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Original Research Article

Effect of supply chain planning of liquid nitrogen and frozen semen on the quality of animal breeding public services in the selected cattle corridor districts of Uganda

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The study aimed to explain the effect of supply chain planning of liquid nitrogen and frozen semen on the quality of animal breeding public services in the selected cattle corridor districts (Mbarara, Mubende, Luwero and Soroti) of Uganda. The research filled the gap of supply chain planning in ensuring proficient and viable supply of animal breeding inputs from supply chain points of view compared to the traditional core science orientation which tend to focus on the biological processes of reproductive technologies. The study adopted cross-sectional survey design embracing both qualitative and quantitative approaches. Data was captured using structured questionnaires, review of records, focus group discussions (FGDs) and key informant interviews (KIIs) for farmers, staff of the National Animal Genetic Resources and Data Bank (NAGRC&DB), artificial insemination (AI) technicians, and Field Extension workers. The study points to gender disparity as a key concern at household levels when it comes to land and animal ownership. The study established that there was positive relationship between planning (χ^2=4.270; p=0.039; $\chi^2_{critical}$=3.841) and animal breeding services in selected cattle corridor districts of Uganda. The study recommends that genetic centres to put in place systems for coordinated and integrated planning to facilitate outreach for AI services in Uganda.

Keywords: Animal resources, artificial insemination services, breeding inputs, gender disparity, genetic centre, quality

INTRODUCTION

World over, the healthy hereditary improvement of animals for upgraded foundation and profitability is done using assisted reproductive technologies (ARTS). One of the well-known animal's breeds and hereditary improvement advancements is through artificial insemination (AI) services (Nishikawa, 1964; Morell, 2011; Engidawork, 2018).

Artificial insemination is a clinical richness treatment where male sperms are removed and specifically embedded in the reproductive system to help in female animal conception. This system is used on farms to monitor mating among different farm animals. Genetically superior animals are raised for meat and milk production using artificial insemination (Morell, 2011; Mugisha et al., 2014; Engidawork, 2018). Artificial insemination is the most significant strategy at any point formulated for hereditary improvement of animals in many aspects including milk and meat production (Dana et al., 1998).

The reported viewpoint of planned artificial insemination services in cattle and different animals started around 1322

A.D when an Arab chieftain who expected to mate his valued female horse with a stallion used cotton containing the scent of the female to stimulate the stallion, making him to discharge. He set the released semen in the reproductive tract of the female horse, initiating conception (Morell, 2011).

In Uganda, until the 1950s, improvement of dairy production in Uganda was based entirely on selective breeding within indigenous cattle with fear that exotic breeds were likely to be adversely affected by the prevailing climate and management conditions. AI of indigenous cattle with exotic semen started in 1959 coupled with the importation of extraordinary dairy stock, for example, Friesian, Jersey, Guernsey and Ayrshire which began during a similar period (NAGRC&DB, 2005). The Animal Breeding Center (ABC) charged with the duty of offering cattle rearing types of assistance got set up in the year 1960. From that point, a trial program to research the performance of indigenous cattle and their crosses with exotic dairy breeds started (Ococh, 2013; MAAIF, 2016; Engidawork, 2018). As a result, there was an increase in the improved cattle population in Uganda from apparently none in 1958 to about 18,000 in 1969 (MAAIF/ILRI, 1996) and from 209,000 in 1994 to 279,000 in 1999.

In Uganda, the use of artificial insemination started in the 1953 (Balikowa, 2011). AI innovation was presented in 1960 first as an open part administration or as a public service (Morell, 2011). As of now private players have come in to offer and improve AI utilization. Kaaya et al., 2005 avers, in spite of execution of the dairy cattle breeding projects of 1994 - 1998, by the end of 2000 only under 4% of the nation's 6 million heads of cattle were results of AI.

Whilst AI has been practiced for many decades, the procedure for preservation semen remained basic using largely chicken eggs and some preservatives for solidification for later use.

Presently the liquid nitrogen is one of the most efficient approach to safeguard the semen, eggs and developing lives as it is done at the National Animal Genetic Resources and Data Bank (NAGRC&DB). The liquid nitrogen is kept at -196°C for cryo-protection of semen, ova, and embryonic organisms till used (Dalton, 1985; Mugisha et al., 2014).

Artificial insemination services in cows have significantly influenced the dairy and meat industry, improving proficiency and growing sustenance flexibly. Cattle farmers use manual semen because of four key points of interest; genetically transcendent sires, crowd upkeep, record-keeping and contamination repugnance which in turn reduces need to keep strong bulls on farms and / or homesteads, and (Dalton, 1985; Mugisha et al., 2014; Lijalem et al., 2015; Engidawork, 2018).

The priority areas for Animal Industry underscored expanded animal production and disease control in the cattle corridor and the entire nation. From that point forward, numerous different projects were established by the Government of Uganda to reinforce livestock production including hereditary improvement like the meat and dairy ground-breaking strategies (Ococh, 2013).

Although, various endeavors are being made in livestock breeding and genetics, animal health, animal nutrition, livestock marketing infrastructure, husbandry techniques including vaccination and biosecurity measures, the rate of increment in the interest and utilization of planned artificial insemination services are still under 5% among households with livestock in selected cattle corridor districts of Uganda (MAAIF, 2016). Thus, there was a strong need to understand from the supply chain planning perspectives how breeding inputs mainly frozen semen and liquid nitrogen can affect the delivery of public animal breeding services in the selected cattle corridor districts of Uganda. Supply chain planning is key to explain the circumstances of deepening the penetration, access, outreach and delivery of breeding services to the farmers using artificial insemination services as one of the assisted reproductive technologies (ARTs).

The alternative hypothesis for this study is that 'there is a positive relationship between planning and the delivery of quality animal breeding services in Uganda'

The models adopted in this study are the Reference Model of flexibly chain activities (SCOR). The Supply Chain Operations Reference Model (SCOR) is an administration apparatus for talking about, creating and imparting gracefully chain the board choices inside an organization or association, for example, the National Genetic Center and with an organization's providers and customers. This model spotlights on five flexibly chain zones: arrangement, source, improvement, conveyance, and return (Bolstorff and Rosenbaum, 2003; Poluha, 2007).

