

Flock Dynamics and Approaches for Reducing Mortality Rate among Mubende Goats at BuZARDI Semi-Intensive Farm, Hoima, Uganda

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Abstract

Goats are globally very important domestic small ruminants being kept for meat, milk, skin, byproducts and several socio-cultural purposes. Goat farmers in the Lake Albert Crescent Zone (LACZ) of Uganda identified dry-season feed scarcity, poor breeds, diseases, informal marketing and theft as major constraints which underscore the scarcity of information on improved management technologies and the need for targeted decisions. At BuZARDI goat farm, a semi-intensive farm that is also experiencing similar challenges, we documented management practices and collected production related data for 2 years. We computed flock dynamics and mortality rates purposely to influence decisions aimed at increasing the farm's productivity. Data were collected using pens and books, validated and analyzed using MS office 2013 and SPSS version 22. The flock size increased from 37 goats in July 2020 to 175 goats in June 2022. One hundred twenty-five goats were introduced into the farm as breeding stock, 89 kids were born on the farm and 61 goats died due to various causes. The average number of goats in the farm per month was 109.2 (SEM = 13.7), female 79.8 (SEM = 10.8) and male 29.4, (SEM = 9.9). Average population of goats at risk of death was 95 and the Mortality rate was 27 goats per 1000 goat months. The disaggregated mortality rate of 5 goats per 1000 goat months and 39 goats per 1000 goat months were obtained for the period FY 2020-2021 and FY2021-2022 respectively. The main contributors to the mortality of goats were worm infestation (33%), fracture and injuries arising from stampedes (18%), Ticks and tick borne diseases (18%), respiratory tract infections (11%) and malnutrition (10%). We recommend strict adherence to the flock health program; improved parasite management, separation & improved care for kids, vaccinations, safer feeding, and evidence based disease management, adoption of digital data collection tools and development

of an appropriate app for more accurate determination of mortality rates.

Keywords

Flock Dynamics, Mortality Rate, Lake Albert Crescent Zone

1. Introduction

1.1. Background

Goats (*Capra aegagrus hircus*) are globally very important domestic small ruminants being kept mainly for meat, milk, skin and their products, dung as a source of organic fertilizer and socio-cultural purposes such as; dowry and spirit cleansing, etc. On average, goat meat has 75.42% water, 3.55% fat, 19.95% protein, 1.06% mineral matter and 580 kJ per 100 g [1]. Goat meat contains low saturated fatty acids and cholesterol compared to mutton, beef and chicken. The protein in goat meat has significant levels of essential amino acids such as lysine, threonine and tryptophan. The sale of goats and products earns income, improves savings which contribute greatly to the improvement of livelihoods and rural development. Goat feeding on a wide range of forage, higher reproduction rate (multiple births), shorter generation intervals and small body size capable of producing meat in small readily usable quantities makes them suitable for both subsistence and commercial production.

The goat value chain employs a sizable number of producers, agro processors and various traders. It is one of the priority animal commodities that can easily be promoted to reduce poverty which currently stands at 10% in the Lake Albert Crescent Zone (LACZ).

World over there are 1.002 billion goats; in Uganda and Albertine Graben in particular, we have approximately 14.1 million and 704,259 goats respectively [2]. The per capita meat and goat meat consumption in Uganda stands at 13 Kg and 1 Kg respectively. Goat meat production stands at 39,990 MT. The demand for goat meat and other products in Uganda outpaces production due to rapid population growth and urbanization, increased incomes and changing lifestyles. The contribution of goat production to local and global poverty reduction is constrained by declining production, limited value addition and poor access to the market. The low production is due to rampant diseases, feed shortages, inadequate extension services, poor breeds and inappropriate farming systems.

In an attempt to increase the production of goats in LACZ, Bulindi Zonal Agricultural Research and Development Institute (BuZARDI) established a goat farm for disseminating management technologies to farmers in the region under the project of commercialization of the goat value chain through industrial park approach in the Lake Albert Crescent Zone. As part of the farm management practices, a series of individual and farm data were collected to determine flock dynamics and production efficiency of the farm. In this study, we analyzed data

captured from the farm over 24 months from July 2020 to June 2022. We computed flock dynamics and mortality rates among goats on the farm to provide yardstick for evaluating management decisions.

Problem

The lack of accurate records and data vital for determining flock dynamics, performance indicators and production efficiency of goat farms across LACZ is making it difficult to precisely address challenges constraining goat production and marketing. Many farms can't evaluate and forecast the impacts of management decisions and profitability. Over 98% of farms keeping wide-ranging breeds of goats under different farming systems in LACZ lack formal records essential for tracking productivity, traceability and formal marketing. In this study, we collected production and epidemiologic data for determining the flock dynamics and mortality rate for optimizing farm management practically emulatable by upcoming goat farmers.

Objectives

- 1) To explore flock dynamics of BuZARDI on-station goat farm over the period of July 2020-June 2022.
- 2) To determine the mortality rate among goats on the farm from July 2020-June 2022.
- 3) To prioritize approaches for reducing the mortality rate among goats on the farm.

1.2. Justification

Data collected from the institute's farm are useful for determining flock dynamics and the production efficiency of the farm. These indices are used for optimizing farm management. More producers visiting the institute get imbued with the culture and skills of using records and procedures for determining the performance parameters of this demonstration farm. Future increases in automation of appropriate production and economic data shall spur increased productivity of goat farms.

