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Cost Benefit Analysis of Bovine Mastitis in Nyabihu and Musanze Districts, Rwanda

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Abstract: **A study was carried out to determine the cost/benefit ratio associated with Mastitis. A sample of 12 farmers and 29 cows were considered for data collection then after data were analysed with Microsoft excel. The results of our study show that bovine mastitis reduces the yield and quality of milk by reducing the lactation period from 305 days to 245 days. The discarded milk with 23 800frws of loss and increasing vet Services in prevention (19 950 frws), treatment (9 600 frws) per Cow /Year/Lactation of losses were observed. This reduces the profitability of farm milk production by calculation of the extent of the economic losses from prevention with (156 115 frws), treatment (142 665 frws), neither treatment or prevention 119 665 Rwfs while when we practicise both prevention and treatment the profitability is increased (329 550 frws) all per Cow / Year / lactation and loss is complex because of factors involved such as prevention, treatment and milk yield and according to those factors there is a variation in the evidence on the relationship between the total income, total cost and total revenue in farm milk production. This provides a consistent analytical framework within which the benefits arising from reduced mastitis in dairy herd in the study area and It is estimated that the revenue per cow per year is increased by both prevention and treatment (329 550 frws). The results of this analysis can be used to suggest maximum costs of additional new control measures produced by research.**

Keywords: **Cost/benefit ratio, mastitis, dairy cows.**

I. INTRODUCTION

Rwanda dairy industry produced around 185 million liters of milk annually (2007 data, dairy value chain in Rwanda), which translates into an average daily yield per cow of just 3.2 liters, an unsurprisingly low yield given that improved breeds constitute less than 10% of the 157 thousand milking cattle in the country, and given that their nutrition is inadequate. In 2012, milk production was approximately 450,000,000 L. The objective is to increase production of milk to 810,000,000 l in 2017 to keep pace with population growth and to be on track to reach 80 l/p/yr in 2020. The cattle herd will increase from 1.33 million head to 1.67 million head in 2017. Those dairy cattle raised in three types of dairy farmers, as defined by the way in which cows are fed – open grazing where the animals are allowed to graze freely on public land and drink from public sources, while a herder manages the herd. Zero-grazing animals are kept in stables and feeds and water are brought to the animal. The semi-grazing is a system in between free and zero grazing. Here a type of shelter is made, but during the day the herdsman allows his cattle to graze (Puck *et al.*, 2004). Despite the fact that several programs were undertaken in order to increase milk production and improve local breed, livestock subsector in Rwanda faces several constraints among others inadequate feeding, animal diseases as well as poor management. All those constraints cause low farm level productivity (ISAR, 2009). Mastitis is considered as the most complex disease and the main constraints on dairy subsector in Rwanda and worldwide because it affects animal health, reduces dairy farm profitability with losses closely related with incidence of the disease and milk yields of diseased animals and treatment cost. The clinical mastitis leads to important economic losses from both milk production quantity, milk quality decreases, discarded milk and transient reductions milk yield, treatment and culling costs; death of the cow, reduced milk quality and price of the milk (Durr *et al*., 2008; Fetrow, 2000; Grohn *et al*., 2005; Wolfova *et al*., 2006), because of its multifactorial causation (Harmon *et al*., 1994).

Despite of many years of research mastitis remains the most economically damaging disease for the dairy industry worldwide (Radostits *et al*., 2007) and the specific inflammatory response from a mastitis incident is dependent on the bacterial species involved (Bannerman, 2008), but the calculation of the extent of this economic loss is complex because of the many factors involved and the lack of information in the evidence on the relationship between the disease and various production factors. The incidence of mastitis is influenced by managerial and environmental factors, such as housing of cows, milking equipment, feeding regime, hygienic quality of feed and water, cleanliness of cows, implementation of preventive measures, and general practices related to, for instance, drying-off (Nyman *et al*., 2007).

The risk of developing clinical mastitis is highest in early lactation whereas the risk of subclinical mastitis increases with increasing days in milk (Busato *et al.*, 2000). Mastitis cows tend to have higher milk yield than non-mastitis cows before they develop clinical mastitis (Gröhn *et al.*, 2004), indicating that high milk yield is a risk factor for clinical mastitis. Multiparous cows are generally at higher risk of developing clinical mastitis because as cow made parturition the microorganisms start to infect the mammary gland and immunity of a cow is reduced, except in the very early stages of lactation where the relationship is the opposite. Season also affects the incidence of mastitis (Steeneveld *et al.*, 2008). Other disorders, such as dystocia; milk fever; retained placenta; metritis; ketosis; and lameness, are also known to increase the risk of clinical mastitis (Svensson *et al.*, 2006).

