FINAL YEAR PROJECT REPORT

CONTEXT-SPECIFIC RECOMMENDATIONS AND STRATEGIES FOR PROMOTING THE ADOPTION OF FEED TECHNOLOGIES IN THE CATTLE ENTERPRISE: A CASE STUDY IN ASURET SUBCOUNTY AND SOROTI WEST DIVISION, SOROTI CITY, UGANDA.

BY

EMAAT EMMANUEL

BU/UP/2023/0019

SUPERVIOR

DR. MATOVU HENRY

THIS DISSERTATION IS SUBMITTED TO THE, FACULTY OF AGRICULTURE AND ANIMAL SCIENCE IN THE PARTIAL FULFILLMENT OF THE AWARD OF THE DEGREE OF BACHELOR OF ANIMAL PRODUCTION AND MANAGEMENT OF BUSITEMA UNIVERSITY

SEPTEMBER, 2026

DECLARATION

I, Emaat Emmanuel, hereby declare that this final year project report entitled "context-specific recommendations and strategies for promoting the adoption of feed technologies in the cattle enterprise: a case study in Asuret subcounty and Soroti west division in Soroti city, Uganda" is my original work and has been prepared by me in partial fulfillment of the requirements for the award of a Bachelor's degree at the University.

I further declare that this work has not been submitted to any other institution for the award of a degree, diploma, or any other academic qualification. All sources of information used in this report have been duly acknowledged and referenced.

Signature: _____

Name: EMAAT EMMANUEL

Date: 24/9/2026

APPROVAL

This final year project report entitled "context-specific recommendations and strategies for promoting the adoption of feed technologies in the cattle enterprise: a case study in Asuret subcounty and Soroti west division, Soroti city, Uganda" has been submitted for examination with the approval of the university supervisor.

Supervisor: DR. MATOVU HENRY

Signature: _____

Date: 28/09/2026

ACKNOWLEDGEMENT

I thank the Almighty God for giving me strength, wisdom, good health and perseverance to finish this project successfully. I sincerely express gratitude to my supervisor, Dr. Matovu Henry for guidance, comments, encouragement and valuable academic support during the development of this project.

I am also grateful to the lecturers and staff of the University, for the knowledge, skills and guidance they gave during my studies. I extend appreciation to the farmers and all individuals who took part in the study and supplied the information and support needed for its completion.

Special thanks go to my family, friends and fellow students for encouragement, moral support and assistance throughout my journey. Their support and motivation contributed greatly to finishing this project.

Finally, I appreciate everyone who contributed directly or indirectly to the success of this study. May God bless you all.

DEDICATION

I dedicate this project report to my family for their constant love, support and encouragement during my time in school. Their sacrifices and always being there, for me helped me stay strong and keep going until I finished this work.

Table of content

Contents

ABSTRACT i

DECLARATION ii

APPROVAL iii

DEDICATION iv

ACKNOWLEDGEMENT iii

LIST OF TABLES viii

LIST OF FIGURES ix

LIST OF ABBREVIATIONS x

CHAPTER ONE: INTRODUCTION 1

1.1 Background to the Study 1

1.2 Statement of the Problem 2

1.3 Aim of the Study 2

1.4 Specific Objective 3

1.5 Research Question 3

1.6 Research Hypotheses 3

1.7 Justification of the Study 3

1.8 Rationale of the Study 3

1.9 Scope of the Study 4

1.10 Significance of the Study 4

2.1 Smallholder Cattle Feeding Systems 6

2.3 Hay as a Feed-Conservation Technology 7

2.4 Pasture Feeding and Its Role in Cattle Production 8

2.5 Nutritional and Production Outcomes of Feeding Systems 8

2.6 Barriers to Adoption of Feed Technologies 9
2.7 Enablers of Adoption 9
2.8 Empirical Evidence on Forage Technologies in Uganda 10
2.9 Research Gap 11
2.10 Conceptual Framework 11
CHAPTER THREE: RESEARCH METHODOLOGY 12
3.1 Research Design 12
3.2 Research Approach 12
3.3 Geographical Area of the Study 12
3.4 Study Population 13
3.5 Sample Size and Sampling 13
3.6 Study Groups and Feeding Conditions 13
3.7 Data Collection Methods 14
3.9 Data Quality Control 15
3.10 Validity and Reliability 15
3.11 Measurements and Operational Definitions 16
3.12 Data Analysis 16
3.13 Ethical and Animal-Welfare Considerations 17
3.14 Methodological Limitations 17
CHAPTER FOUR: RESULTS AND DISCUSSION 19
4.1 Statistical model and test selection 19
4.3 Results 20
4.3.1 Feed Intake under hay and pasture 20
4.3.2 Water Intake 21
4.3.3 Milk Productivity 23

4.3.4 Weight Gain 27
4.3.5 Baseline-Adjusted Week 4 Body Weight 27
4.4 Discussion 28
4.4.1 Feed Intake 28
4.4.2 Water Intake 29
4.4.4 Milk Productivity 32
4.4.5 Integrated Interpretation in Relation to the Research Question 33
4.4.6 Comparison and Contrast with Previous Outcomes 33
4.4.7 Limitations of the Findings 34
4.4.8 Implications for Objective Six 35
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS 36
5.0 Introduction 36
5.1 Conclusions 36
5.1.1 Conclusion on feed intake 36
5.1.2 Conclusion on water intake 36
5.1.3 Conclusion on weight gain 36
5.1.4 Conclusion on productivity 37
5.1.5 Overall conclusion in relation to the research question 37
5.1.6 Conclusion in relation to the hypothesis 38
5.2 Practical Implications, Advantages and Limitations of the Findings 38
REFERENCES 42
APPENDICES 48
Appendix 1: Questionnaire 48
Appendix 1: Images 53

LIST OF TABLES

Table 3.1: Study Groups and Feeding Conditions **15**

Table 3.2: Measurements and Operational Definitions **16**

Table 4.1: Statistical Models and Tests Used for the Study Outcomes **19**

Table 4.2: Independent-Group Comparison of Feed Intake under Hay and Pasture **20**

Table 4.3: Independent-Group Comparison of Water Intake under Hay and Pasture **22**

Table 4.4: Fixed-Effect Results of the Linear Mixed-Effects Model for Daily Milk Production **24**

Table 4.5: Bonferroni-Adjusted Pairwise Comparisons of Daily Milk Production **26**

Table 4.6: Comparison of Daily Milk Production between Hay and Pasture Treatments **27**

Table 4.7: Comparison of Weight Gain between Hay and Pasture Treatments **28**

Table 4.8: Analysis of Covariance of Weight Gain between Hay and Pasture Treatments **28**

Table 5.1: Conclusion in Relation to the Hypothesis **36**

LIST OF FIGURES

Figure 4.1: Independent-Samples Feed-Intake Output and Q-Q Plot 21

Figure 4.2: Descriptive Comparison of Recorded Feed Consumption by Treatment 22

Figure 4.3: Q-Q Plot for Water-Intake Observations 23

Figure 4.4: Descriptive Comparison of Water Consumption by Treatment 24

Figure 4.5: Daily Milk Production across Experimental Weeks 26

Figure 4.6: Q-Q Plot of Residuals for the ANCOVA Weight-Gain Analysis 29

LIST OF ABBREVIATIONS

CI — Confidence Interval

df — Degrees of Freedom

ID — Identification

kg — Kilogram

kg/day — Kilograms per Day

L — Litres

L/day — Litres per Day

LRT — Likelihood Ratio Test

Q-Q — Quantile-Quantile

R^2 — Coefficient of Determination

SD — Standard Deviation

SE — Standard Error

ABSTRACT

Cattle production in Uganda is constrained by seasonal fluctuations in the availability and quality of forage, which can affect animal performance and the reliability of feed supply. Feed technologies such as haymaking offer an opportunity to conserve forage and improve feed availability during periods of pasture scarcity. This study aimed to generate context-specific evidence to support recommendations and strategies for promoting the adoption of feed technologies within the cattle enterprise. The study used a quantitative quasi-experimental design to compare cattle fed on hay with those maintained on pasture in Asuret Sub- County and Soroti West Division, Soroti City. It assessed feed intake, water intake, weight gain and milk productivity. Additional contextual information was obtained from two farmers to provide practical insights relevant to the use of feed technologies. Data were analysed using descriptive statistics, Mann–Whitney U tests, independent-samples t-tests, analysis of covariance (ANCOVA), and a linear mixed-effects model for repeated milk-production measurements, with statistical significance assessed at the 5% level. Results showed significant differences in recorded feed intake between the hay and pasture groups ($U = 0.00$, $p < .001$), with pasture-fed cattle recording higher feed consumption. Water intake was also significantly different ($U = 1024$, $p < .001$), with hay-fed cattle recording higher drinking-water consumption. No significant difference was observed in weight gain between treatments ($U = 148.0$, $p = .443$), and baseline-adjusted Week 4 body weight also showed no significant treatment effect ($F = 0.256$, $p = .617$). Milk productivity differed significantly between treatments, with significant effects of treatment, week and treatment-by-week interaction ($p < .001$), although the mixed-effects model showed convergence and near-singularity concerns that require cautious interpretation. Overall, the findings indicate that hay and pasture have outcome-specific implications, rather than one system being universally superior. The study recommends integrating feed and water management, routine monitoring of animal performance, reliable baseline measurements, practical extension support, and assessment of forage quality and availability when promoting feed technologies. Further research using larger samples, longer study periods and well-controlled experimental designs is recommended to strengthen the evidence base for context-specific cattle feeding strategies.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Livestock production is an important component of the agricultural economy because it contributes to food security, household income, employment, and access to animal-source foods (De Kouchkovsky & Abdul et al., 2016). In sub-Saharan Africa, livestock production is increasingly affected by climate variability, particularly changes in rainfall patterns and prolonged dry periods that reduce the availability and quality of forage. These conditions cause shortages of feed and make it hard for cattle farmers to keep animal productivity steady. The need to improve the availability of livestock feed and the quality of livestock feed and the way livestock feed is used has made the importance of feed technologies greater(De Kouchkovsky & Abdul et al., 2016). In East Africa cattle and dairy farming give ways of living and nutrition to people who live in rural areas. The productivity of animals is limited because there is not enough feed and the quality of feed is not good When dry seasons last a long time (Bernabe et al., 2020). At the time more people are being born and more people are moving to cities and this is making the need for milk and other animal products bigger. To meet this need feeding systems must be able to provide nutrients and make cattle farming more efficient and stronger.

In Uganda cattle play a role in the farming industry and help people who live in rural areas. National plans for farming development focus, on making farming productive and developing farming industries, including making cattle and dairy farming better(Terwilliger & Abdul-Hay, 2017). Despite increases in national milk production, productivity per animal remains below the potential of improved cattle. Continued dependence on natural pasture and crop residues of variable or poor nutritive value contributes to this challenge. Improved forage production, hay, silage, concentrates, and other feed technologies can potentially reduce seasonal feed deficits and improve livestock productivity (Steinmetz et al., 2021). Hay is particularly relevant because it allows forage harvested during periods of relative abundance to be dried and stored for later use. Pasture, in contrast, provides fresh forage directly through grazing but depends strongly on rainfall, land availability, grazing pressure, and pasture management. These differences may affect the quantity of feed consumed, drinking-water requirements, body-weight change, and milk production. Evidence on these outcomes is important because farmers need practical

information about the benefits and requirements of a feeding technology before investing in its adoption (Santomauro et al., 2021).

However, adoption of feed technologies is influenced by factors beyond animal performance, including limited knowledge and skills, high costs, inadequate access to inputs, equipment, credit and extension services, as well as land and labour constraints. Conversely, farmer groups, social networks, demonstrations, market incentives, and perceived profitability can support adoption. Therefore, context-specific strategies should address both technology performance and the conditions needed for successful implementation.

The study was conducted in Asuret Sub- County and Soroti West Division, Soroti City, where seasonal changes in forage availability affect cattle production. Local evidence on hay and pasture can help farmers and extension personnel identify suitable feeding options and the support needed to promote their adoption.

1.2 Statement of the Problem

Cattle farmers in Uganda face seasonal feed shortages as pasture quantity and quality decline during dry periods (Van Barneveld et al., 2019). Although feed technologies such as haymaking can address these shortages, adoption is limited by inadequate knowledge, high costs, limited access to inputs, equipment, credit and extension services, labour and land constraints, and uncertainty about benefits. These challenges affect cattle productivity, livelihoods and food security. Therefore, there is a need for local evidence comparing hay and pasture in terms of feed intake, water intake, weight gain and productivity to guide practical strategies for promoting appropriate feed technologies.

1.3 Aim of the Study

The aim of the study was to generate context-specific evidence to support the adoption and effective use of cattle feed technologies by comparing hay with pasture in relation to feed intake, water intake, weight gain and productivity, and by using the findings to inform practical strategies for cattle farmers and relevant stakeholders in Asuret Subcounty and Soroti West Division, Soroti City.

1.4 Specific Objective

To propose context-specific recommendations and strategies to overcome barriers and strengthen enablers in promoting adoption of feed technologies in cattle production.

1.5 Research Question

How does the use of hay compared with pasture affect cattle feed intake, water intake, weight gain and productivity?

1.6 Research Hypotheses

Null hypothesis (H_0): There is no significant difference between cattle fed hay and cattle fed pasture in terms of water intake, weight gain, feed intake and productivity.