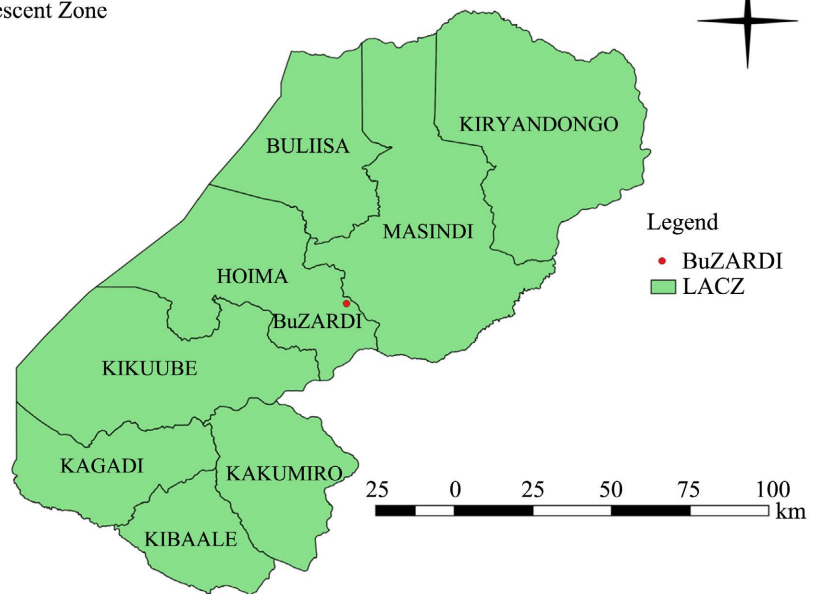
2. Materials and Methods

2.1. Area

The study was conducted at Bulindi Zonal Agricultural Research and Development Institute (BuZARDI) goat farm, which is located in Hoima District, Kyaibigambire sub-county, 20 Km along Hoima-Masindi road. The institute is mandated to conduct applied and adaptive research and spear head promotion of agricultural technology in the Lake Albert Crescent Zone (LACZ) (**Figure 1**). LACZ comprises 8 districts having a human population of 2.3 million and 704,259 goats. The institute's goat farm occupies 85 acres of land, out of which 50 acres are allocated for rotational grazing.

2.2. Design

We conducted a longitudinal study employing mainly quantitative approaches from July 2020 to June 2022.

Map of Lake Albert
Crescent Zone**Figure 1.** Location of BuZARDI in LACZ.

2.3. Population and Sampling (Technique and Size)

2.3.1. Population

Goats in the institute's demonstration farm constituted the study population. There were 37 goats comprising Mubende (46%), Boer (11%) and crosses (43%) on the farm at the beginning of the study period (July 2020). The youngest and oldest goats were 3 and 62 months old respectively while the smallest and heaviest goats were 4.3 kg and 51.2 kg respectively. The mean weight of goats in the flock was 20.08 kg. At the end of the study period (June 2022), the number of goats rose to 175 comprising of female (136) and male (39) goats. Their overall mean weight was 21.78 kg that of female and male were 23.5 kg and 15.7 kg respectively.

Throughout the study period, goats were grazed on pasture land bearing grass, legumes and shrubs daily from 9:00am to 5:00pm, fresh Napier harvested from nearby field was provided in suspended mangers constructed in the resting yard. The mineral supplement was provided as 5 kg blocks per month.

To enhance reproductive performance and genetic selection, bucklings and bucks of superior phylogenic and morphologic characteristics were selected for breeding while keeping conscious of the potential erosion of Mubende breed in case of indiscriminate breeding. Male goats born 2.0 kg and above, heavier and fast growing bucks, born from twin births were selected so as to increase the chances of multiple births in the flock. Males not suitable for breeding were culled/castrated and fattened for disposal as slaughter goats. For simplicity and low cost, random mating breeding system was practiced in the farm throughout the period, over 99% of the pregnant does deliver normally; we performed only two caesarian sections and assisted vaginal deliveries. The proportion of Does kidding successfully unassisted was 99%.

The farm has two Ariel houses with three compartments each measuring 50

m²; they have rain water harvesting and storage systems, urine collection channels and tanks. Each of the houses is situated in chain link fenced resting yard measuring 4000 m².

The flock health management program involve activities aimed at preventing introduction of pathogens into the farm and minimizing the impact of diseases incase outbreak occurs. These activities were scheduled and implemented over the year and included: Identification of new born and procured goats (ear tagging and entry), Spraying against ectoparasites every week, Deworming of the goats every three months, Daily adequate feeding of the goats on safe and nutritious pasture, vaccination of goats against Pest des Petit Ruminates (PPR), Contagious Caprine Pleuropneumonia (CCPP), Foot and Mouth Diseases (FMD) and Clostridial diseases every year, Screening against Brucellosis every year, daily inspection and treatment of goats that come up with the disease.

2.3.2. Sampling Technique and Sample Size

All the goats in the demonstration farm were recruited into the study non-probabilistically through convenience; the study population was disaggregated by sex (male & female), breed (Mubende, Boer & Crosses), age group (kids, weaners and adults (doelings, buckling, does & bucks)) and reproductive stage. There were 37 and 175 goats at the beginning and end of the study period respectively.

2.3.3. Data Collection and Management

Data collection templates were designed to capture data vital for computing individual and flock health and production indices. Measurements of variables made on individual goats and flocks were recorded in hard cover books using pens by technicians and scientists. They include; Tag no, sex, breed, age, weight, color, date of birth, date of delivery, number of kids delivered, state of delivery, temperature, treatments, hospital visits, reasons for culling, estimated carcass weight, source of goats introduced into the farm & disability. The data in the field hard cover books were entered into MS Excel 2013, cleaned, validated, stored and exported to SPSS version 22 and R version 3.4.2 for further exploration and analysis. Descriptive statistics were computed, relationship between desired performance indicators and explanatory variables were assessed and inferences were made based on test statistics (X^2 , F) and p -values at 5% level of significance.

Mortality rate among flock of goats

The mortality rate among the flock of goats over the period was computed using mathematical models proposed by medical statisticians to explain the observed mortality rates [3] [4] [5] [6] [7].

The cumulative mortality of goats over the period of study was computed using the formula;

$$\text{Cumulative Mortality} = \frac{\text{Number of goats in the flock that died over the period}}{\text{Number of goat in the farm in the begining of the period}}$$

While Mortality rate among the flock of goats on the farm was computed using the formula;

$$\text{Mortality rate} = \frac{\text{Number of goats in the flock that died over the period}}{\text{Number of goat time at risk of death in the farm}}$$

The numerator, the number of goats in the flock that died over the period was obtained by counting all death of individual goats in the flock regardless of cause.

The denominator; the number of goat time at risk in an open flock of goats was obtained using the formula;

$$\begin{aligned} & \text{Number of goat time at risk of death in the farm} \\ &= \left\{ \left[N_{\text{start}} + \frac{1}{2} N_{\text{new}} \right] - \frac{1}{2} (N_{\text{lost}} + N_{\text{deaths}}) \right\} \times \text{time} \end{aligned}$$

where:

$$N_{\text{new}} = N_{\text{kids}} + N_{\text{purchased}}$$

N_{start} = number of goat at beginning of the period.

