Economics of Dairy Cow Feeding in Ngoma District, Rwanda

Delice Twahirwa

ISSN: 2616-8456

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Economics of Dairy Cow Feeding in Ngoma District, Rwanda

Delice Twahirwa
Research Project, Delaware Valley University

How to cite this article: **Twahirwa, D. (2024). Economics of Dairy Cow Feeding in Ngoma District, Rwanda.** ***Journal of Agriculture & Environmental Sciences*, 8(1), 114-140. https://doi.org/10.53819/81018102t5338**

Abstract

A pair of studies was conducted in the Zaza Sector of Rwanda's Ngoma District to evaluate both smallholder and large-scale dairy production. The research assessed economic viability, caloric output, and production efficiency in smallholder dairies, while evaluating various feeding options for economic feasibility. The smallholder study, conducted on individual farms, involved survey teams measuring milk output and documenting distances traveled for feed and water collection, supplemented by farmer interviews. Concurrently, the large-scale dairy evaluation examined feeding trials across multiple years and systems, consistently using the same 12 cows throughout. The research employed systematic sampling methods, with smallholders selected through linear systematic sampling and the 12 trial cows chosen randomly from those present throughout the study period. Smallholder operations predominantly used two feeding methods: cutting and carrying Napier grass or grazing on unimproved pasture and scrub. In contrast, the large-scale dairy tested six distinct diets for economic viability. Notably, smallholder operations showed minimal variation in milk production between dairy and local Ankole breeds, both averaging under 3 liters per lactating day, while the large dairy achieved yields exceeding 15 liters with certain diets, though with significant variations in production and profitability. The study revealed that smallholders' effective milk yield (365-day average) remained consistent at approximately 1.5 liters per day, regardless of feeding system or breed. Their primary monetary benefit came from calf sales rather than milk production. The caloric analysis showed modest benefits: grazing systems provided a net gain of 235.24 calories, while Napier cut-and-carry systems yielded only 62.63 calories, with many farmers experiencing caloric deficits. The large-scale operation demonstrated that 22-hour daily grazing on improved Brachiaria pasture outperformed five different confinement feeding options in both milk yield and economic returns, even when considering alternative land uses. However, this system's reduced manure collection capability presented a trade-off. The research concluded that while improved pasture systems might not suit smallholders, who could benefit more from confinement options, their primary challenges lie in market access and storage capabilities rather than production methods alone. The study recommends the development of hub dairy systems centered around operations like SACPP to serve as collection and processing points for smallholder milk production, coupled with a systematic supplementary feeding program and cooperative refrigeration facilities, while implementing a pilot program of maize bran supplementation to demonstrate the potential for increased yields through improved nutrition.

Keywords: *Economics, Dairy, Cow Feeding, Ngoma District, Rwanda*

1.0 Background of the Study

The Rwandan dairy sector has historically struggled with poor performance, characterized by low daily milk yields averaging around three liters during lactation and extended calving intervals. Despite substantial investments from both the Government of Rwanda and various donors, and despite optimistic publications suggesting rapid progress in the sector, actual cow performance remains significantly below international standards. This fundamental challenge has persisted even as various initiatives attempt to modernize and improve the industry. Research by Manzi et al. (2020) at Rwanda Agricultural Board stations, where production typically exceeds national averages, revealed concerning statistics about milk production across different cattle breeds. Their findings showed lactation periods ranging from 211 to 258 days, with native cattle producing only 1.5 liters per day during lactation, while mixed and dairy breeds averaged 3 to 3.5 liters. Over full lactation periods, dairy breeds produced 903 liters compared to local Ankole cows' 316.5 liters - both figures falling well below globally acceptable standards.

A comprehensive study by Mazimpaka et al. (2017) in Rwanda's Eastern Province provided further insight into the industry's challenges, documenting milk yields varying from 2.4 liters per day for local cattle to 10 liters for dairy breeds. The study highlighted that while dairy breeds showed higher production potential, they were typically managed under better conditions than local cattle. However, even these better-managed dairy operations struggled with extended calving intervals and low calving percentages, with even dairy breeds achieving less than 65% annual calving rates. Government and NGO initiatives to provide cows to poor families have shown mixed results. Milkovitch (2018) found that cows given through the Girinka program actually performed worse than those owned by non-beneficiaries, primarily due to poor feed quality, high supplement costs, and limited fertility management knowledge. Similar programs by organizations like Heifer International and Send a Cow achieved modest success, with only 25% of recipient households reaching acceptable nutritional levels, and overall nutritional improvements limited to a 3% increase.

Market access and preservation technology represent another significant challenge in Rwanda's dairy sector. The lack of refrigeration facilities forces farmers to either consume or sell their milk within hours of production to prevent spoilage. This limitation results in approximately 30% of produced milk being wasted, according to the Rwanda New Times. The situation has serious public health implications, with Saskia Hendrickx et al. (2023) reporting over 57,000 illnesses and 55 deaths from contaminated dairy products, primarily due to Salmonella contamination. Given these challenges, the study aimed to examine the economic benefits of dairy cattle ownership in Rwanda, focusing specifically on the Ngoma district. The research employed two key metrics: a monetary analysis comparing various feeding regimen costs against cow output using current market prices, and a caloric budget evaluating the energy expenditure required for cattle care against the caloric output from milk production. This dual approach sought to provide a comprehensive understanding of the true costs and benefits of dairy farming in Rwanda's challenging agricultural context.

2.0 Literature Review

The literature review exposed significant challenges in obtaining accurate data on milk production in Rwanda, highlighting a pattern of inconsistency and potential overreporting. "The Dairy Value Chain in Rwanda" (Technoserve 2008) demonstrated this through contrasting studies where milk

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

production estimates varied widely from 0.7 to 3.2 liters per cow per day, as reported in the 2006 Agriculture Survey and 2007 MINAGRI Annual Report respectively. This data reliability issue was emphatically confirmed by Cosmas Ntare of the Rwanda Jersey Cattle Breeders Association, who pointed out widespread inaccuracies in farmer-reported yields. This systematic issue with data collection and reporting makes it difficult to establish accurate baselines for milk production in Rwanda, complicating efforts to measure improvements or assess the effectiveness of various dairy management strategies. The economic and management aspects of dairy farming in Rwanda revealed significant challenges and questionable assumptions about profitability. Mukasafari et al. (2024) studied 156 smallholder farmers, finding that the vast majority (78%) lacked dairy experience, with most practicing zero grazing. While "The Dairy Value Chain in Rwanda" suggested that zero-grazing operations could generate substantial profits of over 5 million RWF annually, mathematical analysis of these claims revealed inconsistencies, as such profits would require unrealistic production levels of 4,630 liters per cow per lactation.

The study also found that farmers generally didn't maintain accurate financial records, making it difficult to assess true profitability. Instead, farmers often gauged success simply by their ability to pay for basic needs like school fees and clothing.Feed management and production emerged as critical challenges, with Mutimura et al. (2015) documenting that 90% of farmers in the Bugesera District relied primarily on crop residues and collected grasses. This opportunistic feeding approach was further complicated by low crop yields, as demonstrated by Rugimbana (2017) using the Aquacrop model, which showed maize yields under 1.5 tons per hectare. Santos et al. (2016) provided important context about maize plant composition and its impact on silage quality, highlighting the challenges of producing adequate quality feed. While the government promoted confined feeding operations suggesting one hectare could support five cows, this claim lacked experimental verification.

The environmental impacts of various dairy systems revealed complex interactions between land use and ecological sustainability. Nambajimana et al. (2019) documented significant soil losses of 10 tons per hectare annually when converting grassland to cropland, while Bashagaluke et al. (2018) quantified substantial nutrient losses through erosion, particularly in maize systems. However, research by Horricks et al. (2019) and Costa et al. (2022) presented promising solutions through Brachiaria grass systems, showing their potential for improved soil health and carbon sequestration. These studies demonstrated that Brachiaria pastures could reduce N2O emissions by a factor of ten compared to degraded native pastures, while matching tropical forests in carbon capture capacity. Lou and Ledgard (2021) provided further support for pasture-based systems, demonstrating their lower carbon footprint compared to confined feeding operations, with New Zealand's predominantly grazing-based dairy industry showing the lowest greenhouse gas emissions per kilogram of milk among developed nations. These findings suggest that well-managed pasture systems might offer a more environmentally sustainable path forward for Rwanda's dairy industry.

3.0 Data Collection Methodology

Study Area

The study was conducted in the Ngoma district of Rwanda's Eastern Province, specifically in the Zaza Sector. Ngoma was one of Rwanda's poorest districts, characterized by low precipitation levels and temperatures higher than most of Rwanda. The district bordered Lake Mugesera, which provided water access for household and cattle use, though most homes were situated at least 0.5 km from the lake due to housing development policies. The area's soils were predominantly Oxisols and Ultisols with some Inceptisols, featuring low cation exchange capacity and requiring careful nutrient management. The district was primarily agricultural, with 93% of the population engaged in farming, though crop yields were lower than in other parts of the Eastern Province. Most farms were small holdings averaging 0.6 hectares, and fewer than one-third of farmers owned cows. The landscape was dominated by cropland rather than grassland, with limited pasture areas consisting mainly of abandoned farmland or communal areas designated by the government.

Smallholder Data Collection

The study's methodology involved a comprehensive data collection effort from 114 randomly selected smallholder farmers, conducted with proper permission from the Umurenge (local government). The research focused on farmers with average holdings under 0.5 hectares, primarily keeping Friesian and Ankole breeds (with indigenous crosses collectively referred to as Ankole). Using a systematic random sampling method, data collection proceeded in two phases: initial farmer interviews exploring cow history, challenges, and estimated milk production, followed by direct observation of milking and feed collection practices the next day. Rwandan surveyors, fluent in Kinyarwanda and experienced in dairy farming, documented actual milk yields, feed collection methods (ranging from farmstead weed collection to kilometers-long journeys for Napier grass), water collection distances, and grazing patterns using standardized record sheets supplemented by anecdotal notes. Several critical issues emerged during the study: artificial insemination proved consistently unreliable, forcing farmers to use local bull services, often delayed until after lactation ended; no smallholders participated in milk collection centers; lack of refrigeration was partially mitigated by boiling milk and extracting ghee for extended shelf life (though this practice wasn't quantified); and cow manure was universally utilized as fertilizer on farm plots, occasionally being sold. This methodology allowed for a thorough documentation of the challenges and practices in smallholder dairy farming while highlighting the significant gaps between farmer-reported and actual milk production data.