The model has constructive outcome on flexibly chain increases, accelerates the gracefully chain utilization, improve business finesse, animate business process ampleness, improve stock turns, reinforce progressive gracefully chain learning targets and improve operational execution (Bolstorff and Rosenbaum, 2003).

The low percentage demand for using the artificial insemination services could be ascribed to absence of viable supply chain planning perspectives among other factors for the key breeding inputs i.e. liquid Nitrogen and frozen semen in the selected cattle corridor districts of Uganda. Consequently, this study investigated the effect of the supply chain planning of liquid nitrogen and frozen semen on the quality of animal breeding services in selected cattle corridor districts of Uganda.

MATERIALS AND METHODS

Research Design

This study adopted a cross-sectional survey research design picking data *insitu* at about the same time. The study used mixed procedures that included both quantitative and qualitative in order to triangulate data types and sources numeric and qualitative. These procedures limited the weaknesses of qualitative as well as for quantitative approaches (Sarantokos, 2005; Amin, 2005; Mugenda and

Table 1. Sample size and sampling techniques

Districts	Population (Households)	Sample Size (Households)	Sampling technique
Mbarara	45	30	Stratified sampling techniques for the participating households.
Luwero	45	30	
Mubende	45	30	
Soroti	59	39	
Totals	194	129	

Source: Krejcie and Morgan (1970)

Mugenda, 1999; Dawson, 2009).

Study Population

The study focused on the livestock farmers, artificial insemination (AI) technicians, designated artificial insemination centres (satellite centres) of the liquid nitrogen and semen generated by the genetic centre. To understand the supply chain of liquid nitrogen and frozen semen in the last five years (2014-2019) production and import reports to the genetic center were assessed. The total study population for the selected artificial insemination practicing farmers was 194 households.

Determination of the Sample Size

The sample size was easily determined using the Krejcie and Morgan, (1970) tabulated formula. It was found to be 129 sample size. For the study on the effect of the supply chain planning of liquid nitrogen and frozen semen on the quality of animal breeding public services in selected cattle corridor districts of Uganda. The sample sizes in the individual districts were obtained by stratifying the total sample size of 129 across in proportion to population sizes of respective districts as shown in Table 1.

Sampling techniques and procedure

The sampling technique adopted both purposive and probabilistic based sampling techniques. The probability-based sampling techniques is desirable because all the elements in the population for liquid nitrogen and frozen semen used have equal chances of being selected (Sekaran 2003).

The study adopted simple random sampling techniques and involved use of stratified and cluster sampling techniques. The choice of simple random sampling techniques was to ensure that all the participating AI technicians, extension workers, key informants and staff of the genetic centre have equal chances of being selected for the study without bias and that the actors at various strata give their inputs in terms of reviews, interviews (129), focus groups (8-10) and key informants (10). These samples were selected from the participating regions of Uganda engaged in the practice of AI services.

The use of stratified sampling techniques was intended to categorize participating producers, technicians and other supply chain participants so that they could be picked. Stratified sampling was a sampling process involving a population division into smaller groups known as strata.

Stratification was important to provide for consideration of sub-counties and parishes were the concentration of livestock is high, and place emphasis where the practice of livestock artificial insemination services is often practiced. In this study stratification would focus on the various regions, districts, sub-counties, parishes, villages and consideration were also be given to zones and focal areas where farmers have adopted and were quite often practicing artificial insemination services.

The study also undertook the review of records kept by NAGRC&DB that is liquid nitrogen and semen production at the genetic center. The study targeted specific practicing AI technicians in the study districts for key informant interviews (KIIs) and conducted focus group discussions to pick salient issues concerning the production, the sourcing, the distribution of liquid nitrogen and semen supply and utilization in the targeted areas. Other challenges facing the supply network were captured and innovative solutions to improve the processes sought from the respondents.

Data collection methods

The study used structured questionnaires, focus groups discussions, key informant interviews and undertook the review of previous records kept by the National Animal Genetic Resources and Data Bank Centre. The use of mixed methods to collect data from the genetic centre, AI technicians, extension workers, farmers and the other users of liquid Nitrogen and frozen semen for breeding services was justified for collecting precise qualitative and quantitative data (Sekaran, 2003; Amin, 2005; Sarantakos, 2005).

Use of structured questionnaires

The study adopted the use of structured questionnaires, which was carefully designed to collect data according to the specification of research questions and hypothesis. The data collection instrument (questionnaire) consisted of a set of questions to which the subjects responded. The questions captured data on quantities of liquid nitrogen and semen, costs of production. It was structured for purposes of ease of analysis of the data collected. A questionnaire is a onetime gathering device on the variables of interest; it is faster, cheap, places emphasis on anonymity and covers a wide geographical area (Amin, 2005).

Focus group discussions (FGDs)

Focus group discussions (FGDs) focuses on group brainstorm on the issues but the conclusions of the group findings are not the outcome of the group consensus but a synthesis by the researcher. FGDs allows flexibility of the members to discuss freely on the issue, first-hand information is collected, interaction is free and the feelings, experiences and ideas are valued (Sekaran, 2003). The focus group discussion checklist was designed to pick information from the focus groups that would not be easily captured by the questionnaires such as the farmer specific questionnaires.

Key informant interviews (KIIs)

The choice of key informant interviews (KIIs) placed emphasis on specific technical, professional, career wide information that were picked and synthesized for the purposes of strengthening logic patterns, trends and explanatory notes for the study (Sarantakos, 2005). The key informant interview guides supported the collection of qualitative data based on the knowledge, skills and experiences of the informants who are experts to broaden the knowledge gaps on the subject of the study. These data included views collected from the users of AI services, AI technicians and staff of the Genetic Center.

Review of documents and records

The study undertook review of records (using a checklist) from the National Animal Genetic Resources and Data Bank centre on the production (quantities) and the associated financial costs in production and maintenance of liquid nitrogen and frozen semen. The review of records was important to pick information to determine trends and make forecasts for better planning, strategy and implementation modalities for key breeding inputs (Amin, 2005). This involved use of specific items on the specific themes of production quantities, costs and maintenance of genetic resources (semen, liquid nitrogen) that had been recorded over a 5 year period of time to be able to generate trends and patterns. This helps in planning and putting in place effective mechanisms for planning, and delivery of breeding inputs to the users and chain actors.

