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Effects of Livestock Diseases on Dairy Production and Incomes in District Faisalabad, Punjab, Pakistan

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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. All five tehsils of district Faisalabad are included in the study. From each tehsil three villages were chosen, and from each village 10 livestock farmers were chosen randomly to collect survey information. Three categories of farmers were formed on the basis of the adult animal units (buffaloes and cows): small (1-3 animals), medium (4-6 animals), and large farmers (greater than 6 animals). 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 morbidity/incidence rate, mortality rate, and case fatality rate of each disease is determined. The economic losses associated with these diseases are estimated, and the economic returns on controlling these diseases are calculated in the form of benefit-cost ratios. These results are put in overall farm income perspective by reporting the share of livestock income in total farm income and policy recommendations are given.

The results show a large share of the milk production in the livestock sector comes from large farmers despite the presence of large numbers of small farms. 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 by controlling for these diseases, and per animal and per farm income can be increased by avoiding the significant economic losses caused by these diseases. The economic losses caused are proportional to the scale of farming; i.e. the greater the farm size, the higher are the losses. 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. However, the gross margins from dairy for small and medium farmers are only around 5 percent of the total gross farm margins (with the other 95 percent coming from crops), while the gross margins from dairy for large farmers are around 40 percent of their total. The return on controlling these livestock diseases is sufficient to motivate the farmers to move in this direction, and the vast room for improving margins acts as a strong motivating force as well. Yet, when it comes to the treatment of livestock diseases, many farmers rely on traditional methods rather than seeking proper veterinary advice for their animals, which is detrimental to their incomes and the development of the national dairy business. 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.

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INTRODUCTION

Agriculture is an important sector of Pakistan's economy. There are various types of resources enabling the agriculture sector to produce all types of food items. This sector is a mainstay of the country, contributing about 45 percent of employment and 21.4 percent of GDP. About 60 percent of the rural population depends on agriculture for its livelihood. The agriculture sector also provides raw material and inputs to the industrial sector. Livestock, as a subsector of agriculture, plays a vital role in the development of the economy of Pakistan. This sector contributes 55.4 percent of agriculture value added and 11.9 percent of GDP (Govt. of Pakistan, 2013).

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 (FAO, 2010). Pakistan ranks fourth in total milk production in the world. Table 1 shows the ranking of the top ten countries in milk production. Annual milk production in Pakistan is 34 million tons; 58 percent of milk is obtained from buffaloes, 35 of percent from cows; and the remaining 7 percent is produced by camels, sheep, and goats (Tariq *et al*., 2008).

Table 1: Top Ten Milk Producers in the World (Million Tons per Year)

Rank	Country	Production
1	India	110.04
2	United States	85.85
3	China	40.55
4	Pakistan	34.36
5	Russia	32.56
6	Germany	28.69
7	Brazil	27.71
8	France	24.21
9	New Zealand	15.21
10	United Kingdom	13.23

Source: FAO, 2010

Table 2 shows that the population of buffaloes, cattle, and goats in Pakistan has increased over time. This increase is encouraging; it represents the importance of this sector for the development of the country.

Table 2: Livestock Population in Pakistan (Million Head)

Years	Buffalo	Cattle	Goat
2001-02	24.03	22.85	50.91
2002-03	24.75	23.30	52.76
2003-04	25.51	23.75	54.67
2004-05	26.29	24.21	56.66
2005-06	27.33	29.56	53.78
2006-07	28.14	30.67	55.24
2007-08	29.00	31.82	56.74
2008-09	29.88	33.02	58.27
2009-10	30.84	34.31	59.97
2010-11	31.70	35.60	61.50
2011-12	32.70	36.90	63.10
2012-13	33.70	38.30	64.90
2013-14	34.60	39.70	66.60

Source: Government of Pakistan, 2014

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 to 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 systems, farming along traditional lines, and lack of extension services (Bilal, 2004). Livestock is considered a secure source of income for small and landless farmers in Pakistan. It is a source of employment creation at the village level and helps farmers to maintain their income, especially in the case of crop failure. This study sheds further light on this basic descriptive characterization of the livestock sector, especially for Punjab province.

Punjab plays an important role in the economy of Pakistan due to its flourishing agriculture sector. Agriculture contributes 28 percent of the GDP of the province and employs 44 percent of the province's population. About 75 percent of Punjab's population is involved in some way in the livestock sector, which is not surprising because small ruminants and animals have become a part of the household's food basket. Animals are also a secure source of income to finance emergency expenditures (PDB, 2009). About 73 percent of the country's milk production comes from Punjab, while Sindh contributes about 23 percent; the rest comes from various other provinces (Hashami *et al*., 2007).

