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(RESEARCH ARTICLE)

Quantification of economic effect of seasonal fluctuations in milk yield among smallholder dairy farmers in seven (7) major milk bulking centers of southern Zambia

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Abstract

A survey study was carried out with the specific objective of comparing the seasonal milk yield fluctuations and its economic effect among small holder dairy farmers in the Southern Province of Zambia. Secondary data were obtained from seven (7) small holder dairy bulking centers (Monze, Magoye, Silwiili, Batoka, Kalomo, Zimba and Kanchomba) which were purposively selected. The results of the study indicated that small holder dairy farmers produce a total of 228,077.23litres of milk during the rainy season and 149,497.96 litres of milk during the dry season giving average monthly milk yields of 38,012.87litres and 24,916.33litres respectively. Results of the study indicated that the average monthly milk yields (121 ltrs ±25.2 and 244 ltrs ± 25.2 for dry and wet seasons respectively) differed significantly ($p<0.05$) among the seven (7) milk bulking centers in Southern Zambia.

Keywords: Seasonal; Economic; Fluctuations; Milk; Smallholder

1. Introduction

In recent decades, developing countries have increased their share in global dairy production. This growth is mostly the result of an increase in numbers of producing animals rather than a rise in productivity per head. In many developing countries, dairy productivity is constrained by poor-quality feed resources, diseases, limited access to markets and services (e.g., health, credit and training) and dairy animals' low genetic potential for milk production. Unlike developed countries, many developing countries have hot and/or humid climates that are unfavorable for dairying [1].

Dairy industry in Zambia is very small and demand for milk far outweighs supply. The dairy sector in Zambia is a viable industry that could contribute to poverty reduction especially in rural areas. However, over the years this sector has been unable to supply the much needed milk with only an annual supply of about 125 million litres. There is a shortfall of about 25% in the market [2]. The recommended annual consumption of milk by the WHO and FAO report is in the range of 200 million litres per year [3]. According to [4], dairy intake of milk in Zambia stands at less than 40 million litres. The same report indicated that the dairy industry is not well organized. The dairy herd is estimated at 1 – 2% of total national herd of cattle (i. e 500,000).

Dairy production is relatively small in relation to the large domestic market for dairy products. Work by [4], indicated that in 1982 there were about 600,000 small-scale milk producers (traditional dairy sub-sector) and about 100 large-

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scale commercial producers (modern dairy sub-sector). The 600,000 small-scale producers provide for on-farm domestic consumption and the estimated production from this sub-sector in 1982 was 28 million litres. The 100 large-scale dairy farms, including 11 state farms were estimated to have produced about 10.5 million litres during the same period [3].

1.1. Seasonal Changes and its Impact on Feed Resources

Feed quality and quantity have been observed to show seasonal fluctuation a trend which affects animal nutrition and performance. Dry seasons in Zambia and many other tropical countries are marked with periods of feed shortages resulting in general retardation in animal growth and production. Work by [5], revealed that heat stress associated with dry seasons has a negative effect on milk yield while at the same time improving milk quality.

Research by [6] reported variations in milk production trends in Bangladesh to be affected by seasonal fluctuations. It has been observed that the milk production by smallholder dairy farmers during the dry season is significantly reduced. During that period, which might last up to six months per year, the quantity of milk, which the average farmer is able to sell and deliver, is reduced by 35%- 60%. This means that the income of those farmers is also reduced considerably during that period. However, it is also observed that in many cases the milk production and the delivery of milk by commercial and by progressive smallholder dairy farmers is hardly affected. The milk delivery from about 160 farmers at a Smallholder Dairy Farmers Association (SDFA) is reduced in the period April – October, while the delivery of milk by a commercial farmer is rather consistent during the year [3].

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The benefits of small scale dairy farming include the following aspects: The produced milk is considered as a perfect human food. Through home consumption and sales, it contributes considerably to the health status of the people in rural areas. The sold milk provides the farmer with a regular income throughout the year. Income from milk is more reliable than from beef. Milk sales continue during outbreaks of diseases when livestock movements are banned. The animals provide income through the sale of surplus heifers, and at the same time form a source of meat. The animals provide organic (kraal) manure, which is essential to maintain good soil fertility at the farm. Small scale farming is agriculture based rural development enterprise, which creates employment in the rural areas. Small scale farming contributes to the formation of a commercial agro-industry and creates business opportunities. Dairy farming requires and therefore develops discipline among farmers and their workers. Milk enhances the immune system of people and in that way contributes considerably to the reduction of child mortality [3].