Validity and Reliability

To ensure content validity, the dimensions, length and scope of the supply chain for key breeding inputs were in place. Construct validity was established by asking experts to review the key underlying principles in the study and the questions asked (items). The content validity index (C.V.I=Number of relevant items/Total number of items = 0.96) was calculated. Amin (2005) documented that for an instrument to be considered relevant or valid to collect data from the field, the CVI should be at least 0.7 and above. There was adherence of the instruments to variables of the study and the indicators of the study variables fall within the same construct. The use of probabilistic sampling techniques and the triangulation of methods also helped improve on the reliability and validity of the study instruments (Kothari, 1990; Sekaran, 2003; Sarantankos, 2005).

To ensure reliability, the questionnaire had to be subjected to test and retest with Cronbach alpha (α) reliability test, and the questionnaire was also pre-tested before it was generally administered (Kothari, 1990; Amin, 2005). In this study, the Cronbach alpha coefficient (α) of the instrument was 0.7 indicating that the study instruments were reliable. The structured key informant guides and documentary review checklist was peer-reviewed and pre-tested before administration to ensure the reliability of the study instruments.

Procedure of Data Collection

The study interacted with the production, breeding and bull stud managers of the genetic centre. The researcher also interacted with the technicians for semen and liquid nitrogen production at the genetic centre located at Entebbe. The data for annual liquid nitrogen production was collected from the genetic centre for analysis. The review considered data collected for the last five years period (2014-2019). The accounts staff were contacted to avail data on the costs of electricity bills based on utility bills for electricity per annum. The data for semen production for the last five years (2014-2019) was also collected on the repair costs, cost of generator fuel, labour and other operational service costs. The number of semen straws per annum produced over the period, its storage, distribution and utilization were reviewed.

The appropriate costs for semen and liquid nitrogen gathered from the genetic centre, and also from the inseminators to assist avail information on the effect of the supply chain management of semen and liquid nitrogen in the production, distribution and utilization of breeding inputs to deliver livestock artificial insemination services.

Data Analysis

The data on quantities, costs, demands for liquid nitrogen and semen production, storage, distribution and utilization were analyzed using Statistical Package for Social Scientists (SPSS) version 21. The analysis involved data capture, data cleaning, data coding, data entry, data analysis and descriptive and inferential statistics were derived from the analysis of the collected data (Kothari, 1990; Sekaran, 2003; Amin, 2005). Hypotheses tests were conducted at 0.05 level of significance.

Table 2. Tabular representation of socio-economic demographic characteristics of the households in selected Cattle Corridor districts of Uganda

District	Respondents	Gender			Subcounty	Parish	Village
		M	F	Missing			
Mbarara	30	19 (63.3%)	11 (36.7%)	-	8	16	25
Mubende	30	12 (40.0%)	15 (50.0%)	3 (10.0%)	8	7	10
Luwero	30	19 (63.3%)	8 (26.7%)	3 (10.0%)	11	16	23
Soroti	39	20 (51.3%)	12 (30.8%)	7 (17.9%)	7	16	23
Total	**129**	**70 (54.3%)**	**46 (35.7%)**	**13 (10.0%)**	**34**	**55**	**81**

Source: Primary data; M-Male, F-Female

Table 3. Years of the respondents and the length of service in livestock farming business

Parameter	Description	Mbarara	Mubende	Luwero	Soroti
Age (years)	20-29	3(10.0%)	2(6.9%)	1(3.3%)	1(2.7%)
	30-39	11(36.7%)	7(24.1%)	4(13.3%)	6(16.2%)
	40-49	7(23.3%)	6(20.7%)	4(13.3%)	6(16.2%)
	50-59	3(10.0%)	7(24.1%)	12(40.0%)	15(40.5%)
	60-69	2(6.7%)	5(17.2%)	5(16.7%)	8(21.6%)
	70&Above	4(13.3%)	2(6.9%)	4(13.3%)	1(2.7%)
Length of service	Under 1 year	1(3.6%)	1(4.2%)	-	1(2.6%)
	1-2 years	3(10.7%)	6(25.0%)	1(3.3%)	6(15.4%)
	2-5 years	5(17.9%)	9(37.5%)	6(20.0%)	15(38.5%)
	Over 5 years	19(67.9%)	8(33.3%)	23(76.7%)	17(43.6%)

Source: Primary data from the field collections

Quantitative data analysis

Descriptive statistics included the use of frequencies, percentages and mean for the quantities, costs, demands for both semen and liquid nitrogen supply chain. Inferential statistics involved use of chi-square (χ^2) test to establish relationships between semen and liquid nitrogen manufacture and factors related to production, storage, distribution and utilization.

Qualitative Data Analysis

The qualitative data analysis was a continuous process. The analysis was conducted concurrently with the data collection process. The regular occurrence of an idea, word, and description surfaces was used to interpret the importance of the matter being raised. Individual responses were arranged into themes according to the research objectives of the study. The collected data analysis was presented in narrative form for more synthesis.

Ethical Clearance

The study was presented to the panel of the higher research committee for approval. Pre-testing of study instruments was done before the final data was collected from the field to validate the study instruments. A letter of introduction was availed for the researchers by Uganda Management Institute introducing the study to study participants. The researchers ensured anonymity, transparency, informed consent of the participants and the researchers guaranteed that all the study instruments were properly kept in a safe place and information only used for the purposes of the study.

RESULTS

Socio-economic Demographic Characteristics of the Households and related issues in the Selected Cattle Corridor Districts of Uganda

A total of 129 questionnaires were administered to farmers using AI services (54.3% males, 35.7% females) covering 34 sub-counties, 55 parishes and 81 villages as detailed in Table 2.

