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ECONOMIC ANALYSIS OF DAIRY ANIMAL DISEASES IN PUNJAB: A CASE STUDY OF FAISALABAD DISTRICT

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ABSTRACT

This study estimates the prevalence of key livestock diseases in district Faisalabad and evaluates the effects they have on livestock productivity and farm incomes. Particular focus of the study is on the negative consequences on milk production and farm incomes due to mastitis, Parturient Hemoglobinuria, Foot and Mouth Disease (FMD), and tick infestations. The economic losses associated with these diseases are estimated. The analysis of diseases shows that the morbidity rate of tick infestation and FMD is high both in buffaloes and cows, and significant economic losses are being caused by these diseases due to reduced milk production, weight loss, and abortion. The production of milk can be enhanced, and per animal and per farm income can be increased, by controlling for these diseases. The economic losses caused are proportional to the scale of farming. However, on a per animal basis the losses are generally higher for small and medium farms than for large farms. The share of livestock income in total farm income is around 50 percent which makes this sector vital to the survival of the farming community, especially the small farmers. With the help of proper training, extension services, and veterinary care facilities, these diseases can be controlled, and the dairy business improved, thereby lifting the overall agriculture sector of Pakistan.

Keywords: Economic analysis, dairy animal diseases, farm income, benefit-cost ratio, Pakistan.

INTRODUCTION

Agriculture sector engages the largest proportion of Pakistani population. Overall, it provides employment to 43.5 percent of population and about 60 percent of rural population depends on this sector for its livelihood. The share of agriculture in GDP of the country is 20.88 percent (Anonymous, 2015). It can be safely stated that agriculture is the backbone of Pakistan's economy. Livestock is an important subsector of agriculture as it plays a vital role in economic development of the country. The share of livestock in national GDP is 11.8 percent and it contributes a share of 56.3 percent in agricultural value added (Anonymous, 2015).

Livestock is the primary activity, along with crop husbandry, in rural areas of Pakistan. Currently, 33-36 million people are directly and/or indirectly connected with the livestock sector. Most farm families have 2-3 cattle or buffaloes and 5-6 sheep and goats; 20-25 percent of their income is obtained from these animals. About 5.5 million small farmers and landless farmers produce milk, and 93 percent of these farmers possess on average 2-3 milk animals. The low milk yield per animal in Pakistan is found to be due to many factors including losses due to diseases (the focus of this study), late age at maturity, unorganized marketing system, farming on traditional lines, and lack of extension services (Bilal, 2004).

Around the world the production of dairy products is fluctuating. Milk is the chief product of the dairy sector, and a majority of countries in the world consume liquid milk. The total world production of milk is 696.55 million tons per year. Pakistan ranks fourth in total milk production in the world (FAO, 2010). Annual milk production of Pakistan is 34 million tons; 58 percent milk is obtained from buffaloes, 35 percent from cows; and the remaining 7 percent is being produced from camels, sheep and goats (Tariq *et al*., 2008).

At present, most farmers are rearing their animals both for home consumption and commercial use. Mixed farming is practiced commonly in Punjab, as almost every farmer practices crop agriculture activities along with dairy farming. For small farmers, livestock is the source of traction, store of wealth, organic manure, and means of transport. Livestock is also crucial for ensuring food security for rural households. Ali and Khan (2013) found in their study that households having livestock ownership had 19-41 percent higher food security levels as compared to households having no livestock ownership. Landless peasants are also heavily dependent on livestock production activities. These farmers graze their animals along canal banks and water channels or feed their animals by fodder which they get in return of their services as a labor on land owners' farms; in most cases their animals stay underfed.

The dairy sector is becoming a commercial sector despite the scant attention of policy makers. Although Pakistan is a principal milk producer in the world, it is still importing powdered milk to fulfill domestic demand. The value of imported milk, and its related products, was $134.4 million in 2011-12 and

$112.4 million in 2012-13 (Anonymous, 2013). For various reasons, a high portion of the milk produced is used at the farm level and does not enter the dairy industry (Burki *et al*., 2005).

The population of Pakistan is increasing significantly. It is increasing at the rate of 1.57 percent annually; higher than China and India (0.49 and 1.34 percent respectively) (CIA, 2011). The population is increasing faster than the rate of milk production. Production of milk does not meet the per capita milk demand of 176.3 liter per person per year (Saleem and Ashfaq, 2009). Increasing demand for food, coupled with the deficient per capita availability of milk and meat, has put stress on the prices of these goods. The higher prices of dairy products hurt the consumers and their per capita food consumption.

Losses due to diseases are one cause of low milk production and farm incomes. There are many fatal diseases in Pakistan including Foot and Mouth Disease (FMD), Parturient Hemoglobinuria, Bovine Viral Diarrhea (BVD), and black quarter. Farmers do not regularly vaccinate their animals against these diseases which lower dairy production. Every third cow/buffalo is suffered from mastitis, greatly contributing to loss of milk production. Parasites such as ticks are also lowering the production of sector (Saleem and Ashfaq, 2009).

Livestock diseases play a crucial role in the life of dairy farmers because diseases not only lower the production but also weaken the farmers economically. Mortality resulting from diseases deprives the farmers of dairy earnings. Morbidity due to diseases is responsible for the short term and long term product losses. These losses are economically more important as compared to mortality (Husnain and Usmani, 2006).

Within this background, the present study examines four different diseases with an aim to estimate the economic losses caused by these diseases and potential returns if these diseases are controlled for. The main focus of the study is on the diseases, mastitis, Parturient Hemoglobinuria, FMD, and tick infestation. All four of these diseases are economically significant. Brief descriptions of these diseases, and the extent to which they are harmful, are given in the following paragraphs.

Mastitis is a costly and important disease for dairy animals. In the United States, an annual loss of $1 billion is caused to dairy industry by subclinical mastitis, which is the most economically important type of mastitis because of its chronic effects (Ott, 1999). An annual loss of $35 billion is caused by this disease globally (Ratafia, 1987). It is a highly prevalent disease in Pakistan. Ali *et al*., (2011) reported an overall occurrence rate of 44 percent for subclinical mastitis among dairy buffaloes in Punjab province. Mastitis is an inflammation of the mammary gland characterized by physical, chemical, and bacteriological changes in milk and pathological changes in glandular tissue. Common causes include staphylococcus, streptococcus, and Escherichia coli. Reduction in milk production, quality, abortion and death of animals are the direct losses from mastitis (Bennet and Pelarr, 2005). Mastitis is also dangerous for human beings as contaminated milk can be a source of transferring disease to humans. Contaminated milk creates various hazards during the manufacturing of milk products. Mastitis also causes fertility problems in animals (Kossaibati and Esselmont, 1997).