Alternative hypothesis (H_1): There is a significant difference between cattle fed hay and cattle fed pasture in terms of weight gain, feed intake, water intake and productivity.

1.7 Justification of the Study

The study was justified because cattle need feeding when forage changes with seasons. Although hay and other feed technologies can reduce feed shortages the practical value of hay and other feed technologies must be weighed against animal outcomes and the resources required for implementation. Comparing hay and pasture gives evidence on feed intake, water needs, weight change and productivity all of which are outcomes relevant, to cattle management.

The study is also justified because technical performance alone does not guarantee adoption. Farmers require knowledge, skills, inputs, equipment, finance, extension support and other enabling conditions to use a feed technology effectively. Evidence generated under conditions can help stakeholders develop interventions that are both technically appropriate and practically feasible (Karyono et al., 2024).

1.8 Rationale of the Study

The reason for comparing hay and pasture is that they represent different approaches to meeting cattle feed requirements. Pasture provides fresh forage through grazing but is dependent on seasonal availability, whereas hay requires harvesting, drying and storage but can extend forage availability beyond the growing period. Understanding their effects on feed intake, water intake, weight gain and productivity provides a basis for identifying where feed conservation can complement pasture-based production (Bikbov et al., 2020).

The study also provides a basis for developing recommendations that do not assume that one feeding system is universally superior. Where a technology demonstrates a useful outcome, adoption strategies can focus on strengthening the resources and services required for its use. Where responses differ between production indicators, recommendations can identify the circumstances and objectives for which a technology is most appropriate (Nichols et al., 2022)

1.9 Scope of the Study

The geographical scope of the study was Asuret Sub-county and Soroti West Division, Soroti City, in Eastern Uganda. The study focused on cattle and the farmers responsible for their management. The content scope was limited to comparing hay and pasture feeding in relation to four outcomes: feed intake, water intake, weight gain, and productivity, with milk production serving as the principal productivity indicator. The study also considered practical barriers and enabling conditions relevant to adoption of feed technologies, including knowledge and skills, access to inputs and equipment, labour, finance, land, extension support, and farmer-based learning.

The study did not evaluate every livestock feed technology and did not seek to establish universal superiority of hay or pasture. Instead, it generated evidence under the study conditions for the development of context-specific recommendations

1.10 Significance of the Study

The study is expected to benefit cattle farmers by providing practical evidence on the implications of using hay compared with pasture. The findings can support decisions concerning feed conservation, water provision and monitoring of animal performance.

The findings are also relevant to agricultural and livestock extension personnel because they can support more targeted advice on feed technologies. Extension interventions can use the evidence to emphasise not only the potential benefits of a technology but also the skills, resources and management practices required for successful implementation.

For policymakers and development partners, the study provides local evidence that can inform programmes on forage conservation, extension services, access to appropriate inputs and equipment, farmer training, credit and farmer-group development. For researchers, the study

provides a basis for further investigation of feeding technologies under different seasons, forage qualities, animal characteristics and management systems.

CHAPTER TWO: LITERATURE REVIEW

2.1 Smallholder Cattle Feeding Systems

Smallholder cattle production is an important component of rural livelihoods in Eastern Uganda, where cattle contribute to household income, food security, milk and meat production, manure, and other livelihood functions (Van Barneveld et al., 2019). Soroti is an agricultural area in Eastern Uganda and livestock production is influenced by seasonal availability of natural forage. Soroti District reports that agriculture is a major livelihood activity and that rainfall is seasonal, with a pronounced dry period. Such conditions can create fluctuations in the amount and quality of forage available to cattle (Murray et al., 2022)(Nichols et al., 2019). The feeding system used by a cattle farmer is therefore influenced by the interaction between available land, pasture condition, labour, water, animal requirements, access to purchased feeds, and the farmer's knowledge and financial capacity. Where pasture is abundant and nutritious, grazing can provide a relatively low-cash-cost feed source. However, where forage quantity or quality declines, conserved feeds such as hay can provide a means of extending feed availability into periods of scarcity (Anggraeny & Masyithoh, 2022).

(Van Barneveld et al., 2019). Soroti is an agricultural area in Eastern Uganda and livestock production is influenced by seasonal availability of natural forage. Soroti District reports that agriculture is a major livelihood activity and that rainfall is seasonal, with a pronounced dry period. Such conditions can create fluctuations in the amount and quality of forage available to cattle (Karyono et al., 2024).

The feeding system used by a cattle farmer is therefore influenced by the interaction between available land, pasture condition, labour, water, animal requirements, access to purchased feeds and the farmer's knowledge and financial capacity. Where pasture is abundant and nutritious, grazing can provide a relatively low-cash-cost feed source. However, where forage quantity or quality declines, conserved feeds such as hay can provide a means of extending feed availability into periods of scarcity (Anggraeny & Masyithoh, 2022).

2.2 Forage Availability, Seasonality and Feed Scarcity

Seasonal variation in forage quantity and quality is a major constraint to livestock production in sub-Saharan Africa. Ni et al. (2025) describe forage conservation as an important response to seasonal feed shortages and note that forage quantity and quality commonly decline during dry

periods. The review further identifies limited knowledge and skills, resource requirements, labour, equipment, land and economic incentives as constraints to wider adoption of forage conservation technologies (Darmohray et al., 2024).

Evidence from Uganda also demonstrates the importance of seasonal feed management. Schmitges et al. (2016) reported that dry-season feed shortages were among the major challenges faced by dairy farmers and that only a minority of respondents practised forage preservation through hay or silage. More recent Ugandan evidence similarly shows persistent reliance on natural pasture and crop residues and limited feed conservation among smallholder cattle farmers (Schmitges et al., 2016).

The implication for adoption is that a feed technology must fit the seasonal production calendar. Technologies that require substantial investment or technical skill may have limited uptake if farmers cannot see their relevance to the dry-season feed gap or cannot access the resources needed to implement them (Dóka et al., 2019).

2.3 Hay as a Feed-Conservation Technology

Hay is a forage-conservation technology in which forage is harvested and dried sufficiently to permit storage and subsequent feeding. Its principal potential advantage in smallholder systems is the ability to transfer forage from periods of abundance to periods when standing pasture becomes scarce. Balehegn et al. (2022) report that haymaking is practised in many parts of sub-Saharan Africa, although the quality of smallholder-produced hay can be variable because of forage type, harvesting practices, drying and storage.

The usefulness of hay therefore depends on the quality of the conserved forage rather than simply its presence on the farm. Harvest maturity, drying, protection from rain, storage conditions and the characteristics of the source forage can affect nutritive value and voluntary intake. A farmer may consequently adopt haymaking but obtain limited benefits if technical practices are poor. This makes practical training, demonstration and follow-up important components of an adoption strategy (Szymura et al., 2022).

For the present study, hay is treated as a feed technology whose suitability should be judged using measurable animal outcomes as well as practical feasibility. Feed intake, water intake,

weight gain, and milk productivity provide complementary indicators for assessing the consequences of using hay compared with pasture (Bastani et al., 2020).

2.4 Pasture Feeding and Its Role in Cattle Production

Pasture is a source of feed for smallholder cattle because it gives fresh forage without the need to harvest, dry or store like hay does (Distel et al., 2020) . Feeding animals on pasture depends on several factors. These include the season, how grazing pressure there is, how much land is available what kind of forage species are present and how well the pasture is managed. When dry periods come pasture can become harder to find or less nutritious. This leads to a gap, in the feed supply that can affect livestock.

The literature therefore suggests that hay and pasture should not necessarily be viewed as mutually exclusive technologies. A locally appropriate feeding strategy may combine grazing with conserved forage, using pasture when quality and availability are adequate and hay when pasture resources are inadequate. (Romero-Lopez et al., 2020).

The decision should depend on animal requirements, land, forage availability, labour, water, costs and the farmer's capacity to manage the system.

2.5 Nutritional and Production Outcomes of Feeding Systems

Feed intake determines the quantity of nutrients physically available to an animal. It is influenced by forage quality, palatability, fibre characteristics, moisture content, and management (Steinmetz et al., 2021). Measurement of feed offered and refused therefore provides a practical indicator of the quantity consumed and allows comparison between feeding systems.

Water is essential for cattle metabolism, thermoregulation, and digestion. The moisture content of feed can influence the amount of drinking water required. Fresh pasture generally supplies more water as part of the feed than dried hay, so a hay-based system may require greater attention to reliable drinking-water supply (Knaus et al., 2016). Water provision should consequently be considered an integral part of feed-technology adoption.

Weight gain provides an indicator of changes in animal growth and nutritional status over time. However, weight response is influenced not only by feeding treatment but also by initial body

weight, age, breed, health, management, and environmental conditions. Baseline body weight is therefore important when comparing final weights between feeding groups.

Milk production provides a direct economic indicator for lactating cattle because changes in nutrient intake may be reflected in milk output. Milk production is also a repeated outcome when the same cows are measured over several days or weeks. For this reason, evaluation of feeding systems should account for both treatment and time rather than relying on a single milk measurement.

2.6 Barriers to Adoption of Feed Technologies

Feed intake determines the quantity of nutrients physically available to an animal (Alshahrani, 2025). It is influenced by forage quality, palatability, fibre characteristics, moisture content and management. Measurement of feed offered and refused therefore provides a practical indicator of the quantity consumed and allows comparison between feeding systems.

Water is essential for cattle metabolism, thermoregulation and digestion. The moisture content of feed can influence the amount of drinking water required. Fresh pasture generally supplies more water as part of the feed than dried hay, so a hay-based system may require greater attention to reliable drinking-water supply (Spiegal et al., 2022). Water provision should consequently be considered an integral part of feed-technology adoption. Weight gain provides an indicator of changes in animal growth and nutritional status over time. However, weight response is influenced not only by feeding treatment but also by initial body weight, age, breed, health, management and environmental conditions. Baseline body weight is therefore important when comparing final weights between feeding groups (Charlier et al., 2024).

Milk production provides a direct economic indicator for lactating cattle because changes in nutrient intake may be reflected in milk output. Milk production is also a repeated outcome when the same cows are measured over several days or weeks. For this reason, evaluation of feeding systems should account for both treatment and time rather than relying on a single milk measurement (Abdulhamid et al., 2026).

2.7 Enablers of Adoption

The literature points to factors that can help increase adoption. These include support from extension services, demonstration farms learning through farmer-to-farmer interactions,

affordable financial options, access to good quality inputs shared use of equipment formation of farmer groups connections to markets and clear proof of economic benefits. Also highlight the importance of raising awareness building skills and knowledge investing in technology improving forage quality and creating stronger incentives, in the market Bastani et al., (2020) .

Extension should focus on practical skills rather than information alone. For hay, training should cover forage selection, harvesting stage, drying, storage, feeding and monitoring of animal response. Demonstrations can reduce uncertainty by allowing farmers to observe the technology under conditions similar to their own (Karyono et al., 2024). Ainembabazi et al., (2017) reported that farmer groups can reduce the cost of adoption through collective learning, equipment sharing, joint input procurement and market access. The Soroti evidence that farmer-group membership is associated with improved forage technology use supports group-based approaches for promoting feed technologies.

Farmers are more likely to invest where expected benefits justify the costs and where financing is accessible. Improved forage technology research in Soroti found economic advantages among users and an association between credit access and technology use. Adoption programmes should therefore include economic demonstrations and, where feasible, affordable financing mechanisms (Pathak et al., 2025). Direct evidence from animals can strengthen farmer confidence. A farmer is more likely to consider a technology appropriate when its benefits can be observed in locally relevant conditions. The present comparison of hay and pasture therefore provides an important practical evidence base for recommendations.

2.8 Empirical Evidence on Forage Technologies in Uganda

Kiggundu et al. (2021) studied improved forage technologies among 121 farmers in Soroti District and found that farmers using improved forage technologies achieved higher gross margins than those using local feeding methods. Access to credit and farmer-group membership were positively associated with use, while profitability interacted with improved breed in influencing technology decisions.

Recent research in Uganda has also examined improved forage-grass adoption and its effects. The study reported that barriers included limited experience with forage cultivation, local breeds, non-zero-grazing systems and lack of producer-organisation membership. Feeding improved forage grasses was associated with higher milk yield and household income. These findings

suggest that adoption is more likely to succeed when technical, institutional and economic factors are addressed together (Pathak et al., 2025). A recent study of smallholder cattle farmers in Buvuma Island similarly reported persistent reliance on natural pastures and crop residues, limited feed conservation and seasonal constraints on feed quality and availability (Nakanaabi et al., 2026). Although Buvuma differs from Soroti, the evidence reinforces the importance of locally appropriate feed-conservation strategies.

2.9 Research Gap

Existing literature clearly shows the importance of forage conservation and highlights several barriers and enablers of adoption. However, there is still limited context-specific evidence that links the actual performance of feeding technologies to practical recommendations that farmers can use. In particular, little is known about how hay and pasture compare under the local conditions of Asuret Sub-county and Soroti West Division in terms of feed intake, water intake, weight gain and milk productivity. There is also a need to look at animal-level performance alongside the technical, financial, social and institutional realities that determine whether farmers can realistically adopt a feed technology.

This study addresses that gap by generating local evidence on feeding performance and using it to inform context-specific recommendations.