The age groups of the respondents and years served in the farming business are illustrated in Table 3. The data clearly indicates that the respondents mainly fall within the age brackets (years) of 20-29; 30-39; 40-49 and 50-59 age groups in the four districts of Mbarara (80%), Mubende (75.8%), Luwero (69.9%) and Soroti (75.6%). Majority of the farmers have been in the farming business for between 2-5 years and above 5 years in livestock farming as time element provides for investment in livestock infrastructure and growth of the animal farming business through breeding.

Livestock types and numbers in the different sites of the farm are detailed in Figure 1. The mean numbers for cattle per household are 28, 4, 17 and 11 for the districts of

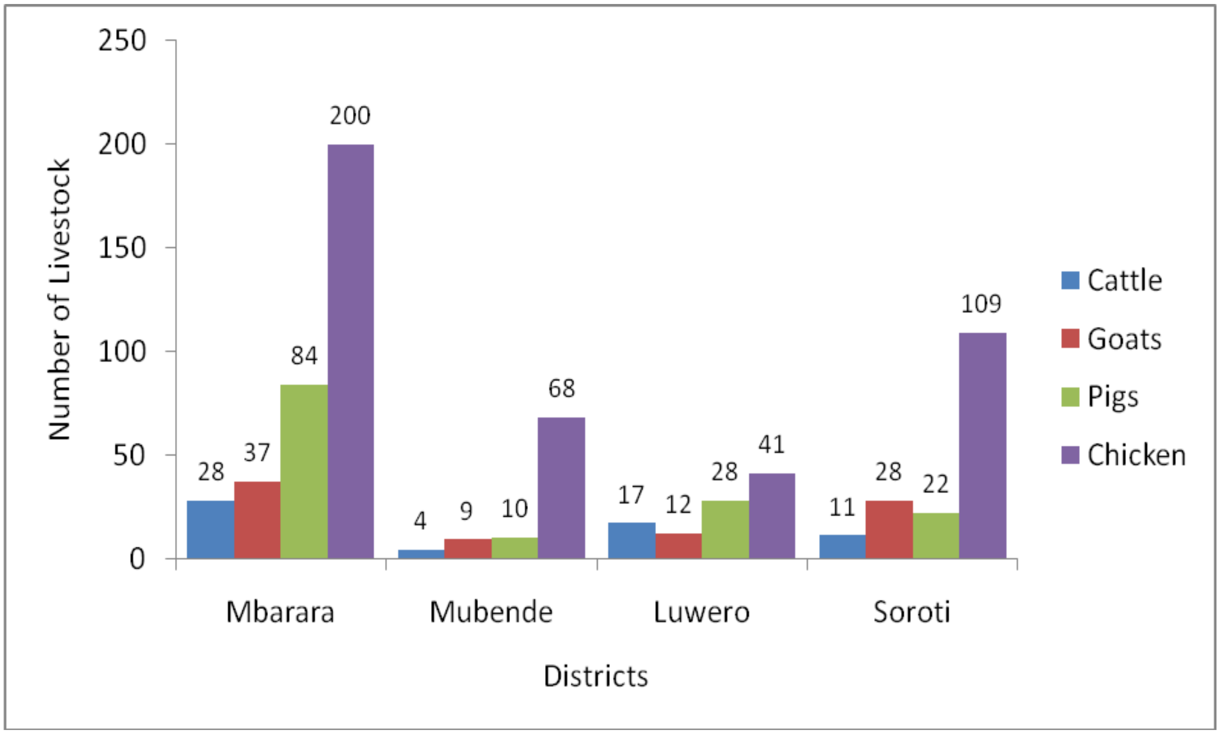

Figure 1: Shows the livestock types and average numbers kept by farmers at household levels.

Mbarara, Mubende, Luwero and Soroti respectively. Considering the population increase, the households own cattle integrated with other farming enterprises like crops. AI services are more in cattle and for other species it is still an emerging trend.

Planning for Liquid Nitrogen and frozen semen production, cost and its effect on the animal breeding public services in selected cattle corridor districts of Uganda

This section presented the production levels for liquid nitrogen and frozen semen, the growth levels and costs associated with the production and maintenance. The quality of animal breeding services is measured through the number of inseminations, timeliness and receptiveness.

The production and utilization of liquid nitrogen produced at the genetic center have been on the upward trend as illustrated in Figure 2. A quantity of 65,483 liters of liquid nitrogen was produced at the genetic centre as of 2018/2019. Of this number produced a total of 50,274 liters were utilized. The number 15,109 liters were lost through evaporation and nonuse of the liquid nitrogen. The number for non-utilization has also been growing over a period of time.

Figure 3 illustrates the cost of liquid nitrogen production in Ugandan shillings (UGX) over the five years. The study found out the total cost of production is increasing over the years with the highest cost being attributed to electricity costs. Other costs include repair and maintenance costs, cost of fuel and lubricants, labour cost to run the liquid nitrogen plant etc. The production costs need to be factored in and explained properly as they are a factor in the overall planning, implementation and running of the facility.

Figure 4 illustrates the quantities of frozen semen produced at the genetic centre for the period 2014/15 to 2018/2019. The total frozen semen (straws) produced per annum is on the upward trend including utilization. In the financial year (FY) 2018/19, a total of 37,286 straws of semen were produced; a total of 26, 738 straws were utilized leaving a total of 10,522 straws not yet utilized as per the FY 2018/2019. A number of mechanisms need to be put in place to improve AI services like the training and refresher courses for practicing AI technicians, availability of AI technicians, the supply of liquid nitrogen and frozen semen, logistics for transport and kits for AI technicians and timely delivery of AI services to the farmers.

Costs are key decision-making factors when selecting providers on what to deliver to facilitate the AI services. The costs detailed in Figure 5 relates to the production of frozen semen at the genetic center over a five-year period from 2014/15 to 2018/2019. The costs arose from the maintenance of bulls, Veterinary care costs, fuel and other lubricants, labour costs etc. other costs include the procurement of bulls and semen equipment for the genetic center.