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 main source of traction, store of wealth, organic manure, and means of transport. 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 for labor on land owners' farms; in most cases their animals stay underfed. Animals are raised as a livelihood, and milk is the main source of income for these farmers. Most farmers pay high attention to lactating animals and feed them better as compared to dry animals. These types of feeding practices lead to undernourishment and deteriorating genetic potential of the animals.

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 (Govt. of Pakistan, 2013). For various reasons, a high portion of milk produced is used at the farm level and does not enter the dairy industry (Burki *et al*., 2005). About 55 percent of milk is consumed fresh.

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 hurts the consumers and their per capita food consumption.

Losses due to disease 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 (B.V.D.), and black quarter. Farmers do not regularly vaccinate their animals against these fatal diseases which lower dairy production. Every third cow/buffalo suffers from mastitis, greatly contributing to loss of milk production. Parasites such as ticks are also lowering the production of the sector (Saleem and Ashfaq, 2009).

Livestock animal 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 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 being caused by these diseases and the potential returns if these diseases are controlled for. The main focus of the study is on the diseases mastitis, Parturient Hemoglobinuria, FMD, and ticks. 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 and milk quality, and sometimes abortion or 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. The specific objectives of the study are as follows:

- To assess the morbidity/incidence rate, mortality rate, and case fatality rate of mastitis, Parturient Hemoglobinuria, FMD, and tick infestation
- To assess the economic losses associated with each disease
- To assess the share of livestock income in the total income of the farm
- To estimate the benefit cost ratio of controlling these livestock diseases
- To give policy recommendations

REVIEW OF LITERATURE

This section sets up the study by reviewing seven previous studies on the economic analysis of livestock diseases with special reference to diseases which have been selected for the current study and on Pakistan and neighboring developing countries. The reviewed studies are presented in chronological order. Additional references are also cited throughout the paper.

Khan et al. (1991) used the active surveillance method to rank the diseases which prevailed in their study area of Pakistan on the basis of their epidemiology and economic losses. They found and ranked ten diseases which affected buffaloes and cattle in the area. The study randomly selected 10 of the 95 villages of *tehsil* Lahore; the livestock farmers in these villages were interviewed directly. On the basis of morbidity and mortality rate and economic losses, they concluded that the highest incidence rate in buffalos was of idiopathic diarrhea followed by FMD, mastitis, and parturient prolapsed. In cattle, the highest incidence rate was for FMD followed by diarrhea and

mastitis. Hemorrhagic Septicemia caused the highest economic losses followed by FMD, parturient prolapsed, and mastitis. Total economic losses were about Rs. 1.8 million annually for the population of the study area.

Riaz et al. (1992) studied the incidence rate and economic losses of the most prevalent diseases in Gujrat, Punjab. The active surveillance method was also used in this study. A sample of 25 livestock farmers were interviewed to collect information about the incidence rates and economic losses of various diseases. It was concluded that the incidence rate of diarrheal disease was about 20 percent in buffaloes followed by FMD (9.72 percent), Hemorrhagic Septicemia (7.24 percent), and pre parturient prolapsed (7.08 percent). The incidence rate of FMD, diarrhea, and Hemoglobinuria were 13.48, 9.24, and 2.69 percent in cattle, respectively. The major disease in sheep and goats was diarrhea. They estimated total economic losses of about Rs. 1.25 million.

Akhtar et al. (1995) studied the morbidity and mortality rates in buffaloes and cattle in four districts of Punjab (Chakwal, Gujrat, Toba Tek Singh, and Khanewal). The convenience sampling technique was used, and 720 farmers were selected for interview. Their results regarding herd size, age, and sex were uniform for large ruminants across the four districts. They concluded that the morbidity rate in Toba Tek Singh and Khanewal was much lower than in Gujrat and Chakwal. The mortality rate was uniform for buffaloes and cattle across all districts. They also concluded that the treatment cost and case fatality rate was higher in the northern districts (Gujrat, Chakwal) as compared to the southern districts (Toba Tek Singh, Khanewal). They suggested that veterinary services and continuous monitoring of diseases should be generalized in Punjab.