For thus in the area of study many dairy cattles have sub clinical and clinical mastitis which are the sources of production loss for the farmers. When considering the cost of any disease, it must be remembered that every disease has direct and indirect costs (Bennett *et al*., 2000). It is even more difficult to quantify the losses associated with sub-clinical mastitis, because they are not visible to farm owners. Direct costs of mastitis to the dairy industry include the costs of treatment, discarded milk herdsman's time, fatalities and the costs associated with repeated cases of mastitis during both the course of treatment and withholding periods. In many cases direct losses are the only cost of mastitis realized by the farmers (Durr *et al*., 2008; Fetrow, 2000). This study aimed at determining clinical mastitis treatment cost.

In the light of the above, this paper determines the cost/benefit ratio associated with Mastitis in Nyabihu and Musanze districts, Rwanda with an attempt to:

- To calculate the production cost in relation with mastitis prevention.
- To compare different scenarios: production cost without mastitis, production cost with mastitis.
- Calculate the ratios: Cost/benefit in these different ratios.
- Develop strategies of sustaining the basic principles of dynamic dairy management
- Train farmers/ milkers on the best milking practices

II. METHODOLOGY

The study enclosed 4 sectors selected randomly such as Busogo and Gataraga of Musanze district; Bigorwe and Rambura of Nyabihu district, respectively in Northern and western Provinces of Rwanda. Cows were selected by using stratified sampling method. A population was divided into strata by farms, given that all farmers are involved under study but they are selected randomly (Kothari, 2004). The inclusion criteria that a dairy cow should have to be selected were that it must be in early lactation stage and it must not have clinical mastitis. Through the dairy dynamic management program 50 dairy cows were selected under study from whole population located in 15 farms. Each cow was sampled the milk quality and quantity one per week within 16 weeks, the price per litter of milk were recorded and the income per cow was calculated. The analysis was emphases on cost carried out during the dairy dynamic management project and relative cost of milk. The possible sequence of future events like milk production cost without mastitis, milk production cost with mastitis was compared and the arithmetical mean between cost and benefits was calculated. The sample size was calculated with 95% of confidence of the reality and 5% of margin errors using the formula of Alain Bouchard (2004.

For a population of 100, 0000 individuals, sample size are calculated by the following formula:

$$n=\frac{No}{1+\frac{No}{N}}=\frac{No\times N}{No+N} \quad \text{with } No=\frac{(ta)^2\ x\ p(1-p)}{d^2}$$

With n= Sample size

N= Universe size

No= Sample size for finite universe

d^2= Margin error

$t\alpha$ = Student value

P= Estimated frequency for sample size n

For our case, we have taken a margin error of 10 % and p of 0.5. Universe size was 50 cows and 15 farmers who have risen at a degree of freedom of 90% and $t\alpha$ =1. 65.

$$No = \frac{(1.65)^2 \times 0.5(1-0.5)}{(0.1)^2} = 68.0625$$

Cow simple size

$$n = \frac{68.0625 \times 50}{50 + 68.0625} \approx 29$$

Farmer simple size

$$n = \frac{68.0625 \times 15}{15 + 68.0625} \approx 12$$

From the above formula a sample of 12 farmers and 29 cows has been taken as representative of whole farmers and cows.

III. DATA COLLECTION AND DATA ANALYSIS

Primary data were collected with the use of validated structured questionnaires included open-ended and closed types of questions administered followed the method described by Thrusfield (1986) and Osotimehin *et al*. (2006), to 15 farms in the study sites and collected back for scoring and processing. The information collected included, farmer's compliance, dairy dynamic management practices, milking times per day and milk production. Documentation, reports, text books, journals and internet are sources of secondary data (Kothari, 2008). Ms Excel has been used to collect data from questionnaires and to produce tables and charts. The total income, total cost and total revenue from both milk with and without mastitis causing bacteria were calculated. Therefore the data has been analyzed qualitatively and quantitatively using Microsoft excel. The analysis was emphases on cost carried out during the dairy dynamic management project and relative cost of milk. The possible sequence of future events like milk production cost without mastitis, milk production cost with mastitis was compared and the arithmetical mean between cost and benefits was calculated.

IV. RESULTS AND DISCUSSION

Investment for mastitis:

Investment assets used for determination of mastitis cost in dairy dynamic management program was divided into three type such as cost categories, income (treatment /prevention) and the income (no treatment / no prevention).