Parturient Hemoglobinuria is a major, economically important, disease of dairy animals. It is an acute worldwide sporadic disease affecting high yielding, pregnant buffaloes as well as cows. It is characterized by intravascular hemolysis, Hemoglobinuria, straining while defection, labored breathing, and death (Jubb and Kenndedy, 1985). Nine percent of total mortality in buffaloes in Pakistan, and five percent of total mortality in cows, is due to Parturient Hemoglobinuria. This disease causes an estimated annual loss of Rs. 490.2 million in buffaloes and Rs. 153.1 million in cows in Punjab (DPE, 1996).

FMD is the most contagious, trans-boundary, animal disease (FAO, 2007). It is characterized by vascular and ulcerative lesions of the mouth and feet of cloven footed animals. It is so infectious that it ranked first among the most noticeable infectious diseases of animals by Office International des Epizootics (OIE) (OIE, 2000). Due to the severity of its economic impacts, and the nature of the virus, FMD is also the most important disease which affects the trade of animals and related products throughout the world (Arzt *et al*., 2011 a, b). Economic losses due to FMD are comprised of losses due to high morbidity and mortality in young animals and production losses in older animals due to decreasing milk production and weight gain (Alexandersen and Garland, 2003).

Ticks are important blood sucking parasites of mammals, birds, and reptiles. Ticks are considered a significant threat to profitable animal production worldwide due to their numerous direct and indirect effects on their hosts. On a global scale, about 80 percent of cattle population is at risk of tick infestation and tick-borne diseases. The economic losses caused by ticks and tick-borne diseases are estimated to have an annual value of as much as $18 billion (deCastro, 1997). In Brazil alone, cattle ticks cause annual losses as high as $2 billion (Grisi *et al*., 2002). The annual losses caused by external parasites to the US beef cattle industry amount to $2.4 billion (Tolleson *et al*., 2007). Ticks cause these economic losses to livestock production by affecting the hosts in several ways such as loss of blood, deterioration of the quality of hides and skin, and by transmitting different protozoan and viral diseases to other animals (Snelson, 1975).

The underlying hypothesis in this study is that the above mentioned livestock diseases are significantly damaging the productivity of the livestock sector in Punjab, Pakistan, and this productivity can be recovered by controlling these diseases.

MATERIALS AND METHODS

Study Area, Sample Size and Data Collection: The study was conducted in district Faisalabad of Punjab province which is one of the major producers of livestock products. It is categorized as mixed cropping zone where wheat, rice, cotton, sugarcane and maize are grown. All types of fodder varieties are also cultivated as animal feed. The population of cattle and buffaloes in district Faisalabad is 461 thousands and 1148 thousands, respectively, according to Livestock Census of 2006.

All five *tehsils* of district were selected for survey. From each *tehsil,* three villages were selected at random. After that, 10 livestock farmers were selected randomly from each village (Table 1). Following this technique, a total of 150 farmers were included in the final sample.

Table 1. Name of *tehsils* and villages included in the study

***Tehsil* Names**	***Village* Names/Number**	**No. of Respondents**
Faisalabad	Gaffaabad	10
	Gharee	10
	Chakaira	10
Samundri	Laadian/213 G. B.	10
	Gujar Pind/217 G. B.	10
	Bhulpar	10
	456 G. B.	10
Tandlianwala	Paareeh	10
	Kanjwaani/541 G. B.	10
Jaranwala	Ambalian	10
	Rodalaa Mandi	10
	28 G. B.	10
Chak Jhumra	Kamal Pur/133 R. B.	10
	Chooti Karaari/190 R. B.	10
	Sultan Naghar	10
Total		**150**

Data were collected through structured questionnaires which were modified after pre-testing in the field. During the data analysis phase, the livestock farmers were categorized into three groups, small, medium and large livestock farmers, before starting the analysis. Livestock farmers having 1-3, 4-6 and greater than 6 adult dairy animals are considered small, medium, and large livestock farmers, respectively, with an assumption that these animals affect overall farm production level. Moaeen and Babar, 2006 used the similar basis to categorize livestock farmers.

Estimation of Gross Margins for Livestock Farmers: The gross margins are calculated by using the following traditional formula:

Gross Margins = Total Revenue – Total Variable Cost (1)

Where; total revenue for the whole farm including livestock and crop production consists of gross income from dairy and gross income from crops. Total variable cost also has two components; (i) variable cost of milk production, and (ii) variable cost of crop production.

The gross income from dairy is calculated as follows:

Gross income from dairy per year = (Total value of milk produced + Total income from dung cake + Total income from selling of animals) (2)

The income part in the above equation is calculated by multiplying the total respective outputs (including output consumed by the farm household) with the output price.

Gross income from crop husbandry per year is determined by the following procedure:

Gross income from crops = $\sum_{i=1}^{n} TP_i \; PC_i$ **(3)**

TP_i = Total production of ith crop at farm

PC_i = Price of one unit of ith crop

Fodder and by-product incomes are not included in the gross income of the crops because these are consumed by the animals and are included as expenditures of the feed cost of the animals.

Figure 1 shows that total expenditures of raising animals consist of fixed and variable cost. Fixed costs include interest and depreciation in the value of the animals, sheds, and equipment. Variable costs consist of labor cost, feed costs, veterinary care cost, and breeding cost. We are only considering variable costs in this analysis.