Singh et al. (2005) studied the effect of vaccination against FMD in India. Twelve villages were selected from Bareilly district in Uttar Pradesh. These villages were linked to the Indian Veterinary Research Institute (IVRI). Many extension services were being provided in those villages by different institutes. The study focus was on vaccination against FMD. Data was collected only from those livestock farmers who participated in IVRI's extension services and were receiving vaccination for their animals. A total of 1,927 farmers were interviewed. They found that 73.74 percent of farmers were vaccinating their buffaloes regularly while 26.25 percent farmers were not vaccinating regularly. They reported that the farmers who were not getting their animals vaccinated saw low milk production. In these cases milk production dropped 25 to 50 percent due to FMD. They found that once an animal's milk production declined due to FMD production, it never returned to previous levels. They suggested that regular vaccination decreased the risk of FMD impacting production negatively.

Cheng et al. (2010) studied the profusion of the pathogens accountable for bovine mastitis in China. They believed that mastitis was an economically important disease for dairy cattle. To conduct the study, they selected dairy cows suffering from clinical and subclinical bovine mastitis. A total of 100 raw milk samples from these cows, selected from five farms in province Jiangsu, were obtained. They concluded that the bacteria Escherichia coli was most common in mastitis cases, showing up in about 82 percent of the samples. After Escherichia coli the percentage of other pathogens, such as Streptococcus uberis, Staphylococcus aureus, Streptococcus dysgalactiae, Streptococcus agalactiae, Staphylococcus epidermis, and Staphylococcus saprophyticus in mastitis cases were 53, 41, 29, 27, 15, and 10 percent, respectively. The study revealed that the Str. uberis and S. aureus were customarily originated into clinical mastitis, as compared to subclinical mastitis, while the statistics of theother five pathogens were almost always the same in both cases.

Mahmood et al. (2012) studied Parturient Hemoglobinuria in Pakistan. A study was conducted in district Chakwal using a population based case control during April 2009 to January 2011. Buffaloes of each age group and breed were selected to estimate the adverse effects related to the disease. In this study, a sample of 80 Hemoglobinuria affected buffaloes was selected and data was gathered from the start of illness date. On the basis of statistical analysis, they concluded that Parturient Hemoglobinuria was strongly dependent on the age of animals, number of lactations, pregnancy stage, post parturient period, and history of previous diseases. All these factors were shown to have a P value that was less than 0.05, which implied that all were statistically significant.

SEBCON (2014) reported the baseline and end-line survey results of Dairy and Rural Development Foundation (DRDF-USAID) project in the Southern and Central Punjab. The project was aimed at increasing the productivity and income of small dairy farmers in Punjab, Pakistan by giving them training in best practices. For the DRDF sample farmers, almost 69 percent of total milk production was being sold and 31 percent was being self-consumed. The project focused on artificial insemination technicians, farm managers, and women livestock extension workers. The average number of adult buffaloes owned by farmers surveyed by DRDF was 3.05, and the average number of adult cows was 2.34. The average per day buffalo milk production on DRDF farms was 6.18 and

7.5 liters in baseline and end-line surveys, respectively, and milk production for cows on DRDF farms averaged 6.86 liter and 7 liter per cow in the baseline and end-line surveys, respectively. These results indicate some improvement over the period of the project. The combined FMD incidence rate for buffaloes and cows was reported as quite low (less than 5 percent) in both the baseline and end-line surveys.

METHODOLOGY

This section covers the methodological aspects of the study.

Selection of the Study Area, Sample Size and Data Collection

This study was conducted in district Faisalabad which is one of the major producers of livestock products. It is a mixed cropping zone where wheat, rice, cotton, sugarcane, and maize are all grown. All types of fodder varieties are also cultivated as animal feed. All five *tehsils*[1] of the 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 3). Following this technique, a total of 150 farmers were included in the final sample.

Table 3: 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
Tandlianwala	456 G. B.	10
	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. The farmers' responses were then transferred to computer programs (Microsoft Excel, SPSS), and 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 levels. Moaeen and Babar, 2006 used a similar basis to categorize livestock farmers.

Estimation of Gross Margins for Livestock Farmers

The gross margins are calculated by using the following traditional formula:

$$\text{Gross Margins} = \text{Total Revenue} - \text{Total Variable Cost} \qquad \textbf{(1)}$$

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:

[1] *Tehsil* is an administrative sub-division of districts in Pakistan.