Zambia is endowed with vast natural resources such as land, water and fertile soils that support agricultural activities. More than 60% of the population found in rural areas derive its livelihood from agriculture related activities. 50% of rural households earn their income from livestock while 40% did so from crops. Livestock farmers are more food secure and able to withstand shocks better than their counterparts in crop production. There are over three hundred and ten thousand (310,000) households or 25% of Zambia's farm population that own cattle and its asset value is estimated at over US $1.5 billion [7].

The relevance of forage production and utilisation in farming systems rests primarily in its applicability and potential to service the need and aspirations of the integrated small-scale livestock farmers. Forage has been and will continue to be an important resource base for feeding dairy animals in the Southeast Asian region. As a matter of fact, smallholder dairy farmers only own small number112 of animals, and therefore, adoption of any new technology involves a risk factor whether in economic outlay or management. A systematic critical appraisal of the establishment and management methods of improved pasture and fodder species is probably relevant in the promotion for better development and utilization of the crop by dairy cattle in the small-scale farming systems [8].

1.2. Environmental, Seasonal and Physiological Factors affecting Milk Quality and Quantity

It has long been known that season of the year has major impacts on dairy animal performance measures including growth, reproduction, and lactation. Fat, protein, lactose, non-fat milk solids (NFMS) and total solids (TS) contents were higher among dairy cows milked in winter season than other seasons. Milk composition is influenced by both season

and regional location. This is due to changes in temperature and feed availability during different seasons. Development of different feeding systems according to season and region is needed to produce high quality and satiable milk production [9].

Milking period affects milk fat, making the fat percentage lower in the morning compared with the evening milking period. Seasonal differences in milk fat, protein and somatic cell count were significant [10].

Research by [11], reported that the critical period, in terms of daily milk production in Tanzania, was from December through February, a period of high ambient temperature and low rainfall. During this period production dropped to as low as 6.1 and 205 litres/day per cow and farm, respectively. However, these workers observed that there was no significant difference between average daily milk production between dry and wet seasons.

Work by [12], showed a significant quadratic relationship between 305-d milk yield and number of lactation [7,607±145 and 9,548±181 kg for first- and ≥6-lactation cows, respectively; mean ± standard error of the mean (SEM)] with the highest production occurring in the fifth lactation. Total milk yields of cows with ≤2 lactations were approximately 4,500 kg less than milk yields of adult cows (the overall average ± standard milk yield was 13,544±5,491 kg per lactation and the average lactation length was 454±154 d). Moreover, 305-d milk production was depressed in cows induced into lactation in spring (8,804±153 kg; mean ± SEM) and summer (8,724±163 kg) than in fall (9,079±151 kg) and winter (9,085±143 kg).

According to [12], year, parity, and season effects have significant influence on milk yield of cows induced into lactation and treated with recombinant bovine somatotropin throughout lactation. While working with Buffaloes [13] discovered that season and parity rank among the important factors in determining milk yield of a give individual animal.

Total Lactation Milk Yield was found to be significantly affected by season ($P \leq 0.05$) but not by year and parity. The highest milk yield was obtained in animals calving in winter followed by rainy and summer. Milk yield of buffaloes in winter was significantly higher than that of animals in summer ($P < 0.05$). The Total Lactation Milk Yield increased over the years with highest milk yield in the year 2006 (2345.1±99.32kg). There was no consistent increase or decrease with the advance in years there on which may be due to the environmental variation in different years. Total Lactation Milk Yield was found lower in first parity and highest in fifth parity thereof decreasing ($P < 0.05$) [14].

Temperature Humidity Index (THI) of 68 is considered the upper limit of dairy cattle comfort zone [15]. According to [16], Temperature Humidity Index value of 74 to 78 is considered hazardous and represents an alert condition for animals. These workers further reported that animals were under severe heat stress during summer and thermo neutral zone during winter. There studies showed that daily milk yields were higher when temperatures were around thermo-neutral zone. Seasonal variations in milk components can be attributed to differences in ambient temperature and light/darkness ratio beside differences in feed quality and feed intake [17]. Milk production changes in both dairy cows and buffaloes due to the change in specific biological functions such as increasing body temperature and enzymatic reactions by climate change [17].