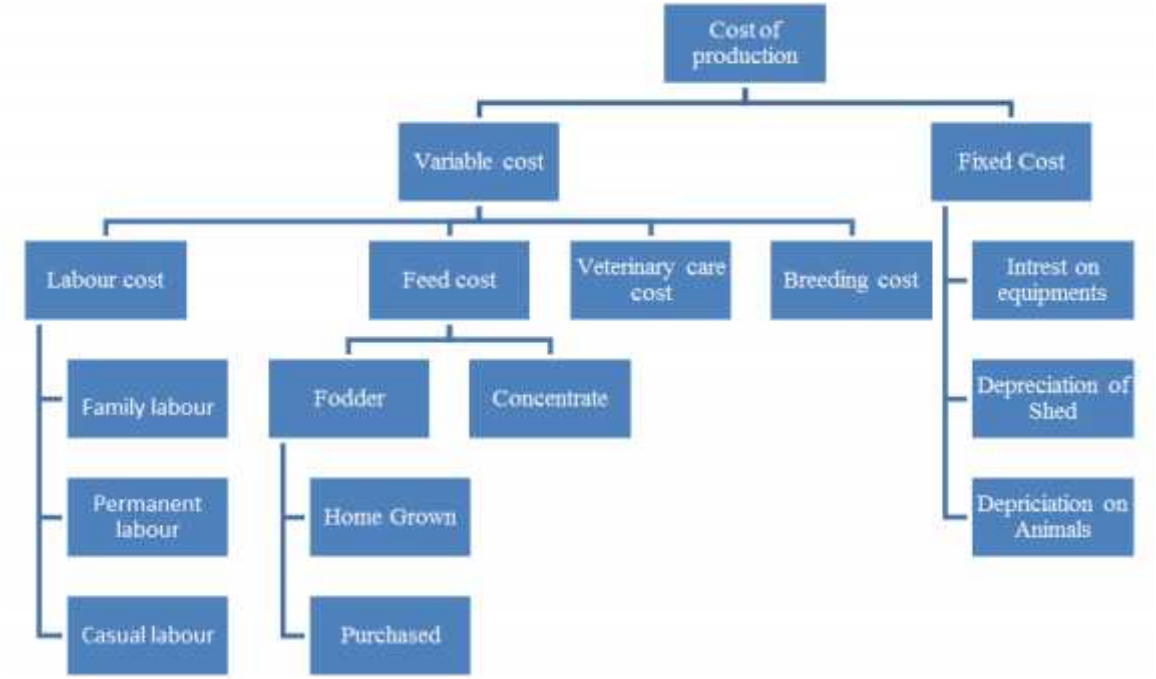

Fig. 1: Factors affecting the Cost of Production of Milk
Source: Adopted from Jayaweera et al. (2007)

The procedures adopted to calculate the different cost components are described as follows: Cost of milk production is estimated by multiplying the quantity of inputs used by the price paid for the inputs. The main costs incurred in milk production are:

Cost of milk production = Labor cost + Feed cost + Veterinary care cost + Breeding cost (4)

Labor Cost: The labor used per animal on a milking animal basis is computed per year as:

MLH = (THL / MA) × 12 (5)

MLH = Labor hours used per milking animal per year

THL = Total hours of labor spent on dairy enterprise per month

MA = Milking animals at farm

The labor cost per milking animal is calculated as:

MLC = MLH × per hour labor cost for dairy enterprise (6)

MLC = Labor cost per milking animal per year

MLH = Labor hours used per milking animal per year

Feed Cost (Fodder and Concentrates): Feed cost includes the cost of green fodders, dry fodder, concentrate, etc. Fodder cost per animal on a milking animal basis is calculated by using the formula:

CMA = TCF / MA **(7)**

CMA = Cost of green and dry fodder, fed per milking animal, in rupees per year

TCF = Total cost of green and dry fodder fed to livestock

MA = Milking animals at farm

Along the same lines, the cost of concentrates for milking animals is calculated.[1]

Veterinary Care Cost: The total annual veterinary care cost is calculated as:

Total veterinary care cost = (No. of vaccination in a year × Expenses per vaccination) + Cost of oil + Cost of salt + Cost of spices (8)

Breeding Cost: Breeding cost consists of payments made while practicing the natural or artificial breeding of animals. Breeding cost in cows/buffaloes is calculated as:

Breeding Cost = (Total services per conception in heifers × charges per service) + (Total services per conception in adults × charges per service) (9)

With these dairy gross income and total variable costs computed, and the gross income and variable cost of crop production calculated for each crop separately and these crop incomes and costs summed up, our final equation to calculate gross margin for the whole farm is as follows:

Gross Margins = [Gross dairy income + Gross farm crop income] – [Cost of milk production + Cost of crop production] (10)

Our analysis mainly focuses on the dairy income, costs, and gross margin. We also compare dairy and crop

[1] See Ahmad *et al*. (1996) and Shah *et al*. (2009) for additional discussion of production cost calculations.

incomes and margins as components of farm total revenue and gross margin.

Morbidity, Mortality, and Case Fatality Rate of the Diseases: Morbidity, mortality, and case fatality rates are calculated for each disease by following Haq *et al*., 2011:
Morbidity/Incidence Rate = (Total No. of affected animals/Total No. of animals at farm)*100 (11)
Mortality Rate = (Total No. of animals which died/Total No. of animals at farm)*100 (12)
Case Fatality Rate = (Total No. of animals which died/Total No. of affected animals)*100 (13)

Estimation of the Losses due to Diseases: Each disease has its own characteristics and different types of losses are associated with it. The following methods are used to calculate the monetary losses associated with each of the four diseases.
Total losses due to mastitis = Value of milk loss + Veterinary or treatment cost + Value of discarded milk + Loss in animal sale value (14)
Total losses due to Hemoglobinuria = Value of milk loss + Veterinary or treatment cost + Losses due to abortion + Loss due to death of animals (15)
Total losses due to FMD = Value of milk loss + Veterinary or treatment cost + Losses due to abortion + Value of loss in weight of affected animals + Loss due to death of animals (16)
Total losses due to tick infestation = Value of milk loss + Veterinary or treatment cost + Value of loss in weight of affected animals (17)
The percent of total losses related to the four diseases due to each disease is calculated as:
Economic Losses (percent) = (Total economic losses due to a disease/Total economic losses due to all disease)*100 (18)

Benefit-Cost Ratio of Controlling for Livestock Diseases: The benefit-cost ratio (BCR) of controlling for livestock diseases is calculated in order to guide the policy making process toward encouraging farmers to control for livestock diseases if it is economically beneficial. This provides a convenient summary of important aspects of this study. The BCR is calculated as:

$$\text{Benefit-Cost Ratio} = \frac{\text{Benefits from Control of a particular disease (Rs.)}}{\text{Prevention cost of the disease (Rs.)}} \quad (19)$$

Benefits from the control of diseases are in fact the 'losses per animal' from the disease which the farmers bear if not controlled for. We can also call them 'losses avoided' after control. Thus, our calculation of per animal economic losses due to each disease becomes the benefits in our BCR analysis.