SACPP Feeding Data Collection

The SACPP LTD Dairy farm's methodology provides a comprehensive examination of different feeding regimens through detailed record-keeping of 10-35 dairy cows since 2018. The study tracked twelve Friesian or Jersey cross cows through various feeding systems, from confined operations to 22-hour grazing on Brachiaria pasture, with data collected over four-week periods for each feeding system. The farm maintained meticulous records of daily milk production and feeding patterns, with milk being sold both to the local community in the evenings and to a bulk buyer in the mornings at consistent prices. Despite lacking chilling facilities, milk waste remained below 1%, though some milk was allocated to calf feeding. The farm abandoned artificial insemination due to low success rates (under 20%) in favor of using a cover bull, which improved calving intervals to 12-12.75 months. The operation maintained strict milking schedules twice daily at 5:00 am and 4:00 pm, using hand milking despite having machine capability, due to solar power limitations and employment considerations.

The farm implemented three distinct feeding regimens: fully confined feeding in a roofed barn with chopped feeds and supplements, partially confined feeding with 6-hour pasture access, and a predominantly grazing system on improved Brachiaria pasture. The forage options were diverse, including native pastures, maize and sorghum silage, Napier grass (both farm-grown and purchased), oat hay, fresh sorghum, and pearl millet. The improved pastures utilized two varieties of Brachiaria: Mulatto 2 (a hybrid combination of Urochloa species) and Urochloa humidicola, known for its biological nitrate inhibition properties. Economic analysis considered both direct feed costs and by-product value, including manure used for fertilizer and biogas production. The confined system allowed for complete manure collection through a concrete floor drainage system, while the grazing system relied on natural nutrient cycling within the paddocks, benefiting from the Brachiaria humidicola's nitrogen retention properties, though this benefit was more difficult to quantify.

4.0 Results

Smallholder Data

The research methodology encompassed a comprehensive data collection effort from over 100 smallholder farmers, where researchers directly measured milk production during morning and evening milkings and accompanied farmers to document feed and water collection distances. While calving intervals could be approximated based on farmers' recollections of last births, lactation periods were less precisely defined, often described in seasonal terms, leading the author to standardize the period to 220 days based on farmer accounts and existing literature. The study employed correlation analysis examining eight key variables: cow breed (including Friesian, local mixed breeds, and Jersey), feed collection distances, water procurement distances, daily milk production during the 220-day lactation period, feeding systems (encompassing Napier grass cut-and-carry, unimproved pasture grazing, and weed feeding), caloric expenditure in feed collection, daily caloric yield, and net caloric balance. This matrix analysis was designed to uncover both the existence of relationships between variables through correlation coefficients and their practical significance through magnitude assessment, providing a comprehensive understanding of the interplay between feeding methods, resource allocation, and dairy productivity in smallholder farming systems.

https://doi.org/10.53819/81018102t5338

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Table 1: Smallholder Correlation Matrix.

	Correlation Matrix							
	Cow Breed	*Distance for food*	*Distance for feed and water*	*Milk Produced daily during lactation*	*Feeding system*	*Calories burned gathering feed daily*	*Effective milk production in calories*	*net caloric gain/deficit*
Cow Breed	1							
Distance for food	-0.15627942	1						
Distance for feed and water	-0.20884899	0.983231321	1					
Milk Produced daily during lactation	-0.156864453	-0.098315531	-0.069156764	1				
Feeding system	-0.059476319	0.190076172	0.216846228	0.289145483	1			
Calories burned gathering feed daily	-0.20884899	0.983231321	1	-0.069156764	0.216846228	1		
Effective milk production in calories	-0.156864453	-0.098315531	-0.069156764	1	0.289145483	-0.069156764	1	
net caloric gain/deficit	-0.034154373	-0.549238627	-0.532441841	0.881261937	0.142605779	-0.532441841	0.881261937	1

The correlation analysis revealed key insights into the relationships between various factors affecting dairy production in smallholder farms. Net caloric impact was most strongly correlated with two primary variables: milk production and the distance traveled to collect feed, while milk production itself showed the strongest correlation with feeding systems and a weaker correlation with cow breed, potentially indicating that feed quality was a limiting factor rather than genetic potential. Among the 114 samples studied, 96% utilized either Cut and Carry Napier or grazing systems, with only four cows on exclusive weed and crop residue diets and a single cow receiving supplemental feed. Statistical analysis demonstrated that milk production levels were remarkably similar between Napier cut and carry and grazing systems, both yielding slightly below 3 liters per day, with a P Value of 0.8408 indicating no statistically significant difference between these methods. Notably, the single supplemented cow emerged as a significant outlier, suggesting the potential impact of improved nutrition on milk production, though this single data point serves more as an indicator for future research direction than a conclusive finding. The overall results indicate that the two predominant feeding systems were equally ineffective at optimizing milk production, pointing to systemic issues in feed quality and management across both approaches.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

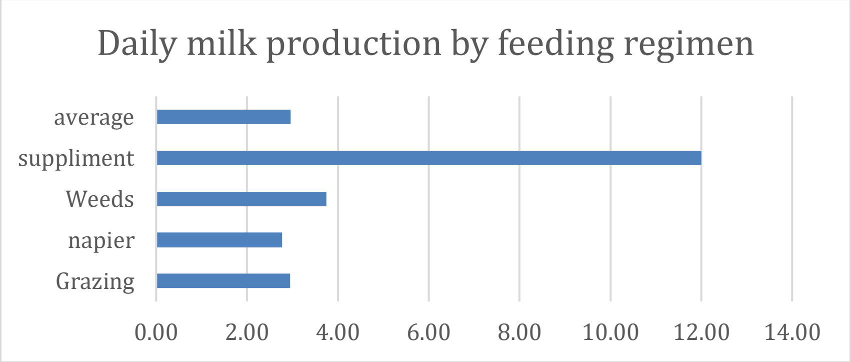

Figure 1: Milk Production by Feeding Method

Cow Breed

As mentioned previously, the cow breeds were dominated by Fresian and Ankole Many cows are crossed between Fresian and Ankole, they were labeled as one or the other based on their general phenotype. There were 3 jersey cows in the sample, that sample size was small enough that it was excused from this analysis. Table 2 shows the mean, standard deviation, and sample size for the two cattle "breeds". The Friesians on average gave 11% more milk than the Ankole. This is in line with correlation matrix which indicated a low correlation between breed and milk production. The P value of 0.2954 indicates the difference is truly insignificant, Friesian cows have a greater potential to produce milk, but the feeding systems in place have not taken advantage of the genetic potential.

Table 2: Smallholder Milk Yield by Breed Significance

Milk Yield by Breed and Significance	
Ankole	
Mean	2.53
Standard Deviation	1.0742546
Sample Size	30
Friesian	
Mean	2.82
Standard Deviation	1.347269511
Sample Size	75
Results of the Comparison	
Difference	0.29
Standard error	0.276
95% CI	-0.2568 to 0.8368
t-statistics	1.052
DF	103
Significance level	P=0.2954

Effective Milk Yield

The effective milk yield is the estimated average daily milk output for a cow. This is computed from the estimated number of lactation days, considers calving interval, and the milk yield during lactation. Note: a deficiency in the study is that only farmers with cows giving milk were selected. These results ignore the cows that did not calve. As mentioned in the literature review, studies have demonstrated that calving percentages tend to be quite low. Determining effective milk yield needs a more focused study to produce an accurate and precise number. The caloric exertion has to be measured against both lactation and dry days during the year. The calving interval averages 410 days, and lactation is estimated at 220 days. When adjusted to Effective milk yield across the 410-day cycle, milk production in both primary systems is close to 1.5 liters per day.

Table 3: Effective Milk Yield by System

Feeding system	Milk yield during lactation	Effective milk yield for full cycle 410-day
Napier cut and carry	2.77	1.49
Grazing	2.95	1.58

Farmers who use a cut and carry feeding system average an average of 1 Km further in feed and water collection than do those grazing. In part this is due to fewer trips to collect water, it also reflects that grazing cows are often pooled and grazed together. Based on effective milk yield, and the caloric output for feed collection, net caloric balance shows a caloric benefit of 235.24 calories for grazing systems and 62.63 calories for Napier Cut and Carry Systems.

Table 4: Net Caloric Benefit

Feeding system	Av distance travelled by farmer for feed/water	Calories Burned collecting/managing feeds	Effective milk yields calories /day	Net AV for daily caloric benefit
Grazing	3.78	453.50	688.74	235.24
Napier cut and carry	4.87	584.90	647.54	62.63

The calculations thus far have not considered waste. It is estimated in other studies as 30%, however lower production leads to lower waste since consumption is rapid. A 10% waste level would put the Cut and Carry system into a Net negative average caloric benefit. Isolation of the variables Net caloric benefit, daily milk production during lactation, and distance traveled to provide feed and water for the cow was input into a correlation matrix (table 5). Net caloric benefit showed a negative relationship to distance traveled for feed collection and a positive relationship to milk yield.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Table 5: Correlation Matrix of Distance for Feed Collection and Caloric Benefit

Correlation Matrix			
	Distance traveled for cow feeds and water	Daily milk production during lactation	Caloric benefit
Daily milk production during lactation.	1		
Daily milk during lactation	-0.069156764	1	
Caloric Benefit	-0.532441841	0.88126194	1

Figure 2

A graphical representation of the daily caloric benefit or deficit for the smallholder farmers based on Effective Milk yield, and calories consumed in feed and water collection. 53 of 114 samples are shown to be at break even or in a deficit situation.