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

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

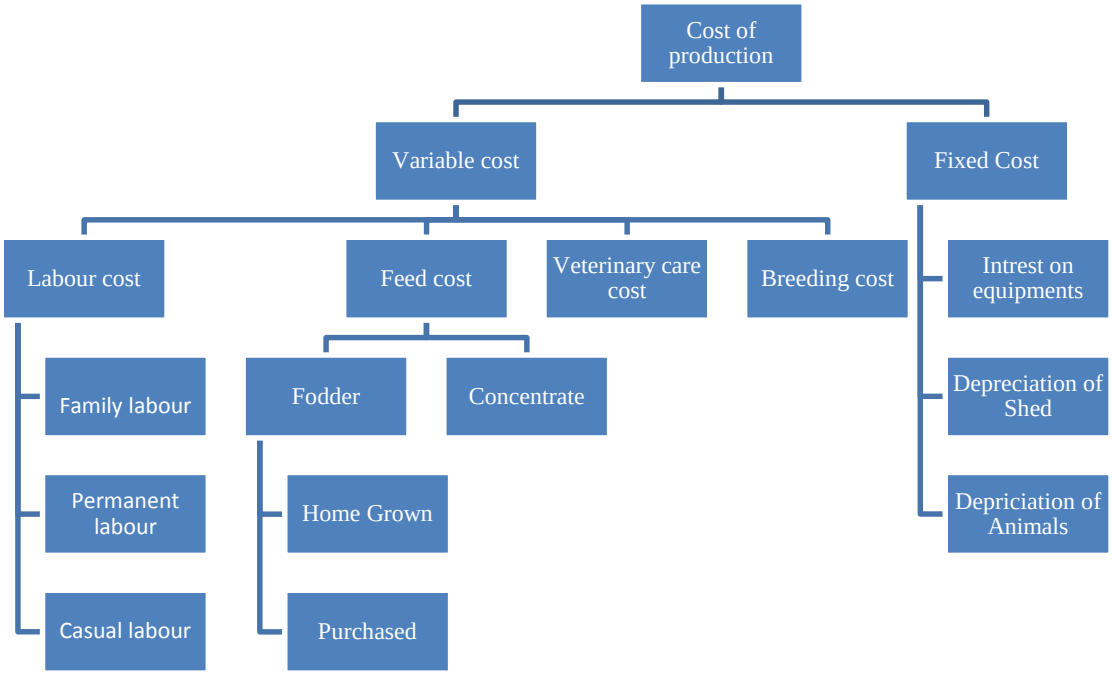
TP_i = Total production of i[th] crop at farm

PC_i = Price of one unit of i[th] 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.

Figure 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:

$$\text{MLH} = (\text{THL} / \text{MA}) \times 12 \quad \textbf{(5)}$$

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:

$$MLC = MLH \times \text{per hour labor cost for dairy enterprise} \quad \textbf{(6)}$$

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:

$$CMA = TCF / MA \quad \textbf{(7)}$$

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.[2]

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 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)**

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

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:

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

Benefits from the control of a 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 4 provides a summary of the socioeconomic characteristics of the livestock 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. Education level of the farmers is generally low in the study area; on average they have 6.71 years of regular schooling.

Table 4: Farmers' Characteristics and Family Type

General Information	Farm Category			
	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 Members (No.)	7.74	9.19	11.29	9.08
Family Type (Percent)				
Nuclear	71.83	59.65	31.82	54.43
Joint	23.94	29.82	31.82	28.53
Extended	4.23	10.53	36.36	17.04

The family size of the farmers is proportional to the farm size, which is an interesting finding. This is due to the increased percentage of farm households living in extended families as farm size increases.

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

Livestock farmers are categorized as small, medium, and large farmers, depending upon the number of adult livestock heads they own, as shown in Table 5. 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 farmers was random, and the fact that most of the selected farmers are small illustrates that the majority of the livestock farming community consists of small farmers.

Table 5: Number of Farms

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

FARM SIZE

Table 6 depicts that the average operational landholdings of respondents is 9.84 acres. On average, the small farmers have operational landholdings of 7.81 acres. Medium farmers have average operational landholdings of 10.38 acres, whereas large farmers have 13.39 acres. The operational landholdings of large farmers is high as compared to other farmers because the large farmers require more land for animals, crops, and fodder cultivation. The proportion of rented-in land is higher than rented-out among all three groups of farmers, implying that livestock farmers require additional land for growing crops and fodder, and they find it profitable to rent-in the land for that purpose. Furthermore, it is also important to note that the categorization of farmers is based on the number of animal units rather than operational landholdings, but still the operational landholdings are proportional to the scale of farming; implying that large farmers often have more operational landholdings, which is a typical feature of Punjab.