2.10 Conceptual Framework

The conceptual framework for the study proposes that adoption of feed technologies is influenced by technical knowledge, extension support, financial capacity, access to inputs and equipment, land and forage availability, labour, farmer-group membership, market incentives and perceived profitability. These factors affect whether farmers can adopt and implement a technology such as haymaking. Implementation affects feed availability and quality and may subsequently influence feed intake, water intake, weight gain and milk productivity. Evidence of animal performance and economic value can in turn strengthen or weaken farmer willingness to continue using the technology.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

The research design employed a quasi-experimental approach. The research design was appropriate because cattle were compared under two feeding conditions. Hay and pasture. Within real smallholder management settings, where complete randomization and control of all environmental variables were not feasible. The research design enabled comparison of animal outcomes while retaining practical farm conditions.

The research design does not establish that every observed difference was caused exclusively by feed type because animal characteristics, management, forage quality and environmental conditions could not be completely standardized. The research design limitation was considered when interpreting the findings and developing recommendations.

3.2 Research Approach

I collected data about feed offered feed refused, feed consumed, water consumed, body weight and milk production. Then we used analysis to compare the two feeding conditions. We chose this approach because the research question required measurable evidence on cattle performance. The study aimed to provide measurable evidence, on cattle performance (Wing et al., 2018).

3.3 Geographical Area of the Study

The study collected numbers about the feed offered feed refused, feed eaten, water drank, body weight and milk produced. The study ran tests to compare the two feeding ways. I chose this method because the research question needed proof about cattle performance.

Soroti is a region in Eastern Uganda. Soroti district says that farming is the way people earn a living and notes a rain pattern that brings a long dry spell from late November to early March. Soroti receives rain of 1,000–1,500 mm each year with heavy rains from March to July and again from September to November. Because forage changes with the seasons Soroti is a spot to study how to preserve feed. Hay is used (Pandey et al., 2023).

I chose two sites in order to could compare hay and pasture while farmers run their cattle routines. The study did not aim to cover every cattle system, in Uganda. The study simply wanted evidence for the context chosen.

3.4 Study Population

The study population included cattle kept in smallholder enterprises within the selected study sites, as well as the farmers responsible for managing them. The main experimental unit was the individual animal, while farmers provided contextual information on feeding and management practices. Information on respondents was available for two participants only. Due to this very small number, respondent characteristics were described but not used for inferential analysis of adoption determinants. The main inferential analyses were therefore based on observations at the cattle level.

3.5 Sample Size and Sampling

The original study protocol specified 32 cattle, with 16 in the hay treatment and 16 in the pasture comparison group. The sample size was calculated based on a two-group comparison of means using a 95% confidence level and 80% statistical power, with the standard deviation and minimum detectable difference specified in the protocol. Cattle were selected according to the eligibility criteria and practical availability at the study sites. The feeding groups were organized as hay-fed and pasture-fed. Farmer participants were included because they were directly responsible for the cattle involved in the feeding activities.

The final analytical dataset differed by outcome. The milk-productivity analysis presented in Chapter Four included repeated observations from 34 cows, while the weight-gain analysis used a smaller dataset for which appropriate individual weight measurements were available. This distinction is reported transparently to ensure the methodology aligns with the actual analyses conducted.

3.6 Study Groups and Feeding Conditions

Table 3- 1: Study Groups and Feeding Conditions

Study site	Hay group	Pasture group	Purpose
Asuret Subcounty	Cattle receiving hay	Cattle receiving pasture	Compare feed and production outcomes
Soroti West Division, Soroti City	Cattle receiving hay	Cattle receiving pasture	Compare feed and production outcomes

The hay group received forage under the study feeding protocol while the comparison group remained under pasture-based feeding. The purpose was to determine whether the feeding condition was associated with differences, in feed intake, water intake, weight gain and productivity.

3.7 Data Collection Methods

Data were gathered using procedures to record baseline information feeding amounts, water consumption, body weight, weight gain, milk production and farmer context details.

Cattle were identified before the feeding comparison began and baseline details such as animal identification, treatment group, age, breed and initial body weight were recorded. Baseline body weight was kept because initial weight can affect weight. Daily feed intake was determined by noting the amount of feed offered and the amount refused, with intake calculated as:

Feed intake (kg/day) = Feed offered (kg/day) − Feed refused (kg/day).

Water intake was measured based on the volume supplied and the volume left at the end of the measurement period and net water consumption was recorded in litres per day using the method for both feeding groups. Body weight was measured at baseline and at scheduled intervals and weight gain was calculated as:

Weight gain (kg) = Final body weight (kg) − Initial body weight (kg).

Week 1 body weight was kept as the baseline measure for the baseline-adjusted comparison of Week 4 body weight. For lactating cattle daily milk production was recorded in liters, with repeated measurements taken for each cow across the weeks. Cow identification was kept to link repeated observations to the animal.

In addition, basic demographic and livestock-enterprise information was obtained from participating farmers to describe the study context. Because two contextual respondents were available this information was used descriptively. Was not treated as representative evidence on adoption determinants.

3.8 Data Collection Instrument

A structured data-collection sheet was used to record animal ID, group, age, breed, initial weight feed offered feed refused, final weight and relevant production measurements. Daily feed and water observations were recorded using units while repeated milk observations were linked to Cow ID.

3.9 Data Quality Control

Data quality was ensured by using measurement definitions consistent units and repeated recording procedures. Each cow was clearly identified to make sure that long-term observations stayed linked to the animal. Body weight was recorded at times and feed intake was calculated using the same formula offered minus refused across all groups. During data processing each observation was reviewed for missing values values that did not make sense and any issues with units. Before choosing tests we checked whether the data met the required distributional assumptions. For the repeated milk data Cow ID was kept as the grouping factor in the model to account for individual differences, over time.

3.10 Validity and Reliability

Validity was strengthened by measuring outcomes that directly corresponded to the research question. Those outcomes included feed intake, water intake, weight gain and productivity. By using measurements we reduced dependence on assessments, for the principal experimental outcomes.

Reliability was supported by repeated milk measurements. Consistent feed and water calculations also added reliability. The use of the measurement definitions across treatment groups increased reliability. Baseline weight measurements supported comparability and baseline-adjusted analysis.

3.11 Measurements and Operational Definitions

Table 3- 2: Measurements and Operational Definitions

Variable	Operational definition	Unit	Analytical role
Treatment	Hay or pasture feeding condition	Categorical	Independent variable
Feed intake	Feed offered minus feed refused	kg/day	Dependent variable
Water intake	Water supplied minus water remaining	L/day	Dependent variable
Weight gain	Final minus initial body weight	kg	Dependent variable
Week 4 body weight	Body weight at Week 4	kg	ANCOVA outcome
Week 1 body weight	Baseline body weight	kg	ANCOVA covariate
Milk productivity	Daily milk output	L/day	Repeated outcome
Week	Experimental measurement period	Week	Fixed effect
Cow ID	Unique animal identifier	ID	Random grouping factor

3.12 Data Analysis

The data were. Examined with statistical software. Descriptive statistics were used to summarizes the study variables and the contextual characteristics of respondents. Inferential tests were chosen based on the distribution and structure of each outcome, with statistical significance set at the 5% level ($\alpha = 0.05$). Feed intake was compared using the Mann–Whitney U test as the main inferential test because the distribution was substantially non-normal, while an independent-samples t-test was retained as a supporting sensitivity analysis. Water intake was compared using an independent-samples t-test, supported by the Mann–Whitney U test. Equality

of variances was assessed with Levene's test, distributional assumptions were examined using Q-Q plots, and effect sizes were reported to show the magnitude of the differences. Daily milk production was analysed using a Gaussian linear mixed-effects model, since observations were repeatedly collected from individual cows across weeks. Treatment, week, and the treatment-by-week interaction were specified as fixed effects, while Cow ID was specified as the random grouping factor. Supporting independent-samples analyses were used to provide additional evidence. Model diagnostics included checks for convergence and singularity; where convergence or near-singularity warnings occurred, the estimates were interpreted cautiously and this limitation was reported rather than treating the estimates as fully stable. Weight gain was compared using the Mann–Whitney U test due to its substantially non-normal distribution, with an independent-samples t-test included as a sensitivity analysis. Finally, ANCOVA was used to compare Week 4 body weight between feeding groups while controlling for Week 1 baseline body weight, providing a baseline-adjusted assessment of the treatment effect.

3.13 Ethical and Animal-Welfare Considerations

The study followed research practices and animal welfare principles. Before any field work began the necessary university and local permissions were obtained. Farmers who took part in the study were fully informed, about what it involved and their participation was entirely voluntary. Animals were treated with care and kindness throughout the feeding comparison. They were closely watched to make sure they stayed healthy and comfortable. Feeding and watering arrangements were set up to ensure each animal had food and clean water at all times. When any animal showed signs of illness veterinary help was given away. All information provided by farmers was kept private. Handled with strict confidentiality.

3.14 Methodological Limitations

The study was carried out in line with research and animal welfare principles. All necessary university approvals and local approvals were obtained before fieldwork began and all participating farmers were fully informed about the study. Participation of participating farmers was voluntary.

Throughout the feeding comparison animals were handled humanely. Closely monitored. Feeding and watering arrangements were managed to ensure nutrition and continuous access, to

water. Where any health issues arose, appropriate veterinary care was provided. All information provided by farmers was treated with confidentiality.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Statistical model and test selection

The statistical tests chosen accounted for the type of outcome, treatment groups, and repeated measurements from the same cattle. Independent-group comparisons of feed and water intake between hay and pasture groups utilized the Mann–Whitney U test where necessary. Weight gain was assessed for normality prior to testing. Milk production was analyzed over time using a linear mixed-effects model, incorporating treatment, week, and their interaction as fixed effects, with Cow ID as a random grouping factor. A baseline-adjusted ANCOVA was used to compare Week 4 body weight while controlling for Week 1 body weight.

Table 4.1: Statistical models and tests used for the study outcomes

Outcome	Principal analysis	Model/test specification	Reason for selection
Feed intake	Mann–Whitney U; t-test as supporting analysis	Feed consumed ~ Treatment	The supplied Q-Q plot showed substantial non-normality.
Water intake	Independent-samples comparison; Mann–Whitney U as robustness check	Water consumed ~ Treatment	The distribution was comparatively orderly and equal variances were supported.
Milk productivity	Linear mixed-effects model; independent-samples tests as supporting analysis	Daily milk production ~ Treatment + Week + Treatment×Week + random Cow ID	Milk was repeatedly measured on the same cows.
Weight gain	Mann–Whitney U; t-test as sensitivity analysis	Weight gain ~ Treatment	Shapiro–Wilk indicated substantial non-normality.
Week 4 body weight	ANCOVA	Week 4 weight ~ Treatment + Week 1 weight	Provides a baseline-adjusted treatment comparison.

4.3 Results

4.3.1 Feed Intake under hay and pasture

Table 4.2: Independent-group comparison of feed intake under hay and pasture.

Test	Statistic	Df	p-value
Student's t-test	t = −84.02	62	< .001
Mann–Whitney U	U = 0.00	—	< .001

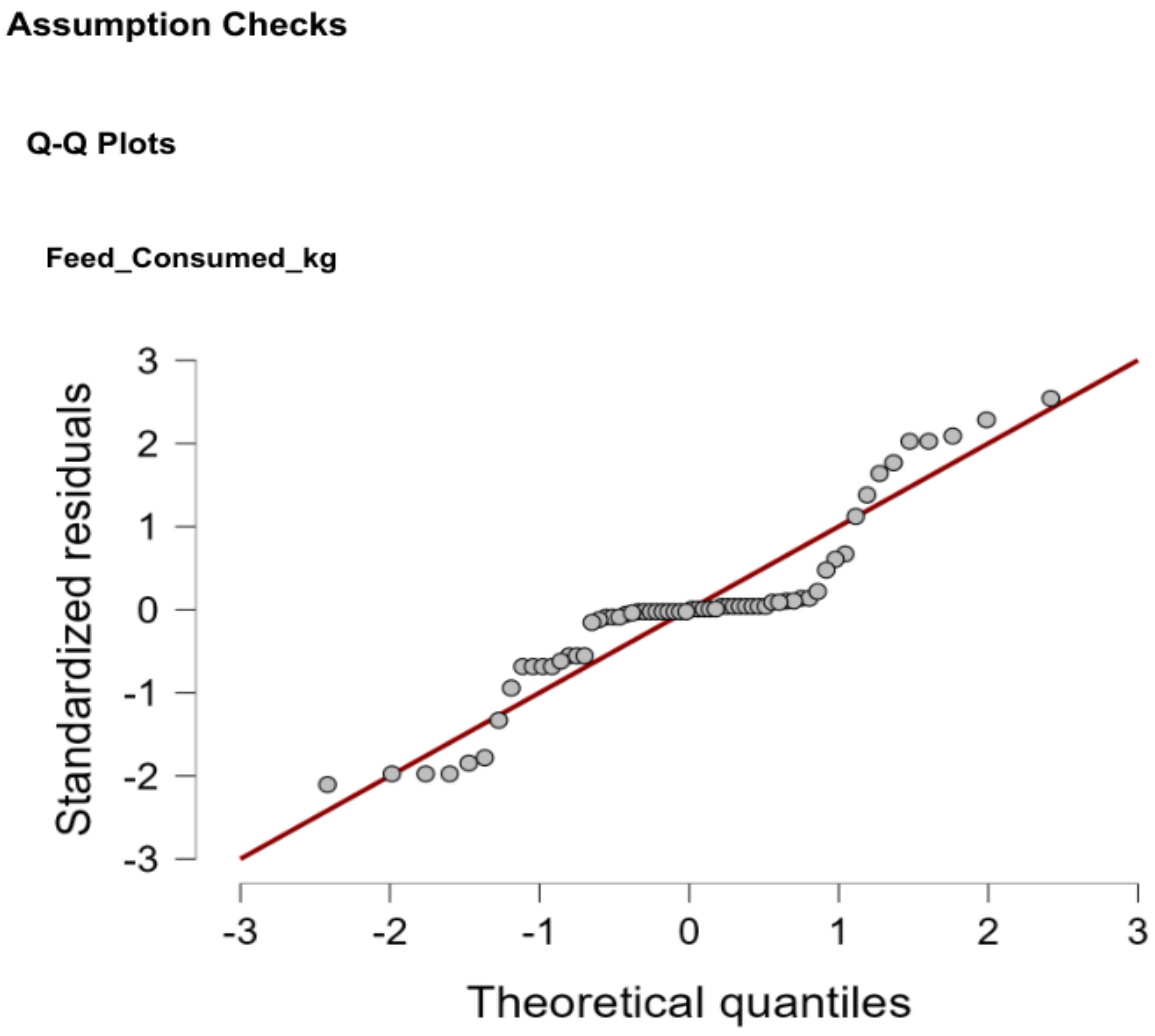


Figure 4.1: Independent-samples feed-intake output and Q-Q plot.