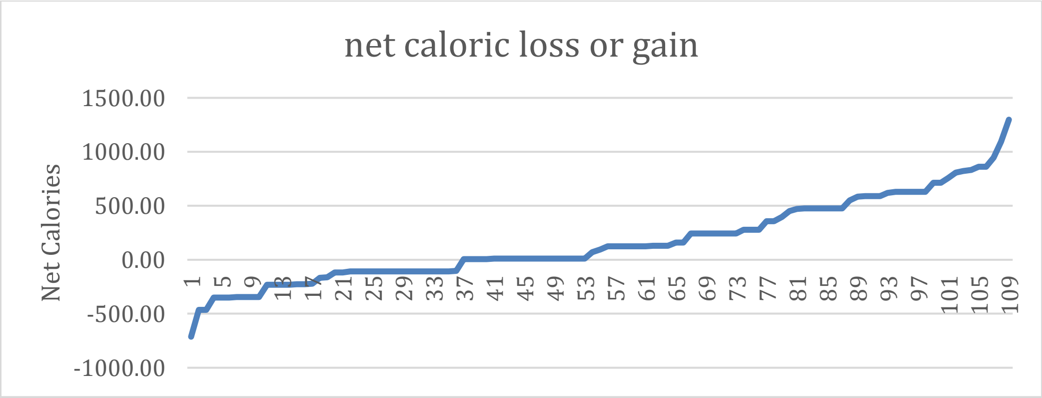

Figure 2: Daily caloric benefit or deficit for the smallholder farmers

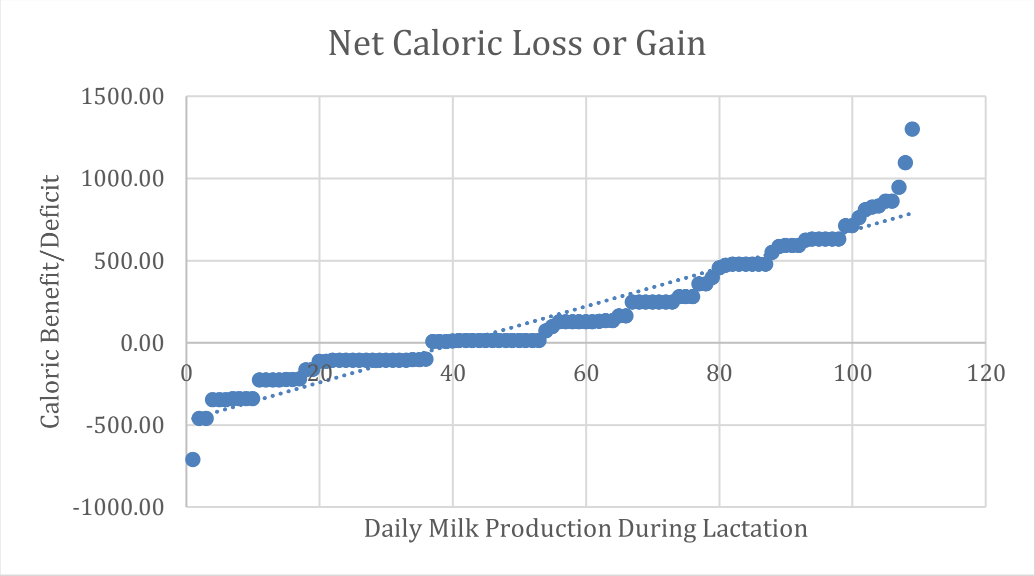

Figure 3: The linear relationship between milk production and caloric benefit

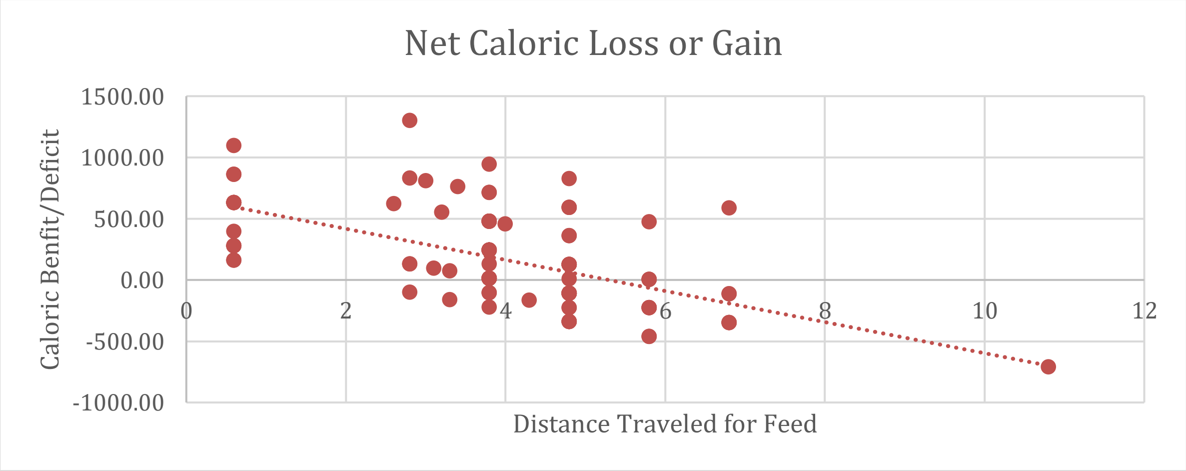

Figure 4: Negative impact distance traveled has on caloric benefit.

The figures reinforce the data from the correlation matrices, showing a stronger correlation between milk yield and caloric benefit and a lesser correlation but still meaningful relationship with distance traveled. The correlation between Caloric benefit/deficit and milk production and distance traveled for feed was supported by the fact that both interactions have had a P value $< .05$. The data shows differences in milk production from the various feeding regimens; however, these differences are small enough to be of little significance. All yields are low, with effective milk production in the 1.5 liters per day area.

Smallholder Cow Ownership Economic Analysis

The economic analysis of smallholder dairy operations revealed a complex picture of costs and returns, primarily based on anecdotal data due to limited record-keeping practices among farmers. The main outputs were milk and calves, with milk production predominantly serving household

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

consumption rather than commercial sales (less than 5% of farmers sold milk regularly, and none supplied collection centers), despite a local market value of 300 RWF per liter. Input costs included veterinary services (estimated at 10,000 RF annually), breeding fees (2,000 RF per cow), salt purchases (2,000 RF), and occasional insurance premiums. While calf survival was estimated at 80% with sales averaging 125,000 RF per calf, calculations suggested an annual monetary benefit of 86,000 RF per cow. However, this figure requires careful interpretation as it only considered lactating cows and didn't account for the overall calving rate, which according to Mazimpaka et al.'s study in Nyagatare District was below 50% in local mixed cattle, suggesting the actual economic returns might be significantly lower when considering the entire cattle population.

Table 6: Smallholder Monetary Returns From Cow Ownership

Income	FR
Milk sales	0RF
Calf sale	100,000 RF
Total income	100,000 RF
Expenses	
Feed	2,000 RF
Breeding	2,000 RF
Veterinary	10,000 RF
Insurance	O RF
Total expense	14, 000 RF
Net	86,000 RF

The economic and nutritional analysis of dairy farming in Ngoma district reveals a complex interplay of factors affecting smallholder decisions. In a region where protein deficiency is common and dairy programs aim to improve children's nutrition, the economic calculations present challenging dynamics: a cow valued at 350,000 RF yields approximately 146,890 RF annually through milk production (2.5 liters daily over 220 lactating days in a 410-day cycle), resulting in a 2.4-3 year payback period without accounting for additional expenses. While farmers could theoretically benefit more calorically from selling milk to buy maize (250 RWF per kg providing 3,840 calories), this would contradict the nutritional goals of dairy programs. The opportunity cost analysis is further complicated by the district's predominantly agricultural economy (93% farmers, mostly subsistence-level) with minimal off-farm employment options, making the 4-hour daily investment in cow care relatively reasonable except during peak farming seasons when cattle care typically suffers. Decision-making is heavily influenced by practical challenges (banking difficulties, risks of holding cash in poor areas) and cultural factors (cows as symbols of wealth and status in Rwandese society), making livestock retention a priority despite potentially suboptimal economic returns.

Manure

An ancillary product from the cows is manure. The current price of manure in Ngoma District is 80,000 RF per 12-ton truckload. This gives a value of 6.7 RF per Kg, wet weight on the market. Most farmers in the survey area use the manure produced by the cows on their crop, but none who were queried had quantified the increase in yield. Assuming the manure value to the farmers as the market price and assuming the ability to capture 6 kg of manure daily, the confined cows

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

produce an additional value stream worth 15,000 RF annually. Farmers are known also to scoop dirt from the floor of cow housing areas, and use it interchangeably with manure. They are taking advantage of the nutrients deposited in the soil by the cow's urine. The confinement operations could take advantage of manure production, including Napier Grass cut and carry and weed feeding operations. The grazing cows deposit a large portion of their manure and urine off the farm. If this is estimated as half the manure and urine it lowers the value of the product by 7,500 RF annually.

Takeaways from the Small Holder Survey

The key findings from the smallholder dairy study revealed several interconnected challenges. Milk yields were consistently low across all cow varieties, with the correlation matrix showing minimal variation between breeds, while the widespread rejection of artificial insemination in favor of local bull services (primarily Ankole) suggested future genetic dilution of dairy traits. Despite farmers' awareness of these challenges and their eager participation in the study, the economic returns from cow ownership proved minimal or non-existent in most cases, though 60% of farmers showed at least a marginal caloric benefit from milk production alone, with additional nutritional benefits possible when calf sale income was directed toward food purchases. While the SACPP feeding trial demonstrated potential benefits of supplementation, the implementation of such strategies faced practical barriers among subsistence farmers lacking cash resources, creating a circular challenge where improved production through supplementation could theoretically generate sellable surplus milk, but the initial investment remained beyond farmers' means.

SACPP Feeding Trial

Input Pricing

The SACPP dairy operation's economic analysis of different feeding systems revealed detailed cost structures across various inputs and methods. Maize production costs were 1,030,832 RF per hectare in 2023, with similar input costs whether harvested as grain or silage, though silage production incurred additional expenses including labor (4,500 RWF per person per day), silage bags (14,000 RF per bag holding one wet ton), and hand processing labor (900 RF per ton). While improved pasture systems eliminated the need for regular herding, they required night security at 4,500 RWF per night (equating to 150 RF per cow daily), and all feeding systems maintained consistent veterinary costs and mineral supplementation. The study noted that while economies of scale were important across all feeding options, their impact was most significant in grazing systems, with cow numbers maintained consistently across all feeding regimens for comparative purposes.