Table 6: Farm Size (Acres)

General Information	Farm Category			
	Small Farmers	Medium Farmers	Large Farmers	Overall
Owned Area	4.80	8.40	6.51	6.10
Rented In	2.88	3.12	6.41	3.83
Rented Out	0.13	1.67	0.16	0.51
Shared In	0.26	0.53	0.26	0.33
Operational Holdings	7.81	10.38	13.39	9.84
Area of Animal Farms in Marla	9.54	21.96	38.13	20.60

Note: Area of Animal Farms is Pens and Facilities for Livestock; 1 acre = 160 marlas

Table 6 also reveals that the average area of livestock pens and facilities of animal farms is 20.60 *Marlas* (1 acre = 160 *marlas*). Comparing farms, the large farmers have 38.13 *Marlas,* which is comparatively higher than small and medium farmers, because more animals require more space.

ANIMAL INVENTORIES OF THE RESPONDENTS

Table 7 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.[3]

Table 7: Animal Inventory (Number)

Animal	Farm Category			
	Small Farmers	Medium Farmers	Large Farmers	Overall
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

LACTATION PERIOD OF ANIMALS

Table 8 reveals that the average lactation periods of buffaloes and cows are about 234 and 257 days. It is observed that the lactation period of the cows is higher as compared to the buffaloes which could make them more productive animals. There is not very much variation in the lactation period among the different farm size groups.

Table 8: Milking Period of Animals (Average Days)

Animal	Farm Category			
	Small Farmers	Medium Farmers	Large Farmers	Overall
Buffalo	232.89	233.33	236.43	234.11
Cow	259.69	246.88	260.57	256.65

SOURCE OF BREEDING SERVICE AND WATER

Type of breeding is important in terms of having more productive animals with superior genetic potential. Table 9 shows that farmers are performing artificial insemination more often in cows (about 58 percent) as compared to buffaloes (about 12 percent). This could be due to the sire of buffaloes being relatively easily available and there being no milk productivity issues related to animal genetics with buffaloes (as perceived by farmers). Another reason, given by the farmers was that sometimes it was relatively difficult to detect the heat of the animal. For cows, the farmers require high quality imported semen to increase the production of milk. Farmers also perform artificial insemination in cows to find quality bulls for racing. Comparing farm sizes, small farmers are mostly associated

[3] 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. A full set of results is available from the authors upon request.

with natural insemination in cows and are found to have less interest in artificial insemination. Small farmers inseminate their animals through bulls which are available to them free of cost from neighbors or friends.

Table 9: Source of Breeding Service and Drinking Water (Percent)

	Farm Category			
	Small Farmers	Medium Farmers	Large Farmers	Overall
Breeding Source				
Buffaloes				
Artificial	10.91	13.72	9.09	11.72
Natural	89.09	86.28	90.91	88.28
Cows				
Artificial	43.33	64.10	68.42	57.95
Natural	56.67	35.90	31.58	42.05
Water Source				
Canal	0.00	5.26	0.00	1.75
Hand pump	28.57	17.04	14.33	19.98
Motor pump	48.57	55.00	65.77	56.45
Canal + Motor pump	8.57	14.04	13.43	12.01
Water course/Tube well	14.29	8.66	6.47	9.81

Table 9 also shows that most farmers are using motor pumps as a water source for their animals. Comparing farms, large farmers are using relatively more motor pumps as a water source than other farm size groups. A higher percentage of small farmers (28.57 percent) are using hand pumps for providing water to their animals, as compared to other farmers. This shows the subsistence nature of small livestock farms, as they may not manage to acquire the necessary capital for such equipment.

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

MORBIDITY/INCIDENCE AND MORBIDITY RATES OF SELECTED DISEASES

Table 10 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 10: Disease Affected Animals (Total Numbers)[4]

	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
FMD	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
FMD	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 11). 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 (SEBCON, 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 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 11: 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
FMD	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
FMD	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

[4] 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.

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 12 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 12: 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 the diseases are calculated to rank the diseases in terms of their economic importance. 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 is the most damaging disease in the area; causing significant economic losses to all three groups of farmers (Table 13). 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 farm size 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 13: Percentage of Economic Losses of Diseases (Percent)

Disease	Farm Category			
	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 14. Losses per animal in Table 14 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.