Table 1: Description of the investment assets of mastitis

Cost categories	**Amounts**
Feed (Frws/day/lactation)	139860
Water (Frws)	3780
Preventive (Frws/day/lactation)	19950
Infrastructure (Frws/cow)	28245
Vet.services (Average Frws/cow)	15000
Treatment (Frws/cow/treatment)	9600
Discarded milk (L/Day/Milk price)	23800
Income (Treatment/Prevention)	362950

Yield (L)	7
Milk price (rwf)	170
Lactation (Days)	305
Income (no treatment or prevention)	291550
Yield (L)	7
Milk price (Frws)	170
Lactation (Days)	245

Relationship cost of total income, total cost and total revenue based on different scenario:

The following state amount of money calculated based on different state of management was done us prevention, treatment, combination of both or without use it. For the total cost, it is calculated when you add all investment used such as amount of feeds, amount of water, amount of infrastructure , amount of veterinary services, amount of prevention and amount of treatment. The total income is calculated when you multiply the milk price per litler, milk yield and milking days and the total revenue is calculated when you do the different between total income and the total cost.

Table 2: The relationship between the total cost, total income and total revenue

	Scenerio with prevention	**scenerio with treatment**	**Scenario with prevention and treatment**	**Scenerio with no prevention or treatment**
Total income	362950	362950	362950	291550
Total cost	206835	220285	33400	171885
Total revenue	156115	142665	329550	119665

The result obtained is based on scenario and each scenario has its own total revenue from total income minus total cost but when we combine treatment and prevention we obtained the highest profit or revenue (329 550 frws) when we compare with result from others scenarios such as neither prevention and treatment (119 665 frws) and when we did prevention (156 115 frws) or treatment (142 665 frws) only.

Considering that clinical mastitis is one of endemic diseases seen in dairy farming enterprises, which has important financial results (Wolfova *et al*., 2006), in our study the treatment cost of clinical mastitis per animal is estimated to be (156 115-119 665) =137 890 frws as an average cost of bovine mastitis per cow per year while others studies that define mastitis losses, report that annual loss per cow is $118-182 in 80s (Jasper, 1982; Seykora *et al*., 1985). Although some of diseases related cost items such as amount of milk discarded in short term, increased labor costs and exclusion of animals from the herd are not included in the scope of this study, calculated costs were within the range that was defined by previous studies (Jasper, 1982; Seykora *et al*., 1985; Yalcin, 2000). This is through to be related with low milk yield and high treatment costs.

The cost scenario for prevention:

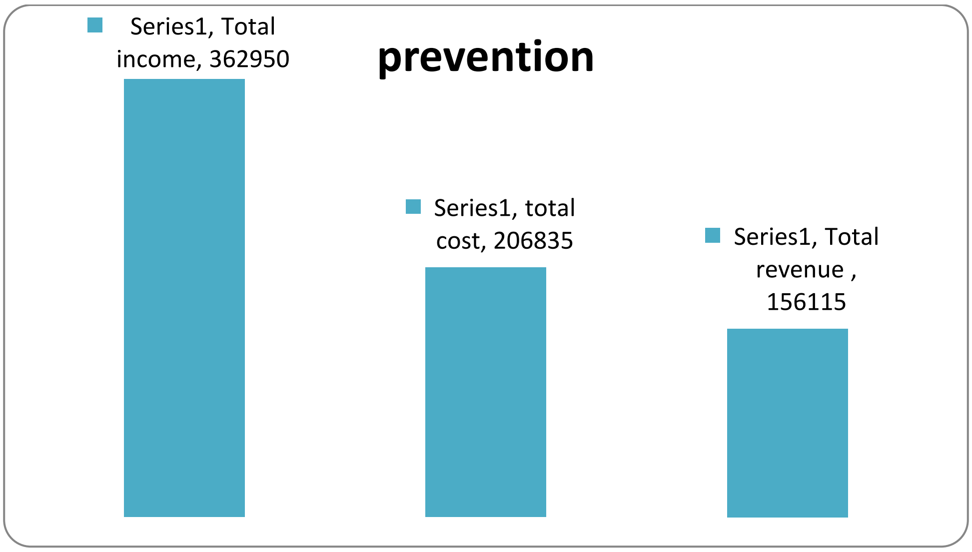

Figure 1: The presentation of the cost scenario for prevention

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The results of our study in figure 1 present how the cost varies when we use prevention, the total cost is 206 835 frws, the total income is 362 950 frws and total revenue is 156115 frws means that if bovine mastitis disease is controlled with prevention only the total revenue must be moderated.