Table 7: List of Feed Prices

List of feed sources, prices, and cost of production.	
Feed Sources	Price (dry/ Kg)
Napier Grass	15RF
Fish meal	2,300 RF
Ground Maize	250 RF
Maize Bran	80 RF
Sunflower Seeds	250 RF
Soya	750 RF
Oil Extracted Soya	350 RF
Sorghum Forage	15 RF
Oat hay	15 RF
Maize Forage	20 RF
Pear Millet Forage	12 RF
Sorghum Silage	30 RF
Maize Silage	40 RF

Brachiaria Pasture has an establishment cost as well as maintenance expenses for fencing, weeding, etc. It also requires a night watchman. The aggregate cost per cow per day is 200 RF. The various diets fed to the cattle. The first 5 diets were confinement feeding systems, Diet 6 was using improved pasture, and the average daily milk production was fed.

Table 8: Various diets fed to the cattle.

	Diet1	Diet2	Diet3	Diet4	Diet5	Diet6	
Ground maize	5.85	5.94	6.31	6.19	6.25	0.00	
oats	0.00	0.00	6.33	0.42	0.00	0.00	
Napier grass	18.08	18.08	14.83	20.75	19.88	0.00	
Bracharia pasture	0.00	0.00	0.00	0.00	0.00	22hrs	
Soya	1.28	1.16	0.72	0.65	0.51	0.00	
Sunflower	0.16	0.17	0.16	0.13	0.06	0.00	
Fresh Sorghum	0.04	0.00	0.00	0.00	0.00	0.00	
Fresh maize	2.63	0.00	0.00	0.00	0.00	0.00	
Oil Soya	0.11	0.53	0.83	0.84	0.41	0.00	
Fish Meal	0.000	0.00	0.00	0.00	0.00	460.00	
Maize Bran	0.00	0.00	0.00	0.00	0.00	483.33	
millet	0.00	0.00	0.00	0.00	7.50	0.00	
Sorghum silage	0.00	7.48	0.00	0.00	0.00	0.00	
Maize silage	0.00	0.00	0.00	8.73	0.35	0.00	
Average daily milk production in litres	8.59	9.74	9.96	9.85	9.85	14.95	

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Table 9 shows the expenses, and associated costs for each cow diet included in the trial. The total cost for each diet is calculated. The chart also shows the average diet cost and the percentage difference from the mean of each diet.

Table 9: Expenses, and associated costs for each cow diet included in the trial

	Diet1	Diet2	Diet3	Diet4	Diet5	Diet 6
Ground maize	1463.54	1484.38	1576.39	1546.88	1562.50	0.00
outs	0.00	116.88	95.00	6.25	0.00	0.00
Napier grass	271.25	200.63	222.50	311.25	298.13	0.00
Bracharia	0.00	0.00	0.00	0.00	0.00	200.00
Soya	960.94	960.94	541.67	484.38	378.92	0.00
Sunflower	39.06	39.06	39.93	32.55	14.32	0.00
Fresh sorghum	0.63	0.63	0.00	0.00	0.00	0.00
Fresh Maize	52.50	52.50	0.00	0.00	0.00	0.00
Oil Soya	40.10	40.10	291.67	295.31	142.19	0.00
Fish meal	0.00	0.00	0.00	0.00	0.00	460.00
Maize bran	0.00	0.00	0.00	0.00	0.00	483.33
Millet	0.00	0.00	0.00	0.00	90.00	0.00
Sorghum silage	0.00	0.00	0.00	0.00	0.00	0.00
Maize Silage	0.00	0.00	0.00	0.00	0.00	0.00
Daily feed cost	2,828RF	2.897RF	2,677RF	2,677RF	2,487FR	1,143RF
% difference from Mn cost	9.950	12.33	2.67	1.42	13.49	12.40
Average Cost					2,466RF	

There is not a statistically significant difference between milk production using Diets 1-5. (see Table 10), Diet 6, however, demonstrates 50% greater milk production than the average. This is in line with the studies on Brachiaria sp. such as "Milk production and ingestive behavior of cows grazing on Marandu and Mulato II pastures under rotational stocking" (Demski et al 2019). This study in Brazil showed similar milk yields to this study on Brachiaria Mulatto 2 variety pastures. Significantly similar feeding results would suggest that production costs per liter be within 20% of the mean or less. The standard deviation for the feed trial is 89.32. The results show a standard deviation of 36% of the mean. If Diet 6 is removed from the data set standard deviation falls to 28.88, a standard deviation of 10% of the mean.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Table 10: Standard Deviation of Milk Production Costs across Diets

Standard Deviation based on Milk Production cost/Diet
s =
89.31904
Variance
s^2 =
7977.891
samples
6
Mean
250.89
Sum of Squares
39889.455

The cost of production of each liter of milk for each diet was calculated and shown in the table. Also included is income from milk sales after subtracting feed expenses, this incorporates milk yield.

Table 11: The cost of production of each liter of milk for each diet was calculated and shown in the table

	Income after feed expenses				
	Daily feed cost	Avg Milk Production	Income after feed expense/cow	Cost per liter	Percentage difference from mean cost
Diet 1	2,828 RF	8.59	177 RF	329.36 RF	24%
Diet 2	2,897 RF	9.74	514 RF	297.28 RF	16%
Diet 3	2,767 RF	9.96	719 RF	277.82 RF	10%
Diet 4	2,677 RF	9.85	769 RF	271.87 RF	8%
Diet 5	2,486 RF	9.85	960 RF	252.51 RF	1%
Diet 6	1,143 RF	14.95	4,088 RF	76.50 RF	70%
			Average	250.89 RF	

Figure 5

A graphical representation of income after expenses, alongside daily feed costs for each diet.

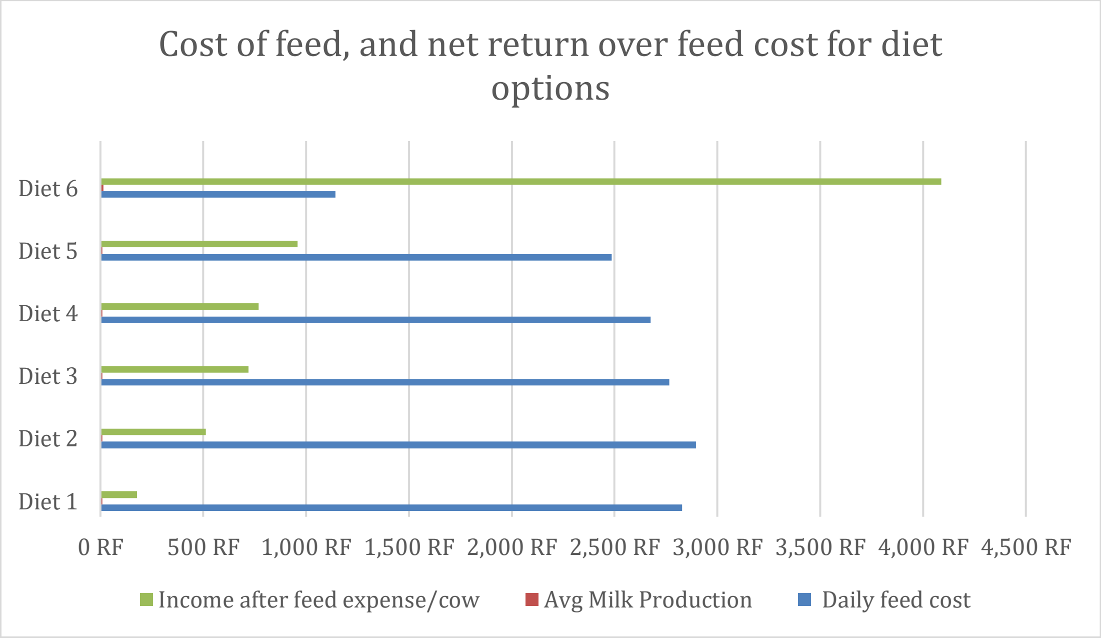

Figure 5: A graphical representation of income after expenses, alongside daily feed costs for each diet

Note in the figure that the green line represents a net return after feed cost. All show a return over feed expenses. Not surprising is that as feed costs elevate, the net return decreases. This difference is exacerbated by the increased milk yield in diet 6. It can be argued that the feed costs are elevated for Diets 1-5 since they fed ground maize at 250 RF per kg, rather than maize bran at 80 RF per kg. Substituting maize bran for ground maize would be expected to give similar milk yields in diets 1-5. Making the substitution changes income after feeds lowered feed costs by 35% on average. Excepting the Brachiaria grazing system. This brought feed costs closer in terms of cost; however, the Improved Pasture diet still had double the income per cow when compared with the highest-producing alternative diet.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Table 12: Feed costs projection if maize bran was substituted for ground maize in all diets.

	Income after feed expenses substituting Maize Bran for ground maize				
	Daily feed cost	Avg Milk Production	Income after feed expense/cow	Cost per liter	Percentage difference from mean cost
Diet 1	1,833 RF	8.59	1,172 RF	213.46 RF	25%
Diet 2	1,887 RF	9.74	1,523 RF	193.69 RF	17%
Diet 3	1,695 RF	9.96	1,791 RF	170.20 RF	6%
Diet 4	1,625 RF	9.85	1,821 RF	165.03 RF	3%
Diet 5	1,424 RF	9.85	2,022 RF	144.59 RF	10%
Diet 6	1,143 RF	14.95	4,088 RF	76.50 RF	52%
			Average	160.58 RF	

Ground maize was included in the diets except Diet 6. The table above is a projection of substituting maize bran for ground maize. This is an area that may need additional study. In this projection, daily feed costs dropped which made the dairy operation much closer to economically viable with diets 1 through 5. However, milk production cost per liter was still twice the cost of diet 6.