Table 14: Diseases Related Economic Losses in Buffaloes and Cows (Rupees)[5]

Disease	Small Farmers	Medium Farmers	Large Farmers	Overall
Buffaloes				
Mastitis				
Loss per Farm	4,201	11,206	31,434	13,236
Loss per Animal	3,218	3,177	2,041	2,287
Hemoglobinuria				
Loss per Farm	3,110	2,284	8,845	4,213
Loss per Animal	2,382	647	574	728
FMD				
Loss per Farm	26,916	114,588	196,325	105,723
Loss per Animal	20,616	32,482	12,744	18,270
Tick Infestation				
Loss per Farm	2,405	12,042	57,511	21,776
Loss per Animal	1,842	3,413	3,733	3,763
Total Losses				
Loss per Farm	36,632	140,120	294,115	144,948
Loss per Animal	28,059	39,719	19,092	25,049
Cows				
Mastitis				
Loss per Farm	3,431	4,463	4,941	3,659
Loss per Animal	5,370	3,031	1,070	1,873
Hemoglobinuria				
Loss per Farm	3,369	3,406	6,171	4,021
Loss per Animal	5,273	2,314	1,336	2,059
FMD				
Loss per Farm	10,102	32,550	48,021	25,951
Loss per Animal	15,811	22,109	10,396	13,286
Tick Infestation				
Loss per Farm	631	7,339	26,164	8,865
Loss per Animal	988	4,985	5,664	4,539
Total Losses				
Loss per Farm	17,532	47,758	85,297	42,497
Loss per Animal	27,442	32,439	18,466	21,756

The losses per farm are found to be generally proportional to the scale of farming for each disease; a natural outcome as we saw earlier that the number of affected animals was also generally proportional to the total number of animals 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 11). 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 10). Large farmers bore the highest total economic losses for each disease, both in cows and buffaloes, while having lower losses per animal, except for the case of ticks.

The results in Table 14 show that, for buffaloes, FMD accounted for the highest per animal, and per farm, economic losses in the study area, as it significantly affects milk production. These overall losses for buffaloes are

[5] 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.

Rs. 18,270 and Rs. 105,723, respectively. FMD is also the most damaging disease in cows in terms of losses per animal and total economic losses. The losses due to this disease are the highest, followed by losses caused by tick infestation. The same order of economic importance is observed for both buffaloes and cows. As is evident from the results, the contribution of Hemoglobinuria toward total economic losses is lowest both in buffaloes and cows.

COMPONENTS OF ECONOMIC LOSSES ON PER ANIMAL BASIS

Economic losses caused by disease have several components, and these components are different for each disease. These losses were calculated on a per animal basis jointly for buffaloes and cows. The per animal losses are again calculated using only milking animals (in this case, buffaloes and cows). The results are presented in Table 15. FMD was the major contributor toward the economic losses caused by diseases. The order of importance of the 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.

Table 15: Components of Losses per Animal Calculated Jointly for Buffaloes and Cows (Rupees)

	Small Farmers	Medium Farmers	Large Farmers	Overall
Mastitis				
Milk Loss	3,489	2,756	1,566	1,890
Treatment Cost	436	378	251	293
Loss per Animal	3,925	3,134	1,817	2,183
Hemoglobinuria				
Milk Loss	335	90	148	144
Treatment Cost	365	119	126	145
Mortality Loss	2,632	928	476	775
Loss per Animal	3,332	1,138	750	1,064
FMD				
Milk Loss	9,947	16,845	6,694	9,516
Treatment Cost	351	519	112	269
Loss Due to Abortion	5,160	5,330	2,791	3,501
Weight Loss	3,580	6,733	2,606	3,725
Loss per Animal	19,038	29,428	12,203	17,012
Tick Infestation				
Milk Loss	822	2,328	2,002	2,084
Treatment Cost	12	16	29	24
Weight Loss	728	1,532	2,147	1,851
Loss per Animal	1,562	3,876	4,179	3,959
Total				
Milk Loss	14,593	22,020	10,410	13,634
Treatment Cost	1,163	1,033	519	731
Mortality Loss	2,632	928	476	775
Loss Due to Abortion	5,160	5,330	2,791	3,501
Weight Loss	4,308	8,265	4,753	5,576
Loss per Animal	27,856	37,576	18,948	24,218

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.

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.

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 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.

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

We calculate the gross margins per animal and per farm to gain perspective on the rural livestock sector in the study area. To find out the economic importance of livestock to rural households, we calculate the share of livestock income 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 16 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 the 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 16 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 15) for small and medium farmers (Rs. 27,855 and Rs. 37,575, respectively) are about ten times larger than their gross margins (Rs. 2,649 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).