N_{new} = number of goats introduced in the flock through birth or purchases in the period.

N_{kids} = number of goats introduced in the flock through kidding in the period.

$N_{\text{purchased}}$ = number of goats introduced in the flock through purchases in the period.

$N_{\text{Withdrawn}}$ = number of goats lost from the flock through death and non-death disappearance to follow up in the period, e.g., death, slaughter, sales, theft, etc.

N_{deaths} = number of goats that died over the period.

$N_{\text{non death}}$ = number of goats lost from the flock through non-death in the period, e.g., slaughter, sales, theft, straying, etc.

Time = period of study (months).

$N_{\text{start}} = a$, $N_{\text{new}} = b$, $N_{\text{sold}} = c$, $N_{\text{slaughtered}} = d$, $N_{\text{theft}} = e$, $N_{\text{final}} = f$ and $N_{\text{deaths}} = g$, time = h , $N_{\text{kid}} = k$, and $N_{\text{purchased}} = p$.

$$\text{Mortality rate} = \frac{\text{Number of goats that died in the farm over the period}}{\left\{ \left[N_{\text{start}} + \frac{1}{2} N_{\text{new}} \right] - \frac{1}{2} (N_{\text{Withdrawn}} + N_{\text{deaths}}) \right\} \times \text{time}}$$

Mortality rate

$$= \frac{\text{Number of goats that died in the farm over the period}}{\left\{ \left[N_{\text{start}} + \frac{1}{2} (N_{\text{kids}} + N_{\text{purchased}}) \right] - \frac{1}{2} (N_{\text{sold+slaughtered+theft}} + N_{\text{deaths}}) \right\} \times \text{time}}$$

$$\text{Mortality rate} \left(\frac{\text{goats}}{\text{goatmonths}} \right)$$

$$= \frac{g}{\left\{ \left[a + \frac{1}{2} (k + p) \right] - \frac{1}{2} ((c + d + e) + g) \right\} \text{goat} \times h}$$

Factors contributing to crude mortality of goats were described through per-

centages and graphs

$$\text{Percentage of goats dead with factor (\%)} = \frac{\text{Number of goats that died in the period}}{\text{Total number of goats that died in the period}} * 100$$

The percentages were then ranked from highest to smallest.

2.3.4. Conceptual Framework

The population of goats on the farm increases through the acquisition of breeding stock and kidding in the farm. This number is reduced by the mortality of goats due to various causes, sale of goats, donations and loss through theft (**Figure 2**). Mortality rate and survival rate among goats are vital indicators for evaluating the effectiveness of management practices.

3. Results and Discussions

3.1. The Production System and Management (Breeding, Feeding, Housing and Health Management)

3.1.1. The Production System

The farm employs semi intensive goat production system where goats have house, resting yard, browse on natural grass and shrubs in the pastureland paddocked by bands. They get feed supplements such as crop residues, fodder trees and concentrates. The grazing land bears numerous grass and woody species like natural pasturelands in many parts of Uganda described by Nampanzira *et al.* [8].

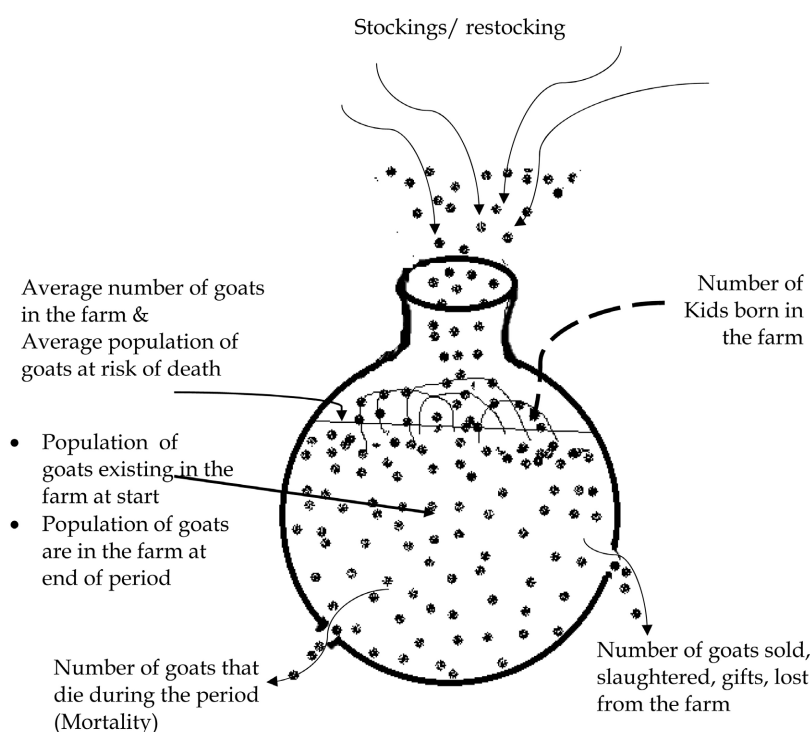


Figure 2. Conceptual frame work illustrating flock dynamics of the goat farm.

3.1.2. The Breed of Goats and Breeding

The farm is rearing mainly Mubende goats (**Figure 3**), one of the outstanding small east African goats. These goats are mainly black (80%) and spotted (15%) in color, tolerant to several environmental insults, reared for meat and have approximately 32% multiple births. Breeding males are being selected based on phenotypically observable traits; weight gain, color, quality of meat, tolerance to disease, quality of skin, etc. and allowed to mate Does and Doelings naturally. The goats are identified using mechanical ear tags widely practiced in developing countries [9].

3.1.3. Feeding of the Goats

Like any other living animals, goats need nutrients; proteins, carbohydrates, lipids, vitamins, minerals and water in quantities matching their physiological requirements. Feed is needed for growth, maintenance, reproduction and production [10]. Goats get nutrients from eating a number of feed resources; grass, shrubs, legumes, cultivated fodder, crop residues, pods and cladodes, most of which are naturally occurring in Uganda [8].