Studies by [18] revealed significant effects of temperature on milk production and milk components. During winter season buffaloes produced higher milk and milk components than in summer season. They reported positive correlations between plasma ALT with each of total milk yield (TMY), daily milk yield (DMY) and FCM.

Work by [19], revealed that environmental factors affect lactation curve parameters as well as some production characteristics of Tunisian Holstein Friesian cows. The averages of individual lactations according to the calving season showed a seasonal variation of the shape of the lactation curves.

Feeding efficiency of lactating cows is influenced by seasons due to effect on dry matter intake and T4 levels. The stress induced physiological response like respiration rate, pulse rate and rectal temperature can be used as indicators of heat stress in lactating cows [20].

Heat stress decreases dry matter intake in cattle, and a decrease in milk production follows. However, the decrease in dry matter intake observed during periods of heat stress only accounts for about 35% of the observed decrease in milk yield. Other metabolic factors influence milk production during periods of heat stress. Heat stressed animals may have lower levels of blood protein and energy due to the in-efficiencies of rumination and metabolism during this heat challenge. Both blood protein and energy levels can influence milk and milk fat yields. In addition to eating less and drinking more, feeding patterns change during heat stress [21].

Feed quality and quantity have been observed to show seasonal fluctuation a trend which affects animal nutrition and performance. Dry seasons in Zambia and many other tropical countries are marked with periods of feed shortages resulting in general retardation in animal growth and production.

It has been observed that the milk production by smallholder dairy farmers during the dry season is significantly reduced. During that period, which might last up to six months per year, the quantity of milk, which the average farmer is able to sell and deliver, is reduced by 35%- 60%. This means that the income of those farmers is also reduced considerably during that period. However, it is also observed that in many cases the milk production and the delivery of milk by commercial and by progressive smallholder dairy farmers is hardly affected. The milk delivery from about 160 farmers at a Smallholder Dairy Farmers Association (SDFA) is reduced in the period April – October, while the delivery of milk by a commercial farmer is rather consistent during the year [3].

1.3. Dynamics of Milk Marketing (Demand/Supply relationships)

According to [22], milk price fluctuates with level of production and has been reported to be a function of seasonal changes. The highest price is received during the period October to January. The driving force behind the current interest in grass-based pasture as the primary source of forage is price. Farmers historically receive the lowest milk price for milk sold during the six months following spring pasture flush. Agricultural prices have shown a seasonal price pattern that corresponds to changes in production/harvest (supply) and end-use (demand).

The smallholder sector offers the greatest potential for the improvement of milk production in Zambia as it holds the largest number of cattle. Although this is so, the sector has not performed as well as it should have for several reasons include Government policy, shortage of capital, insufficient inputs and poor marketing infrastructure. In the past, this sector had not been involved in commercial milk production.

Livestock sector comprise of beef cattle, dairy and poultry among others. It is a key economic sector in Zambia. In 2009 and 2010 respectively, it contributed 6.4% and 7.4% to the Gross Domestic Product. About 45-47% of the rural population in Zambia depends on livestock for their livelihood with 39.2% of their income coming from the sector [23].

The dairy sector in Zambia is a viable industry that could contribute to poverty alleviation especially in our rural areas. However over the years this sector has been unable to supply the much needed milk with only an annual supply of about 125 million litres. There is a shortfall of about 25% in the market. According to [3], the recommended annual consumption of milk by the WHO and FAO is 2000 million litres.

Another study [2], reported that there a number of challenges that dairy industry in Zambia faces. These include the high cost of feed, poor breeds of dairy cows, lack of appropriate milk production technology to produce large quantities of milk. This calls for intervention from government and well- wishers as many small scale dairy farmers do not have the capacity to find solutions to some of these challenges.

A recent parliamentary report reviews the current state of livestock farming in Zambia. The livestock sector in Zambia is worth over $1.5bn, accounting for around 35% of agriculture' share of national gross domestic product (GDP). The good news is that the sector has experienced stead growth in recent years. Beef and dairy products are growing around 7% and 10% annually respectively [7]. However, despite these positive trends the sector continues to face many challenges which are helpfully highlighted. These include inadequate development funding and taxation reform from GRZ; rampant livestock disease outbreak; poor disease control mechanisms; poor supply of breeding stocks; high cost of cheap and long term finance; poor infrastructure such as roads, and a lack of processing facilities in the form of abattoirs and milk collection centres, among others; high energy costs; shortage and high cost of feedstock; absence of input support; inadequate and inappropriate research; poor extension support; poor organisation of marketing services; and high number of levies on livestock and livestock products [24].