Figure 4.1 displayed that the feed intake data departed clearly from the expected normal distribution, as most points did not closely follow the reference line, especially at the higher and

lower quantiles. This supported the use of the Mann–Whitney U test for comparing feed intake between the hay and pasture groups.

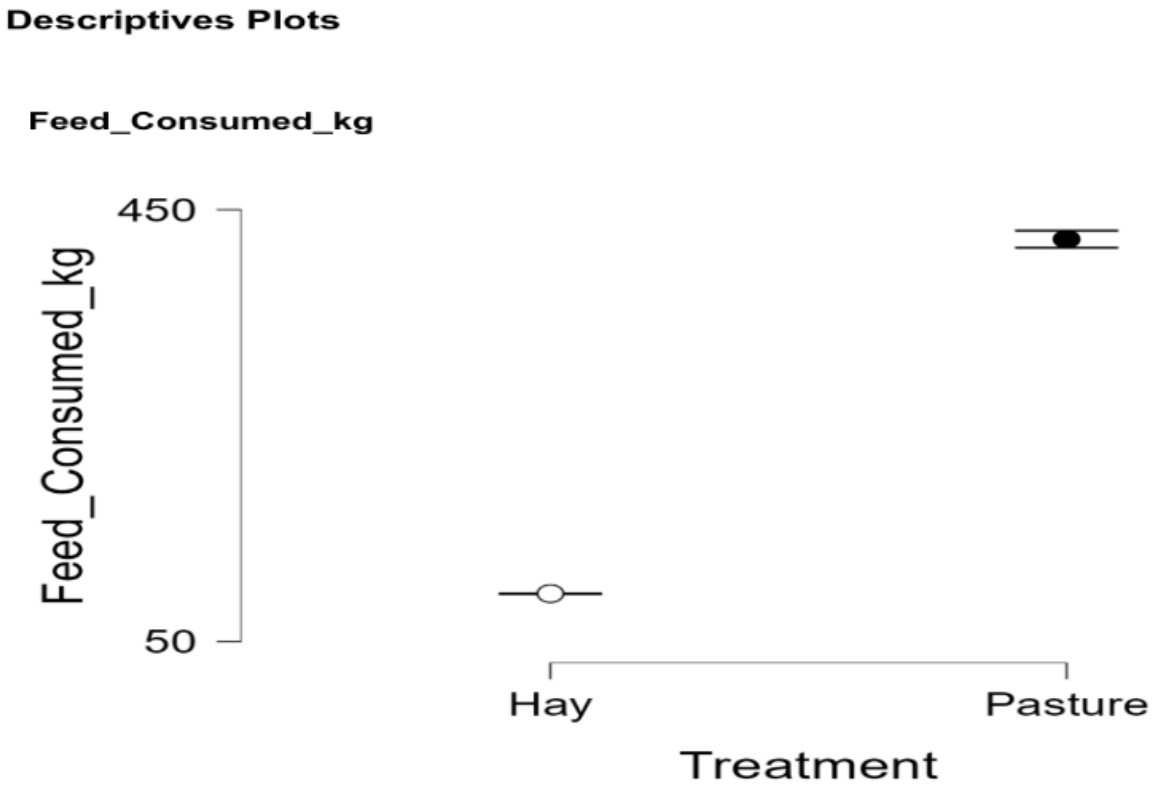


Figure 4.2: Descriptive comparison of recorded feed consumption by treatment.

Figure 4.2 shows a clear difference in recorded feed consumption between the two treatments. Cattle receiving pasture had much higher recorded feed consumption than those receiving hay. The figure also shows relatively small variation within each treatment. Overall, the pattern is consistent with the significant difference found in the inferential analysis ($p < .001$)(Pavlova et al., 2021).

4.3.2 Water Intake

Table 4.3 Independent-group comparison of Water intake under hay and pasture.

Test	Statistic	Df	p-value	Effect-size output
Student's t-test	t = 369.3	62	< .001	Cohen's d = 92.3
Mann–Whitney U	U = 1024	—	< .001	Rank-biserial correlation = −1.00

Treatment	N	Mean (L)	Median (L)	SD	SE
Hay	32	691	692	1.97	0.349
Pasture	32	494	494	2.29	0.405

Table 4.3 shows a statistically significant difference in water intake between cattle receiving hay and those receiving pasture. Cattle in the hay group had a higher mean water intake (691 L) than those in the pasture group (494 L). The Mann–Whitney U test confirmed a significant difference ($U = 1024$, $p < .001$), with a rank-biserial correlation of −1.00, indicating a very strong difference between the two groups (Perli & Govindarajan et al., 2020).

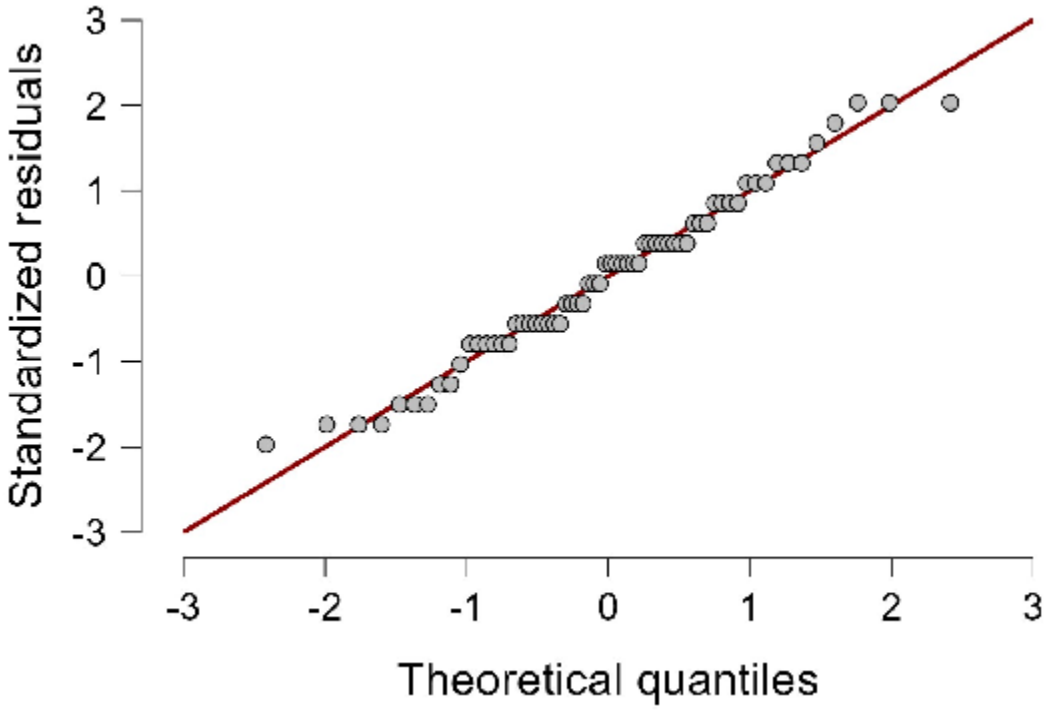


Figure 4.3: Q-Q plot for water-intake observations.

Figure 4.3 shows that the water-intake observations generally followed the reference line closely, with only a few points showing some deviation, particularly at the lower and upper ends. This suggests that the water-intake data were approximately normally distributed.

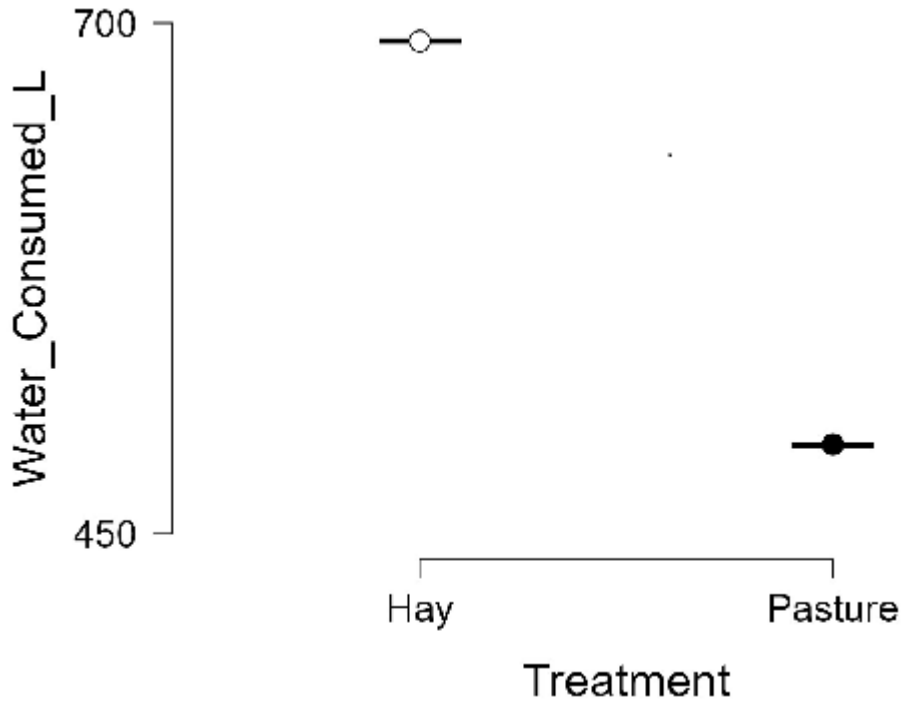


Figure 4.4: Descriptive comparison of water consumption by treatment.

Figure 4.4 shows that water consumption was higher among cattle receiving hay than those receiving pasture. The hay group had a mean water intake of 691 L, compared with 494 L for the pasture group. This visual difference is consistent with the statistically significant difference observed between the two treatments ($p < .001$)(Schildt et al., 2021).

4.3.3 Milk Productivity

Table 4.4 – Fixed-effect results of the linear mixed-effects model for daily milk production

Model component	**R^2**	**Df**	**LRT χ^2**	**p-value**
Conditional	0.408	21	153.228	< .001
Marginal	0.408	6	151.031	< .001
Effect	**F**	**Df**	**Residual df**	**p-value**
Treatment	162.7	1	711	< .001
Week	11.6	4	130	< .001
Treatment × Week	164.7	1	696	< .001

Term	**Estimate**	**SE**	**95% CI**	**df**	**T**	**p-value**
Intercept	134.023	11.8	110.9 to 157.1	103.5	11.3982	< .001

Pasture − Hay	313.400	21.2	271.9 to 354.9	680.0	14.8159	< .001
Week 2 − Week 1	−1.171	24.0	−48.3 to 45.9	959.9	−0.0488	.961
Week 3 − Week 1	−0.852	20.0	−40.1 to 38.4	961.1	−0.0426	.966
Week 4 − Week 1	−195.409	20.8	−236.2 to −154.6	754.6	−9.3945	< .001
Week 5 − Week 1	−160.441	38.3	−235.6 to −85.3	37.7	−4.1883	< .001
(Pasture − Hay) × (Week 4 − Week 1)	−392.618	30.6	−452.7 to −332.6	696.0	−12.8324	< .001
Random component		**Variance**		**SD**		
Cow ID: Week 1		0.0000		0.000		
Cow ID: Week 2		0.0188		0.137		

Table 4.5 shows that treatment, week, and the treatment-by-week interaction all had significant effects on milk production ($p < .001$). The effect of treatment was strong ($F = 162.7$, $p < .001$), and milk production also varied across weeks ($F = 11.6$, $p < .001$). The significant treatment-by-week interaction ($F = 164.7$, $p < .001$) indicates that the difference between the hay and pasture groups changed over time (Lin et al., 2020).

Overall, the model explained 40.8% of the variation in daily milk production ($R^2 = .408$). There was a significant difference between the pasture and hay groups (estimate = 313.400, $p < .001$). Milk production in Weeks 4 and 5 also differed from Week 1 ($p < .001$), and there was a significant treatment-by-week interaction in Week 4 (estimate = −392.618, $p < .001$). These results indicate that feeding treatment influenced milk production, and that this effect varied across the study period rather than remaining consistent over weeks.