The chi-square test (df=1) showed a significant positive relationship between planning and the delivery of quality animal breeding services in Uganda (χ^2=4.270; p=0.039; $\chi^2_{critical}$=3.841). In this test, keeping of records was

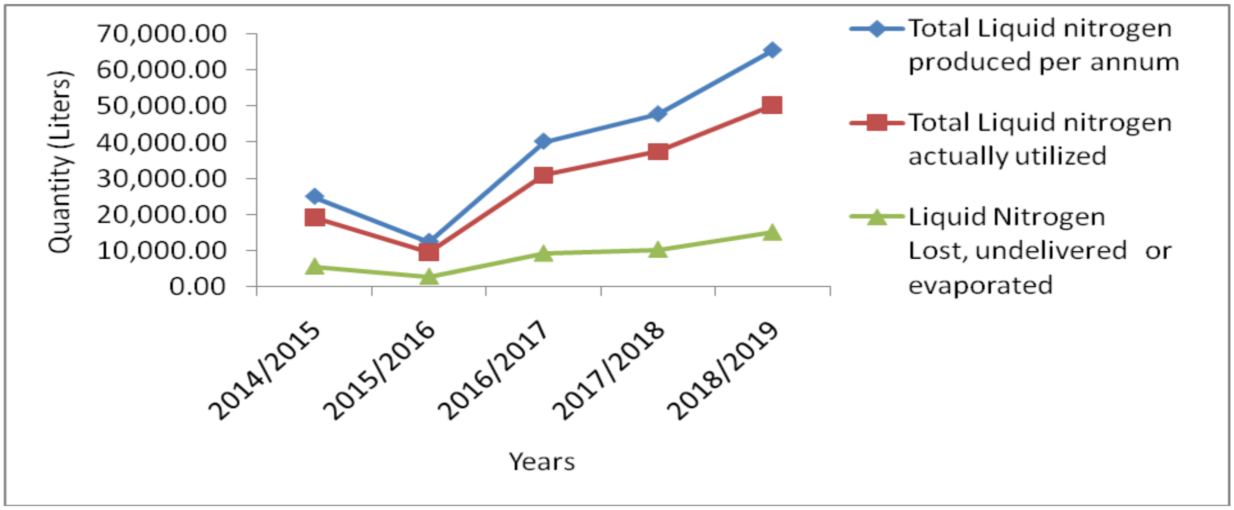

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Figure 2: Quantities of Liquid Nitrogen production from 2014-2018 at the genetic centre

Source: Secondary data, National Animal Genetic Resources and Data Bank Records
The Liquid Nitrogen Plant at the Genetic Centre has production capacity of 89 liters of liquid nitrogen per hour running on average of 10 hours per day

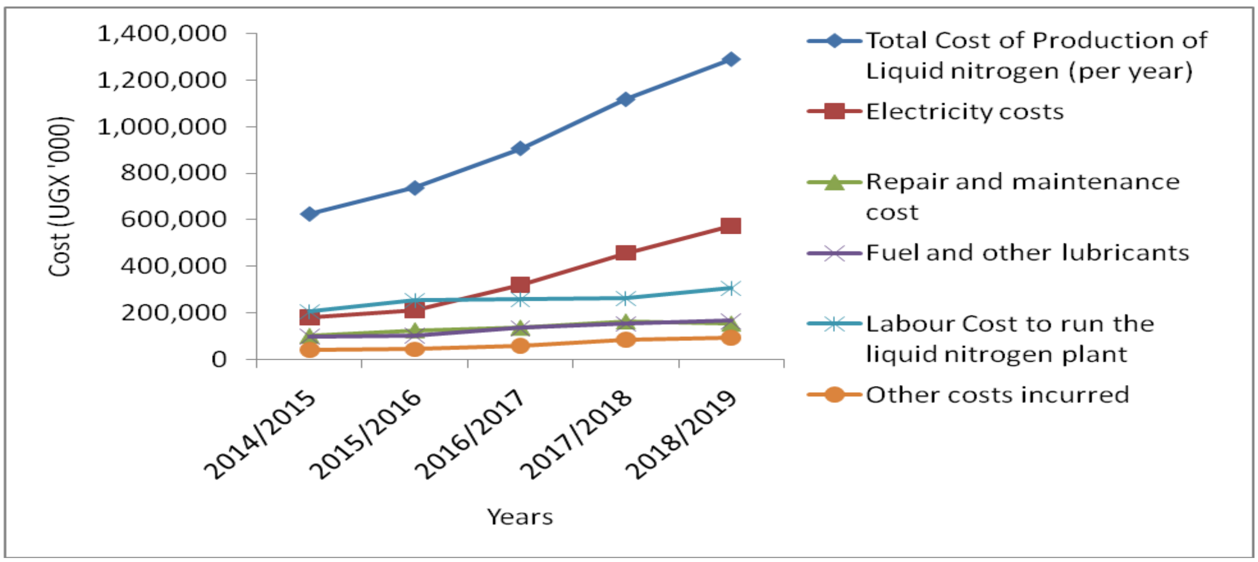

Figure 3: Cost of Liquid nitrogen production from 2014-2018 at the production centre

Source: Secondary data, National Animal Genetic Resources and Data Bank Records

considered as a planning tool while the delivery of quality animal breeding services in Uganda was a factor of percentage of animals that conceive through AI services.

DISCUSSION OF FINDINGS

Socio-economic Demographic Characteristics of the Households and related issues in the Selected Cattle Corridor Districts of Uganda

The key findings in these socio-economic demographic characteristics are the gender disparity among the households (Table 2) where men dominate the land and animal ownership. This is a typical patriarchal society in many of the community settings in Uganda. It has effects on access benefit sharing for the livestock kept. Men always dominate and women do most of the work in terms of rearing, milking and treatments for the animals that fall sick yet goals and priorities of men and women in the households differ (MAAIF, 2016; UBOS, 2017).