There's currently no livestock development policy to deal with these challenges. The government is allegedly in the process of developing one. But it's unclear how robust such a policy is likely to be because one of the things that are clear from the report is that GRZ is working with poor statistics. The exact numbers of livestock in the country are not known. Without proper data it is challenging to formulate strategies that address the key problems [24].

1.4. Statement of the Problem

It has been observed that milk yield among small holder dairy farmers has been erratic over the years. The levels of seasonal fluctuation of milk yield and its economic effect on household food security, domestic and national income

have not been evaluated. It is against this background that a research project was carried out in seven (7) districts of the southern province of Zambia and it was designed:

- To compare the seasonal fluctuation in milk yield among small holder dairy farmers in Southern Province?
- To evaluate economic effect of seasonal fluctuations in milk yield.

2. Material and methods

2.1. Research Site

The research was conducted in Southern Province of Zambia. The population of Southern Province as captured by central statistics office (CSO) during the 2010 Census of Population and Housing was 158,992 populations. The province lies at an altitude range of 400- 1400 metres above sea level. It has a mean annual temperature ranging from 14°C to 28°C. It receives an annual rainfall of 700mm to 1000mm .The soil type ranges from clay to sandy loam [25].

2.2. Research Design and Data Collection

The seven (7) dairy bulking centres used in the research were randomly selected to provide secondary data for milk yields. Quantitative data was obtained from records available at bulking centres. A Semi-structured questionnaire and interviews were used to collect qualitative data. There were differences in number of years of existence of each bulking centre and hence differences in available milk records. Farmers interviewed were selected by purposive sampling procedure from among lists of farmers supplying milk to each bulking centre. Equal numbers of farmers from each bulking centre were interviewed. The research was an observational study or survey during which both quantitative and qualitative data were collected. It was a comparative study.

2.3. Statistical Analysis

Data was analysed using the Statistical Analysis System on the General Linear Model computer. Treatment means were compared using the F-test (Table 3).

3. Results

Table 1 shows the total milk yields among small holder dairy farmers in different bulking centers in the Southern Province of Zambia. Figures 1 and 2 reflect the trends of average monthly milk yields from January to December among the seven (7) milk bulking centers.

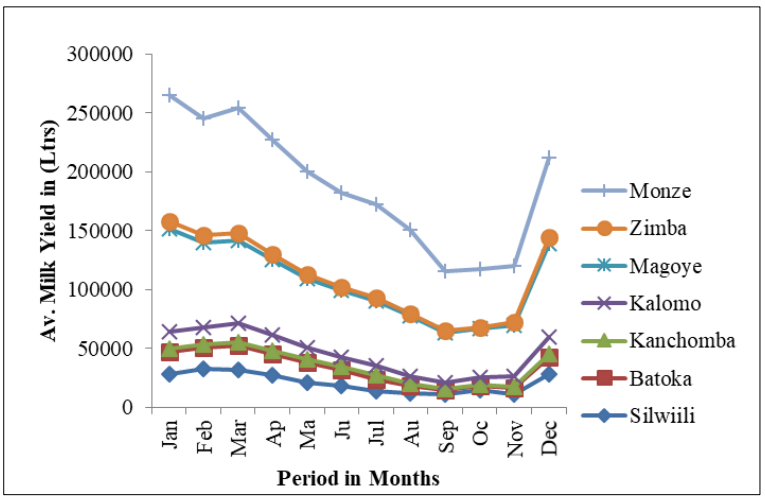

Figure 1 Av. Monthly Milk Yield

Table 1 Av. Monthly Milk Yields (Ltrs)