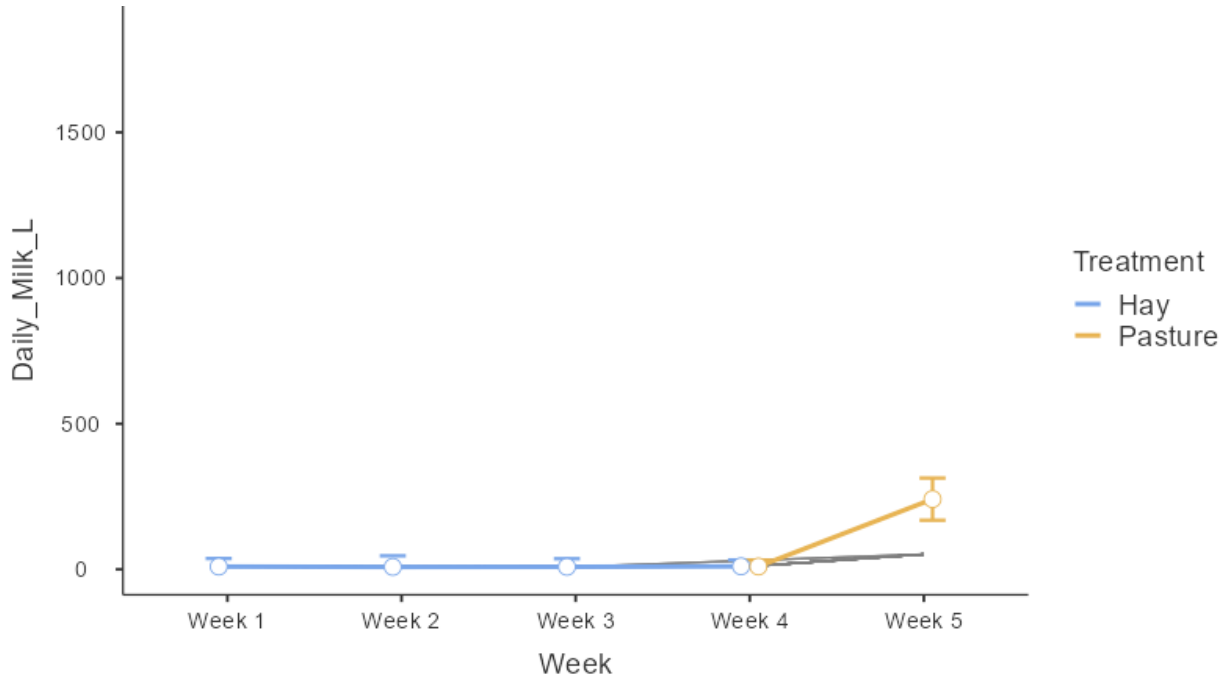


Figure 4.5: Daily milk production across experimental weeks

Figure 4.5 shows that daily milk production differed between the hay and pasture treatments across the study period. Milk production remained relatively low and stable during Weeks 1–3, with a clear increase by Week 5, particularly for the pasture group. The pattern also shows that the difference between the two treatments changed across the weeks, which is consistent with the significant treatment-by-week interaction ($p < .001$) reported in the mixed-effects model (Yazwinski et al., 2022).

Table 4.5: Bonferroni-adjusted pairwise comparisons of daily milk production

Comparison 1	Comparison 2	Difference	SE	T	Df	Bonferroni p
Hay W1	Hay W5	160.441	38.3	4.1883	37.7	.003
Hay W1	Pasture W5	−231.482	38.1	−6.0740	37.2	< .001
Hay W2	Hay W5	159.271	40.6	3.9232	45.8	.006
Hay W2	Pasture W5	−232.653	40.4	−5.7568	44.0	< .001
Hay W3	Hay W5	159.589	38.4	4.1604	34.9	.004
Hay W3	Pasture W5	−232.335	38.2	−6.0880	32.3	< .001
Hay W4	Hay W5	161.342	37.2	4.3371	32.4	.003
Hay W4	Pasture W5	−230.582	37.0	−6.2293	33.5	< .001

Hay W5	Pasture W4	−160.647	37.3	−4.3116	32.9	.003
Hay W5	Pasture W5	−391.923	26.1	−15.0016	674.5	< .001
Pasture W4	Pasture W5	−231.277	37.0	−6.2435	32.8	< .001

The Bonferroni-adjusted comparisons showed several significant differences in daily milk production. Within the hay treatment, Week 5 differed significantly from Weeks 1–4 ($p = .003$–$.006$). Week 5 under pasture also differed significantly from Weeks 1–4, with all comparisons being significant ($p < .001$). In addition, a significant difference was observed between hay Week 5, and pasture Week 5 (difference = −391.923, $p < .001$). This finding indicated a marked difference in milk production between the two treatments by Week 5. The comparison between hay Week 5 and pasture Week 4 was also significant (difference = −160.647, $p = .003$). Overall, the pairwise results support the finding that milk production changed substantially by Week 5, and the pattern differed between the hay and pasture treatments.

Table 4.6: Comparison of daily milk production between hay and pasture treatments

Treatment	**N**	**Mean (L)**	**Median (L)**	**SD**	**SE**
Hay	692	10.1	10.0	2.88	0.109
Pasture	315	63.7	9.00	289	16.3

Test	**Statistic**	**df**	**p-value**	**Mean difference**	**95% CI**	**Effect size**
Student's t-test	−4.880	1005	< .001	−53.6	−75.2 to −32.1	Cohen's d = −0.332
Mann–Whitney U	91,480	—	< .001	—	—	Rank-biserial = −0.161

Levene's test	**F**	**df1**	**df2**	**p-value**
Daily milk production	98.2	1	1005	< .001

Table 4.6 shows a significant difference in daily milk production between the two treatments ($p < .001$). Milk production was higher under the pasture treatment, with a mean of 63.7 L, compared with 10.1 L under hay. The difference was statistically significant based on both the Student's t-test ($t = −4.880$, $p < .001$) and the Mann–Whitney U test ($U = 91{,}480$, $p < .001$). The effect size was relatively small (Cohen's $d = −0.332$), although the large difference in the treatment means indicates that the feeding treatments were associated with different levels of daily milk production.

4.3.4 Weight Gain

Table 4.7: Comparison of weight gain between hay and pasture treatments

Test	Statistic	df	p-value
Student's t-test	1.131	30	.267
Mann–Whitney U	148.0	—	.443

Variable	W	p-value
Weight gain (kg)	0.3699	< .001

The results in Table 4.7 show that there was no statistically significant difference in weight gain between the hay and pasture treatments. The Student's t-test was not significant (t = 1.131, df = 30, p = .267), and the Mann–Whitney U test also showed no significant difference (U = 148.0, p = .443). Therefore, the type of feeding treatment did not have a significant effect on weight gain during the study period (Saemi Soudkolaei et al., 2021).

4.3.5 Baseline-Adjusted Week 4 Body Weight

Table 4.8: Analysis of covariance of weight gain between hay and pasture treatments

Source	Sum of Squares	Df	Mean Square	F	p-value	ω²
Treatment	3.46	1	3.46	0.256	.617	−0.000
Week 1 weight	47,341.21	1	47,341.21	3499.939	< .001	0.991
Residuals	392.26	29	13.53			

Test	F	df1	df2	p-value
Levene's test	2.28	1	30	.142

Comparison	Mean difference	SE	df	t	p-value
Hay − Pasture	0.756	1.49	29.0	0.506	.617

Table 4.8 shows that the feeding treatment did not have a significant effect on weight gain after controlling for Week 1 body weight. The treatment effect was not significant (F = 0.256, p = .617), with a mean difference of 0.756 kg between the hay and pasture groups.

In contrast, Week 1 weight was a highly significant predictor of the outcome (F = 3499.939, p < .001), explaining a very large proportion of the variation (ω^2 = .991). Levene's test was also not significant (F = 2.28, p = .142), indicating that the assumption of equal variances was met.

Overall, the results suggest that initial body weight, rather than feeding treatment, was the main factor associated with the observed weight differences

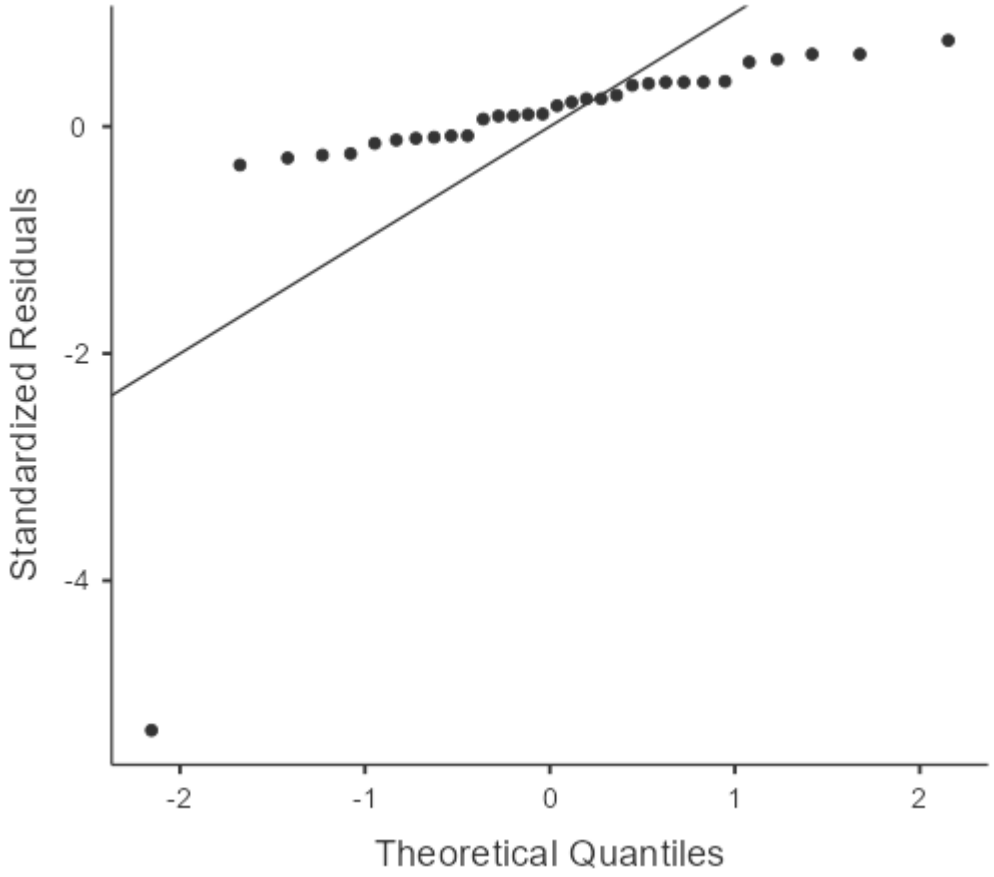


Figure 4.6: Q-Q plot of residuals for the ANCOVA weight-gain analysis

Figure 4.6 shows that most of the standardized residuals did not closely follow the reference line, with a particularly large deviation at the lower end. This suggests some departure from normality in the residuals, although most of the remaining points follow a fairly consistent pattern.

4.4 Discussion

4.4.1 Feed Intake

The study found a clear difference in recorded feed consumption between cattle maintained on hay and those maintained on pasture. Pasture-fed cattle recorded substantially higher feed consumption, and the difference was statistically significant (Mann–Whitney U = 0.00, $p < .001$). The Q-Q plot showed that the feed-intake observations departed considerably from normality, particularly towards the lower and upper ends of the distribution. For this reason, the Mann–Whitney U test provides a more appropriate basis for interpreting the difference than the

supporting parametric test. The descriptive plot also showed a clear separation between the two feeding groups, with relatively little variation within each group.

The finding can be understood in relation to the characteristics of the two feeding systems. Pasture provides fresh forage directly through grazing, whereas hay is a conserved feed whose quality depends on the forage harvested, stage of harvesting, drying and storage. Balehegn et al. (2022) noted that the quality of conserved forage in smallholder systems can vary considerably because of differences in forage type, harvesting practices and storage. This is important when interpreting the present result because the amount of feed consumed is not determined simply by whether the feed is called hay or pasture. The physical and nutritional quality of the forage can influence how readily cattle consume it.

The result is also broadly consistent with (Wilkinson et al., 2020) who discussed important differences between pasture-based and indoor feeding systems and showed that cattle responses to the two systems depend on the characteristics of the feeding environment and the animals involved. Pasture-based systems can support efficient use of forage, but their performance depends on the availability and quality of the pasture. The present finding therefore supports the view that feeding system influences feed consumption, but it should not be interpreted as evidence that pasture is always superior to hay.

From a practical perspective, the finding suggests that farmers using hay should pay attention not only to the quantity offered but also to hay quality. Good-quality forage should be harvested at an appropriate stage, properly dried and protected during storage. This is important because forage conservation is most useful when it maintains adequate feed quality during periods when pasture is limited. Balehegn et al. (2020) similarly emphasized the importance of improving the quality, production and utilization of conserved forage in smallholder systems.