Total cost distribution during the prevention:

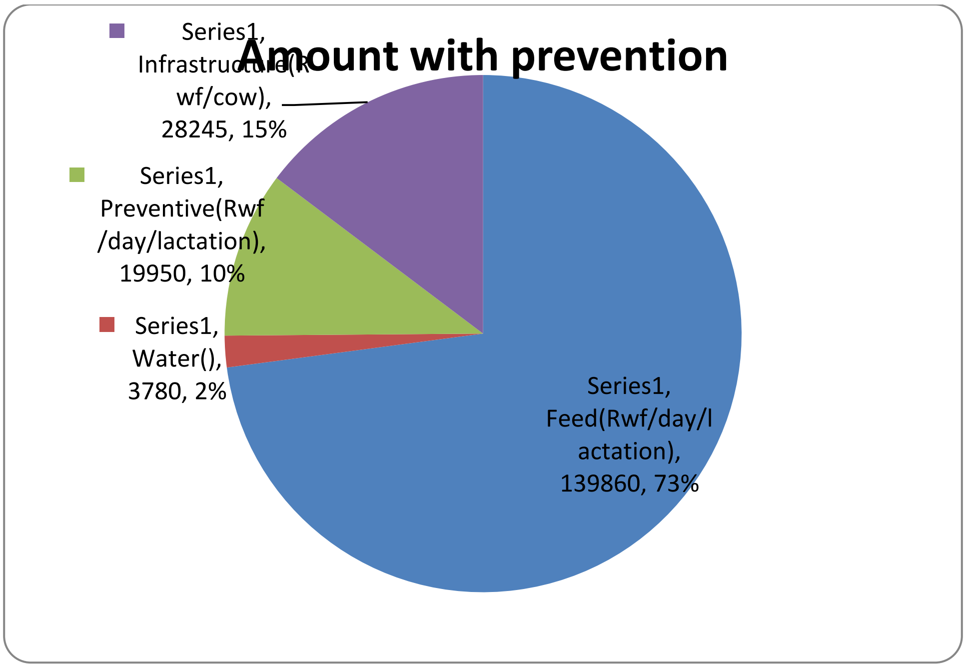

Figure 2: Total cost distribution during the prevention

The figure 2 presents how the cost varies when we use prevention, each component has its own percentage. These component are respectively presented by the infrastructure (15%), the prevention (10%), water (2%) and the feeds (73%).The feeds occupied large space because is very important during the raising of animal.

Cost scenario for treatment:

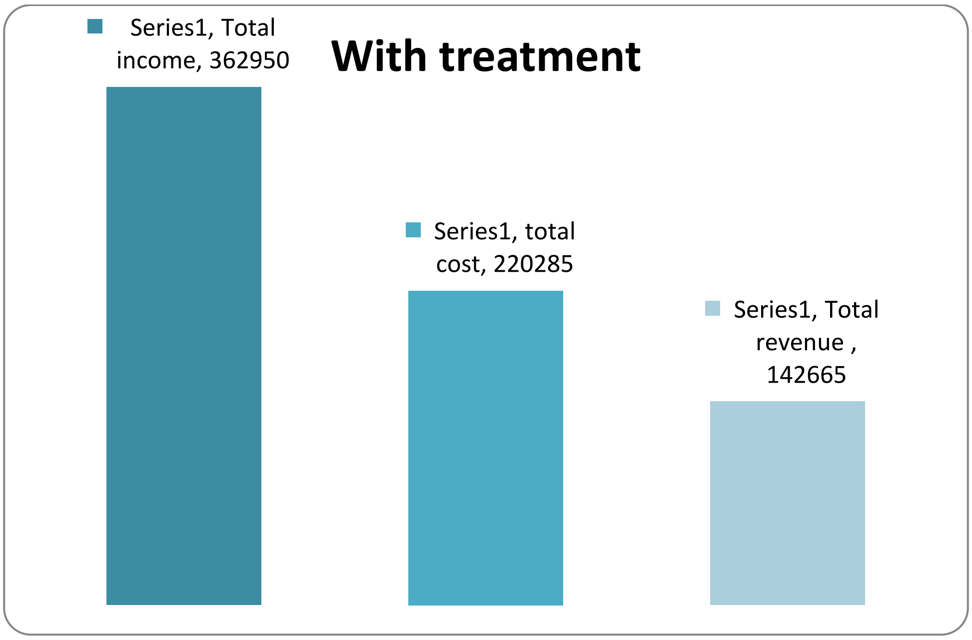

Figure 3: Cost scenario for treatment

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The figure 3 presents how the cost varies when we use treatment: the total cost is 220285 frws, the total income is 362950 frws and total revenue is 142667 frws.