Month												
Bulking Centre	**Jan**	**Feb**	**Mar**	**Apr**	**Ma**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Silwiili	27741	32874.3	31634	27026	20938	18503.7	14076.3	11683	10562.7	14250.7	11161.3	27701.7
Batoka	18976.4	17989.9	20652	18207.1	16880.4	13292.6	9989.6	6897.8	4156.2	3890.8	5695.2	14634.68
Kanchomba	2738.5	2236.8	2433.3	2948.1	2587.3	2506.3	2830.5	1792.6	1062.8	833.9	730.8	2828.3
Kalomo	14794.2	14301.5	16928.5	13177.4	10028.1	8363.96	8320.2	6281.2	4948.1	6085.2	8678.9	14722.1
Magoye	87329.1	72533.1	70193.1	63754.61	58856.21	56500.4	54841.64	50586.7	42755.2	41826.51	43390.02	78992.4
Zimba	6409.97	6174.5	6063.5	4812.7	3548.4	3106.5	2574.2	2197.7	1342.8	1271.9	2806.03	5726.8
Monze	107,033	99,177	106,301	97,638	87,294	79,466	79,256	70,783	51,112	49,283	47,955	67,085

Tables 2 and 3 show the seasonal milk averages and the analysis of variance for the dry and wet seasons.

Table 2 Average Milk Yield for Effect of Seasons (Ltrs)

TRT	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**TOTAL (Yt)**	**MEAN (⍰)**
DRY SEASON	17045.58	15438.74	13239.83	10804.63	11359.84	12077.04	69532.3	149,497.96	21,356.85
RAIN SEASON	24101	26331.53	24351.68	24650.73	22279.50	19331.29	87031.5	228,077.23	32,582.46
								∑Yt =377,575.19	$\bar{\bar{y}}$ =26,969.66

Table 3 Analysis of Variance for Effect of Season

Source Of Variation	**Degrees of Freedom**	**Sum of Squares**	**Mean Square**	**F_{cal}**	**F_{tab}**
Total	13	370282977			
Treatment	1	310897913	310897913	53.5*	4.96
Error	11	58385064	5838506.4		

CV= 31.5%

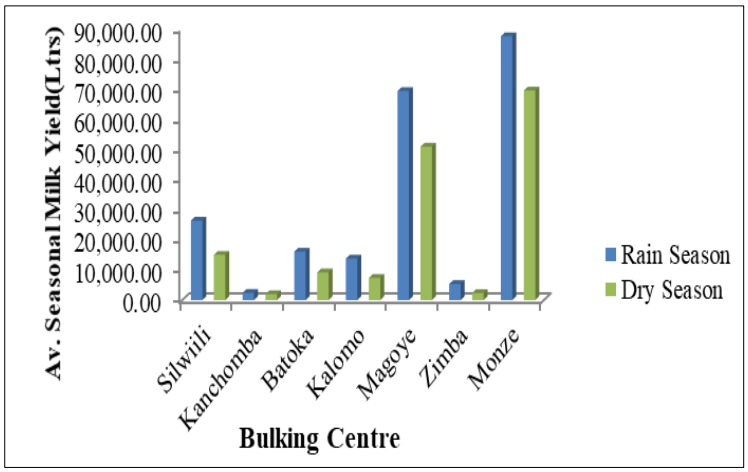

Figure 2. Bulking Center Seasonal Milk Yield

Table 4 and figures 3 and 4 show comparisons of the milk yields during the dry and wet season.

Table 4 Av. Dry and Wet Season Monthly Milk Yields (Ltrs)

			M o n t h				
Season	**Ma**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Dry Season	17045.58	15438.74	13239.83	10804.63	11359.84	12077.04	79,865.66
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	
Rain Season	24101	26331.53	24351.68	24650.73	22279.5	19331.29	141,045.73