During the 24-month period, goats grazed on 50 acres of pasture land. The land is moderately covered with a number of woody and herbaceous species palatable and nutritious to goats. This includes;

- 1) *Hyparrhenia rufa* and other species;
- 2) *Panicum maximum*, *Panicum coloratum* (Ebikonzi);
- 3) *Brachiaria brizantha*, *Brachiaria ruziziensis* (Ejubwa);
- 4) *Imperata cylindrica* (Esojo);
- 5) *Cynodon nlemfuensis*;
- 6) *Neonotonia wightii*;
- 7) *Desmodium intortum*;
- 8) *Macroptilium atropurpureum*;
- 9) *Setaria anceps*;
- 10) *Acacia Senegal*;
- 11) *Acacia sieberiana*;
- 12) *Melia azedarach*;
- 13) *Acacia Seyal Delile* etc.



Figure 3. Mubende goats on the farm.

The farm regularly rids pasture lands of toxic plants, *e.g.*, *Solanum incanum*, *phytolaca dodecandra*, *lantana camara*, *etc.* Toxic plants are uprooted using hoes. Bear spots are planted with grazable pasture such as *Brachieria brizantha*, *Panicum maxima*, *etc.* Pasture is also conserved as standing hay. Cool moist fires are set to trim off very bushy and extremely lignified pasture areas.

Cultivated fodder

The farm cultivates fodder grasses (*Chloris gayana*, *Panicum maximum* and *Pennisetum purpureum*, *etc.*) and legumes (*Centrosema pubescens*, *Desmodium intortum*, *Lablab purpureus*, *Leucaena leucocephala* and *Cajanus cajan*).

These are conserved as hay and used to feed the goats during dry season (Figure 4).

Minerals and Vitamins

Goats need minerals and vitamins for proper functioning of their physiological systems. The farm supplements essential vitamins such as Vitamin A, D, E & K in diet and also avail macro minerals (calcium, phosphorus, magnesium, sodium, potassium, sulfur and chlorides) and micro minerals (copper, cobalt, manganese, zinc, iodine, selenium, molybdenum, *etc.*) through commercial and crude mineral licks (Figure 5).

Water

The sources of water for goats on the farm are boreholes and rainwater (Figure 6). Water is given in troughs.



Figure 4. Goats feeding on *Chloris gayana* hay, and *Chloris gayana* field, seed & hay.



Figure 5. Goats licking crude and commercial mineral licks.



Figure 6. Rain water harvesting system.

3.1.4. Housing

With due consideration for goat houses of desired qualities, location and design which are vital for enhancing production, health and security of goats. The farm has two aerial houses and a resting yard created by a fence which provides open space for goats to relax. The houses are penetrated adequately by sunshine and located in a well-drained area. The houses protect the goats against rain, cold wind, direct sunlight, predators, thieves and diseases. Each house has 3 rooms (5 m × 25 m) capable of accommodating 150 goats (**Figure 7**). The houses are made of iron sheet roof, timber wall, slated floor which helps in separating dung and urine. The ground surface is cemented to facilitate the collection of urine [11].

3.1.5. Health Management

A number of routine activities are carried out by the farm to prevent and minimize the impact of diseases on the farm.

- Refresher meetings of goatherds on health management every six months.
- Construction, repair and ensuring the farm infrastructures (houses, water sources, dip, crush, fences) are functional & evaluated regularly.
- Acquire disinfectants and sanitize fomites such as feed troughs and hoof trimmers.



Figure 7. Goat house in the farm.

- The farm purchase breeding goats from known sources of healthy farms (Records, physical and laboratory examinations are considered).
- Isolate new, sick goats and treat them.
- Routinely (yearly) vaccinate entire flock of goat against common diseases, e.g., Anthrax, clostridial disease, PPR, Brucellosis, CCPP, RVF, etc.
- Try level best to feed the goats adequately.
- Deworm entire flock of goats every three months (February, May, August and November).
- Spray all the goats against ectoparasite, e.g., ticks, lice and fleas with appropriate Acaricide once a week during rainy season and once in two weeks during the dry season.
- Examine and treat herdsmen identified sick animals promptly.

3.2. The Flock Dynamics of Goats in the Farm from July 2020 to June 2022

3.2.1. The Population of Goats in the Farm

There were 37 goats on the demonstration farm in July 2020 and 175 goats in June 2022. The lowest and highest number of goats on the farm was recorded in November 2020 and November 2021 (**Figure 8**). Over the 24-month period, the mean number of goats per month was 106 (SEM = 14.4). The monthly flock size increased every month through acquisition of breeding goats and kidding (**Figure 1** and **Figure 3**) and this also led to changes in flock structure (**Figures 9-12**) of the semi-intensive production system [12].

3.2.2. Number of Goats Acquired and Introduced into the Farm

A total of 125 goats were acquired and introduced into the farm during the study period. They were acquired from Kyarushesha in Kikuube district (37), Abi ZARDI (06) in Arua district, Kyabigambire in Hoima district (5) and Ruhengere NAGRIC & DB farm in Kiruhura district (77) as shown in **Table 1**.

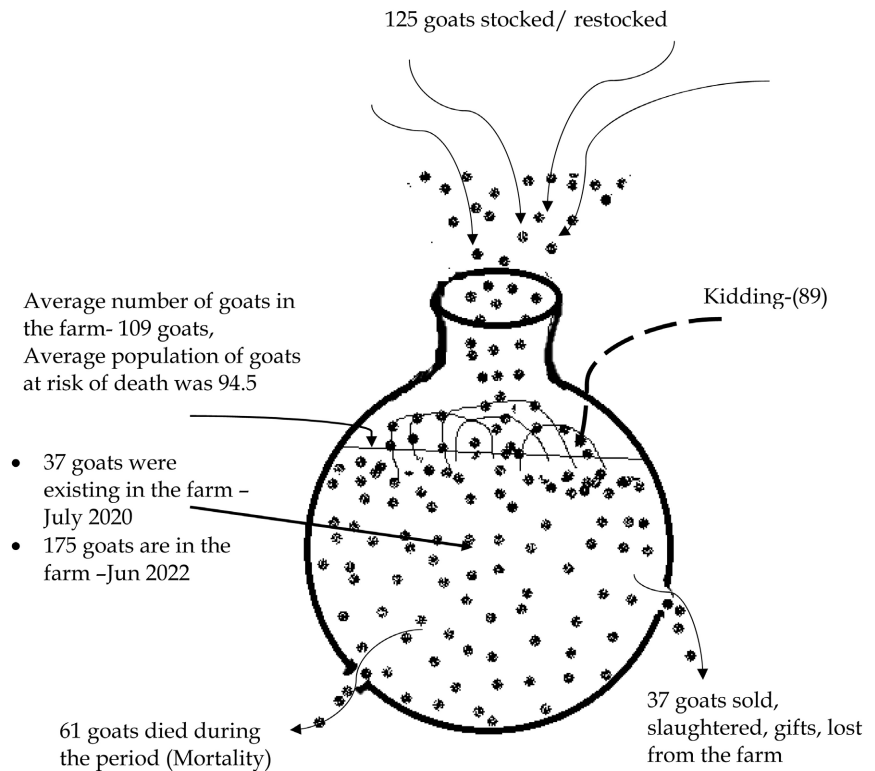


Figure 8. presentation of flock dynamics of the farm.