Total cost distribution during the treatment:

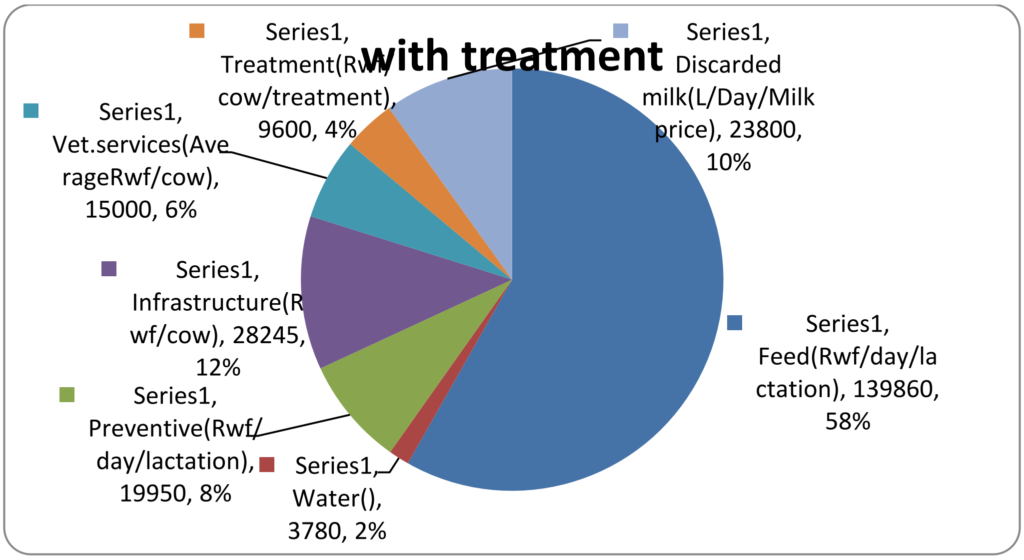

Figure 4: Total cost distribution during the treatment

The results of our study in figure 4 present the distribution of cost in percentage when using the treatment. The feeds (58%) represent the very important factor during the raising of animals comparing to the infrastructure, discarded milk, prevention, vet services and water which have respectively 12%, 10%, 8%, 6% and 2%.

Cost scenario for treatment and prevention:

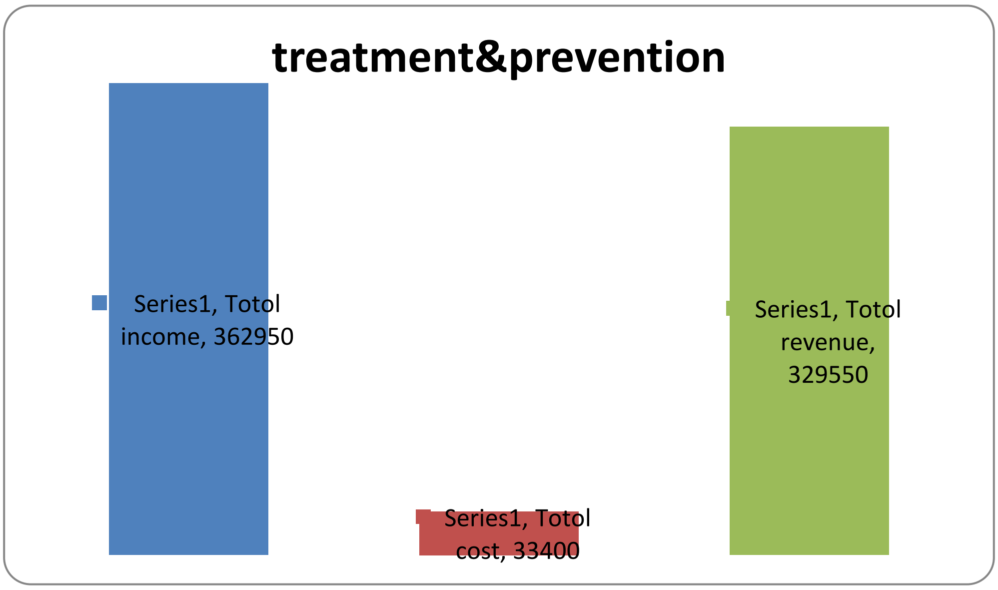

Figure 5: Cost scenario for treatment and prevention

The results of our study in the figure 5 reveal that the total cost, the total income and the total revenue varies when using prevention and treatment with respectively 33 400 frws, 362 950 frws, and 329 550 frws. When we compare the total revenue of Cost scenario for treatment and prevention and the above scenarios we observe that here there is the greatest total revenue.