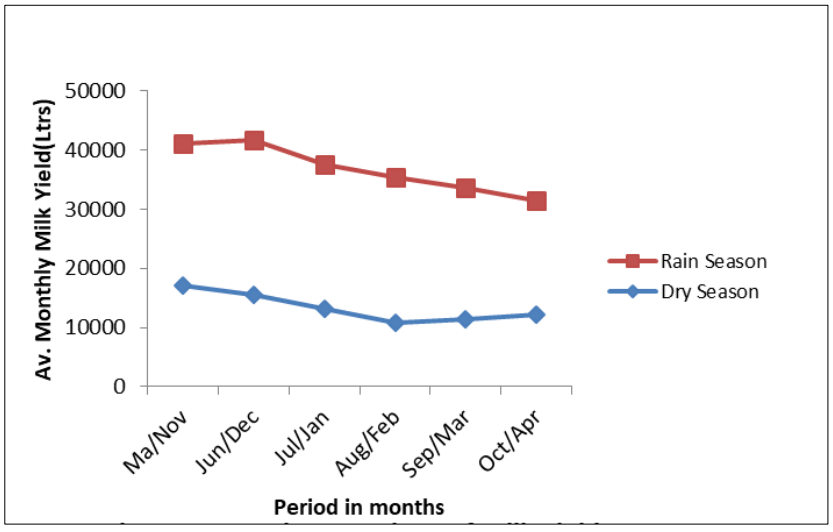

Figure 3 Seasonal Comparison of Milk Yield

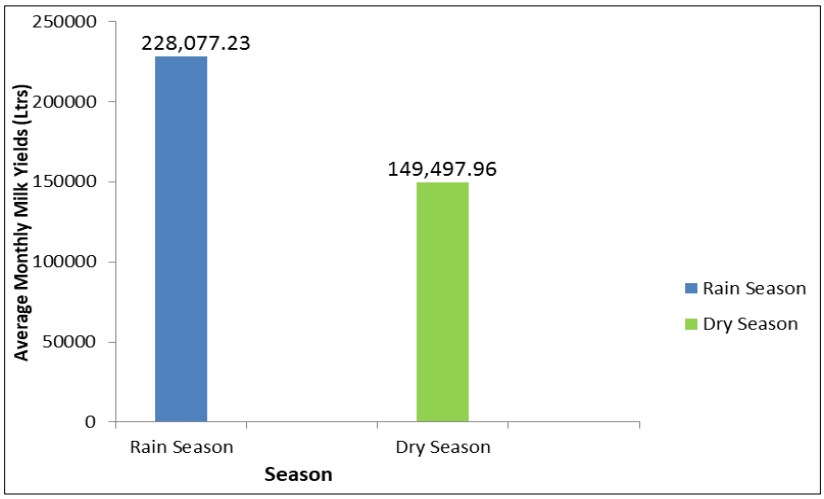

Figure 4 Total Seasonal Milk Yield

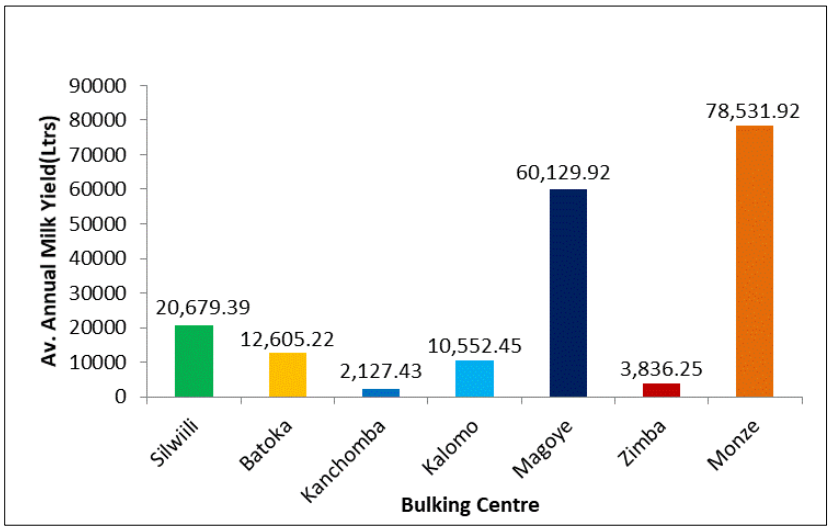

Figure 5 Av. Annual Milk Yield per Center

Figure 5 shows comparisons of average annual milk yield among the seven (7) milk bulking centres in Southern Zambia.

- The average price of milk per litre in Southern Zambia is ZK3.50
- Total average dry season income level= 79, 865.66 x ZK3.50 = ZK27, 9529.81
- Total average wet season income level= 141, 045.73 x ZK3.50 = ZK49, 3660.055
- Total average annual income loss due to seasonal milk fluctuations = ZK214, 130.245

4. Discussion

Technology transfer aspect of the study revealed that smallholder dairy farmers lack knowledge on latest dairy technology such as milking hygiene, breed improvement, animal nutrition and livestock management. Results of the focus group discussions during the training and technology transfer indicated knowledge gap regarding marketing of milk among smallholder dairy farmers.