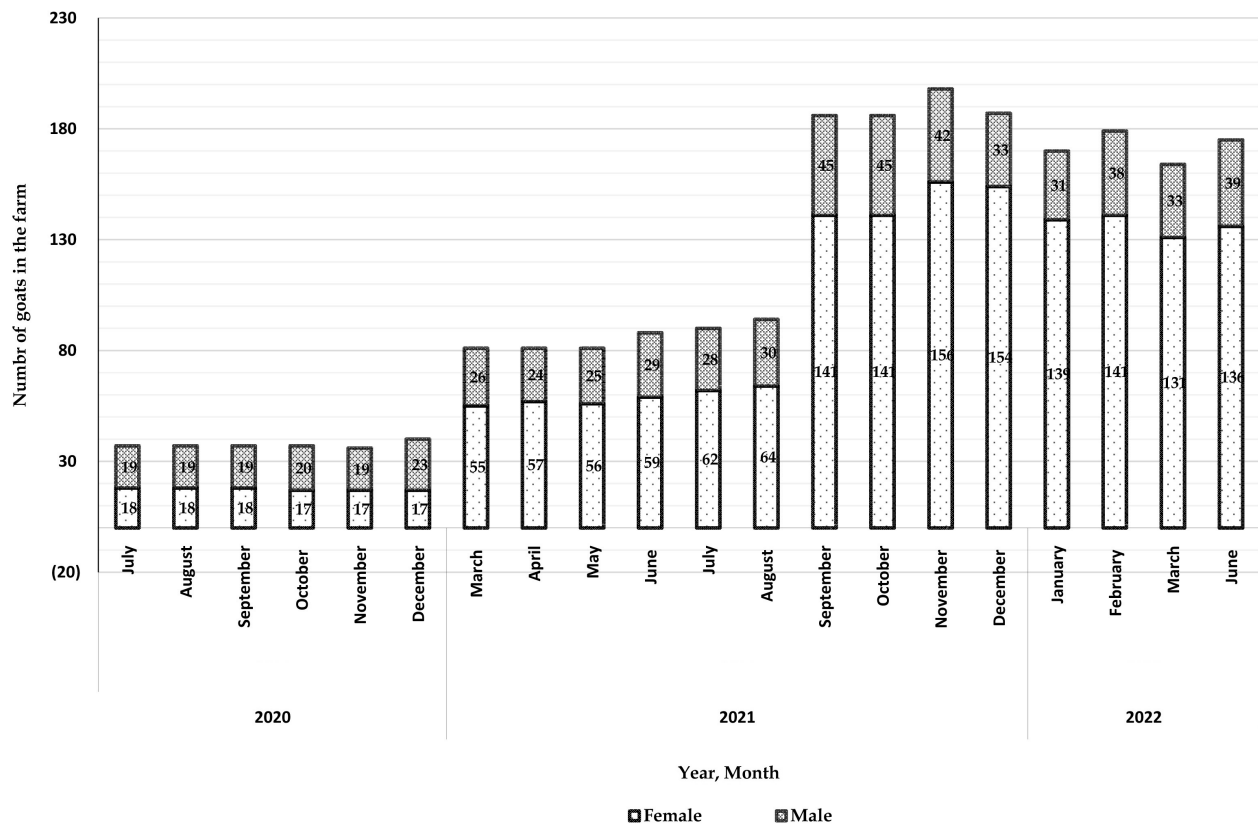
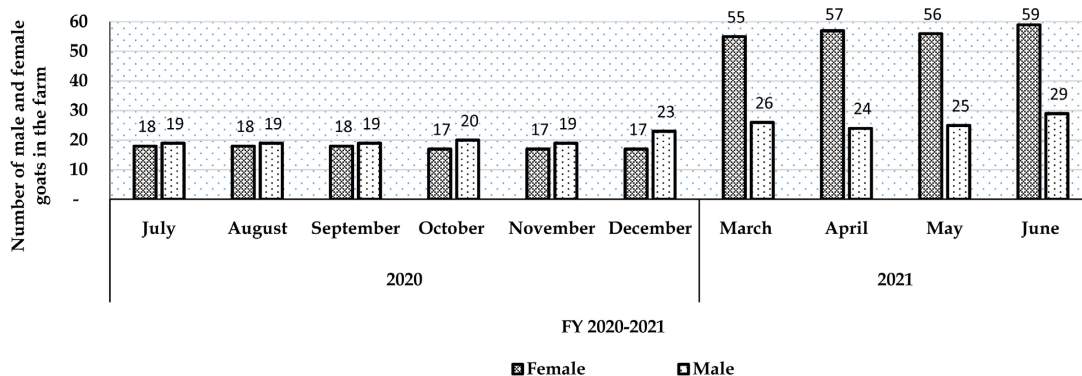
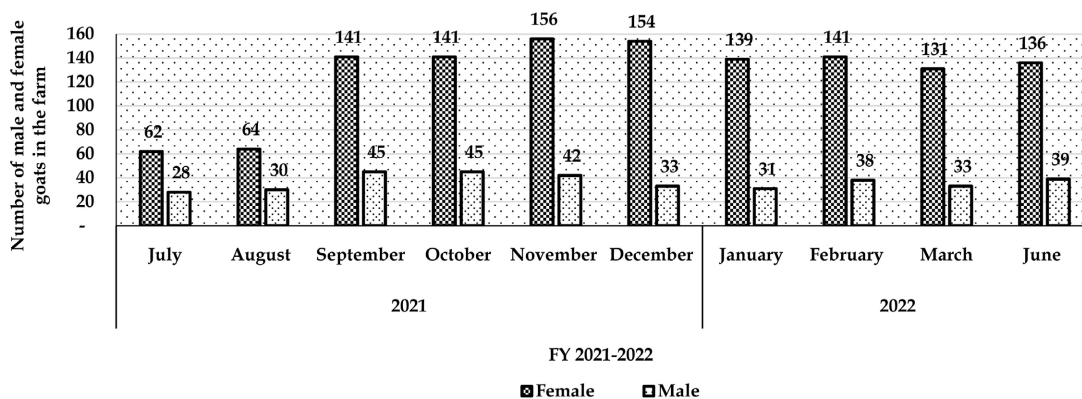
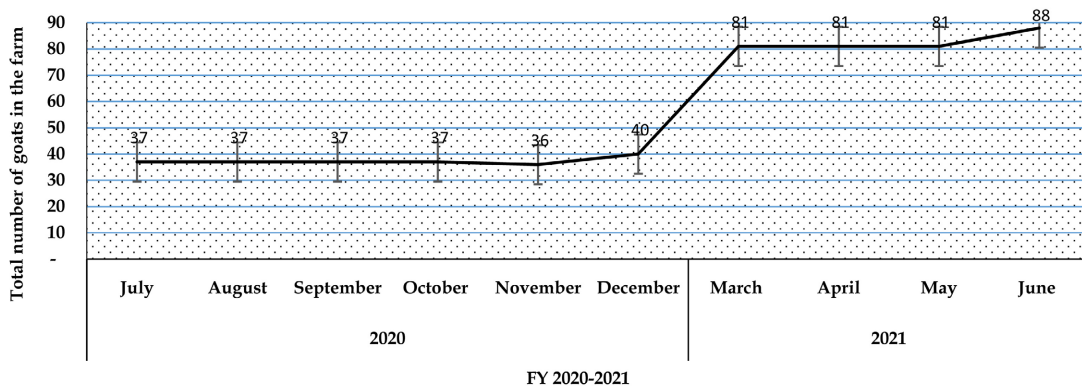