The costs of prevention for each disease were calculated by consulting experts from the Department of Clinical Medicine and Surgery of the University of Agriculture, Faisalabad and doctors practicing in veterinary hospitals.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Livestock Farmers: Table 2 provides a summary of some of socioeconomic characteristics of farmers. The farmers in the study area are on average about 42 years old with an average farming experience of about 18 years. There is not much variation in these characteristics across farm sizes. Also, the means of age, education level, and livestock farming years of farmers were not significantly different when tested using independent samples t-test. Education level of farmers is generally low in the study area; on average they have 6.71 years of regular schooling. The family size of livestock farmers is proportional to the farm size, which is an interesting finding. The means of family size across farm sizes were significantly different at 10%, 0%, and 15% level of significance when tested for small-medium, small-large, and medium-large farmers, respectively.

Table 2. Farmers' Characteristics.

	Farm Size Groups			
General Information	**Small Farmers**	**Medium Farmers**	**Large Farmers**	**Overall**
Age (Years)	42.38	42.94	40.81	42.07
Livestock Farming Experience (Years)	18.97	19.00	18.50	18.85
Schooling (Years)	6.54	7.47	6.36	6.71
Family Size (No.)	7.74	9.19	11.29	9.08

Characteristics of Livestock Farms: In this section the farm related characteristics of livestock farmers are discussed under various sub-sections.

Number of Farms in the Sample: The categorization of farmers in based on the number of animal units they possess as shown in Table 3. Almost half of the farmers in the sample are small farmers, while medium and large farmers each constitute about one fourth of the total sample. The selection of the farmers was random, and the fact that most of the selected farmers are small illustrates

that majority of livestock farming community consists of small farmers.

Table 3. No. of Farms.

Farmer's Category	Frequency	Percentage
Small Farmers	72	48
Medium Farmers	36	24
Large Farmers	42	28
Total	150	100

Animal's Inventories of the Respondents: Table 4 shows average numbers of animals broken down by farm size. As a reminder, farm size categories were determined by the number of adult buffaloes and cows; other animals are included here for more context. The average number of adult buffaloes is about 6, and the average number of cows is about 2. Large farmers are found to have larger total numbers of animals; a natural outcome. It is also important to mention that there are two very large farmers having 70 and 140 buffaloes, because of which the average number is raised for the large farm category.[2]

Table 4. Animal Inventory (Number)

Animal	Farm Category			
	Small Farmers	Medium Farmers	Large Farmers	Over all
Buffaloes				
Adult Buffaloes	1.31	3.53	15.40	5.79
Heifer Buffaloes	0.69	1.56	3.69	1.74
Cows				
Adult Cows	0.64	1.47	4.62	1.95
Heifer Cows	0.29	0.69	1.93	0.85
Buffaloes and Cows				
Bulls	0.57	1.11	1.19	0.87
Calves	1.28	2.92	9.48	3.97
Goats				
Adult Goats	0.92	1.89	3.60	2.45
Young Goats	0.08	0.50	1.44	1.07
Bucks	0.35	0.67	1.26	0.68

The Morbidity/Incidence, Mortality, and Case Fatality Rates of Diseases

Morbidity/Incidence Rates of Selected Diseases: Table 5 shows the results regarding the number of disease affected animals separately for buffaloes and cows. It is evident from the table that large farmers who have a higher number of both buffaloes and cows also have a higher number of animals affected for all four diseases. There is a natural correlation between the numbers of animals a farmer owns to the number of affected animals. This could be due to the infectious nature of some diseases.

Table 5. Disease Affected Animals (Total Numbers)[3]

	Small Farmers	Medium Farmers	Large Farmers	Overall
Buffaloes				
Total No. of Buffaloes	94	127	647	868
Total No. of affected Animals	55	112	451	618
Mastitis	14	17	65	96
Hemoglobinuria	5	2	14	21
Foot and Mouth Disease	19	59	108	186
Tick Infestation	17	34	264	315
Cows				
Total No. of Cows	46	53	194	293
Total No. of affected Animals	29	44	138	211
Mastitis	5	4	8	17
Hemoglobinuria	5	3	4	12
Foot and Mouth Disease	11	16	27	54
Tick Infestation	8	21	99	128

After calculating the morbidity/incidence of each disease from the above data, it is revealed that the morbidity rate of FMD in buffaloes is higher among small and medium farmers as compared to other diseases (Table 6). FMD has also been reported as the most prevalent livestock disease in the Islamabad Capital Territory of Pakistan by Hussain *et al*., (2005), while lower FMD morbidity rates than we find are reported for the DRDF-USAID project (Anonymous, 2014). Among the large farmers, the morbidity rates of mastitis and FMD are lower than what is found in the buffaloes of small and medium farmers. This is due in part to the fact that large farmers can afford to vaccinate their animals; a practice less frequently observed among small and medium farmers. Tick infestation is the most commonly found disease in the buffaloes of large farmers and had the highest overall morbidity rate among the buffaloes of all three groups of farmers. The reason might be the lack of hygienic conditions at animal farms and absence of

[2] The two largest farmers have been left in the sample presented in the tables and analyzed in the text as they were part of the random sample selected. For comparison, in several footnotes we also present results for the large farm category and overall (all farms) excluding these two largest farms.

[3] The high number of total affected animals for buffaloes for Large Farmers as compared to other farm categories is in part because of the two very large farmers in the sample having 70 and 140 animals.

dipping ponds coupled with the low level of training and awareness. Also, during the field survey and discussion with the farmers, it was discovered that the farmers did not perceive this disease as an important contributor toward milk reduction or any other significant loss.