This finding is in agreement with previous studies conducted by Mugisha et al. (2008). It can be stated here that many women lack land as a result, it is difficult for

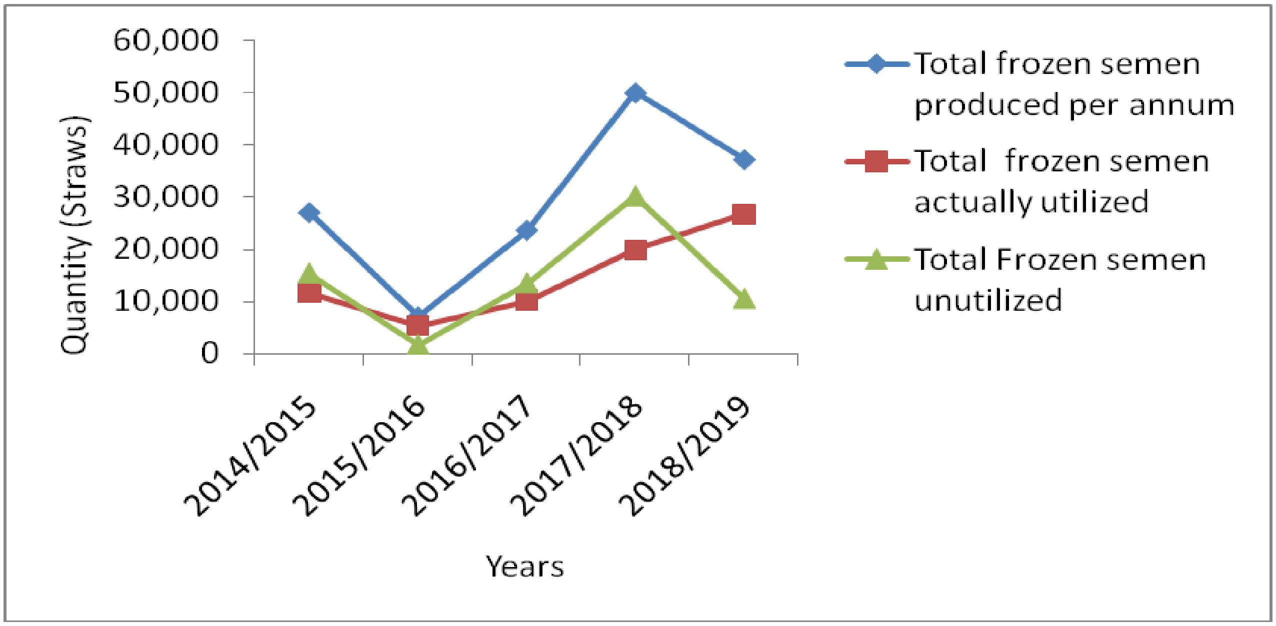

Figure 4: Quantities of frozen semen production from 2014-2018 at the genetic centre

Source: Secondary data, National Animal Genetic Resources and Data Bank Records
The semen packing machine can pack twelve thousand straws per hour working on 6 hours per day; having 100 bulls at the bull stud currently the number of bulls at the genetic Centre bull stud is 27 bulls: One (1) Bull gives 400 doses of straws (assume enough skilled human resources, reagents).

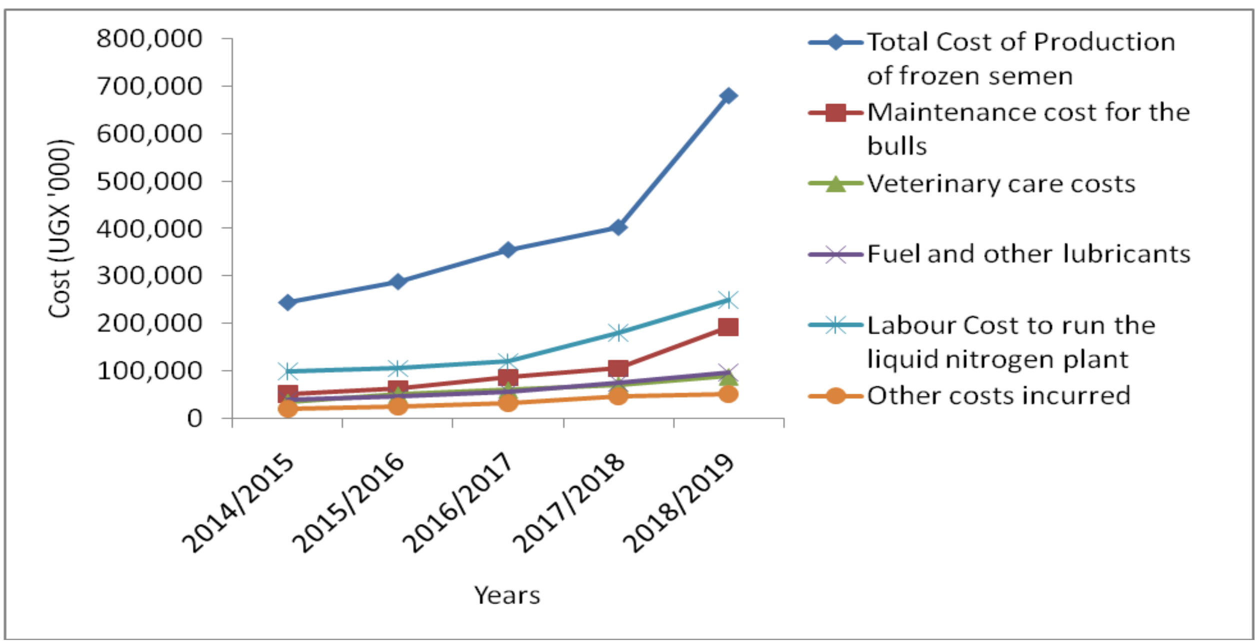

Figure 5: Costs Related to Production of Semen from 2014-2018 at the genetic Centre

Source: Secondary data, National Animal Genetic Resources and Data Bank Records
1 USD= 3,700 Uganda Shillings)

women to carry out livestock farming in isolation from their spouses if married and if young, from their parents who must exhibit consent to a particular size of the land resources for rearing the stock (Statistical Abstract, UBOS, 2017).

However, the findings of the present study are contrary to those of Ahisibwe (2019) whose findings indicated that more female farmers were found using AI than male farmers attributed to the willingness and ease of convincing females to take up new technologies in a given society.

More youthful farmers were more occupied with utilization of AI administrations than more seasoned farmers. Kaaya et al. (2005) discovered that age was negatively associated with utilization of AI in central Uganda. Similarly Howley (2017) in Ireland reported a relationship between age and adoption and use of AI where age is negatively associated with the use of AI services (Bragg and Dalton, 2004).