Discussion of SACPP Data

The SACPP feeding trial demonstrated clear advantages for Diet 6 (improved Brachiaria pasture system) in terms of both production costs and milk yield. While feed-based economics were primary considerations, the value of calves (selling at 200,000 RF at 8 months) provided additional revenue to offset costs. The land requirements varied significantly between systems: Brachiaria grazing required one hectare per five cows, silage systems needed one hectare per three cows, while Napier-dependent systems had lower direct land requirements but relied on external purchases. When comparing opportunity costs, Diet 6 generated 6,132,000 RF per hectare annually, surpassing the combined returns of alternative crops (French Beans at 2,936,395 RF and Maize at 2,345,000 RF per hectare). SACPP's triple-bottom-line approach considered economic, social, and environmental impacts. While the Maize and Bean rotation provided higher community wages (769,620 RF versus 584,500 RF for dairy), the dairy operation offered additional benefits as a potential hub for smallholder milk marketing. Diet 6's improved pasture system showed superior environmental performance through reduced erosion, enhanced nutrient cycling, increased carbon sequestration, and decreased pesticide use, though these benefits were challenging to quantify in monetary terms. Manure management represented another significant consideration in the feeding systems comparison. Confined feeding systems (Diets 1-5) facilitated manure collection through concrete floor drainage systems, generating approximately 30 tons monthly, valued at 200,000 RF per month or 60,000 RF annually per cow. While Diet 6's grazing system limited collectible manure to small amounts for biogas production, the Brachiaria pasture's biological nitrification inhibition properties enabled efficient nutrient cycling within the system. Though confinement systems offered more flexibility in manure allocation across crops, the grazing system's integrated nutrient cycling provided substantial environmental benefits despite reduced manure collection potential.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

5.0 Conclusion

The study concludes that smallholder dairy operations in Rwanda's Ngoma district face significant challenges, with effective milk yields averaging only 1.5 liters per day and 27% of farmers experiencing caloric deficits from cow management activities. While the smallholder operations showed minimal income from milk sales and struggled with issues of feed collection, market access, and limited refrigeration capacity, the analysis revealed that when considering manure value and calf sales, cow ownership still provided net benefits to farmers. However, the contrast with SACPP's commercial operation, which achieved up to 14.5 liters per day using improved pasture systems, highlighted the potential for increased productivity through better feeding practices and management. The research identified several potential pathways for improvement, including the possibility of smallholder land aggregation to achieve economies of scale, the development of hub dairy concepts, and cooperative refrigeration systems. SACPP's success with Brachiaria pasture systems demonstrated both economic and environmental benefits, though implementation of such systems at the smallholder level faces significant barriers including land constraints and risk aversion among subsistence farmers. The study proposes several immediate actions, including a pilot program by SACPP to supplement 20 smallholder cows with maize bran, and emphasizes the need for further exploration of market access solutions, hub dairy concepts, and milk waste mitigation strategies to bridge the significant productivity gap between smallholder and commercial operations.

6.0 Recommendations

The study recommends that immediate interventions should focus on addressing the critical barriers facing smallholder dairy farmers in the Ngoma district. A hub dairy model, with SACPP or similar commercial operations serving as central collection and processing points, could provide a viable solution to the market access and refrigeration challenges currently limiting smallholder productivity. This approach should be coupled with a systematic supplementary feeding program, similar to SACPP's planned pilot with 20 smallholder cows, to demonstrate the potential for increased milk yields through improved nutrition. Furthermore, cooperative ownership of refrigeration facilities should be explored as a means to aggregate milk from multiple smallholders, making collection more attractive to brokers and potentially enabling value-added processing. The proposed trade system of milk for maize bran could provide a practical solution to the challenge of supplement affordability for subsistence farmers. For longer-term development, the study recommends exploring the potential for smallholder land aggregation, where groups of approximately 14 farmers could combine their half-hectare holdings to support more efficient dairy operations modeled after SACPP's successful Brachiaria pasture system. However, this approach must carefully consider the high opportunity costs of land use and incorporate risk mitigation strategies for participating farmers. Additionally, efforts should be made to improve the genetic potential of smallholder herds through better access to quality bull service, given the widespread failure of artificial insemination programs. These recommendations should be implemented with careful consideration of the subsistence farmers' risk tolerance and immediate food security needs, potentially phasing in improvements gradually to allow for adaptation and proof of concept. The successful implementation of these recommendations could transform smallholder dairy operations from marginally profitable enterprises into significant contributors to household income and nutrition.

REFERENCES

Beyi, A. F., & Dahl, G. (2016). Rwanda: Animal Source Foods Production and Marketing Brief. Gainesville, FL, USA: Feed the Future Innovation Lab for Livestock Systems.

Bishop, H., & Pfeiffer, D. U. (2007). Factors affecting reproductive performance in Rwandan cattle. Tropical Animal Health and Production, 40(3), 181–184. https://doi.org/10.1007/s11250-007-9078-1

Bucagu, C., Ndoli, A., Cyamweshi, A. R., Nabahungu, L., Mukuralinda, A., & Smethurst, P. J. (2020). Determining and managing maize yield gaps in Rwanda. Food Security, 12(6), 1269–1282. https://doi.org/10.1007/s12571-020-01059-2

Characterization of cattle production systems in Nyagatare District of Eastern Province, Rwanda. (n.d.). https://www.omicsonline.org/open-access/characterization-of-cattle-production-systems-in-nyagatare-district-ofeastern-province-rwanda.pdf

Climate Data Library. (n.d.). Available at: http://maproom.meteorwanda.gov.rw/maproom/Climatology/index.html (Accessed: 17 March 2024).

Colverson, K. E. (2018). Increasing the Health and Nutritional Outcomes of the Government of Rwanda's "One Cow per Poor Family" Program from a Gender Perspective. Food Studies, 8(2), 31–44. https://doi.org/10.18848/2160-1933/cgp/v08i02/31-44

Community participation and performance of One Cup Milk per Child program in Rwanda; a case of selected school-based Early Childhood Developments in Gicumbi District. (2023). Journal of Education, 6(1), 91–114. https://doi.org/10.53819/81018102t5183

Costa, C., Villegas, D., Bastidas, M., Matiz-Rubio, N., Rao, I. M., & Arango, J. (2022). Soil carbon stocks and nitrous oxide emissions of pasture systems in Orinoquía region of Colombia: Potential for developing land-based greenhouse gas removal projects. Frontiers in Climate, 4. https://doi.org/10.3389/fclim.2022.916068

D'Andre, H. C., Kugonza, D. R., Murekezi, T., Rwemarika, J. D., Kayitesi, A., Musemakweri, A., Shabayiro, J. P., Shumbusho, F., Manzi, M., & Safari, T. (2017). Management and phenotypic features of indigenous cattle in Rwanda. International Journal of Livestock Production, 8(7), 95–112. https://doi.org/10.5897/ijlp2017.0362

Dessie, G. (2011). Eucalyptus in East Africa: Socio-economic and environmental issues. Research Papers in Economics. https://www.fao.org/docrep/014/am332e/am332e00.pdf

Demski, J. B., Arcaro, I., De Andrade Gimenes, F. M., De Toledo, L. M., Miranda, M., Giacomini, A. A., & Da Silva, G. A. (2019). Milk production and ingestive behavior of cows grazing on Marandu and Mulato II pastures under rotational stocking. Revista Brasileira de Zootecnia, 48. https://doi.org/10.1590/rbz4820180231

De Vries, A., Kaylegian, K., & Dahl, G. E. (2020). MILK Symposium review: Improving the productivity, quality, and safety of milk in Rwanda and Nepal. Journal of Dairy Science, 103(11), 9758–9773. https://doi.org/10.3168/jds.2020-18304

Habiyaremye, N., Ouma, E. A., Mtimet, N., & Obare, G. A. (2021). A review of the evolution of dairy policies and regulations in Rwanda and its implications on inputs and services delivery. Frontiers in Veterinary Science, 8. https://doi.org/10.3389/fvets.2021.611298

Holka, M., & Bieńkowski, J. (2020). Carbon Footprint and Life-Cycle Costs of maize production in Conventional and Non-Inversion tillage systems. Agronomy, 10(12), 1877. https://doi.org/10.3390/agronomy10121877

Horrocks, C., Arango, J., Arévalo, A., Núñez, J., Cardoso, J. A., & Dungait, J. A. J. (2019). Smart forage selection could significantly improve soil health in the tropics. Science of the Total Environment, 688, 609–621. https://doi.org/10.1016/j.scitotenv.2019.06.152

Kamanzi, M., & Mapiye, C. (2012). Feed inventory and smallholder farmers' perceived causes of feed shortage for dairy cattle in Gisagara District, Rwanda. Tropical Animal Health and Production, 44(7), 1459–1468. https://doi.org/10.1007/s11250-012-0087-3

Luo, J., & Ledgard, S. (2021). NEW ZEALAND DAIRY FARM SYSTEMS AND KEY ENVIRONMENTAL EFFECTS. Frontiers of Agricultural Science and Engineering, 8(1), 148. https://doi.org/10.15302/j-fase-2020372

MacMillan, S. (2016, December 19). Secrets of Brachiaria: An African pasture grass holds enormous promise for reducing greenhouse gases. IORI Clippings. https://clippings.ilri.org/2013/09/15/secrets-of-brachiaria-an-african-pasture-grass-holds-enormous-promise-for-reducing-greenhouse-gases/

Manzi, M., Rydhmer, L., Ntawubizi, M., Hirwa, C. D., Karege, C., & Strandberg, E. (2020). Milk production and lactation length in Ankole cattle and Ankole crossbreds in Rwanda. Tropical Animal Health and Production, 52(6), 2937–2943. https://doi.org/10.1007/s11250-020-02311-9

Manzi, M., Rydhmer, L., Ntawubizi, M., Karege, C., & Strandberg, E. (2018). Reproductive performance of Ankole cattle and its crossbreds in Rwanda. Tropical Animal Health and Production, 51(1), 49–54. https://doi.org/10.1007/s11250-018-1658-8

Mazimpaka, E., Mbuza, F., Tukei, M., Gatari, E. N., Bukenya, E. M., & Okwee-Acai, J. (2017). Current status of the cattle production system in Nyagatare District-Rwanda. Tropical Animal Health and Production, 49(8), 1645–1656. https://doi.org/10.1007/s11250-017-1372-y

Mazzetto, A. M., Falconer, S. J., & Ledgard, S. F. (2022). Mapping the carbon footprint of milk production from cattle: A systematic review. Journal of Dairy Science, 105(12), 9713–9725. https://doi.org/10.3168/jds.2022-22117

Mukasafari, M. A., Mpatswenumugabo, J. P., Ndahetuye, J. B., Wredle, E., & Båge, R. (2024). Management factors affecting milk yield, composition, and quality on smallholder dairy farms. Research Square (Research Square). https://doi.org/10.21203/rs.3.rs-3841728/v1

Mutimura, M., Ebong, C., Rao, I. M., & Nsahlai, I. (2015). Nutritional values of available ruminant feed resources in smallholder dairy farms in Rwanda. Tropical Animal Health and Production, 47(6), 1131–1137. https://doi.org/10.1007/s11250-015-0839-y

Mutimura, M., Lussa, A., Mutabazi, J., Myambi, C., Cyamweshi, R. A., & Ebong, C. (2013). Status of animal feed resources in Rwanda. Tropical Grasslands - Forrajes Tropicales, 1(1), 109. https://doi.org/10.17138/tgft(1)109-110

National strategy for transformation. (n.d.-a). English. Available at: https://vision2050.minecofin.gov.rw/ (Accessed: 17 March 2024).