Table 6. Morbidity Rate of Diseases (Percentage)

	Small Farmers	Medium Farmers	Large Farmers	Overall
Buffaloes				
Mastitis	14.89	13.39	10.05	11.06
Hemoglobinuria	5.32	1.57	2.16	2.42
Foot and Mouth Disease	20.21	46.46	16.69	21.42
Tick Infestation	18.09	26.77	40.80	36.29
Cows				
Mastitis	10.87	7.55	4.12	5.80
Hemoglobinuria	10.87	5.66	2.06	4.10
Foot and Mouth Disease	23.91	30.19	13.92	18.43
Tick Infestation	17.39	39.62	51.03	43.69

Incidence rates of mastitis and Hemoglobinuria in cows are found to be higher among small farmers, as compared to the other two categories, and lowest among large farmers. This could be due to a lack of preventive measures adopted by small farmers who are financially constrained. The incidence rate of tick infestation is again highest in the cows of large farmers. Tick infestation is found to be the most prevalent disease in the case of cows, as was found in buffaloes for large farmers, and in these cases the incidence rate of this disease is higher in cows than in buffaloes. The same higher incidence rate of tick infestation in cattle was reported by Muhammad *et al*., (2008). FMD is the second most prevalent disease, both in cows and buffaloes.

Mortality Rate and Case Fatality Rate due to Hemoglobinuria: In the sample, mortality occurred due to Hemoglobinuria only. The results presented in Table 7 show that the mortality rate is highest in both the buffaloes and cows of small farmers. This is perhaps because small farmers usually rely on traditional methods of treatment rather than proper veterinary care. Overall, the mortality rate in cows is higher than in buffaloes. The reason could be that buffaloes are more resistant animals as compared to cows. The case fatality rate is also much higher in cows than buffaloes. For cows, the case fatality rate is highest among large farmers. This could be because large farmers often own cows of superior breeds which are more productive but have less resistance toward diseases.

Table 7. Mortality Rate due to Hemoglobinuria (Percentage).

	Small Farmers	Medium Farmers	Large Farmers	Overall
Buffaloes				
Mortality Rate	2.13	0.79	0.31	0.58
Case Fatality Rate	40.00	50.00	14.28	23.81
Cows				
Mortality Rate	6.52	3.77	1.55	2.73
Case Fatality Rate	60.00	66.67	75.00	66.67

Economic Losses Associated with the Selected Diseases: Economic losses associated with diseases are calculated to rank the diseases in terms of their economic importance, the losses associated with the diseases were calculated. The overall economic losses associated with each disease, as well as losses for buffaloes and cows, are calculated. Losses per animal and per farm are also calculated for each disease and discussed below.

Overall Economic Losses Associated with Selected Diseases: Calculations find that FMD the most damaging disease in the area; causing significant economic losses to all three groups of farmers (Table 8). Overall, about 70 percent of total economic losses calculated are caused by FMD Tick infestation is the second most damaging disease and it accounts for about 16 percent of total economic losses. Mastitis and Hemoglobinuria are responsible for less than 10 percent and 5 percent of total economic losses, respectively. The economic losses when compared across farmers groups show little systematic pattern for mastitis, Hemoglobinuria, and FMD. However, the percentage of losses due to ticks increases with farm size, consistent with the higher morbidity.

Table 8. Percentage of Economic Losses of Diseases (Percent).

Diseases	Farm Size			
	Small Farmers	Medium Farmers	Large Farmers	Overall
Mastitis	14.09	8.34	9.59	9.01
Hemoglobinuria	11.96	3.03	3.96	4.39
FMD	68.34	78.31	64.40	70.25
Tick infestation	5.61	10.32	22.05	16.35

Disease related Economic Losses per Farm and per Animal in Buffaloes and Cows: Average economic losses associated with each disease are broken down for

buffaloes and cows by farm groups in Table 9. Losses per animal in Table 9 are calculated using the number of milking animals on the farm only, defined as adult buffaloes or adult cows, respectively. The sum of the number of adult buffaloes and the number of adult cows was used to calculate results on a per animal basis.

The losses per farm are found to be generally proportional to scale of farming for each disease; a natural outcome which we saw earlier that the number of affected animals was also generally proportional to the total number of animal a farmer had. However, morbidity rates are not the same for all the farm sizes; for example, large farmers have a higher number of total animals with reduced morbidity percentages, except in the case of ticks (Table 6). This is seen in losses per animal, which generally went down as farm size increased. Tick Infestation is the exception, with a larger number of animals leading to higher per animal losses. This is primarily due to the high prevalence of this disease on large farms. The higher per animal economic losses due to FMD in the medium farmers' category is partly due to the higher morbidity rate of disease in the same category. Therefore, we can say that losses per animal tend to correspond to the morbidity rate, and losses per farm tend to correspond to the number of affected animals on each farm. Thus, the losses per farm are proportional to farm size in terms of number of affected animals in each farm category (Table 5). Large farmers bore the highest economic losses for each disease, both in buffaloes and cows, while having lower losses per animal, except for the case of ticks. The results showed that, for buffaloes, FMD accounted for highest per animal, and per farm, economic losses in the study area, as it significantly affects the milk production. These overall losses for buffaloes are Rs. 18270 and Rs. 105723, respectively.

FMD is also the most damaging diseases in cows in terms of losses per animal and total economic losses. The economic losses due to this diseases are highest followed by losses caused by tick infestation. The same order of economic importance of diseases is observed for both buffaloes and cows. As it is evident from the results, the contribution of Hemoglobinuria toward total economic losses is lowest both in buffaloes and cows. The mean differences of per animal losses, between small and medium farmers, were significant for all diseases except Hemoglobinuria in both buffaloes and cows. Per animal losses when compared across small and large farmers, the mean differences were significant only in case of FMD for cows. The mean differences of per animal losses, compared across medium and large farmers, were significant for all diseases except Hemoglobinuria in case of buffaloes, and in case of cows the differences were only significant for tick infestation.

Table 9. Diseases Related Economic Losses in Buffaloes and Cows (Rupees)[4].