Dominant part of the livestock farmers using the AI services have been in the livestock farming industry for some time (i.e. 2-5 years and above 5 years). According to Kaaya et al. (2005), farmers who used AI for breeding had been involved in farming for a longer period. Ahisibwe (2019) reported that respondents with 1-5 years' experience in dairying had the highest percentage use of AI attributed to the fact that the more, the experience of the farmer in dairying, the more the knowledge to enable them adopt new technology with the aim to increase production. Furthermore, Temba (2011) obtained a statistically significant positive relationship between the numbers of years in dairying with AI use.

Majority of the farmers have been in the farming business for some time (Table 3) and this is expected since Uganda's back borne is Agriculture and Livestock farming (MAAIF, 2016; Statistical abstract, UBOS, 2017).

Planning for Liquid Nitrogen and frozen semen production, cost and its effect on the animal breeding public services in selected cattle corridor districts of Uganda

The study established that there was a positive relationship between planning and the delivery of quality animal breeding public services in selected cattle corridor districts of Uganda. It was established that farmers receive AI Services on the farms. The AI technicians provide most of this service. Other providers include the Veterinary Officers, Field Extension workers and other service providers. Quite a good number of AI technicians would respond within 30 minutes to 3 hours when you call an AI technician to serve your cows on heat except in Mbarara where AI technicians would take much longer time to respond to farmers call. However, the performance and perception of the farmers on AI services in terms of response, conceptions, return rates are mixed as earlier documented by (Ococh, 2013; MAAIF, 2016; Engidawork,2018).

Farmers keep different livestock types at different sites (Figure 1) in genetic improvement of stock to enhance production and productivity (Nishikawa, 1964; Morell, 2011; Engidawork, 2018). Nevertheless, the study established that AI services are commonly practiced in large ruminants like cattle and less in sheep, goats, and pigs and very rare in chickens. This is mainly due to the level of skills among the AI technicians which is tailored to AI services in Cattle than on other species. Furthermore, the AI equipment, consumables are more focused on serving the cattle rather than other livestock species which makes the AI services unsustainable. Thus the genetic centre is still struggling with ensuring the adoption and uptake of AI services by the livestock farmers is to sustainable levels (MAAIF, 2016).

Record keeping is a key animal husbandry and breeding practices including business activities on the farm. Farmers in this present study also keep some form of AI records on their farms with a resultant increased use of AI services. Adoption of the AI service was highly ($p< 0.05$) dependent on availability of extension services and record keeping practice ($p< 0.05$) (Mugisha et al., 2014). Mwanga et al. (2019) reported positive relationship between records keeping and AI in Uganda ($p = 0.004$). However, the extent to which record keeping is practiced is dependent on the level of education, literacy among the households, the level of awareness and how the farmers view the record-keeping in terms of helping them to make farm decisions (Ococh, 2013).

The farmers in the present study requested for regular training of farmers on heat detection, record keeping, and regular meeting with AI technicians. They ranked Heifer project International, Send a Cow, NGOs, CBOs and other farmer organizations as providers of AI services. There is a need to train more technicians and regulate the AI service providers by the Government to ensure high standards of service (Kaaya et al., 2005).

It was clear that in the countryside, there are few AI technicians and the trained AI technicians lack AI kits, field flasks, liquid nitrogen, frozen semen reservoir tanks to store the liquid nitrogen and frozen semen adequately. To make matters worse the access, the delivery of liquid nitrogen and semen to the various AI technicians so that they can access them regularly has been a big constraint as observed by the various reports by (EPRC, 2019; MFPED, 2017; MAAIF, 2016; UIA, 2016). This is attributed to the fact that the National Animal Genetic Resources Centre and Data Bank has one liquid nitrogen plant-based at Entebbe headquarters. The Centre has three delivery trucks and a few trained resource personnel attached to the liquid nitrogen plant to deliver the liquid nitrogen to the regions of the country. The same human resource also is engaged in semen collection and processing and storage.

The plant has a production capacity of 89 litres of liquid nitrogen per hour (Figure 2). It can produce approximately 26,700 litres of liquid nitrogen per month at a time period of at least 10 hours per day. It can produce a total of 324,850 litres of liquid nitrogen per year, hence making it one of the biggest plants in the East and Central African Region. The plant has sufficient capacity to produce all the liquid nitrogen to support AI services in the country and beyond. But so far because of lack of effective planning and organizing the supply chains, the centre does not have an arrangement to produce to meet the expected demands and trigger supply chain issues for utilization and efficient delivery of animal breeding public services in selected cattle corridor districts of Uganda and the region. This is in agreement with studies by (Kiwanuka and Machethe, 2016; NAGRC&DB, 2017).

Despite the high quantities of liquid nitrogen produced (Figure 3), there are no sufficient and effective measures to distribute the liquid nitrogen and frozen semen using a supply chain network that supports efficiency and effectiveness in the delivery mechanisms. This corroborates well with similar studies by Uganda Bureau of Studies Statistical abstract, (UBOS, 2017).

The supply chain operations reference model (SCOR) is a management tool for discussing, developing and communicating supply chain management decisions within a company or organization such as the National Animal Genetic Resources Centre and with a company's suppliers and clients. This model focuses on five supply chain areas: preparation, origin, development, distribution, and return (Bolstorff and Rosenbaum, 2003; Christopher, 2005; Poluha, 2007; Johnson and Anna, 2015). The study observed the presence of other actors like Heifer Project International, Send a Cow, some NGOs, CBOs and other farmer organizations like Uganda Crane Creameries Cooperative Union (UCCCU), Reline, Dairy farmer's network etc as actors in the use of AI services. In most of the cases, AI services were provided by private practitioners and NGOs, and government played a less significant role, providing only 19% of the AI services (Mugisha et al., 2014).

Although the responsibility of the supply chain for the delivery of liquid nitrogen and frozen semen majorly lies with the National Animal Genetic Resources Centre & Data bank, the study observed that the Centre had not put in place effective supply chain measures and strategies to network with the various value chain actors to distribute liquid nitrogen and frozen semen to the technicians and farmers' cooperatives to holistically conduct AI services. This is in agreement with observations by (Christopher, 2005; Ayers, 2010).