Farmers alluded to the fact that shortage of adequate feed and shortage of water for animals during the dry season is a result of climate change. They stated that climate change has led to perpetual droughts which have affected their dairy enterprises negatively by reducing milk yield through shortage of forage and hence their domestic income. Outcomes of the discussions indicated that climate change is responsible for prevalent livestock diseases, poor nutrition, poor milk yield and increased poverty among smallholder dairy farmers.

Generally, results of the training discussions revealed that drought has led to shortage of water, high disease incidences, high livestock mortality, and shortage of feed and poor milk yields.

The study also revealed that knowledge of feed management is very poor among smallholder dairy farmers in Southern Zambia despite the presence of a wide range of forage and stover on their farms. It was clear that farmers do not know conditions necessary for preserving feeds. Farmers have little knowledge on feed processing and treatment. This results in poor storage and spoilage of feed. Furthermore, farmers do not know how to select feed ingredients to meet the nutritional requirement of their dairy animals and there is no distinction in the composition of feeds given to their animals on their farms according to physiological state of the animal. This has led to poor milk yield.

There was a gradual increase in monthly milk yield upon onset of rain, being highest in December (26331.53ltrs) and lowest in April (19331.29ltrs). Conversely, monthly milk yields declined upon onset of dry season ranging from 17045.58ltrs in May to 12077.04ltrs in October (Table 4). Fig 1 shows a similar trend in monthly milk yields among all bulking centres. It was observed that the highest decline in milk yield occurs during the period September – early November (Fig. 1). The study revealed that total monthly milk yields differed among the bulking centres with Monze Dairy Bulking Centre(MDBC) showing highest monthly and average annual (78,531.92Ltrs) values and Kanchomba Dairy Bulking Centre(KDBC) showing the lowest monthly and average annual (2,127.43Ltrs) values (Table 1and Fig. 5). The differences can be attributed to variations in number of farmers engaged in the dairy enterprise, poor record keeping by bulking centres and inconsistence in milk supply by farmers. Table 2 and Fig. 4 indicate that total monthly milk yield were highest (228,077.23ltrs) during the wet season and lowest (149,497.96ltrs) during the dry season. Fig. 3 and Fig. 2 show that monthly milk yields are generally higher during the rainy reason. Average seasonal milk yield were significantly ($p<0.05$) different (Table 3). Results of this study were echoed by [6], who observed that pronounced seasonal patterns of milk yield and composition are evident in cattle. These seasonal patterns are largely induced by climatological variables, breed effects and management factors, such as feed quality and reproductive management.

The total milk volume loss during the dry season amounts to 61,080.07litrs which translates into 43.3% of the farmer's income from his/her dairy business. The drastic decline in milk yield is a result of poor nutrition during the dry season. Most small holder farmers lack training in livestock management particularly the technology of livestock feeding. Work by [27], reported that milk production does not only vary from one smallholder farm to another due to variations in management levels but is highly affected by climatic factors which accompany change in season.

The results are in agreement with the observation of [28], who reported that farmers deriver 15.37 litres of milk per day to the milk collection centres in the dry season and average of 27.69 litres per day in the rain season. This shows that milk production in Zambia reduces by 44 percent during the dry season due to inadequacies in quantity of food and water for animals. Results of the current study are also in agreement with those of [29] who observed that milk yield in Egyptian Buffaloes fluctuates with change in seasons.

5. Conclusion

The results of the study showed that milk yields fluctuate between the two seasons. The study indicated that milk yields increased upon onset of rain and declined with the beginning of the dry season. This means that farmers experience an increase in revenue during the rainy season for the period November - April and a drop in their dairy business during the dry season from May - October. With results of today's study, dairy enterprise is no longer a steady business as it is known in areas where management levels are high and feed resources do not fluctuate. Farmers attributed the loss in milk yield to poor nutrition during the dry season. The study revealed a high need for intervention particularly during the dry season through improved feeding strategies.

Compliance with ethical standards

The present research work does not contain any studies performed on animals/humans subjects by any of the authors'. Informed consent was obtained from all individual participants included in the study.

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Disclosure of conflict of interest

As authors of this article we have no conflict of interest/or competing interest individually or collectively relating to the outcome of the study and the publication of the same.

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