Ngango, J., & Hong, S. (2022). Assessing production efficiency by farm size in Rwanda: A zero-inefficiency stochastic frontier approach. Scientific African, 16, e01143. https://doi.org/10.1016/j.sciaf.2022.e01143

Ngaruye, I., Nzabanita, J., Niragire, F., Rizinde, T., Nkurunziza, J., Ndikubwimana, J. B., Ruranga, C., Kabano, I., Muhoza, D. N., & Ahishakiye, J. (2023). Child stunting prevalence determination at sector level in Rwanda using small area estimation. BMC Nutrition, 9(1). https://doi.org/10.1186/s40795-023-00806-w

Ngoma - ruanda: Daten und Statistiken. (n.d.). Knoema. Available at: https://knoema.de/atlas/Ruanda/Ngoma (Accessed: 17 March 2024).

Niyonzima, Y. B., Strandberg, E., Hirwa, C. D., Manzi, M., Ntawubizi, M., & Rydhmer, L. (2022). The effect of high temperature and humidity on milk yield in Ankole and crossbred cows. Tropical Animal Health and Production, 54(2). https://doi.org/10.1007/s11250-022-03092z

Nyabinwa, P., Kashongwe, O. B., Hirwa, C. D., & Bebe, B. O. (2020). Influence of endometritis on milk yield of zero-grazed dairy cows on smallholder farms in Rwanda. Veterinary and Animal Science, 10, 100149. https://doi.org/10.1016/j.vas.2020.100149

Paul, B. K., Frelat, R., Birnholz, C. A., Ebong, C., Gahigi, A., Groot, J., Herrero, M., Kagabo, D. M., Notenbaert, A. M. O., Vanlauwe, B., & Van Wijk, M. T. (2018). Agricultural intensification scenarios, household food availability and greenhouse gas emissions in Rwanda: Ex-ante impacts and trade-offs. Agricultural Systems, 163, 16–26. https://doi.org/10.1016/j.agsy.2017.02.007

Phillips, L. (2021). Getting a silage maize crop into the bunker chop-chop. Farmer's Weekly. Available at: https://www.farmersweekly.co.za/crops/field-crops/getting-a-silage-maize-crop-into-the-bunker-chop-chop/ (Accessed: 17 March 2024).

Rugimbana. (2022, April 7). Predicting maize (Zea Mays) yields in the eastern province of Rwanda using the Aquacrop model. CCAFS: CGIAR Research Program on Climate Change, Agriculture, and Food Security. https://ccafs.cgiar.org/resources/publications/predicting-maize-zea-mays-yields-eastern-province-rwanda-using-aquacrop

Rwanda's dairy sector celebrates the successes of a 5-year dairy program. (n.d.). MINAGRI. Available at: https://www.minagri.gov.rw/updates/news-details/rwanda-s-dairy-sector-celebrates-the-successes-of-a-5-year-dairy-program (Accessed: 17 March 2024).

Santos, E., Mari, L., Reis, R., Ferreira, G., Brown, A., Bernardes, T., Ramos, E., Oliveira, C., Chavira, J., Refat, B., Yu, P., Unpaprom, Y., Ramaraj, R., & Hutňan, M. (2016). Advances in Silage Production and Utilization. https://doi.org/10.5772/61574

Shibata, M., Sugihara, S., Mvondo-Zé, A. D., Araki, S., & Funakawa, S. (2017). Nitrogen flux patterns through Oxisols and Ultisols in tropical forests of Cameroon, Central Africa. Soil Science and Plant Nutrition, 1–12. https://doi.org/10.1080/00380768.2017.1341285

Solar-powered irrigation: Changing lives of rural women farmers in Ngoma District in Rwanda. (n.d.). United Nations. Available at: https://rwanda.un.org/en/218289-solar-powered-irrigation-changing-lives-rural-women-farmers-ngoma-district (Accessed: 17 March 2024).

Telling our carbon footprint story. (n.d.). AgResearch. Available at: https://www.agresearch.co.nz/our-research/telling-our-carbon-footprint-story/ (Accessed: 17 March 2024).

Tongwane, M. I., Mdlambuzi, T., Moeletsi, M. E., Tsubo, M., Mliswa, V., & Grootboom, L. (2016). Greenhouse gas emissions from different crop production and management practices in South Africa. Environmental Development, 19, 23–35. https://doi.org/10.1016/j.envdev.2016.06.004

Understanding the disease burden of dairy products in Rwanda. (2023, June 15). Agrilinks. https://agrilinks.org/post/understanding-disease-burden-dairy-products-rwanda

Winowiecki, L. A., Bargués-Tobella, A., Mukuralinda, A., Mujawamariya, P., Ntawuhiganayo, E. B., Mugayi, A. B., Chomba, S., & Vågen, T. (2021). Assessing soil and land health across two landscapes in eastern Rwanda to inform restoration activities. Soil, 7(2), 767–783. https://doi.org/10.5194/soil-7-767-2021

Writer, S. (2019, July 24). Eastern Province Auctions 831 Cattle Found “Illegally” Grazing On RDF Land. THE CHRONICLES. https://www.chronicles.rw/2019/07/24/eastern-province-auctions-831-cows-found-illegally-grazing-on-rdf-land/

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Appendix 1: Complete Survey of Local Small Holder Cow Owners

		FARMERS SURVEY						
NO	Cow breed	distance travelled to get feed Iin KM	distance traveled For feed and water	amount of milk In L/ day	types of feed	calories burned	calories yielded	net caloric loss or gain
35	Ankole	0	0.6	1.5	grazing	72	350.12	278.12
36	Ankole	0	0.6	4	grazing	72	933.66	861.66
37	FRIESIAN	0	0.6	1.5	grazing	72	350.12	278.12
38	Ankole	0	0.6	1.5	grazing	72	350.12	278.12
39	Ankole	0	0.6	3	grazing	72	700.24	628.24
40	Ankole	0	0.6	3	grazing	72	700.24	628.24
41	Ankole	0	0.6	3	grazing	72	700.24	628.24
42	Ankole	0	0.6	1	grazing	72	233.41	161.41
43	Ankole	0	0.6	3	grazing	72	700.24	628.24
44	Ankole	0	0.6	4	grazing	72	933.66	861.66
45	Ankole	0	0.6	3	grazing	72	700.24	628.24
46	FRIESIAN	0	0.6	5	grazing	72	1167.07	1095.07
47	Ankole	0	0.6	2	grazing	72	466.83	394.83
48	FRIESIAN	0	0.6	1	grazing	72	233.41	161.41
28	FRIESIAN	1	2.8	5	Napier	336	1167.07	831.07
30	FRIESIAN	1	2.8	2	Napier	336	466.83	130.83
26	FRIESIAN	1.2	3	5	Napier	360	1167.07	807.07
51	FRIESIAN	1.3	3.1	2	weeds	372	466.83	94.83
49	FRIESIAN	1.4	3.2	4	weeds	384	933.66	549.66
21	JESI	1.5	3.3	2	Napier	396	466.83	70.83
50	FRIESIAN	1.6	3.4	5	weeds	408	1167.07	759.07
1	Ankole	2	3.8	2	Napier	456	466.83	10.83
2	Ankole	2	3.8	2.5	Napier	456	583.54	127.54
10	FRIESIAN	2	3.8	2	Napier	456	466.83	10.83
15	FRIESIAN	2	3.8	2	Napier	456	466.83	10.83
16	JESI	2	3.8	2	Napier	456	466.83	10.83
25	FRIESIAN	2	3.8	2	Napier	456	466.83	10.83
27	FRIESIAN	2	3.8	6	Napier	456	1400.49	944.49
52	FRIESIAN	2	3.8	3	weeds	456	700.24	244.24
31	FRIESIAN	2.2	4	4	Napier	480	933.66	453.66
22	FRIESIAN	2.5	4.3	1.5	Napier	516	350.12	-165.88
4	FRIESIAN	3	4.8	2	Napier	576	466.83	-109.17
7	FRIESIAN	3	4.8	1	Napier	576	233.41	-342.59
8	Ankole	3	4.8	2	Napier	576	466.83	-109.17
19	FRIESIAN	3	4.8	3	Napier	576	700.24	124.24
20	FRIESIAN	3	4.8	2	Napier	576	466.83	-109.17
24	FRIESIAN	3	4.8	2	Napier	576	466.83	-109.17
32	FRIESIAN	3	4.8	5	Napier	576	1167.07	591.07
5	FRIESIAN	4	5.8	5	Napier	696	1167.07	471.07
6	Ankole	4	5.8	2	Napier	696	466.83	-229.17
9	Ankole	4	5.8	2	Napier	696	466.83	-229.17
14	Ankole	4	5.8	1	Napier	696	233.41	-462.59
23	FRIESIAN	4	5.8	3	Napier	696	700.24	4.24
3	FRIESIAN	5	6.8	3	Napier	816	700.24	-115.76
11	JESI	5	6.8	2	Napier	816	466.83	-349.17
12	FRIESIAN	5	6.8	2	Napier	816	466.83	-349.17
13	FRIESIAN	5	6.8	2	Napier	816	466.83	-349.17
18	FRIESIAN	5	6.8	3	Napier	816	700.24	-115.76
29	FRIESIAN	5	6.8	6	Napier	816	1400.49	584.49
17	FRIESIAN	9	10.8	2.5	Napier	1296	1087.5	-208.50
	FRIESIAN	4	5.8	2	grazing	696	870.00	174.00
	FRIESIAN	2	3.8	2	grazing	456	870	414.00
	Ankole	3	4.8	1	grazing	576	435	-141.00
	FRIESIAN	2	3.8	2	grazing	456	870	414.00
	FRIESIAN	3	4.8	2	grazing	576	870	294.00
	FRIESIAN	4	5.8	1	grazing	696	435	-261.00
	FRIESIAN	1	2.8	7	grazing	336	3045	2709.00
	FRIESIAN	2	3.8	2	grazing	456	870	414.00
	FRIESIAN	2	3.8	2	grazing	456	870	414.00
	Ankole	3	4.8	2	grazing	576	870	294.00
	Ankole	3	4.8	2	grazing	576	870	294.00
	FRIESIAN	4	5.8	3	grazing	696	1305	609.00
	FRIESIAN	2	3.8	2	grazing	456	870	414.00
	FRIESIAN	2	3.8	2	grazing	456	870	414.00
	FRIESIAN	3	4.8	1	grazing	576	435	-141.00
	FRIESIAN	3	4.8	3	grazing	576	1305	729.00
	FRIESIAN	2	3.8	4	grazing	456	1740	1284.00
	FRIESIAN	2	3.8	4	grazing	456	1740	1284.00
	Ankole	2	3.8	5	grazing	456	2175	1719.00
	FRIESIAN	2	3.8	3	grazing	456	1305	849.00
	FRIESIAN	2	3.8	2	grazing	456	870	414.00
	Ankole	2	3.8	3	grazing	456	1305	849.00
	Ankole	3	4.8	1.5	grazing	576	652.5	76.50
	Ankole	1.5	3.3	1	grazing	396	435	39.00
	FRIESIAN	3	4.8	2	grazing	576	870	294.00
	Ankole	4	5.8	2	grazing	696	870	174.00
	Ankole	4	5.8	3	grazing	696	1305	609.00
	Ankole	2	3.8	4	grazing	456	1740	1284.00
	FRIESIAN	2	3.8	2	grazing	456	870	414.00
	FRIESIAN	1	2.8	1	grazing	336	435	99.00
	FRIESIAN	2	3.8	1.5	grazing	456	652.5	196.50
	FRIESIAN	2	3.8	1.5	grazing	456	652.5	196.50
	FRIESIAN	2	3.8	1	grazing	456	435	-21.00
	FRIESIAN	3	4.8	3	grazing	576	1305	729.00
	FRIESIAN	3	4.8	1.5	grazing	576	652.5	76.50
	FRIESIAN	2	3.8	3	grazing	456	1305	849.00
	FRIESIAN	3	4.8	5	grazing	576	2175	1599.00
	FRIESIAN	3	4.8	3	grazing	576	1305	729.00
	FRIESIAN	3	4.8	2	grazing	576	870	294.00
	FRIESIAN	3	4.8	2.5	grazing	576	1087.5	511.50
	FRIESIAN	3	4.8	2	grazing	576	870	294.00
	FRIESIAN	3	4.8	3	grazing	576	1305	729.00
	FRIESIAN	3	4.8	2	grazing	576	870	294.00
	Ankole	3	4.8	4	grazing	576	1740	1164.00
	Ankole	3	4.8	4	grazing	576	1740	1164.00
	FRIESIAN	3	4.8	6	grazing	576	2610	2034.00
	FRIESIAN	3	4.8	1	grazing	576	435	-141.00
	FRIESIAN	3	4.8	3	grazing	576	1305	729.00
	FRIESIAN	3	4.8	5	grazing	576	2175	1599.00
	FRIESIAN	0.8	2.6	4	grazing	312	1740	1428.00
	FRIESIAN	1	2.8	2	grazing	336	870	534.00
	FRIESIAN	1	2.8	12	Supplimente	336	5220	4884.00
	FRIESIAN	2	3.8	4	grazing	456	1740	1284.00
	Ankole	2	3.8	3	grazing	456	1305	849.00
	FRIESIAN	2	3.8	3	grazing	456	1305	849.00
	FRIESIAN	2	3.8	4	grazing	456	1740	1284.00
	FRIESIAN	2	3.8	3	grazing	456	1305	849.00
	FRIESIAN	2	3.8	4	grazing	456	1740	1284.00
	FRIESIAN	2	3.8	5	grazing	456	2175	1719.00
	FRIESIAN	3	4.8	2	grazing	576	870	294.00