4.4.2 Water Intake

Water consumption was significantly higher among cattle receiving hay than among those receiving pasture. The mean recorded water intake was 691 L in the hay group compared with 494 L in the pasture group, and the Mann–Whitney U test confirmed a statistically significant difference ($p < .001$). This finding is important because it shows that the choice of feeding system may have implications beyond the quantity of feed consumed and may also affect the amount of drinking water required.

The observed pattern is biologically plausible because the amount of drinking water consumed by dairy cattle is influenced by the dry-matter content of the diet and by the amount of dry matter consumed. Golher et al. (2021), for example, examined water consumption in lactating dairy cows at pasture and reported that water intake was related to dietary dry-matter intake and dry-matter concentration, in addition to environmental factors. Thus, the higher drinking-water consumption recorded under hay in the present study may partly reflect the greater proportion of dry feed compared with cattle obtaining fresh forage from pasture.

The finding also agrees with the general distinction between conserved forage and fresh pasture. Hay is dried before storage, whereas pasture is consumed as fresh forage. (Herforth et al., 2025) highlights the substantial differences between pasture-based and more confined feeding systems, including differences in feed characteristics and feeding environment. This supports the interpretation that water management should be considered together with feed management rather than treated as a separate issue.

Nevertheless, the present study measured drinking-water consumption and did not quantify the amount of water supplied by the moisture contained in fresh pasture. Therefore, the results cannot establish that the cattle on pasture had lower total water requirements. The difference should instead be interpreted as a difference in recorded drinking-water consumption. Environmental conditions, animal productivity, feed dry-matter content and actual forage moisture could all contribute to the observed pattern. (Monteiro et al., 2024) similarly showed that water consumption is influenced by more than one factor.

The unusually large parametric effect size reported in the study should also be interpreted cautiously because the within-group variation in the recorded water measurements was very small. The consistency of the rank-based test, however, indicates that the two groups were clearly separated in the available records. From a practical perspective, the finding reinforces the need for farmers using hay or other conserved forages to plan for dependable access to clean drinking water.

4.4.3 Weight Gain

In contrast to feed and water intake, the study found no statistically significant difference in weight gain between cattle fed hay and those maintained on pasture. The Mann–Whitney U test was not significant ($p = .443$), and the supporting t-test was also non-significant ($p = .267$).

Similarly, the baseline-adjusted analysis showed that treatment did not significantly affect Week 4 body weight ($p = .617$). The strongest predictor of Week 4 body weight in the ANCOVA was Week 1 body weight.

The absence of a significant treatment effect indicates that the feeding systems did not produce a detectable difference in short-term weight gain under the conditions of this study. This result is important because a feeding system that differs in feed consumption does not necessarily produce a corresponding difference in body-weight change over a relatively short period. Body weight is a cumulative outcome that can be influenced by initial animal size, age, breed, health status, management and the nutritional quality of the feed.

The importance of initial animal status is particularly evident in the present analysis. Week 1 body weight accounted for a very large proportion of the variation in Week 4 body weight, whereas the treatment effect remained non-significant after baseline adjustment. This suggests that differences in starting body size were more closely related to subsequent body weight than the feeding treatment itself.

The finding should therefore be interpreted differently from the feed- and water-intake results. A significant difference in intake does not automatically imply a significant difference in weight gain. The amount of feed consumed must be considered together with its nutrient composition, digestibility, maintenance requirements and the physiological demands of the animal. Consequently, the present study does not provide sufficient evidence to conclude that either hay or pasture produced greater short-term weight gain (Divya Devi, Ashish Mishra et al., 2025).

The difference between the present finding and some of the broader literature on forage-based feeding may partly be explained by differences in forage quality, animal characteristics, management and duration of feeding. (Ntakyo et al., 2020), working in south-western Uganda, demonstrated that the nutritional and economic value of conserved feeds such as hay and silage depended on the characteristics of the forage and feeding conditions. Their study therefore provides useful Ugandan evidence for the importance of feed quality and conservation practices, but it was not a direct experimental comparison of hay and pasture for weight gain.

The relatively small weight-gain dataset and the non-normal distribution of weight-gain observations also reduce the ability of the present study to detect small treatment differences. The result should therefore be interpreted as evidence that a statistically detectable short-term

difference was not demonstrated, rather than proof that hay and pasture can never produce different growth responses.

4.4.4 Milk Productivity

Milk productivity showed a different pattern from weight gain. The mixed-effects analysis indicated significant effects of treatment, week and the treatment-by-week interaction ($p < .001$). The interaction is particularly important because it indicates that the difference between the hay and pasture groups was not constant throughout the experimental period. The descriptive results showed relatively low and stable production during the earlier weeks followed by a marked increase, particularly in the pasture group, towards Week 5.

The finding is consistent with evidence that feeding system and forage availability can influence milk production. (Balehegn et al., 2020) noted that pasture-based dairy systems differ from indoor high-input systems in their production patterns and feed-use efficiency, and that the response of dairy cattle depends on the characteristics of the feeding system and the animals involved. The present study similarly indicates that milk production differed according to feeding condition and changed over the experimental period.

The Ugandan evidence from (Balehegn et al., 2022) also provides useful context. Their study found that conserved feeds such as hay and silage could have nutritional and economic value for dairy production during periods of feed scarcity, but the results varied according to the forage and conservation method used. This supports the broader interpretation that the performance of a feed technology depends on the quality of the feed and the conditions under which it is used.

There is, however, an important difference between the present study and (Ntakyo et al., 2020). The latter focused on the nutritional and economic benefits of hay and silage during dry-season feeding in south-western Uganda, whereas the present study directly compared cattle under hay and pasture feeding conditions in Asuret. Differences in geographical location, forage species, conservation practices, animal characteristics, management and study duration can therefore produce different milk-production responses. The two studies should not be expected to produce identical results.

The present milk results should also be treated with greater caution than the simpler feed- and water-intake comparisons. The mixed-effects model generated convergence and near-singularity

concerns, while the pasture group had substantial variability in milk production. These issues mean that the evidence supports a difference in the recorded milk-production patterns, but the exact magnitude of the longitudinal treatment effect should not be treated as definitive until the model is successfully re-estimated and its assumptions checked.

The marked change over time is nevertheless important for interpretation. Milk production is a repeated outcome, and evaluating it at only one point could miss changes that occur as animals adapt to a feeding system or as forage availability changes. Therefore, the present results support monitoring milk production throughout the feeding period rather than relying on a single observation.

4.4.5 Integrated Interpretation in Relation to the Research Question

The research question asked how hay compared with pasture affects feed intake, water intake, weight gain and productivity. The findings indicate that the effects are outcome-specific. Pasture was associated with higher recorded feed consumption, while hay was associated with higher recorded water consumption. Milk productivity also showed evidence of a treatment-related difference, with the supplied longitudinal output indicating a changing treatment difference across weeks. In contrast, neither weight gain nor baseline-adjusted Week 4 body weight differed significantly between treatments.

The overall pattern does not justify a blanket conclusion that either hay or pasture is superior for every production outcome. Instead, the feeding system appears to influence different components of cattle performance in different ways. For practical feeding decisions, this means that evaluation should include feed consumption, water use, milk output and body-weight change rather than relying on one indicator alone.

4.4.6 Comparison and Contrast with Previous Outcomes

Overall, the results were somewhat in line with earlier studies. There were differences in feed intake between the feeding regimes, with pasture exhibiting higher recorded consumption. Prior studies have also shown that intake is influenced by the type, quality, and availability of forage. When interpreting the effects of feeding systems, environmental conditions, baseline status, and study duration should be taken into account. The finding that hay-fed cattle consumed more

drinking water was consistent with (Carvalho et al., 2026) suggesting that feed moisture content influences water requirements. On the other hand, Renzaho Ntakyo et al. (2020) showed somewhat larger weight gains among cattle fed pasture, which contrasted with the non-significant difference in weight growth. Variations in fodder quality, animal traits, feeding length, initial body weight, management, and study design may account for this discrepancy. The present ANCOVA further showed that baseline body weight was a stronger predictor of final weight than feeding treatment.

Overall, the findings demonstrate that responses to hay and pasture are not uniform across production outcomes. Differences in forage quality, moisture content, animal characteristics, environmental conditions, baseline status and study duration should therefore be considered when interpreting the effects of feeding systems.

4.4.7 Limitations of the Findings

The study had several limitations that should be considered when interpreting the findings. First, the respondent sample was very small, consisting of only two contextual participants, so their characteristics cannot be generalized to all cattle farmers. Second, the quasi-experimental design means that differences between hay and pasture groups may partly be due to pre-existing differences in animals, management or forage quality.

Third, feed-intake data were not normally distributed, making the Mann–Whitney U test the more appropriate analysis, while possible repeated measurements may have affected the independence of observations. Fourth, the water-intake analysis produced an unusually large effect size because within-group variation was very small, so the magnitude should be interpreted cautiously.

Fifth, the milk-productivity mixed model had convergence and near-singularity problems, together with substantial variability and unequal variances in the pasture group. Therefore, its longitudinal estimates should be interpreted cautiously until the model is successfully re-estimated. Sixth, the weight-gain sample was relatively small and the data were substantially non-normal, which may have limited the ability to detect smaller treatment effects.

Finally, the study period and available measurements may not reflect longer-term or seasonal effects, particularly changes in pasture availability and forage quality. Therefore, the findings

should be interpreted within the specific experimental conditions of the study rather than as universal effects of hay and pasture.

4.4.8 Implications for Objective Six

Objective Six seeks to propose context-specific recommendations and strategies for overcoming barriers and strengthening enablers in the promotion of cattle feed technologies. The quantitative findings provide an empirical basis for those recommendations by showing that feeding systems have measurable implications for feed intake, water use and productivity, while short-term weight gain did not differ significantly. Accordingly, feed-technology recommendations should be framed around multiple measurable outcomes and should not assume that an intervention that improves one outcome will automatically improve all others.

The results also support an integrated feed-management approach. Technologies or practices intended to improve forage utilization should be accompanied by appropriate water-management arrangements and monitoring of animal performance. Because milk productivity differed over time in the supplied analysis, monitoring should extend beyond a single measurement period. Similarly, because baseline body weight strongly predicted final weight, future implementation and evaluation should record reliable baseline measurements before introducing a new feeding practice.

The respondent characteristics provide limited contextual information because only two participants were available. They should therefore be used only to describe the setting and not to generalize the findings to all cattle farmers. More importantly, the small contextual sample should not be combined with the experimental cattle records as though they represented the same unit of analysis.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the conclusions and recommendations arising directly from the findings and discussion in Chapter Four. The study examined how hay compared with pasture in terms of cattle feed intake, water intake, weight gain and productivity, with milk production used as the main measure of productivity. The conclusions are therefore based on the evidence generated under the experimental conditions of the study and are linked to the research question, hypothesis and Objective Six. The recommendations are drawn from these conclusions and focus on practical aspects of cattle-feeding management, monitoring, and areas that require further investigation.

5.1 Conclusions

5.1.1 Conclusion on feed intake

The study concludes that hay and pasture were associated with significantly different recorded feed intake. Pasture-fed cattle recorded higher feed consumption than hay-fed cattle, and the Mann–Whitney U test showed a statistically significant difference ($U = 0.00$, $p < .001$). However, because the feed-intake data were substantially non-normal and the independence of repeated records must be considered, the result should be interpreted as evidence of a difference in recorded feed consumption under the study conditions rather than as definitive proof of a causal individual-animal effect.

5.1.2 Conclusion on water intake

The study concludes that water intake differed significantly between the two feeding systems. Cattle fed on hay recorded higher drinking-water consumption than those fed on pasture, with the Mann–Whitney U test showing a statistically significant difference ($U = 1024$, $p < .001$). This finding suggests that the type of feeding system has practical implications for water provision. The unusually large parametric effect size should, however, be interpreted with caution, as within-group variation was very small.

5.1.3 Conclusion on weight gain

The study concludes that there was no statistically significant difference in weight gain between cattle fed hay and those fed pasture. The main Mann–Whitney U test was non-significant (U =

148.0, p = .443), and the supporting t-test was also non-significant. In addition, the baseline-adjusted analysis found no significant effect of treatment on Week 4 body weight ($F(1,29) = 0.256$, $p = .617$). Instead, Week 1 baseline body weight was a very strong predictor of Week 4 body weight. The study therefore does not provide sufficient evidence that either feeding system led to greater weight gain in the short term.

5.1.4 Conclusion on productivity

The study concludes that milk productivity differed between the hay and pasture treatments in the available records. The longitudinal analysis showed significant effects of treatment, week, and treatment-by-week interaction ($p < .001$), indicating that the difference between treatments changed over the experimental period. Supporting independent-group analyses were also significant. However, the mixed-effects model produced convergence and near-singularity warnings, and the pasture records showed considerable variability and unequal variances. The study therefore supports the conclusion that recorded milk productivity differed between treatments, but the precise magnitude and pattern over time should be interpreted with caution.