Total cost distribution during the treatment and prevention:

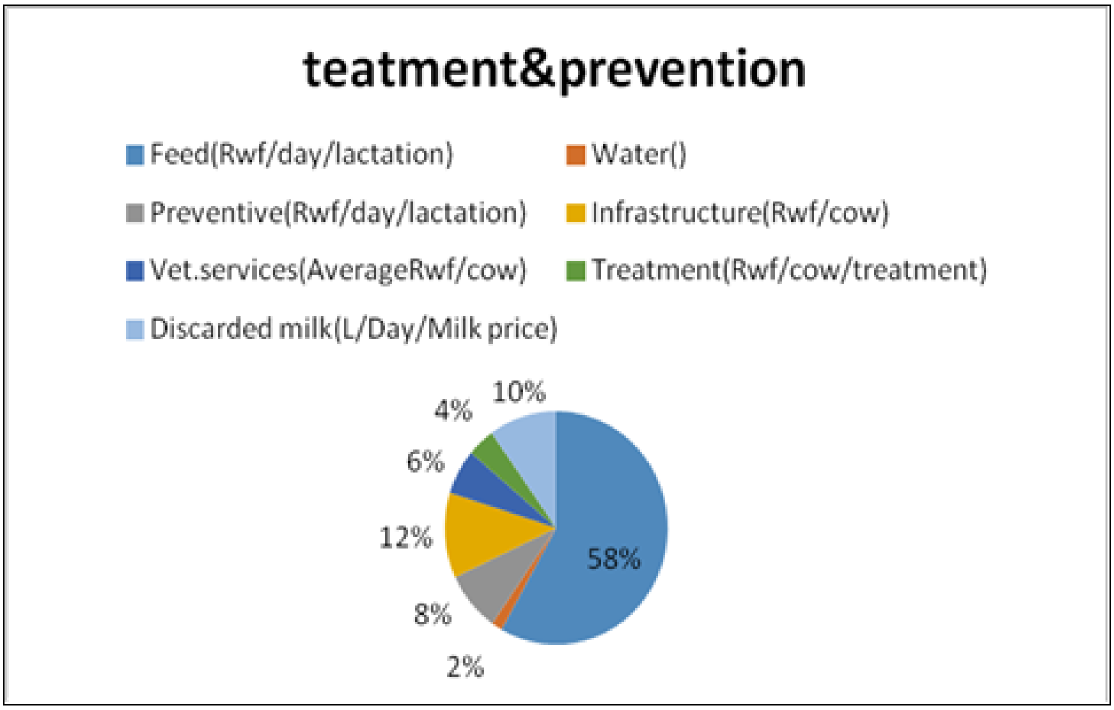

Figure 6: Total cost distribution during the treatment and prevention

The results of our study in figure 7 show that even during the treatment and prevention the cost of feeds is also greater than other cost related to the infrastructure (12%), the prevention (8%), the water (2%), the discaseded milk (10%), the veterinary services (6%) and the treatment (4%) because is very important during the raising of animal.

In our study all strategies of mastitis control increased the economic performance of dairy herds. The profitability of a certain preventive measure is determined by the cost of its implementation and the value of the reduction in mastitis incidence that it can achieve. In order to improve decision support concerning whether individual herds ought to invest in preventive measures and to facilitate prioritization, the expected economic viability of preventive measures should be investigated. There are technological tools, such as Herd Navigator®, available on the market that enable detection of SCM at an early stage of infection and, thus, allow for early intervention. With early treatment of mastitis, cure rate can be expected to be higher and the economic loss can thereby be reduced. In theory, such equipment has the potential to revolutionize udder-health management. It is, however, associated with an investment of considerable magnitude, and research is required to assess the economic viability of this kind of technology. Preferably, economic calculations should consider the consequences of a possibly, increased usage of antibiotics resulting from more cases of mastitis being detected (Allore *et al.*, 1999).

But our study, the treatment increased the economic performance of dairy herds because the treatment eradicate causal of mastitis and increased milk production in quality and quantity (reducing discarded milk), discarding milk with high SCC was not an effective strategy to increase herd net return under the current milk-pricing system. This resulted is decrease of the volume of sold milk, which was not offset by the increase in milk price. Under the current milk-pricing system, it is, consequently, more profitable for farmers to sell a larger volume of milk with higher SCC than to discard high SCC milk in order to obtain a higher average milk price. Reduced milk production constitutes the major cost component of the total economic loss caused by mastitis. The magnitude of yield loss is determined by the stage of lactation in which the cow develops mastitis.