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Appendix 2: SACPP Ltd Maize and French Bean Production Cost

Fiinal report for maize from 28/12/2022 to 27/4/2023					
Area: 10633msq					
Amount of seed : 27kg					
No	**Items**	**Unit**	**Number**	**Unit cost**	**Tot.cost**
	I.Labour				
	1.1.Land preparation				
2	1st ploughing	Man/day	71	1000	71,000
	S/total 1	**0**	**0**	**0**	**71,000**
	1.2.Planting				
5	Planting	Man/day	20	1000	20,000
	S/total 2	-	-	-	**20,000**
	1.3.After planting				
7	watering	Man/day	30	1000	30,000
8	application of inorganic fertilizer	Man/day	5	1000	5,000
9	weeding	Man/day	60	1000	60,000
10	Spraying of pesticides	Man/day	18	1000	18,000
11	Harvesting	Man/day	54	1000	54,000
	S/Total 3	-	-	-	**167,000**
	II. Input and material				
	2.1.Seed				
12	Seeds	Kg	27	1000	27,000
	S/Total 4	-	-	-	**27,000**
	2.3.Fertilizer:				
14	Urea	Kg	496	722	358,112
15	DAP	Kg	180	654	117,720
	S/Total 6	-	-	-	**475,832**
	2.4.Pesticides:				
17	Rocket	L	12	12,500	150,000
18	Dudu	L	12	10,000	120,000
	S/Total 7	-	-	-	**270,000**
	Main Total	-	-	-	**1,030,832**
	Yield	**kg**	**6700**		

The average sale price for maize is 350 RF per KG, this crop was sold for a net profit of 2,345,000 RF

Final report for Beans Plot no:5745sqm					
Area: 5745sqm					
Planting date:05/06/2023					
Last harvesting:15/08/2023					
No	**Items**	**Unit**	**Number**	**Unit cost**	**Tot.cost**
	I.Labour				
	1.1.Land preparation				
1	1st ploughing	Man/2Months	20	1300	26,000
2	Making Beds	Man/2Months	14	1300	18,200
	S/total 1	**0**	**0**	**0**	**44,200**
	1.2.Planting				
3	Transportation&mixing of manure with soil on the plot	Man/2Months	15	1300	19,500
4	Planting	Man/2Months	22	1300	28,600
	S/total 2	-	-	-	**48,100**
	1.3.After planting				
5	watering	Man/2Months	15	1500	22,500
6	weeding	Man/2Months	54	1500	81,000
7	Application of inorganic Fertilizers	Man/2Months	15	1500	22,500
8	Spraying of pesticides & fungicides	Man/2Months	10	1500	15,000
9	Harvesting	Kgs on the farm	6302	60	378,120
	S/Total 3	-	-	-	**519,120**
	II. Input and material				
	2.1.Seed				
10	Beans	Kg	18	12500	225,000
11	Innoculant	bag	1	5000	5,000
	S/Total 4	-	-	-	**230,000**
	2.3.Fertilizer:				
12	Urea/N	Kg	77	768	59,136
13	DAP/P2O5	Kg	115	923	106,145
14	Organic manure	Truckload	3	80000	240,000
	S/Total 5	-	-	-	**405,281**
	2.4.Pesticides& fungicides				
15	***Theamidol***	***L***	**0.78**	**23000**	**17940**
16	***Dethane***	***Kgs***	**6**	**4400**	**26400**
17	A.Cypermethrin	L	2.9	9,000	26,100
18	Easy grow Flours &Fruits	kgs	3	5,500	16,500
19	Copper oxychloride	Kgs	12	9,000	108,000
	S/Total 6	-	-	-	**194,940**
20	**Transport**				**523,000**
	Main Total	-	-	-	**1,441,641**
		Kgs Sorted	**4,992.00**	**650.00**	**3,244,800**
		Kgs rejected	**1,356.00**	**300.00**	**406,800**
	income			-	**3,651,600**
	Benefit				**1,686,959**

This Bean Crop Netted 1,686,959 RF, when adjusted it is a net of 2,936,395 RF per Hectare