Diseases	Small Farmers	Medium Farmers	Large Farmers	Overall
Buffaloes				
Mastitis				
Loss per farm	4201	11206	31434	13236
Loss per animal	3218	3177	2041	2287
Hemoglobinuria				
Loss per farm	3110	2284	8845	4213
Loss per animal	2382	647	574	728
FMD				
Loss per farm	26916	114587	196325	105723
Loss per animal	20616	32481	12744	18270
Tick Infestation				
Loss per farm	2405	12041	57511	21776
Loss per animal	1842	3413	3733.33	3763
Total Losses				
Loss per farm	36632	140120	294115	144948
Loss per animal	28059	39719	19092	25049
Cows				
Mastitis				
Loss per farm	3431	4463	4941	3659
Loss per animal	5370	3031	1070	1873
Hemoglobinuria				
Loss per farm	3369	3406	6171	4021
Loss per animal	5273	2314	1336	2059
FMD				
Loss per farm	10102	32550	48021	25951
Loss per animal	15811	22109	10396	13286
Tick Infestation				
Loss per farm	631	7339	26164	8865
Loss per animal	988	4985	5664	4539
Total Losses				
Loss per farm	17532	47758	85297	42497
Loss per animal	27442	32439	18466	21756

Components of Economic Losses on per Animal Basis: Economic losses caused by diseases had several components, and these components are different for each disease. These losses were calculated on a per animal basis jointly for buffaloes and cows. Per animal losses are again calculated using only milking animals (in this case, buffaloes and cows). The results are presented in Table 11. FMD was the major contributor toward the economic losses caused by diseases. The order of importance of diseases, in terms of economic losses, stays the same in the joint calculation for both buffaloes and cows. The order is: (a) FMD, (b) tick infestation, (c) mastitis and (d) Hemoglobinuria.

[4] The high Loss per farm for buffaloes by Large Farmers as compared to other farm categories is partly because of the presence of two very large farms in the sample as indicated earlier.

Table 11. Components of Losses per Animal Calculated Jointly for Buffaloes and Cows (Rupees)

	Small Farmers	Medium Farmers	Large Farmers	Overall
Mastitis				
Milk Loss	3489	2756	1566	1890
Treatment cost	436	378	251	293
Loss Per Animal	3925	3134	1817	2183
Hemoglobinuria				
Milk Loss	335	90	148	144
Treatment cost	365	119	126	145
Mortality Loss	2632	928	476	775
Loss Per Animal	3332	1138	750	1064
Foot and Mouth Disease				
Milk Loss	9947	16845	6694	9516
Treatment cost	351	519.	112	269
Loss Due to Abortion	5160	5330	2791	3501
Weight Loss	3580	6733	2606	3725
Loss Per Animal	19038	29428	12203	17012
Tick Infestation				
Milk Loss	822	2328	2002	2084
Treatment cost	12	16	29	24
Weight Loss	728	1532	2147	1851
Loss Per Animal	1562	3876	4179	3959
Total				
Milk Loss	14593	22020	10410	13634
Treatment cost	1163	1033	519	731
Mortality Loss	2632	928	476	775
Loss Due to Abortion	5160	5330	2791	3501
Weight Loss	4308	8265	4753	5576
Loss Per Animal	27856	37576	18948	24218

In the case of mastitis, per animal losses are highest for small farmers and lowest for large farmers, owing to the reasons already discussed. Value of milk loss due to mastitis is greater than the treatment cost, and overall economic losses per animal amounted to Rs. 2,182. However, the mean differences of these losses when compared across farm sizes were not significant between small and medium farmers, but the mean differences were significant between small and large farmers, and medium and large farmers.

In case of Hemoglobinuria, economic losses consist of milk loss, treatment cost, and mortality loss. For this disease, treatment cost is about equal to the value of milk loss; opposite of what is observed for mastitis. The reason is Hemoglobinuria does not affect the milk yield as much as mastitis does. Mortality is the major component of per animal economic losses causes by Hemoglobinuria. The mean differences of these losses were significant between small and medium farmers, and small and large farmers. For medium and large farmers, the mean differences of losses were not significant.

FMD has four components contributing to total economic losses per animal. These components are milk loss, treatment cost, losses due to abortion, and weight loss. As FMD greatly reduces the milk yield, milk loss is the major component contributing to total economic losses per animal. Losses due to abortion and due to weight loss are smaller, but added together they cause 42 percent of the losses. The average losses were significantly different between small and medium farmers, and medium and large farmers. However, the mean losses of small and large farmers were not significantly different from each other.

The calculations of per animal economic losses caused by tick infestation show that treatment cost is minimal. Economic losses due to weight loss are almost equivalent to losses due to milk loss. Per animal economic losses are lower on large farms for all diseases except for the case of tick infestation. This is due to the high prevalence of this disease on the large farms. The mean losses were significantly different from each other for small and medium farmers, and medium and large farmers. However, the means losses for small and large farmers were not significantly different from each other.

Overall, milk loss is the major contributor to total economic losses per animal caused by all the diseases, followed by weight loss, and losses due to abortion. Losses due to mortality and treatment cost per animal are almost the same.

Livestock Income and its Share in Total Farm Income

Gross Margins from Livestock: Gross margins are simply the difference of average value of output from livestock and total average variable cost (see equations 1, 2 and 4). Table 12 shows the costs, value of output, and gross margins per animal for all three groups of farmers and for the overall. The per animal costs were again calculated using the number of milking animals (adult buffaloes plus cows). Results show that fodder and concentrate costs were the major contributors to total variable cost per animal, followed by health care costs. Farmers obtain market returns by selling either the milk from animals or animals themselves. We include the value of home consumption in their value of milk output (but income from dung cake shown in equation 2 is not in the calculations).

The results in Table 12 show variable costs per animal are highest for small farmers and decline as farm

size increases. Smaller farms have higher input costs for several reasons; for example, they are less likely to own cultivation equipment and have to rent land preparation and cultivation services, raising costs. Smaller farmers are also more likely to purchase fodder, which increases costs, or to pay higher prices for concentrate in smaller quantities. In addition, the ratio of milking animals to total animals is lower for small and medium farmers than for large farmers, and so costs are lower on the lager farms on a per milking animal basis.

Value of output per animal is also reported to be somewhat higher for small farmers than for medium or large farmers in our survey, but not by enough to offset their higher variable costs. Taking these results together, gross margins per animal of the farmers were proportional to scale of farming. Large farmers have the highest gross margins per animal, amounting to Rs. 30,486. Overall, average gross margins per animal are Rs. 19,828 for all farmers. Yet, small and medium farmers earn only a small gross margin on each animal (Rs. 2,649 and Rs. 3,763, respectively). Essentially, with a small number of animals, and with the losses they are incurring due to diseases, the small and medium farms earn very little gross margin from their dairy production. Total disease losses (Table 11) for small and medium farmers (Rs. 27,856 and Rs. 37,576, respectively) are about ten times larger than their gross margins (Rs. 2,650 and Rs. 3,763, respectively). For large farmers, their smaller disease losses per animal (Rs. 18,948) are about 60 percent of their gross margin per animal (Rs. 30,486).