Figure 9. Number of male and female goats in the farm in respective months.

Table 1. Source of goats acquired for breeding.

S/no	Period	Source	Number of goats
1	February 2021	Kikuube	37
2	March 2021	Hoima	5
3	May 2021	Arua	6
4	August 2021	Kiruhura	77
Total			125

**Figure 10.** Number of male and female goats in the farm in FY 2020-2021.**Figure 11.** Number of male and female goats in the farm in FY 2021-2022.**Figure 12.** Total number of goats in the farm in FY 2020-2021.

3.2.3. Number of Goats Produced within the Farm

In total 89 kids were produced by Does in the farm over the 24-month period. Forty percent of them were born as twins and triplets. Sixty-six percent of the kids were born between October 2021 and February 2022.

3.2.4. Goats Sold or Given out

Thirty-seven goats were sold (29) for revenue, lost through theft (2) and slaughtered (6) at the institute's function over the period (Figure 8).

3.2.5. Mean Weight of Goats in the Farm

The highest mean weight of female and male goats on the farm was recorded in October 2020 and November 2020 respectively (Figures 13-16).

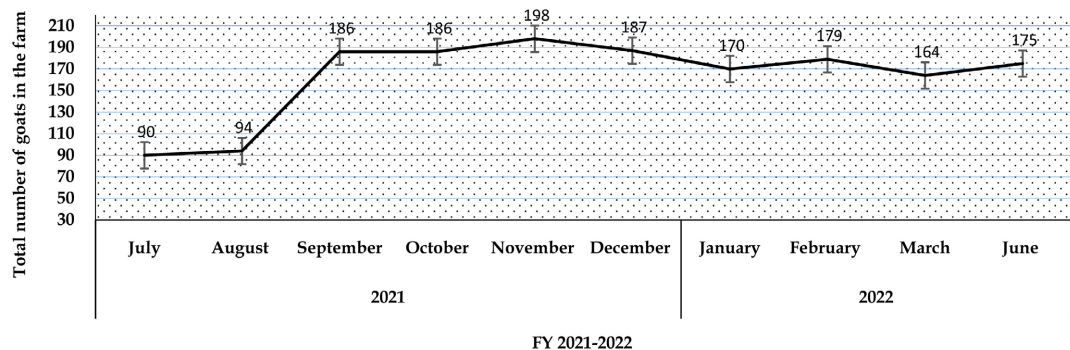


Figure 13. Total number of goats in the farm in FY 2021-2022.