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Cost scenario for no treatment and no prevention used:

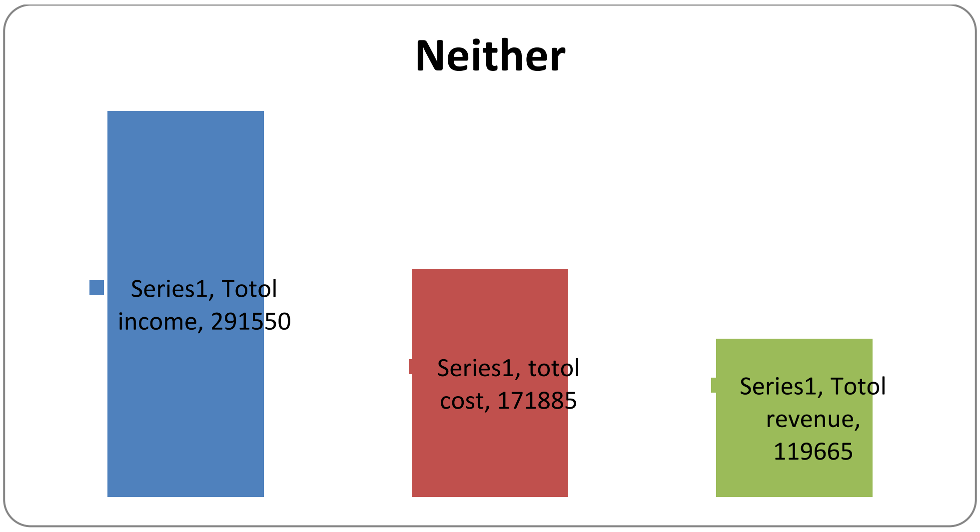

Figure 7: Cost scenario for no treatment and no prevention used

The figure 7 presents how the cost varies when we didn't use prevention and treatment showing the total cost of 171 885 frws, the total income of 291 550 frws. The mean of total revenue is low and lead to the losses of production (119 665 frws) caused by mastitis.

Total cost distribution during the no treatment and no prevention:

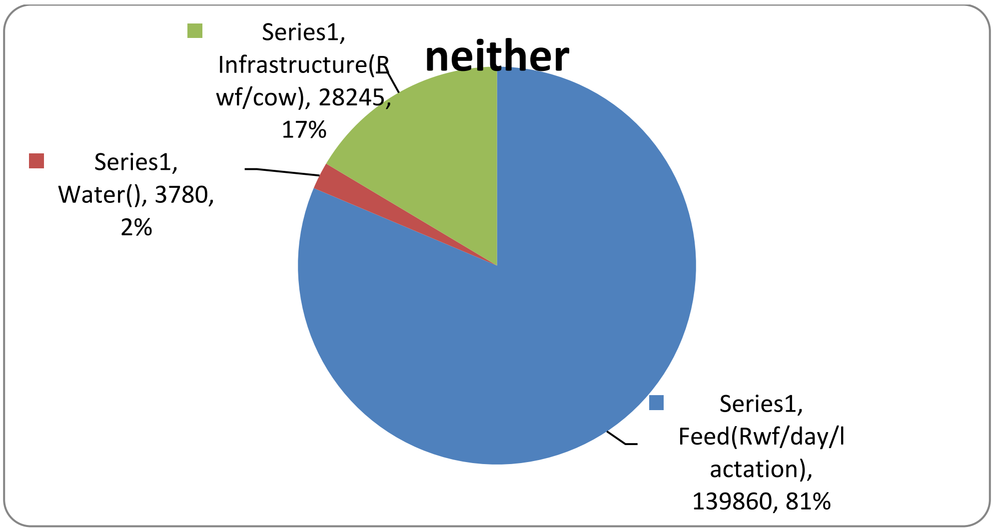

Figure 8: Total cost distribution during the no treatment and no prevention

The figure 8 presents how the cost varies when there is no treatment and no prevention. This is characterized by infrastructure (17%), water (2%) and the feeds (81%).