Gross margins calculated on a per farm basis show similar trends (Table 13). In this case, the larger margin per animal is reinforced by the larger number of animals on the larger farms. Large farmers enjoy large gross margins per farm, whereas small and medium farms earn very little. Overall, gross margins per farm are as high as Rs. 153,474 only because it is dominated by the large farms. Gross margins per farm are only Rs. 5,152, on average, for the small farmers and Rs. 18,816 for medium farmers.

Share of Livestock Income in Total Farm Income: Finally, the importance of livestock sector was assessed by measuring its share in the total farm revenue and total farm gross margins. The results in Table 14 are average values, for each farm size category and for the overall. There are two main sources of farmer's revenue; crop income and dairy income. The results show that the income from crops is higher than from dairy for small and medium farmers, but for large farmers dairy income is higher than crop income. The overall share of livestock income in farm revenue is about 50 percent. This shows how important the livestock sector is for rural households. Share of dairy income in total farm revenue is about 42 percent, 32 percent, and 60 percent for small, medium, and large farmers, respectively. The reason why large farmers have a very high share of dairy income in total farm revenue is perhaps that they can afford to buy and feed productive animals, which is not possible for other two groups of farmers.

Table 12. Gross Margins per Animal (Rupees)[5].

Average Cost per Animal	Small Farmers	Medium Farmers	Large Farmers	Overall
Fodder cost	44,613	36,593	23,325	28,148
Concentrate cost	30,166	26,861	17,311	20,827
Labor cost	2,855	1,738	1,017	1,364
Health care cost	4,089	5,355	2,447	3,139
Breeding cost	232	123	76	103
Total Variable cost	81,955	70,670	44,175	53,582
Average Value of Output per Milking Animal per Year (Rupees)				
Milk	68,536	57,904	61,944	60,262
Selling of animals	16,069	16,530	12,717	13,149
Total	84,605	74,434	74,661	73,410
Gross Margin	2,650	3,763	30,486	19,829

Table13. Gross Margin per Farm (Rupees)[6].

	Small Farmers	Medium Farmers	Large Farmers	Overall
Average cost per Farm				
Fodder cost	86748	182967	467056	217863
Concentrate cost	58656	134303	346628	161203
Labor cost	5552	8692	20364	10561
Health care cost	7951	26774	48990	24296
Breeding cost	450	615	1518	800
Total Variable cost	159358	353351	884556	414722
Average value of output per farm per year (Rupees)				

[5] When the two largest farmers are removed from the Large Farmers category in Table 16, gross margins per animal drop from Rs. 30,486 to Rs. 17,745 and the overall average drops from Rs. 19,828 to Rs. 14,285. The main story remains the same: the gross margins per animal for large farmers are still much larger than those for medium and small farmers.

[6] Similar to Table 16, when the two largest farmers are removed from the sample, the gross animal margin per large farm drops from Rs. 610,449 to Rs. 251,104 and the overall average from Rs. 153,474 to Rs. 85,521. Again, large farmers have much higher gross margins than small and medium farmers, although again the difference is moderated.

Milk selling of animals	133265	289518	1240358	466426
Total	31245	82649	254648	101770
Gross Margin	164510	372168	1,495006	568196
	5152	18816	610450	153474

Table 14. Share of Livestock and Crop Income and Margins in Total Farm Revenue and Margins[7].

Income	Small Farmers	Medium Farmers	Large Farmers	Overall
Crops Income (Rs.)	222000	768386	981175	570069
Dairy Income (Rs.)	164510	372168	1495006	568196
Total Farm Income (Rs.)	386510	1140553	2476181	1138265
Share of Dairy Income (% age)	42.56%	32.63%	60.38%	49.92%
Gross Margins				
Crops Total Variable Cost	137414	419243	578529	334597
Crops Gross Margins (Rs.)	84586	349142	402646	235472
Dairy Total Variable Cost	159358	353351	884556	414722
Dairy Gross Margins (Rs.)	5152	18816	610450	153474
Total Farm Gross Margins (Rs.)	89738	367959	1013096	388946
Share of Dairy Gross Margins (Percent)	5.74%	5.11%	60.26%	39.46%

The Return on Effective Control of Livestock Diseases: Economic Incentive for the Farmers to Control Livestock Diseases: The previous discussion on economic losses due to livestock diseases would be incomplete without providing the optimistic picture of the economic benefits of controlling for these diseases in the first place. As the saying goes - "Prevention is better than cure". Therefore, we have calculated the costs of prevention for the four diseases, for which our previously calculated per animal losses will become the benefits of such a measure. Thus, the potential benefits in each case are the overall per animal economic losses which we have shown in Table 11. Here we are assuming the benefits that will occur if the diseases are prevented.

The 'costs' which we use to estimate such benefit-cost ratios are prevention costs related to each disease. These costs are different for different diseases and were calculated by consulting veterinary doctors. Hence, the costs provided in the following table reflect average expenses to reduce the chances of a particular disease from occurring. Table 15 shows the resultant Benefit-Cost ratios of controlling for livestock diseases.

Table 15. Benefit-Cost Ratios for Controlling Livestock Diseases.

Disease	Prevention Cost per Animal (Rs.)	Benefit per Animal (Rs.)	B/C Ratio
Mastitis	3250	2183	0.67
Hemoglobinuria	328	1064	3.24
FMD	768	17012	22.15
Tick Infestation	1,180	3959	3.35
Overall	5526	24218	4.38

The results show that the BCR for all the diseases, except mastitis, is more than 1, which implies that controlling for these livestock diseases is an economically viable option. In the case of mastitis, the BCR is less than 1, and one may think that mastitis control is not an economically viable option, but it must be noted that it is an infectious disease. If not controlled for, it can spread to other milking animals, which could make prevention an economically viable option. Secondly, the resulting decrease in the value of animals has not been included; otherwise the benefits would be much higher. Results also show that the return on FMD control is very high. Overall, the benefit-cost ratio is about 22.15, which means that spending 1 rupee on disease control fetches Rs. 22.15 in return; an attractive economic outcome.