The collaborative efforts with other supply chain actors in the breeding industry will enhance sustainable supply, address time lag in the supply, solve the bullwhip effects and create a sustainable and resurgent supply chain for the efficient and effective delivery of quality animal breeding services to attain production and productivity of quality animal resources in selected cattle corridor districts of Uganda (Ayers, 2010).

The production and utilization of liquid nitrogen produced at the genetic Centre have been on the upward trend as illustrated in Figure 2. The study also captured information on the cost of Liquid Nitrogen production (Figure 3) at the production centre, quantities of frozen semen production (Figure 4) from 2014-2018 at the genetic Centre, the costs related to the production of semen (Figure 5) at the genetic Centre for the period 2014/15 to 2018/2019. The costs arose from the maintenance of bulls, Veterinary care costs, fuel and other lubricants, labour costs etc. Other costs included the procurement of bulls and semen equipment for the Genetic Centre. Costs were key decision-making factors when selecting providers on what to deliver to facilitate the AI services (Christopher, 2005; Lysons and Farrington, 2016).

Timely and good planning supports the delivery of quality animal breeding services in selected cattle corridor districts of Uganda. It makes decisions to maximize returns, consider all alternatives, and know the costs and consequences according to alternatives and fixed preferences. Planning helps to stay focused on long term objectives while retaining the flexibility to cope with short term problems and opportunities (Lysons and Farrington, 2016; Johnson and Anna, 2015).

The maximum quantity of liquid nitrogen produced was 65,483 litres for the period 2018/2019. This represents only 20% of the overall production capacity. Of the 65,483 liters of liquid nitrogen produced, a total of 50,274 liters were utilized while 15,109 liters (Figure 2) was lost through evaporation and nonuse of the liquid nitrogen (NAGRC&DB, 2018/19). So operationally from the supply chain perspectives, the operations of the genetic Centre can be termed as non-efficient and non-effective.

Record keeping plays an important role in monitoring demands for liquid nitrogen. The demand for liquid nitrogen for conducting AI services is very high at countryside yet one of the key constraints affecting the delivery of efficient AI services at farmer level is low, inadequate and lack of consistent delivery of liquid nitrogen to the farms and satellite centres which are areas designated for AI services by the farmers (Holt, 2000; Engidawork, 2018).

The genetic centre based on its current production quantities of 65,483 litres for FY2018/19 can only raise about 458,381,000 UGX (approx. 123,886.76 USD) if all the liquid nitrogen are purchased. Yet what the centre managed to utilise is only 50,374 litres hence raising only 352,618, 000 UGX (approx. 95,302.16 USD) per annum at a rate of 7,000 UGX (1.89USD) per litre of liquid nitrogen produced.

The total cost to run the liquid nitrogen centre which includes the cost of electricity, repairs and maintenance, fuel and lubricants, labour costs and other maintenance costs is 1,288,500,000 UGX. (348,243.24 USD) The implication of this figure is that the centre is working at a gross loss of 935,882,200 UGX. (252,941.14 USD). What is buffering the centre is that they get central Governmnet releases to meet some of the recurrent costs like electricity, fuel and lubricants, labour, wages etc (MFPED 2018). The lack of central government releases will make the centre to close because it is making losses without the managers knowing that they are in losses in operating the liquid nitrogen plants.

In any case if the liquid nitrogen plant was operating full capacity of 324,850 litres per annum it can generate about 2,273,950,000 UGX (614,581.08 USD) and hence be able to meet its costs totalling to 1,288,500,200 UGX (348,243.30 USD) and leaving a profit of 985,449,800 UGX (266,337.78 USD) for the Centre or for Government as Non Tax Revenue (NTR) yet services would have been fully offered and the animal industry would have benefited. Currently, this is not the case, a matter in agreement by Monczka et al. (2009).

On the semen production and storage component, the centre is equally in business losses. The total cost to produce 37,286 straws of semen is 679,400,500 UGX (183,621.76 USD) consisting of maintenance of the bulls, veterinary care costs, fuel and lubricants, labour costs for production of semen and other related costs (Figure 4 and Figure 5).

Based on the current production and rate of 4,000 UGX (1.08 USD) per straw for the locally produced semen at the National Animal Genetic Resources Centre and Data Bank, the centre can only raise 149,144,000 UGX (40,309.19 USD) only if all the straws are purchased. Otherwise, the centre can only raise 106,936,000 UGX. (28,901.62 USD). This leaves the centre to operate at a loss amounting to 572,464,500 UGX (154,720.14 USD) only. The centre would not be functioning if it was not the releases from the Government to meet crucial input activities of maintaining the bulls, the labour, electricity costs and costs related to feeding the bulls (NAGRC&DB, 2018/19). Planning is fundamental to address these long term gaps and approaches to creating sustainable supply chains for liquid nitrogen and semen production at the National Animal Genetic Resources Centre and Data Bank.

CONCLUSION AND RECOMMENDATIONS

The study of the effect of the supply chain planning of liquid nitrogen and frozen semen on the delivery of quality animal breeding public services in selected cattle corridor districts of Uganda reveal the presence of gender disparity in land and animal ownership at household levels. This in effect determines the structural and functional supply chain dynamics for the key breeding inputs in the animal resources sector.

The study reveals that planning in terms of human resources, production quantities, costs of production, other costs essential for liquid nitrogen and frozen semen production is key for reliable supply of the AI services to the users in selected cattle corridor districts of Uganda and beyond.

There is a need by government to address gender disparity in the land and animal ownership at household levels; this has effects on the supply chain for key breeding inputs for animal breeding public services in selected cattle corridor districts of Uganda.

The study recommends government undertakes effective planning at all animal resources value chain levels to ensure efficient and effective delivery of animal breeding services in selected cattle corridor districts of Uganda in a more focused and coordinated way among the value chain actors.

Limitations of the study

More studies need to be conducted to understand how sourcing of breeding inputs affects the delivery of animal breeding services in the selected cattle corridor districts of Uganda.

Conflict of interests

The authors declare that they have no conflicting interests.

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