to wander anywhere including public land/pasture strips, roadside grasslands, and market garbage hips. It was noted that the cross and exotic breeds are given much attention due to their high milk yield potential compared to indigenous breeds (Balikowa, 2011).

The age of the household head had a negative significant influence on land allocation to dairy farming such as increasing the age by a year, reducing the land allocated by 14.3%. It was explained that as farmers age, they become less interested in the enterprise because of the costs and risks associated. Additionally, as the farmer ages, there is a subsequent reduction in the potential and energy to manage the enterprise. This observation is supported by the previous finding by Brown et al. (2019) indicating that aging farmers are more risk averse and, thus invest less land expecting lower returns with known risks rather than higher returns with unknown risks. Education level had a positive significant effect on land investment towards dairy production. Most dairy farmers were elite indicative of general knowledge of management, nutrition, and economic importance of dairy farming among dairy farmers. This implies that as individuals attain more education, they improve their knowledge, skills, and capacity to manage dairy farming hence prioritizing investment in the enterprise. However, the Gender of the farmer, number of years in dairy farming, and local breeds did not play a significant role in land allocation for dairy production.

CONCLUSIONS AND RECOMMENDATIONS

Large pieces of land are allocated to dairy production influenced by the type of breed, with cross breeds giving the highest milk production but the critical challenge is high mortality is catalyzed by ECF. Number of cross breeds, education level and age of respondent had a significant effect on land resource allocation to dairy production. Therefore, the hypotheses that number of breed (cross), education level and age of respondent had a significant effect on land is not rejected at 1%, 5% and 10% respectively. However, number of exotic breeds did not show any significant effect on land resource allocation to dairy production thus the hypothesis of significant effect of exotic breeds on land allocation to dairy production is rejected at 1%. Average land allocation to dairy production including owned, hired & rented is only 10 acres supporting the argument that intensive zero grazing systems offer optimal resource use and economic dairy production on small land ownerships common in highland farming systems. This study recommends intensive farming systems and robust cattle breeding programs for acclimatized cross breeds that optimize land resource allocation and dairy production in the

highland areas.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENTS

The authors thank the corresponding district dairy value chain actors (dairy farmers, local government officials, processors, service providers, and consumers for valuable data and information) that enriched the study and also the National Agricultural Research Organization (NARO) of Uganda is highly applauded for financially supporting this study.

REFERENCES

- Balikowa D (2011). Dairy Development in Uganda; A review of Uganda's Dairy Industry. International Journal of Livestock Production.
- Belay D, Kecher Y, Jansens GPJ (2012). Socio-Economic Factors Influencing Urban Small-Scale Dairy Management Practices in Jimma Town, Ethiopia the assessment of water resources quality View project husbandary practices and constraints to smallholder urban dairy systems in Jimma, Ethiopia View project 1(3):7-12. <https://www.researchgate.net/publication/234026792>
- Brown P, Daigneault A, Dawson J (2019). Age, values, farming objectives, past management decisions, and future intentions in New Zealand agriculture. Journal of Environmental Management 231:110-120. <https://doi.org/10.1016/j.jenvman.2018.10.018>
- Byaruhanga C, Oluoka J, Olinga S (2015). Socio-economic Aspects of Goat Production in a Rural Agro-pastoral System of Uganda. Universal Journal of Agricultural Research 3(6):203-210. <https://doi.org/10.13189/ujar.2015.030604>
- OECD, FAO (2022). OECD-FAO Agricultural Outlook 2022-2031. FAO; OECD.
- Greene WH (2003). Econometric Analysis. In: P. Education (Ed.), Journal of the American Statistical Association 97:457. Prentice Hall. <https://doi.org/10.1198/jasa.2002.s458>
- Gregory KE, Trail JCM, Marples HJS, Kakonge J (1985). Heterosis and Breed Effects on Maternal and Individual Traits of Bos Indicus Breeds of Cattle. Journal of Animal Science 60(5):1175-1180. <https://doi.org/10.2527/jas1985.6051175x>
- Gujarati DN (2004). Basic Econometrics (fourth edi). New York: McGraw-Hill Inc.
- Herrero M, Grace D, Njuki J, Johnson N, Enahoro D, Silvestri S, Rufino MC (2013). The roles of livestock in developing countries. Animal 7(s1):3-18. <https://doi.org/10.1017/S1751731112001954>
- Kabi F, Muwanika V, Masembe C (2016). Indigenous cattle breeds and factors enhancing their variation, potential challenges of intensification and threats to genetic diversity in Uganda. Animal Genetic Resources/Ressources Génétiques Animales/Recursos Genéticos Animales 58:1-12. <https://doi.org/10.1017/S2078633615000326>
- Kahi AK, Wasike CB (2019). Special Issue-Dairy goat production in sub-Saharan Africa: Current status, constraints and prospects for research and development. Asian-Australasian Journal of Animal Sciences 32(8):1266-1274. <https://doi.org/10.5713/ajas.19.0377>
- Mugisha J, Alobo S (2012). Determinants of land management practices in the agricultural highlands of Uganda: A case of Kabale highlands in Western Uganda. In Ruforum third biennial conference, Entebbe, Uganda pp. 24-28.
- Mweya WNM (1993). The impact of the introduction of exotic cattle in East and southern Africa. International Livestock Centre for Africa.

- Srivastava AK, Patel JB, Ankuya KJ, Chauhan HD, Pawar MM, Gupta JP (2019). Conservation of Indigenous Cattle Breeds. *Journal of Animal Research* 9(1). <https://doi.org/10.30954/2277-940X.01.2019.1>
- Twagiramaria F, Tolo CU (2016). Climate Variability and Soil Nutrients Status along Altitudinal Gradient in Kigezi Highlands, Southwestern Uganda. *Natural Resources* 7(1):1-22.
- Uganda Bureau of Statistics (UBOS) (2014). Abstract. Kampala, Uganda and Calverton.
- Yegon M, Omunyin M, Bii F, Ruto J (2016). Observations on Dairy Cattle Production Related to Landholding, Value Addition and Marketing of Milk in Kericho and Bomet Counties of Kenya. *International Journal of Livestock Research* 6(1):68. <https://doi.org/10.5455/ijlr.20160112094645>