The same BCR analysis is conducted for the various farm sizes to determine which category of farmers is expected to gain more from controlling for the diseases. The 'costs of prevention' per animal are assumed to be same for all three farm categories, because there are no practical differences at field level. The 'benefits' in this case are taken from Table 11 which are per animal losses for each disease under each farm category. The final BCR ratios are presented in Table 16. It can be seen from the table that per dollar invested in prevention, small farmers are expected to gain more from FMD and Hemoglobinuria prevention, while large farmers are expected to gain the most by preventing FMD

[7] Interestingly, when the two largest farmers are removed for Large Farmers crop gross margins increase from Rs. 402,646 to Rs. 424,240. This leads us to conclude that the two largest farmers have specialized in dairy, while the other large farmers rely more on crop income.

and tick Infestation. The control of FMD is highly beneficial for medium farmers. On the whole, the BCR ratios for all diseases under all farm categories are more than 1, except for mastitis, where the BCR is less than 1 for medium and large farmers. But this value is in fact much higher had we considered the other costs related to this disease, such as the infectious nature of mastitis and the loss in animal's sale value. These results can pave the way for implementable policy options to increase the awareness among farmers and to uplift the livestock sector in general.

Table16. Benefit-Cost Ratios by Farm Size.

Disease	Benefit-Cost Ratios		
	Small Farmers	Medium Farmers	Large Farmers
Mastitis	1.21	0.96	0.56
Hemoglobinuria	10.16	3.47	2.29
FMD	24.79	38.32	15.89
Tick Infestation	1.32	3.28	3.54

Also reflected in the BCRs presented here is the story gleaned from the comparison of gross margins presented in Table 14. This is the story of the potential impact on gross margins from targeting disease prevention towards the three different farm categories. Large farmers have BCRs greater than 1 for all diseases except mastitis. When this potential benefit is applied to the margins seen by large farmers from dairy, it will lead to a large increase in overall margins for the dairy sector. This means helping large farmers with disease prevention has the greatest absolute impact. However, the larger BCRs found for small and medium farmers (except for ticks) show that helping with disease prevention for these farmers has a greater percentage impact on dairy incomes. The margins presented in Table 14 showed that there is a great deal of room for improvement which could have a serious impact on the lives of small and medium farmers and the dairy sector in general.

Conclusions and Policy Options: Pakistan ranks fourth among the top ten producers of milk and its livestock stock sector is far from harnessing its full potential. There are several constraints which constantly hinder the productivity of this sector, and the issue of livestock diseases is not being given its due. This study was conducted with an aim to investigate the extent of economic losses caused by four important livestock diseases (mastitis, Hemoglobinuria, FMD and tick Infestation), and potential of dairy industry to raise its production if these diseases were controlled for.

Based on the results of this study, the following conclusions could be drawn:

- Livestock sector mainly consists of small farmers having 2-3 animals, but most of its production (about 75 percent) comes from large farmers. These farmers are lacking in education & awareness about the control of livestock diseases. They possess more buffaloes than cows while other animals (small ruminants and others) are even less in number.
- The morbidity rates of tick infestation and FMD are quite high in both buffaloes and cows, and significant economic losses are being caused by these diseases due to reduction in milk production, weight loss, and abortion. The production of milk can be greatly enhanced by controlling these diseases, and farmers' per animal and per farm incomes can be increased by avoiding the significant economic losses caused by these diseases.
- Total economic losses caused by these diseases are generally proportional to the scale of farming, i.e. the greater the farm size, the higher the losses.
- Economic losses are lower per animal on large farms, except in the case of tick infestations.
- The return on controlling the livestock diseases (benefit-cost Ratio) is sufficiently high to motivate the farmers to invest in controlling measures to increase their economic returns.
- Livestock sector is vital for the survival of rural households' especially the small farmers. Also, the share of dairy income in total gross farm income is more than 40 percent for small farmers, rising to 60 percent for large farmers. Therefore, this sector is very much important for whole farming community of Punjab. Yet our results indicate small and medium farmers earn little net income from their livestock. Better disease control could increase these low gross margins.

Recommendations: The agriculture sector of Pakistan is struggling, and high value agriculture has huge potential to help the sector progress. The economic analysis livestock diseases done in this study leads to the following recommendations to help uplift the livestock sector of Punjab:

- As it is a well-known fact that cows are more productive animals as compared to buffaloes, steps should be taken toward increasing the population of cows. Results show that farmers currently have more buffaloes than cows.
- As most of the production comes from large farms, the policy focus should be more on the large farms if the objective is to expand national dairy production.
- Small farmers have the highest disease losses compared to the gross margins they earn per dairy animal. Focusing on small farmers would help alleviate poverty.
- There are millions of small farms which could act as disease repositories. However, our results showed that preventive measures are not expensive. Therefore, the need is to spread the awareness among

farmers. Private sector agencies could be hired to fast-track the process.

- Although the incidence of diseases is generally higher among cows than buffaloes, this could be controlled and production can be increased above current levels, as cows have a higher production potential.
- Proper and well-targeted extension services, along with veterinary care services, should be provided to farmers for the control and treatment of livestock diseases; especially FMD and tick infestation which appear to be a cause of significant amount of economic losses. Tick infestation can be easily controlled by dipping, but this is not happening; firstly, due to farmers' lack of awareness about its economic losses; secondly, because farmers are unaware about dipping; and thirdly, because dipping ponds are non-existent in many areas. This problem could be overcome by spreading awareness about the importance of ticks along with making community dipping ponds available at union council levels.
- Mastitis and Hemoglobinuria account for a relatively small percentage of economic losses from the four diseases examined. Nevertheless, more attention needs to be paid to these disease. Our study may underestimate the losses due to mastitis and Hemoglobinuria because, in fact, hemoglobinuria is the most deadly of the four diseases.
- Farmers should be given training, from time to time, regarding vaccination against livestock diseases. This can be done by using the plat form of Farmer's Organization already being established in many rural areas.
- Mobile health services should be provided by the government to control the diseases. In this way, health care services for animals could be provided at the farm level, and even remote areas could be covered.
- Livestock provide over half of farm income in Pakistan, but it does not get the same weight in public expenditure. Increases in public expenditures should be focused on both animal health and animal nutrition. There exists a vicious cycle here; poor feeding practices lead to poor animal health, and affected animals reduce farmers' incomes, which makes it difficult for them to feed the animals properly.

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