Table 16: Gross Margins per Animal (Rupees)[6]

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				
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

Gross margins calculated on a per farm basis show similar trends (Table 17). 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.

Table 17: Gross Margin per Farm (Rupees)[7]

	Small Farmers	Medium Farmers	Large Farmers	Overall
Average cost per Farm from Animals				
Fodder Cost	86,748	182,967	467,056	217,863
Concentrate Cost	58,656	134,303	346,628	161,203
Labor Cost	5,552	8,692	20,364	10,561
Health Care Cost	7,951	26,774	48,990	24,296
Breeding Cost	450	615	1,518	800
Total Variable Cost	159,358	353,351	884,556	414,722
Average Value of Output from Animals per Farm per Year				
Milk	133,265	289,518	1,240,358	466,426
Selling of Animals	31,245	82,649	254,648	101,770
Total	164,510	372,168	1,495,006	568,196
Gross Margin	5,152	18,816	610,450	153,474

Finally, the importance of the livestock sector is assessed by measuring its share in total farm revenue and total farm gross margins. The results in Table 18 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

[6] 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.

[7] 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.

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 18: Share of Livestock and Crop Income and Margins in Total Farm Revenue and Margins[8]

Income	Small Farmers	Medium Farmers	Large Farmers	Overall
Gross Crops Income (Rs.)	222,000	768,386	981,175	570,069
Gross Dairy Income (Rs.)	164,510	372,168	1,495,006	568,196
Total Farm Revenue (Rs.)	386,510	1,140,553	2,476,181	1,138,265
Share of Dairy Income (Percent)	42.56%	32.63%	60.38%	49.92%
Gross Margins				
Crops Total Variable Cost	137,414	419,243	578,529	334,597
Crops Gross Margins (Rs.)	84,586	349,142	402,646	235,472
Dairy Total Variable Cost	159,358	353,351	884,556	414,722
Dairy Gross Margins (Rs.)	5,152	18,816	610,450	153,474
Total Farm Gross Margins (Rs.)	89,738	367,959	1,013,096	388,946
Share of Dairy Gross Margins (Percent)	5.74%	5.11%	60.26%	39.46%

Our analysis and Table 18 also show how little dairy margins contribute to the overall gross margins per farm for the small and medium farmers. The dairy gross margins only represent 5.74 percent and 5.11 percent of total farm gross margins, respectively. For large farmers, dairy makes up 60.26 percent of total gross margins.

What this tells us, in terms of disease prevention, is that there is a twofold story. First, disease prevention among large farmers will do more to increase overall production and incomes because of their large number of animals. Second, there is a great deal of room for improving per animal and per farm incomes in the small and medium farmers. Because the gross margins seen from dairy income are so small for these groups, and the disease losses presented earlier so large by comparison, prevention of these diseases could dramatically push up the gross margins these farmers see from dairy income. This assessment will be further borne out in the later benefit-cost ratio analysis.

SHARE OF DIFFERENT FARM SIZES IN TOTAL MILK PRODUCTION

The share of various farm sizes in total milk production is calculated to find out their relative contribution. Results show that most of the milk production comes from large farmers, while small and medium farmers contribute the rest with almost an equal percentage (Table 19). This result is also supported by Aden et al. (2008) who found that daily milk production per farm was proportional to farm size.

Table 19: Contribution to Total Milk Production by Different Farm Sizes (Percent)

Farmer Category	Contribution to Total Production of Milk
Small	13.31
Medium	14.45
Large	72.24
Total	100.00

[8] 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.

RELATIVE CONSUMPTION AND MARKETING OF MILK PRODUCTION

Farmers marketed surplus milk left over after consumption at home. Table 20 shows the quantities (in litres) of milk production, home consumption, and milk sold in total by the group of surveyed farmers in each size category.[9]

Table 20: Consumption and Marketing of Total Milk Production (Litres)[10]

Farm Categories	Total Milk Production	Total Home Consumption	Percentage Home Consumption	Total Milk Sold	Percentage Milk Sold
Small	213,225	108,693	50.98	104,532	49.02
Medium	231,615	86,453	37.33	145,161	62.67
Large	1,157,667	125,031	10.80	1,032,636	89.20
Total	1,602,507	320,178	19.98	1,282,329	80.02

The percent home consumption of milk was inversely proportional to farm size; large farmers consume smaller proportions (10 percent) while the small farmers consume half of the milk produced (51 percent). This implies that large farmers spare a very high proportion of milk (about 90 percent) for marketing purposes while small farmers spare only 49 percent of milk for the same purpose. It was noted earlier that small and medium farmers' share in total milk production is quite low as compared to large farmers, and also they take livestock as a subsistence enterprise. Therefore, their consumption is higher leaving even less surplus of milk for marketing.