5.1.5 Overall conclusion in relation to the research question

The research question asked how hay compares with pasture in terms of cattle feed intake, water intake, weight gain and productivity. The findings show that the effects were outcome-specific. Pasture was associated with higher recorded feed consumption, while hay was associated with higher recorded drinking-water consumption. Milk productivity also showed evidence of a treatment-related difference that varied over time. In contrast, there was no significant difference between treatments in weight gain or in baseline-adjusted Week 4 body weight. The evidence therefore does not support a blanket conclusion that either hay or pasture is universally superior. Instead, the choice of feeding system should be assessed against the specific production outcome being targeted

5.1.6 Conclusion in relation to the hypothesis

Table 5- 1 Conclusion in relation to the hypothesis

Outcome	Finding	Hypothesis decision
Feed intake	Significant difference; pasture higher ($p < .001$)	Reject H_0 for feed intake
Water intake	Significant difference; hay higher ($p < .001$)	Reject H_0 for water intake
Milk productivity	Evidence of treatment/time difference; model-fit caution required	Evidence against H_0 for productivity, with caution
Weight gain	No significant difference ($p = .443$)	Fail to reject H_0 for weight gain

Overall, the null hypothesis cannot be rejected uniformly across all four outcomes because the results were not consistent across all indicators. The null hypothesis is rejected for feed intake and water intake and there is evidence of a productivity difference, subject to the mixed-model limitation, whereas it is not rejected for weight gain. The most appropriate overall conclusion is therefore that hay and pasture produced outcome-specific differences rather than a uniform effect across all measured outcomes.

5.2 Practical Implications, Advantages and Limitations of the Findings

5.2.1 Practical implications and advantages

The findings provide cattle farmers and livestock extension personnel with evidence that feeding-system decisions should consider several indicators simultaneously rather than relying on weight gain or milk production alone.

The higher recorded water consumption under hay feeding highlights the importance of ensuring reliable access to adequate clean drinking water when conserved forage is used.

The difference in recorded feed consumption provides a basis for monitoring forage utilization and evaluating whether a feeding system is meeting the intended intake requirements under local management conditions.

The productivity finding indicates the value of monitoring milk output over time because treatment-related differences may change during the feeding period.

The absence of a significant weight-gain difference cautions against assuming that a feeding system that improves one production indicator will necessarily improve body-weight gain.

5.2.2 Limitations affecting application of the findings

The respondent-context information was based on only two participants and is descriptive rather than representative of the wider cattle-farming population.

The quasi-experimental design does not provide the same level of control over pre-existing differences as a fully randomized experiment; animal characteristics, management and forage conditions may therefore contribute to observed differences.

Feed-intake data did not follow a distribution and the repeated nature of the records means we must be careful when counting how many independent observations are really present.

The large effect size for water intake should not be taken at face value. It needs to be considered alongside the variability within groups and the way measurements were recorded over time.

The mixed model used for milk production showed convergence issues and near-singularity warnings. This suggests that the longitudinal estimates from this model are not fully reliable and need refinement and validation before being trusted.

Weight gain also did not follow a pattern. Combined with a comparison group this could make it harder to detect smaller treatment differences even if they exist.

The study period and the measurements collected may not reflect longer-term trends or seasonal changes. These missing elements include shifts, in pasture availability and forage quality which could influence outcomes over time.

5.3 Recommendations

The following recommendations are derived directly from the study findings. They are intended to support practical cattle-feeding decisions and to strengthen the use and evaluation of feed technologies under conditions similar to those represented in the study.

Farmers and livestock extension personnel should adopt a multi-indicator approach when evaluating hay and pasture feeding systems, monitoring feed intake, water consumption, milk productivity and body-weight change together.

Where hay or other conserved forage is used, farmers should ensure dependable access to adequate clean drinking water and include water availability in feed-management planning.

Feed intake should be routinely monitored and recorded using consistent measurement procedures so that changes in forage consumption can be distinguished from changes caused by recording practices or management conditions.

Milk production should be monitored across the feeding period rather than assessed from a single observation, because the present findings indicate that treatment-related differences may change over time.

Farmers and extension personnel should record reliable baseline body weights before introducing a new feeding practice and continue periodic weighing, because baseline weight was a strong predictor of subsequent body weight in this study.

Extension services should emphasize that no single feeding system should be assumed to improve every production outcome. Recommendations should instead be matched to the specific objective, such as maintaining feed intake, managing water requirements or improving milk productivity.

Before scaling up a feeding technology or management practice, farmers and extension personnel should evaluate forage quality, moisture content, availability and management conditions because these factors may influence the response to hay and pasture.

Institutions supporting cattle production should encourage standardized record keeping for feed offered, feed consumed, water consumed, milk yield and body weight to improve the quality of farm-level decision making and future research.

5.4 Recommendations for Further Study

A larger, fully randomized or well-controlled longitudinal study should be conducted to confirm the effects of hay and pasture while controlling for animal characteristics, baseline measurements, forage quality and management conditions.

Future studies must re-estimate the milk-production mixed-effects model with a random-effects structure and confirmed repeated-measures data so that treatment, time and treatment-by-time effects are estimated more reliably.

Longer-duration studies that cover seasons should be carried out to find out whether the feeding-system effects seen before stay the same when pasture availability, forage quality and climate conditions change.

Future research should measure the water intake, including water that comes from fresh forage, when possible, instead of depending only on drinking-water measurements.

Further studies should look at feed quality and nutrient composition with intake so that differences in consumption can be understood in relation to the nutritional value of the forage.

Studies that use numbers of cattle should be done to increase statistical power and detect smaller differences in weight gain and other production results.

Future work should examine feed efficiency and the economic effects of hay and pasture feeding including how feed consumption, water use, milk production and changes, in body weigh were connected.

REFERENCES

Abdulhamid, A., Muhammad, W. A., Haruna, T. M., Ibrahim, W., Abdul-Rahman, M., & Modu, B. M. (2026). Hyacinth beans (Lablab purpereus) as an emerging plant protein source for animal pr o duction: A review. In *Veterinary Integrative Sciences* (Vol. 24, Issue 1). https://doi.org/10.12982/VIS.2026.015

Ainembabazi, J. H., van Asten, P., Vanlauwe, B., Ouma, E., Blomme, G., Birachi, E. A., Nguezet, P. M. D., Mignouna, D. B., & Manyong, V. M. (2017). Improving the speed of adoption of agricultural technologies and farm performance through farmer groups: evidence from the Great Lakes region of Africa. *Agricultural Economics (United Kingdom)*, *48*(2), 241–259. https://doi.org/10.1111/agec.12329

Alshahrani, A. (2025). Adopting Emerging Technologies in Digital Government: A Multi-Case Analysis of Drivers, Enablers, and Challenges in Saudi Arabia. *Digital Government: Research and Practice*, *6*(3). https://doi.org/10.1145/3719297

Anggraeny, N. D., & Masyithoh, S. (2022). Pengaruh Penggunaan Metode Jarimatika Terhadap Kemampuan Berhitung Perkalian Anak Usia Sekolah Dasar. *Elementar : Jurnal Pendidikan Dasar*, *2*(1). https://doi.org/10.15408/elementar.v2i1.24530

Balehegn, M., Ayantunde, A., Amole, T., Njarui, D., Nkosi, B. D., Müller, F. L., Meeske, R., Tjelele, T. J., Malebana, I. M., Madibela, O. R., Boitumelo, W. S., Lukuyu, B., Weseh, A., Minani, E., & Adesogan, A. T. (2022). Forage conservation in sub-Saharan Africa: Review of experiences, challenges, and opportunities. *Agronomy Journal*, *114*(1), 75–99. https://doi.org/10.1002/agj2.20954

Balehegn, M., Duncan, A., Tolera, A., Ayantunde, A. A., Issa, S., Karimou, M., Zampaligré, N., André, K., Gnanda, I., Varijakshapanicker, P., Kebreab, E., Dubeux, J., Boote, K., Minta, M., Feyissa, F., & Adesogan, A. T. (2020). Improving adoption of technologies and interventions for increasing supply of quality livestock feed in low- and middle-income countries. *Global Food Security*, *26*(June), 100372. https://doi.org/10.1016/j.gfs.2020.100372

Bastani, P., Sheykhotayefeh, M., Tahernezhad, A., Hakimzadeh, S. M., & Rikhtegaran, S. (2020). Reflections on COVID-19 and the ethical issues for healthcare providers.

International Journal of Health Governance, *25*(3). https://doi.org/10.1108/IJHG-05-2020-0050

Bernabe, E., Marcenes, W., Hernandez, C. R., Bailey, J., Abreu, L. G., Alipour, V., Amini, S., Arabloo, J., Arefi, Z., Arora, A., Ayanore, M. A., Bärnighausen, T. W., Bijani, A., Cho, D. Y., Chu, D. T., Crowe, C. S., Demoz, G. T., Demsie, D. G., Forooshani, Z. S. D., … Kassebaum, N. J. (2020). Global, Regional, and National Levels and Trends in Burden of Oral Conditions from 1990 to 2017: A Systematic Analysis for the Global Burden of Disease 2017 Study. *Journal of Dental Research*, *99*(4), 362–373. https://doi.org/10.1177/0022034520908533

Bikbov, B., Purcell, C., Levey, A. S., Smith, M., Abdoli, A., Abebe, M., Adebayo, O. M., Afarideh, M., Agarwal, S. K., Agudelo-Botero, M., Ahmadian, E., Al-Aly, Z., Alipour, V., Almasi-Hashiani, A., Al-Raddadi, R. M., Alvis-Guzman, N., Amini, S., Andrei, T., Andrei, C. L., … Vos, T. (2020). Global, regional, and national burden of chronic kidney disease, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, *395*(10225), 709–733. https://doi.org/10.1016/S0140-6736(20)30045-3

Carvalho, N. I., Oliveira, I. C. R., Toledo, A. F., Barboza, R. D. F., Dantas, J. G., Prado, M. J., Marino, E. D., Ribeiro, P. H. C., & Bittar, C. M. M. (2026). Effect of water quality on performance and health of dairy calves. *Journal of Dairy Science*, *109*(1), 503–512. https://doi.org/10.3168/jds.2025-26524

Charlier, J., Cicchelero, L., Cloherty, A. P., Hanon, E., Hofer, M., Goossens, F., & Arnouts, S. (2024). From discovery to innovation in animal health: Maturing emerging technologies for industrial development. *Biologicals*, *87*. https://doi.org/10.1016/j.biologicals.2024.101783

Darmohray, L. M., Darmohray, O. O., Migdal, W., & Migdal, L. (2024). FODDER GALEGA (GALEGA ORIENTALIS LAM.) - CHEMICAL COMPOSITION AND APPLICATION IN ANIMAL NUTRITION. *Journal of Hygienic Engineering and Design*, *46*.

De Kouchkovsky, I., & Abdul-Hay, M. (2016). ‘Acute myeloid leukemia: A comprehensive review and 2016 update.’ *Blood Cancer Journal*, *6*(7). https://doi.org/10.1038/bcj.2016.50

Distel, R. A., Arroquy, J. I., Lagrange, S., & Villalba, J. J. (2020). Designing Diverse Agricultural Pastures for Improving Ruminant Production Systems. *Frontiers in Sustainable*

Food Systems, *4*(October), 1–18. https://doi.org/10.3389/fsufs.2020.596869

Dóka, R., Kiss, M., & Bárány-Kevei, I. (2019). Land use anomalies on wetlands in different time horizons - A case study from Hungary. *Carpathian Journal of Earth and Environmental Sciences*, *14*(2). https://doi.org/10.26471/CJEES/2019/014/080

Golher, D. M., Patel, B. H. M., Bhoite, S. H., Syed, M. I., Panchbhai, G. J., & Thirumurugan, P. (2021). Factors influencing water intake in dairy cows: a review. *International Journal of Biometeorology*, *65*(4), 617–625. https://doi.org/10.1007/s00484-020-02038-0

Herforth, N., Tirivanhu, P., Ewell, H., Miethbauer, T., & Nawrotzki, R. (2025). Appetite for forages? The adoption and multidimensional impacts of improved forage grasses in Uganda. *Frontiers in Sustainable Food Systems*, *9*(July), 1–17. https://doi.org/10.3389/fsufs.2025.1585410

Karyono, T., Herlina, B., Utama adlan, Z., Aliansyah, A., & Trianah, Y. (2024). PEMBERDAYAAN MASYARAKAT MELALUI PROGRAM PEMBUATAN HAY SEBAGAI PAKAN TERNAK PADA MUSIM KEMARAU DI DESA KETUAN JAYA KABUPATEN MUSI RAWAS. *MASDA*, *3 (1)*(1).

Kiggundu, M., Kigozi, A., Walusimbi, H. K., & Mugerwa, S. (2021). Farmers' perception of calf housing and factors influencing its adoption on dairy cattle farms in Uganda. *Scientific African*, *12*, e00805. https://doi.org/10.1016/j.sciaf.2021.e00805

Knaus, W. (2016). Perspectives on pasture versus indoor feeding of dairy cows. *Journal of the Science of Food and Agriculture*, *96*(1), 9–17. https://doi.org/10.1002/jsfa.7273

Monteiro, A., Santos, S., & Pereira, J. L. S. (2024). Efficient Water Use in Dairy Cattle Production: A Review. *The Open Agriculture Journal*, *17*(1), 1–12. https://doi.org/10.2174/0118743315270668231127190323

Murray, C. J., Ikuta, K. S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., Han, C., Bisignano, C., Rao, P., Wool, E., Johnson, S. C., Browne, A. J., Chipeta, M. G., Fell, F., Hackett, S., Haines-Woodhouse, G., Kashef Hamadani, B. H., Kumaran, E. A. P., McManigal, B., … Naghavi, M. (2022). Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*, *399*(10325), 629–655. https://doi.org/10.1016/S0140-6736(21)02724-0

Nakanaabi, J., Nampanzira, D. K., Kizza, D., Nalubwama, S., Baluka, S., Twinamasiko, R., & Asuman, S. (2026). *Forage resources , nutritional evaluation , and management practices among smallholder cattle farmers in Buvuma Island , Uganda*.