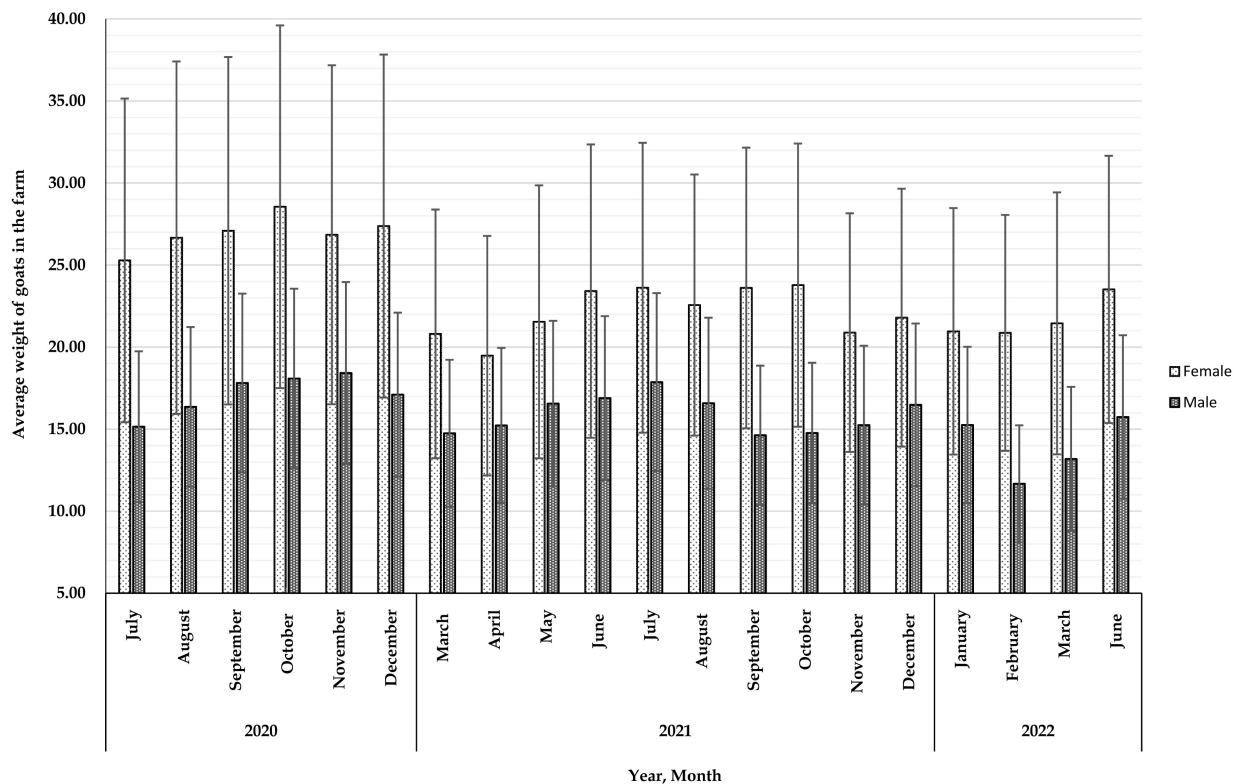


Figure 14. The average weight of male and female goats captured in respective month.

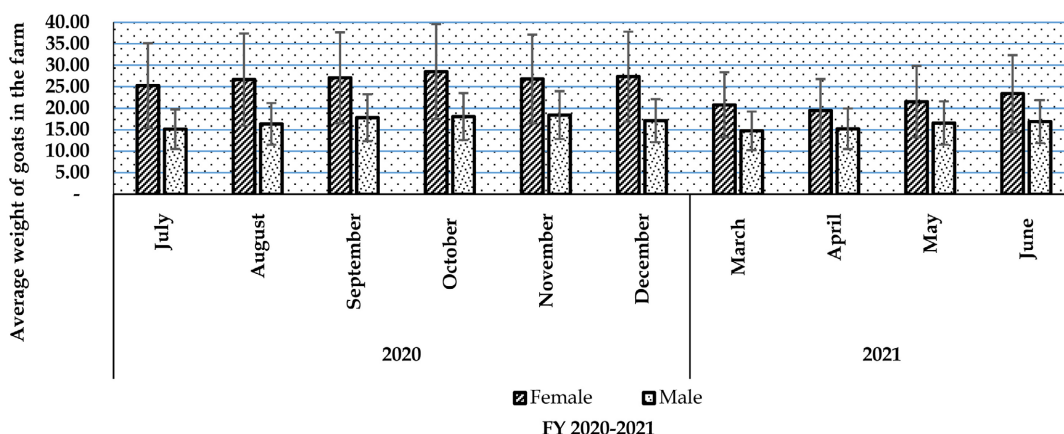


Figure 15. Average weight of male and female goats in the farm in FY 2020-2021.

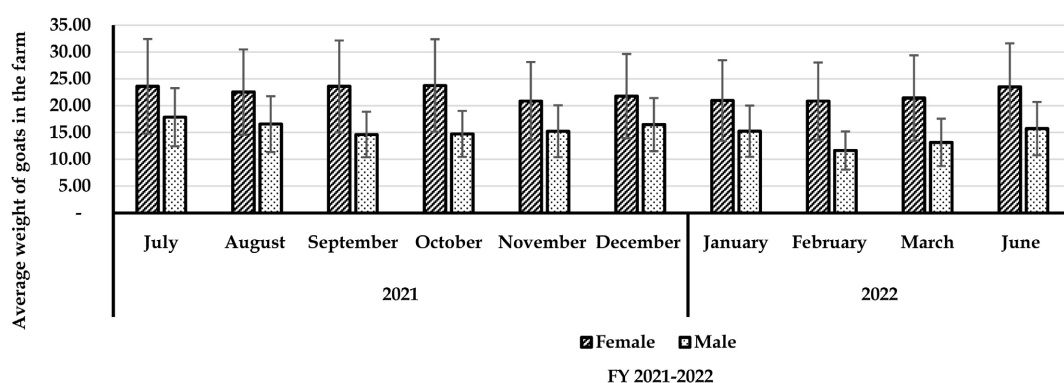


Figure 16. Average weight of male and female goats in the farm in FY 2021-2022.

3.3. Crude Mortality, Mortality Rate and Category of Diseases Contributing to Death among Goats in the Farm

3.3.1. Crude Mortality

Sixty-one goats died during the two years period. Forty-nine percent were kids ($n = 30$) and the death occurred mainly during October 2021 to December 2021 heavy rain period (**Table 2**). The majority of the kids died of worm infestation. Adults constituted the second highest percentage of mortalities (30%) and the majority of them died of ticks and tick borne diseases. Most of the adult goats were breeding goats introduced from NAGRIC & DB farm and their kids were weak and could not withstand high tick challenge. The majority of their kids died due to inadequate colostrum and milk from their does. Weaners constituted the least percentage (21%) of goats that died in the last 24 months (**Table 2** & **Table 3**). Merkin Tifashe *et al.* in Wolaita Soddo Zuria District, Southern Ethiopia also found that kids had higher mortality compared to other age groups and gastro intestinal diseases accounted for the highest mortality of goats [13] [14].

3.3.2. The Mortality Rate among Flock of Goats

Using the formula elucidated on pages 7 & 8, we computed the mortality rate among goats on the farm over the last 24 months and disaggregated it into FY 2020-2021 & FY 2021-2022 and shown in **Table 4**.

Table 2. Number and percentage of mortalities by age group.

Age group	Number that died	Percentage
Kids	30	49%
Weaners	13	21%
Adults	18	30%
Total	61	100%

Table 3. Number of goats that died due to specific disease.

Age group	Category of diseases							Total
	clostridial disease	Fracture and injuries	Respiratory tract infections	Starvation and malnutrition	Ticks and tick borne diseases	Toxic weeds and software disease	worm infestation	
Adults	0	1	3	0	8	2	4	18
Kids	2	8	4	6	0	1	9	30
Weaners	0	2	0	0	3	1	7	13
Total	2	11	7	6	11	4	20	61
%	3%	18%	11%	10%	18%	7%	33%	

Table 4. Mortality rate among flock of goats in the farm for FY 2020-2021 & FY 2021-2022, FY 2020-2021 and FY 2021-2022.