The formula show how the income are calculated

a) Income (Income over cow/year)

-Yield (L/day) x milk price x days of milking = total income

b) Income loss (Income over cow/year)

-Yield loss (L/day) x milk price (poor quality milk) x reduced days of milking = total income

c) As result it seems that there are different benefit depend on scenerio

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Total cost (investment) – Total income (no mastitis) = 156 115 frws

Total cost (investment) – Total income (with mastitis but no-treatment) = 119 665 frws

Total cost (investment) – Total income (with mastitis but treatment and care) = 329 550 frws

As shown the above benefits by calculating the cost benefits we observe that due to occurrence of bovine mastitis or not, there is greatest profit when mastitis is treated and controlled. The profit when mastitis have been prevented is greater than when mastitis is not prevented and treated. Profit centered dairy farms strive to maximize milk price and control costs. One way to control costs is by minimizing the rate of disease. The most costly disease of dairy cattle is generally considered to be mastitis.

Table 3: The different cost on milk with mastitis and without mastitis

Cost (Amount)	**No mastitis**	**Clinical mastitis**
Total Costs /year (frws)	206 835 frws	171 885 frws
Total Income /year (frws)	362 950 frws	291 550 frws
Gross revenue /year (frws)	156 115 frws	119 665 frws
Gross revenue /cow /year (frws)	156 115 frws	119 665 frws

As shown above the total costs/year with mastitis is greater than the total cost/year with no mastitis. The total income/year with no mastitis is greater than the total income with clinical mastitis and also gross revenue/cow/year with no mastitis is greater than when the gross revenue/cow/year with clinical mastitis.

V. DISCUSSION

In our study all strategies of mastitis control increased the economic performance of dairy herds. The profitability of a certain preventive measure is determined by the cost of its implementation and the value of the reduction in mastitis incidence that it can achieve. In order to improve decision support concerning whether individual herds ought to invest in preventive measures and to facilitate prioritization, the expected economic viability of preventive measures should be investigated. There are technological tools, such as Herd Navigator®, available on the market that enable detection of SCM at an early stage of infection and, thus, allow for early intervention. With early treatment of mastitis, cure rate can be expected to be higher and the economic loss can thereby be reduced. In theory, such equipment has the potential to revolutionize udder-health management. It is, however, associated with an investment of considerable magnitude, and research is required to assess the economic viability of this kind of technology. Preferably, economic calculations should consider the consequences of a possibly, increased usage of antibiotics resulting from more cases of mastitis being detected (Allore *et al.*, 1999).

But our study, the treatment increased the economic performance of dairy herds because the treatment eradicate causal of mastitis and increased milk production in quality and quantity (reducing discarded milk), discarding milk with high SCC was not an effective strategy to increase herd net return under the current milk-pricing system. This resulted is decrease of the volume of sold milk, which was not offset by the increase in milk price. Under the current milk-pricing system, it is, consequently, more profitable for farmers to sell a larger volume of milk with higher SCC than to discard high SCC milk in order to obtain a higher average milk price. Reduced milk production constitutes the major cost component of the total economic loss caused by mastitis. The magnitude of yield loss is determined by the stage of lactation in which the cow develops mastitis.

VI. CONCLUSION AND RECOMMENDATIONS

This study clearly demonstrates that the cost benefits ratio of dairy herds can be improved by reducing the incidence of mastitis. A lower incidence of mastitis can be achieved by implementation of mastitis control programs. There are large variations between studies in the calculation of economic damage of mastitis management. The resultants also shown that factors included in the calculation varied between studies.

Animal husbandry is a dynamic process with factors that affect milk yields in dairy cow such breed, lactation period, and number of daily milking, milking interval and weight, nutrition, environmental temperature, calving season, dry period, diseases and exercise. This study on cost benefits analysis for mastitis milk yield for economic losses related to all of these factors above into consideration in determining the area and almost impossible to do the field work, is far from being rational. Therefore, at the farm level in mastitis incidence and yield losses at the level of farm, knowledge is needed.

A treatment plan for the clinical mastitis needs early detection, diagnosis of the pathogen and effective treatment. In present study, vet clinicians did not reported that were made a somatic cell numbers control applications and pathogen diagnosis in the field conditions. The other important finding was the treatment cost which does not vary in regard with the strain of the animal. However, some recommendations are formulated to maximize the cost benefit for bovine mastitis in the study area and in the whole country in general, and also for the improvement of the dairy cow production. The government should update the guidelines for prevention and control of bovine mastitis and sensitize the farmers to sell milk according to their quality in order to get more profitability, to adopt treatment and prevention of dairy cow that produce more and train them. On the other hand, farmers should monitor cow mastitis status and milk quality; invest in preventive measures rather than in milk-sorting equipment and estimate the price of milk according to their quality to improve cost benefit whereas researchers should undertake this research and find out strategy of increasing milk marketing.

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