Ni, G., Wang, M., Walker, N., Muetzel, S., Schmidt, O., Fischer, A., Stemmler, R. T., Leung, P. M., Zhang, X., Li, Q., Jain, S., Jespersen, M., Grinter, R., Archer, S. D. J., Pacheco, D., Lowe, K., Pope, P. B., Müller, V., Pitta, D. W., … Greening, C. (2025). Methanogenesis inhibition remodels microbial fermentation and stimulates acetogenesis in ruminants. *Proceedings of the National Academy of Sciences of the United States of America*, *122*(41). https://doi.org/10.1073/pnas.2514823122

Nichols, E., Steinmetz, J. D., Vollset, S. E., Fukutaki, K., Chalek, J., Abd-Allah, F., Abdoli, A., Abualhasan, A., Abu-Gharbieh, E., Akram, T. T., Al Hamad, H., Alahdab, F., Alanezi, F. M., Alipour, V., Almustanyir, S., Amu, H., Ansari, I., Arabloo, J., Ashraf, T., … Vos, T. (2022). Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. *The Lancet Public Health*, *7*(2), e105–e125. https://doi.org/10.1016/S2468-2667(21)00249-8

Nichols, E., Szoeke, C. E. I., Vollset, S. E., Abbasi, N., Abd-Allah, F., Abdela, J., Aichour, M. T. E., Akinyemi, R. O., Alahdab, F., Asgedom, S. W., Awasthi, A., Barker-Collo, S. L., Baune, B. T., Béjot, Y., Belachew, A. B., Bennett, D. A., Biadgo, B., Bijani, A., Bin Sayeed, M. S., … Murray, C. J. L. (2019). Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet Neurology*, *18*(1), 88–106. https://doi.org/10.1016/S1474-4422(18)30403-4

Ntakyo, P. R., Kirunda, H., Tugume, G., & Natuha, S. (2020). *Dry Season Feeding Technologies : Assessing the Nutritional and Economic Benefits of Feeding Hay and Silage to Dairy Cattle in*. 627–648. https://doi.org/10.4236/ojas.2020.103041

Pandey, P., Madhusudhan, M., & Singh, B. P. (2023). Quantitative Research Approach and its Applications in Library and Information Science Research. *Access: An International Journal of Nepal Library Association*, *2*(01). https://doi.org/10.3126/access.v2i01.58895

Pathak, B., Alakkad, M. F., & Kumar, V. (2025). Institutional Environment and the Use of

Blockchain Technology: Exploring the Context and Conditions of Using Blockchain in the Higher Education Institutions. *Higher Education Quarterly*, *79*(3). https://doi.org/10.1111/hequ.70034

Renzaho Ntakyo, P., Kirunda, H., Tugume, G., & Natuha, S. (2020). Dry Season Feeding Technologies: Assessing the Nutritional and Economic Benefits of Feeding Hay and Silage to Dairy Cattle in South-Western Uganda. *Open Journal of Animal Sciences*, *10*(03), 627–648. https://doi.org/10.4236/ojas.2020.103041

Romero-Lopez, A., Ramos, F., Ochoa, C. Y., Mataran, A., Olmo, R. M., Lopez, J. C. F. M., Fuentes-Guerra, R., Givens, G., Dunning, R., Michel-Villarreal, R., Vilalta-Perdomo, E. L., Hingley, M., Ruppen, S., Wolfgramm, B., Scheidegger, R., Bader, H. P., Kiss, K., Ruszkai, C., Szucs, A., … Trestini, S. (2020). MARKET RESEARCH ABOUT AGRISO MOBILE APPLICATION FOR FARMERS. *SUSTAINABILITY*, *12*(1).

Santomauro, D. F., Mantilla Herrera, A. M., Shadid, J., Zheng, P., Ashbaugh, C., Pigott, D. M., Abbafati, C., Adolph, C., Amlag, J. O., Aravkin, A. Y., Bang-Jensen, B. L., Bertolacci, G. J., Bloom, S. S., Castellano, R., Castro, E., Chakrabarti, S., Chattopadhyay, J., Cogen, R. M., Collins, J. K., … Ferrari, A. J. (2021). Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *The Lancet*, *398*(10312), 1700–1712. https://doi.org/10.1016/S0140-6736(21)02143-7

Schmitges, F. W., Radovani, E., Najafabadi, H. S., Barazandeh, M., Campitelli, L. F., Yin, Y., Jolma, A., Zhong, G., Guo, H., Kanagalingam, T., Dai, W. F., Taipale, J., Emili, A., Greenblatt, J. F., Hughes, T. R., Zhou, X., Weeks, S. D., Ameloot, P., Callewaert, N., … Zammit, P. P. S. (2016). Attachment-1 copy 2.jpeg.pdf. *Skeletal Muscle*, *6*(1).

Spiegal, S., Webb, N. P., Boughton, E. H., Boughton, R. K., Bentley Brymer, A. L., Clark, P. E., Collins, C. H., Hoover, D. L., Kaplan, N., McCord, S. E., Meredith, G., Porensky, L. M., Toledo, D., Wilmer, H., Wulfhorst, J. D., & Bestelmeyer, B. T. (2022). Measuring the social and ecological performance of agricultural innovations on rangelands: Progress and plans for an indicator framework in the LTAR network. *Rangelands*, *44*(5). https://doi.org/10.1016/j.rala.2021.12.005

Steinmetz, J. D., Bourne, R. R. A., Briant, P. S., Flaxman, S., Taylor, H. R., Jonas, J. B., Abdoli,

A., Abrha, W. A., Abualhasan, A., Abu-Gharbieh, E., Adal, T. G., Afshin, A., Ahmadieh, H., Alemayehu, W., Alemzadeh, S. A., Alfaar, A. S., Alipour, V., Androudi, S., Arabloo, J., … Vos, T. (2021). Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: The Right to Sight: An analysis for the Global Burden of Disease Study. *The Lancet Global Health*, *9*(2), e144–e160. https://doi.org/10.1016/S2214-109X(20)30489-7

Szymura, M., Świerszcz, S., & Szymura, T. H. (2022). Restoration of ecologically valuable grassland on sites degraded by invasive Solidago: lessons from a 6-year experiment. *Land Degradation and Development*, *33*(12). https://doi.org/10.1002/ldr.4278

Terwilliger, T., & Abdul-Hay, M. (2017). Acute lymphoblastic leukemia: a comprehensive review and 2017 update. *Blood Cancer Journal*, *7*(6). https://doi.org/10.1038/BCJ.2017.53

Van Barneveld, R. J., Dunshea, F. R., Beddhu, S., Filipowicz, R., Chen, X. X.-W. X. X., Neilson, J. L., Wei, G., Huang, Y. C. Y. Y., Greene, T., Loladze, A. V, Stull, M. A., Rowzee, A. M., DeMarco, J., Lantry III, J. H., Rosen, C. J., LeRoith, D., Wagner, K.-U. H., Hennighausen, L., Wood, T. L., … Meng, M. (2019). Bone Health in Gynecologic Cancers-does FOSAVANCE Help? *American Journal of Clinical Nutrition*, *10*(1).

Wilkinson, J. M., Lee, M. R. F., Rivero, M. J., & Chamberlain, A. T. (2020). Some challenges and opportunities for grazing dairy cows on temperate pastures. *Grass and Forage Science*, *75*(1), 1–17. https://doi.org/10.1111/gfs.12458

Wing, C., Simon, K., & Bello-Gomez, R. A. (2018). Designing Difference in Difference Studies: Best Practices for Public Health Policy Research. In *Annual Review of Public Health* (Vol. 39). https://doi.org/10.1146/annurev-publhealth-040617-013507

APPENDICES

Appendix 1: Questionnaire

Section A: Respondent Profile (Demographics)

1. Age (years)

☐ Under 25 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65+

2. Gender

☐ Male ☐ Fe male ☐ Prefer not to say ☐ Other

3. Highest level of education

☐ No formal education ☐ Primary ☐ Secondary ☐ Diploma/Certificate ☐ Bachelor's degree or higher

4. Location

Country/Region: _____

☐ Rural ☐ Peri-urban ☐ Urban

5. Main livestock type(s) (select all that apply)

☐ Cattle (dairy/beef) ☐ Goats/Sheep ☐ Poultry ☐ Pigs ☐ Other: _____

6. Number of livestock owned

☐ <10 ☐ 10-49 ☐ 50-99 ☐ 100-499 ☐ 500+

7. Farm experience (years in livestock farming)

☐ <5 ☐ 5-10 ☐ 11-20 ☐ >20

8. Please share your monthly income from livestock using either your local currency or US dollars. This average monthly income from livestock is important, for our records.

Section B: Mobile Phone and Technology Access

9. Do you own a mobile phone?

☐ Yes (smartphone) ☐ Yes (basic/feature phone) ☐ No

10. Do you have access to the internet on your phone?

☐ Yes, regularly ☐ Yes, occasionally ☐ No

11. How frequently do you use mobile apps?

☐ Daily ☐ Several times a week ☐ Occasionally ☐ Never

12. Which types of mobile apps have you used? (select all that apply)

☐ Weather ☐ Market prices ☐ Banking/Mobile money ☐ Agricultural advisory

☐ social media ☐ None ☐ Other: _____

Section C: Adoption of Livestock Feed Technologies

13. How familiar are you with the following livestock feed technologies? (1 = Not familiar, 5 = Very familiar)

Technology	**1**	**2**	**3**	**4**	**5**
Improved forage/pasture varieties					
Silage/Hay making					
Feed formulation & ration balancing					
Feed quality testing					
Use of crop residues/supplements					
Commercial concentrates					

14. Which of the above technologies have you adopted/used in the last 12 months? (select all that apply)

15. On a scale of 1-5, how important is proper feed management to your livestock productivity?

(1 = Not important, 5 = Extremely important) → ____

16. What are the main challenges you face in adopting better feed technologies? (select all that apply)

☐ High cost ☐ Lack of knowledge/skills ☐ Limited access to inputs/seeds ☐ Labor shortage ☐ Poor market information ☐ Lack of extension services ☐ Other: _____

Section D: Relevance and Importance of a Mobile Phone App

Imagine a phone application created especially to help with animal food technologies (like details about plants for animal food tools to calculate food mixes connections to buy or sell, videos and lessons chat with experts and more).

17.How useful do you think a phone application would be, for helping you use animal food technologies?

(1 = Not 5 = Very useful) → ____

18. Assess how important the following features of the app would be (1 = Not important, 5 = Very important)

Feature	1	2	3	4	5
Educational videos & tutorials					
Feed ration calculator / formulation tool					
Information on improved forage varieties					
Market prices for feeds & inputs					
Weather-based feeding advice					
Connect with extension officers/vets					
Community forum / farmer experiences					
Feed quality testing guidance					
Reminders for planting/harvesting feeds					

19. If this application was available in your language how likely would you be to download and use it? (1 = Very unlikely 5 = likely) → ____

20. What would make you use the application often? (Check all that apply)

☐ Free to use ☐ Available in language ☐ Offline functionality ☐ Training on how to use the application ☐ Testimonials, from other farmers ☐ Integration with existing applications ☐ Other: _____

21.Perceived Ease of Use (1 = Strongly Disagree, 5 = Strongly Agree)

- I would find the app easy to learn and use. → ____
- The app would save me time in managing livestock feeds. → ____
- I trust information provided through a mobile app. → ____

22.Perceived Usefulness (1 = Strongly Disagree, 5 = Strongly Agree)

- Using the app would improve my livestock productivity. → ____
- The app would help me overcome current feed-related challenges. → ____
- A mobile app is one of the best ways to get timely livestock feed information. → ____

Section E: Open-Ended Questions

23. What specific features would you like to see in a livestock feed technology mobile app?

24. What barriers might prevent you from using a mobile app for livestock information?

25. Any additional comments or suggestions?

Section F: Objective Specific Questions

26. Do you have access to information on modern feed technologies (e.g., silage, hydroponic fodder, precision feeding)?

- ☐ Yes
- ☐ No

27. How do you usually receive agricultural information?

- ☐ Extension services
- ☐ Farmer groups/cooperatives
- ☐ Radio/TV
- ☐ Internet/social media
- ☐ Other

28. Do you have access to financial support for farm investments

29. Do you have adequate storage facilities for silage or improved forages?

30. Do you receive regular support from extension officers.

Section G: GPS Coordinates

Latitude:

Longitude:

Appendix 1: Images



Image 1: Weighing hay to determine the daily feed ration

The photograph shows the researcher weighing a bundle of hay using a hanging weighing scale before feeding the cattle. The hay is placed in a container suspended from the scale, while additional hay can be seen in the feeding area. The weighing procedure was carried out during the study to determine and standardize the quantity of hay provided to the cattle each day.



Image 2; Measuring the initial body weight of cattle using heart-girth measurement

The photograph shows the researcher measuring the heart girth of a cow using a measuring tape while the animal is restrained in a cattle-handling facility. The tape is positioned around the animal's chest, behind the forelegs. The heart-girth measurement was taken to estimate the animal's initial body weight, which provided the baseline measurement used to assess subsequent changes in body weight during the feeding trial.