Parameters		FY 2020-2021 & FY 2021-2022	FY 2020-2021	FY 2021-2022
1	N_{start} = number of goat at beginning of the period	37	37	90
2	N_{final} = number of goats end of the period	175	88	175
3	N_{new} = number of goats introduced in the flock through kidding & purchases in the period	214	66	148
4	N_{kids} = number of goats introduced in the flock through kidding in the period	89	18	71
5	N_{purchase} = number of goats introduced in the flock through purchases in the period	125	48	77
6	$N_{\text{Withdrawn}}$ = number of goats lost from the flock through death and non-death in the period. e.g. slaughter, sales, theft, death etc.	98	13	85
7	N_{death} = number of goats lost from the flock through death in the period.	61	4	57
8	$N_{\text{non death}}$ = number of goats lost from the flock through non-death in the period. e.g. slaughter, sales, theft etc.	37	9	28
9	Period (Month)	24	12	12
10	Average number of goats in the farm	109	56	163

Continued

11	Average population in the farm at risk of death	95	64	122
		0.026754386	0.005249344	0.03909465
12	Mortality rate	or 27 goats per 1000 goat months	or 5 goats per 1000 goat months	or 39 goats per 1000 goat months

During the period July 2020 to June 2022 (FY 2020-2021 & FY2021-2022), the number of goats reared on the farm increased from 37 to 175. One hundred twenty-five goats were sourced and introduced into the farm as breeding stock. Eighty-nine kids were born on farm. Sixty-one goats died due to various causes with worm infestation and stamped contributing the most. The average number of goats on the farm per month was 109. (SEM = 13.7), female 79.8 (SEM = 10.8), male 29.4, (SEM = 9.9). The average population of goats at risk of death was 95 and the mortality rate was 27 goats per 1000 goat months. This figure is quite high for a farm employing semi-intensive farming system. The mortality rate is significantly higher during FY2021-2022 (39 goats per 1000 goat months) than in FY2020-2021 (5 goats per 1000 goat months).

3.3.3. Category of Diseases Contributing to Mortality among Goats in the Farm

Numerical differences exist in the proportion of mortalities attributable to various causes. Worm infestation accounted for the highest number of deaths (33%), followed by fractures and injuries arising from stampedes (18%), Ticks and tick borne diseases (18%), respiratory tract infections (11%) and malnutrition (10%). Upadhyay *et al.*, similarly ranked gastro intestinal diseases as the highest cause of mortality [15]. It is also in agreement with the findings of Chandran *et al.*, where the following mortality due to enteritis is pneumonia (respiratory tract infection) [16]. Although production system is similar (semi-intensive system) Buzardi goat farm has aerial houses for the goats.

3.4. Priority Approaches for Reducing Mortality Rate among Goats in the Farm

In order to improve flock performance and production efficiency of the farm, systems must be put in place to;

1) Improve adherence to flock health program that involves appropriate parasite management regime, vaccinations, biosecurity, safe feeding and evidence based disease management.

2) Extra care should be taken in the management of kids irrespective of the season; separate kids and other vulnerable goats from the rest, provide adequate warmth during too much rain, ensure kids suckle adequate colostrum following birth; colostrum provides valuable antibodies from the doe which help protect newborn kids against disease. Regular and rigorous inspection of kids for timely detection and management of diseases among them.

3) Improve sanitation of goat houses and their resting yard. The grass within

the resting yard is heavily loaded with eggs and larvae of worms; keeping goats within the resting yard up to late hours of the day force them to graze on dirty infested grass leading to increased incidences of gastro intestinal diseases. Adequate ventilation of goat houses helps minimize the spread of contagious respiratory tract infections.

4) Strict adherence to vaccination schedule spelt in the flock health program. Vaccinate all the goats against clostridial diseases, contagious Caprine Pleuropneumonia (CCPP), pest des petit ruminates (PPR), Brucellosis and Rift valley fever every year.

5) Improve feeding of the goats on safe pasture; regularly remove toxic plants, store hay safely and provide adequate minerals licks.

6) Continue selecting multi-stress tolerant individuals. The farm should not only cull goats in case of unmanageable disease or as a means to economize during episodes of high feed costs but also to improve genetics and phenotypic traits.

4. Conclusions and Recommendations

4.1. Conclusions

The goat farm studied has an open population where new stock is introduced into the flock through kidding and purchases anytime. Individuals also leave the flock through death, sale of live goats, slaughters, gifts and theft anytime. It is for this reason that the mortality rate is more accurate in describing the death of goats on the farm. The denominator is goat-time at risk (goat months). During the period from July 2020 to June 2022, the number of goats reared under a semi-intensive system increased from 37 to 175. Sixty-one goats died due to various causes with worm infestation and stamp contributing the most. Average number of goats in the farm per month was 109.2 (SEM = 13.7), female 79.8 (SEM = 10.8), male 29.4, (SEM = 9.9). The average population of goats at risk of death was 95.

The mortality rate of 27 goats per 1000 goat months and 39 goats per 1000 goat months for the period FY 2020-2021 to FY2021-2022 and FY2021-2022 respectively are very high. This calls for a more detailed investigation into determinants of goat mortality in the farm and other farms in LACZ employing different production systems.

4.2. Recommendation

In order to reduce the mortality rate among goats on the farm, systems should be put in place to improve the management of the goats; improve adherence to flock health programs; improved parasite management, separation and care for kids, vaccination against clostridial diseases and other trade sensitive diseases, safer feeding, continue selecting for multi-stress tolerant individuals, sanitation and biosecurity, and evidence based disease management. Efforts should also be put in place to adopt electronic record collection and storage. Develop an app

for monitoring mortality rates more accurately. Formal record management and use of mortality rate as an indicator for evaluating production based approaches for increasing the productivity of goats in farms should be disseminated to producers in the LACZ.

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Ethical Statement

The authors confirm that the ethical policies of the journal's author guideline page and applicable national guidelines have been adhered to. The protocol of this non-invasive study on farm animals has been approved by the institute's Scientific Committee.

Conflicts of Interest

The authors declare that there is no conflict of interest at all.

Statement on Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' Contributions

This study is part of the job description of the first author WG. SDB, LPA, LM, PK and JM are members of the research team and contributed hugely to shaping design, data collection, analysis and logistics.

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