Appendix 3: Feed Data Set SACPP Cow Herd

Cow Milk Production and Feeding, SACPP Farm - 2021-2024

Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk	TMR	def.tmr&tfc
140601		week 10	4		20		1											55		
		week 11	5		20		1	0.25										6		
		week 12	5		20			0.25	1									54		
		week 13	5		20			0.25	1									63		
		week 14	5	20				0.25			1				6			66		
		week 15	6	20				0.25			1.5				6			70		
		week 16	6	20				0.25			1.5				6			60		
		week 17	6	20			1.5	0.25			1.5				6			65		
		week 18	6	20				0.25			1.5							66		
		week 19	6	20				0.25			1.5							69		
		week 20	6	20							1.5							63		
		week 21	6		20						1.5					12		73		
		week 22	6		20						1.5					12		65		
		week 23	6		20						1.5					12		68		
		week 24	6		20											12		71		
		week 25	6		20									8				66		
		week 26	6		20									8				70		
		week 27	6											8				65		
		week 28	6											8				66		
		week 2				ful lday						400	5					153		
		week 3										400	5					160		
		week 4										400	6					165		
		week 5										400	6					171		
Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
969583		week 10	6				2	0.25		20								54		
		week 11	7				2	0.25		20								66		
		week 12	6				2	0.25		20								54		
		week 13	8		20		2	0.25										69		
		week 14	7		20		2	0.25							8			63		
		week 15	7	20			2.5	0.25							8			61		
		week 16	5	20			2.5	0.25							8			61		
		week 17	5	20			2.5	0.25							8			70		
		week 18	7	20				0.25			2.5							70		
		week 19	7		20			0.25			2.5							77		
		week 20	7		20		1.25	0.25										63		
		week 21	7		20		1.25	0.25								9		61		
		week 22	7		20		1.25	0.25								9		61		
		week 23	7		20		1.25	0.25								9		68		
		week 24	7		20		1.25	0.25								9		70		
		week 25	7		20		1.25							9				66		
		week 26	7		20		1.25							9				81		
		week 27	7		20		1.25							9				65		
		week 28	7		20		1.25							9				66		
		week 2										400	6					153		
		week 3										400	7					160		
		week 4										400	7					165		
		week 5										400	7					171		
Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
969050		week 10	7				2	0.25		22								60		
		week 11	7				2	0.25		22								61		
		week 12	6					0.25		22	2							54		
		week 13	6		22			0.25			2							71		
		week 14	6		22			0.25			2				9			75		
		week 15	7	22				0.25			2.5				9			70		
		week 16	7	22				0.25			2.5				9			60		
		week 17	7	22			2.5	0.25							8			87		
		week 18	7	22			2.5	0.25										70		
		week 19	7		22			0.25			2.5							69		
		week 20	7		22		1.25	0.25										63		
		week 21	7		22		1.25									9		70		
		week 22	7		22		1.25									9		70		
		week 23	7		22		1.25	0.25								9		68		
		week 24	7		22		1.25									9		73		
		week 25	7		22		1.25	0.25						8				66		
		week 26	7		22		1.25	0.25						7				81		
		week 27	7		22		1.25	0.25						8				65		
		week 28	7											8				66		
		week 2										400	6					153		
		week 3										400	6					160		
		week 4										400	6					165		
		week 5										400	7					171		
Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
253236		week 10																60		
		week 11	6		22		1.5	0.25										61		
		week 12	6		22		1.5	0.25										71		
		week 13	6		22		1.5	0.25										80		
		week 14	6	22			1.5	0.25							8			87		
		week 15	7	22			1.5	0.25							8			70		
		week 16	7	22			1.5	0.25							8			60		
		week 17	7	22			1.5	0.25							8			86		
		week 18	7	22				0.25			2							76		
		week 19	7	22				0.25			2							69		
		week 20	7	22				0.25			2							63		
		week 21	7		22			0.25			2					10		70		
		week 22	7		22			0.25			2					10		70		
		week 23	7		22			0.25			2					10		68		
		week 24	7		22			0.25			2					10		88		
		week 25	7		22		2				2			8				66		
		week 26	7		22		2							8				81		
		week 27	7		22		2							8				65		
		week 28	7		22		2							9				70		
		week 2										400	6					153		
		week 3										400	6					160		
		week 4										400	6					165		
		week 5										400	7					171		
Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
547399		week 10	6		22		1.5	0.25										64		
		week 11	5		22		1.5	0.25										71		
		week 12	5		22		1.5	0.25										61		
		week 13	5		22		1.5	0.25										80		
		week 14	5		22		1.5	0.25							6			72		
		week 15	5		22		1.5	0.25							6			60		
		week 16	5		22		1.5	0.25							6			63		
		week 17	5		22		1.5	0.25							6			79		
		week 18	5		22		1.5	0.25										86		
		week 19	5		22		1.5	0.25										69		
		week 20	5		22		1.5	0.25										63		
		week 21	5		22		1.5	0.25								9		70		
		week 22	5		22		1.5	0.25								9		70		
		week 23	5		22		1.5	0.25								9		68		
		week 24	5		22		1.5	0.25								9		91		
		week 25	5		22		1.5	0.25						7				66		
		week 26	5		22		1.5	0.25						7				81		
		week 27	5		22		1.5	0.25						7				65		
		week 28	5		22		1.5	0.25						7				66		
		week 2										400	6					153		
		week 3										400	6					160		
		week 4										400	6					165		
		week 5										400	7					171		
Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
969694		week 10	6		22		1.5	0.25										66		
		week 11	6		22		1.5	0.25										61		
		week 12	6		22		1.5	0.25										54		
		week 13	6		22		1.5	0.25										80		
		week 14	6		22		1.5	0.25							8			87		
		week 15	6		22		1.5	0.25							8			70		
		week 16	6		22		1.5	0.25							8			60		
		week 17	6		22		1.5	0.25							8			86		
		week 18	6		22		1.5	0.25										90		
		week 19	7		22		1.5	0.25										69		
		week 20	7		22			0.25										63		
		week 21	7		22			0.25										70		
		week 22	7		22		1.5	0.25								8		70		
		week 23	7		22		1.5	0.25			2					8		68		
		week 24	7		22			0.25			2					8		6		
		week 25	7		22						2			8		8		66		
		week 26	7		22						2			8				81		
		week 27	7		22						2			8				65		
		week 28	7		22						2			8				66		
		week 2										400	6					153		
		week 3										400	6					160		
		week 4										400	6					165		
		week 5										400	6					171		

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 8||Issue 1 ||Page 114-140|| November|2024|
Email: info@stratfordjournals.org ISSN: 2616-8456

Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
9616564		week 10	7		20		1.5	0.25										71		
		week 11	7		20		1.5	0.25										71		
		week 12	7		20		1.5	0.25										61		
		week 13	7		20		1.5	0.25										80		
		week 14	7	20			1.5	0.25							7			72		
		week 15	7	20			1.5	0.25							7			60		
		week 16	7	20			1.5	0.25							7			65		
		week 17	7	20			1.5	0.25							7			79		
		week 18	7	20			1.5	0.25										86		
		week 19	7	20			1.5	0.25										69		
		week 20	7	20			1.5	0.25										63		
		week 21	6	20			1.5	0.25										70		
		week 22	6		20		1.5	0.25								9		70		
		week 23	6		20			0.25								9		68		
		week 24	6		20			0.25			2					9		94		
		week 25	7		20			0.25			2			6		9		66		
		week 26	7		20			0.25			2			6				81		
		week 27	7		20			0.25			2			6				65		
		week 28	7		20			0.25			2			6				66		
		week 2										400	7					153		
		week 3										400	7					160		
		week 4										400	7					165		
		week 5										400	7					171		

Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
S002		week 10	6		23		1.5	0.25										54		
		week 11	6		23		1.5	0.25										66		
		week 12	6		23		1.5	0.25										54		
		week 13	6		23		1.5	0.25										69		
		week 14	6		23		1.5	0.25							8			63		
		week 15	6		23		1.5	0.25							8			61		
		week 16	6		23		1.5	0.25							8			61		
		week 17	6		23		1.5	0.25							8			70		
		week 18	6		23		1.5	0.25										70		
		week 19	6		23		1.5	0.25										77		
		week 20	6		23		1.5	0.25										63		
		week 21	6		23		1.5	0.25								9		61		
		week 22	5		23		1.5	0.25			2					9		61		
		week 23	5		23		1.5	0.25			2					9		68		
		week 24	5		23		1.5	0.25			2					9		70		
		week 25	5		23		1.5							8				66		
		week 26	5		23									8				81		
		week 27	5		23									8				65		
		week 28	5		23									8				66		
		week 2										400	6					153		
		week 3										400	6					160		
		week 4										400	6					165		
		week 5										400	7					171		

Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
S008		week 10	5		20		1.5											55		
		week 11	5		20		1.5											6		
		week 12	5		20		1.5											54		
		week 13	5		20		1.5											63		
		week 14	5		20		1.5								8			66		
		week 15	5		20		1.5								8			70		
		week 16	5		20		1.5								8			60		
		week 17	5		20		1.5				1				8			65		
		week 18	5		20						1							66		
		week 19	5		20						1							69		
		week 20	5		20						1							63		
		week 21	5		20						1					8		73		
		week 22	5		20						1					8		65		
		week 23	5		20						1					8		68		
		week 24	5		20						1					8		71		
		week 25	5		20									7				66		
		week 26	5		20									7				70		
		week 27	5		20									7				65		
		week 28	5		20									7				66		
		week 2										400						153		
		week 3										400						160		
		week 4										400						165		
		week 5										400						171		

Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
S007		week 10	5		18		1.5											64		
		week 11	5		18		1.5											71		
		week 12	5		18		1.5											61		
		week 13	5		18		1.5											80		
		week 14	5		18		1.5								7			72		
		week 15	5		18		1.5								7			60		
		week 16	5		18		1.5								7			65		
		week 17	5		18		1.5								7			79		
		week 18	5		18		1.5											86		
		week 19	5		18		1.5											69		
		week 20	5		18		1.5											63		
		week 21	5		18		0.75									9		70		
		week 22	5		18		0.75									9		70		
		week 23	5		18		0.75									9		68		
		week 24	5		18		0.75									9		94		
		week 25	5		18									6				66		
		week 26	5		18									6				81		
		week 27	5		18									6				65		
		week 28	5		18									6				66		
		week 2										400						153		
		week 3										400						160		
		week 4										400						165		
		week 5										400						171		

Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
S0017		week 10	7		23		1											54		
		week 11	7		23		1											66		
		week 12	7		23		1											54		
		week 13	7		23						1.5							69		
		week 14	7		23						1.5				8			63		
		week 15	7		23						1.5				8			61		
		week 16	7		23						1.5				8			61		
		week 17	7		23						1.5				8			70		
		week 18	7		23						1.5							70		
		week 19	7		23						1.5							77		
		week 20	7		23						1.5							63		
		week 21	7		23						1.5					8		61		
		week 22	7		23						1.5					8		61		
		week 23	7		23						1.5					8		68		
		week 24	7		23						1.5					8		70		
		week 25	7		23									8				66		
		week 26	7		23									8				81		
		week 27	7		23									8				65		
		week 28	7		23									8				66		
		week 2										400	6					153		
		week 3										400	6					160		
		week 4										400	6					165		
		week 5										400	6					171		

Cow Name/Number	Cow Breed	Date	Ground Maize	oats	Nipper gass	bracharia	Soya	Sunflower	Fresh sorghum	Fresh maize	oil soya	fish meal	maize bran	millet	sorghum silage	maize sailge	t.feed cost	T.milk/w	TMR	def.tmr&tfc
S0012		week 10	5		22		1											60		
		week 11	5		22		1											6		
		week 12	5		22		1											54		
		week 13	5		22		1											63		
		week 14	5		22						1.5				7			66		
		week 15	5		22						1.5				7			70		
		week 16	5		22						1.5				7			60		
		week 17	5		22						1.5				7			65		
		week 18	7		22						1.5							66		
		week 19	7		22						1.5							69		
		week 20	7		22						1.5							63		
		week 21	7		22						1.5					9		73		
		week 22	7		22						1.5					9		65		
		week 23	7		22						1.5					9		68		
		week 24	7		22						1.5					9		71		
		week 25	7		22						1.5			7				66		
		week 26	7		22									7				70		
		week 27	7		22									7				65		
		week 28	7		22									7				66		
		week 2										400	6					153		
		week 3										400	6					160		
		week 4										400	6					165		
		week 5										400	7					171		