Farmers Attitude toward Livestock Diseases

Results show that livestock diseases cause significant economic losses. Therefore, the quality of veterinary care provided to the animals becomes equally important. It is observed that many farmers in the study area rely on traditional methods for controlling disease rather than proper veterinary care services. Table 21 shows that a significant percentage of medium farmers (about 39 percent) and large farmers (about 29 percent) are using traditional (indigenous) methods for controlling livestock diseases. Small farmers too are using these methods, but their percentages were relatively less than other two groups. This is because small farmers are more cautious about losing their few animals. Large farmers use relatively less modern disease control methods and still they experience lower morbidity rates for their animals. This could be due to better nutrition provided by large farmers to their animals which partly offsets the impact. Another reason might be due to better quality of medicine purchased in bulk from reliable sources. Overall, 27 percent of farmers are relying on traditional methods, which represents a poor animal health care situation. The figures in Table 21 represent only those farmers who solely rely on the use of traditional methods of treatment; making the problem even more serious. Apart from these, there are also farmers who use a mix of traditional and modern methods. So overall, farmers relying on traditional methods for controlling livestock diseases could be very high. This is most likely due to a lack of awareness in farmers and negligence of the livestock department toward the extent and severity of the problem.

Table 21: Farmers Using Traditional Methods for Controlling the Diseases

Farmer's Category	Frequency	No. of Farmers (In Each Category)	Percentage of Farmers
Small Farmers	15	72	20.83
Medium Farmers	14	36	38.88
Large Farmers	12	42	28.57
Total	41	150	27.33

[9] The quantities of total production by the surveyed farmers in each category can be converted to the average value of output by the farms in that category by multiplying the quantity (liters) by price at the time of the survey (Rs. 45/litre) and dividing by the number of farms in the category as given in Table 5.

[10] When the two largest farmers are dropped from the Large Farm category total milk production drops from 1,157,667 liters to 702,268 liters, with the two largest farmer producing 455,399 litres. The production by the large farers category still exceeds the sum of production by the small and medium farmers.

Farmers were asked about the reasons for the occurrence of diseases to obtain a rough outline of the situation. Table 22 presents the responses of farmers to this question. Overall, most of the farmers thought that diseases were caused by unhygienic conditions at the animal farms. Poor quality of groundwater used by animals for drinking purpose and natural occurrence of the diseases were the other main reasons quoted by farmers. Traditional methods of dairy farming, lack of awareness about diseases, contamination of fodder by pesticides and fertilizers used, untimely vaccination, low quality of fodder, and seasonal occurrence of diseases were some of the other reasons.

Table 22: Farmers' Responses about Reasons for Occurrence of Diseases (Number)

Reasons	Small Farmers	Medium Farmers	Large Farmers	Total
Unhygienic Condition of Animal Farm	27	18	16	61
Poor Quality of Ground Drinking Water	13	12	14	39
Naturally Occurred	22	4	9	35
Use of Traditional Methods for Disease Control	7	7	9	23
Low Level of Awareness About Diseases	4	4	10	18
Diseases Come on Seasonal/Cyclical Basis	10	4	3	17
Low Quality of Fodder	6	7	3	16
Use of Chemicals (Fert. & Pesticides) for Fodder Production	6	7	11	14
Poor Quality of Medicine	4	2	5	11
No Timely Vaccination	5	3	2	10

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 15. 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 23 shows the resultant Benefit-Cost ratios of controlling for livestock diseases.

Table 23: Benefit-Cost Ratios for Controlling Livestock Diseases

Disease	Prevention Cost per Animal (Rs.)	Benefit per Animal (Rs.)	B/C Ratio
Mastitis	3,250	2,183	0.67
Hemoglobinuria	328	1,064	3.24
FMD	768	17,012	22.15
Tick Infestation	1,180	3,959	3.35
Total	5,526	24,218	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 15 which are per animal losses for each disease under each farm category. The final BCR ratios are presented in Table 24. 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 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.

Table 24: 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 18. 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 18 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 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 the potential of the dairy industry to raise its production if these diseases were controlled for.

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

- The 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 and 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 majority of farmers use natural sources of breeding for their animals, causing genetic deterioration.
- 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 for livestock diseases (benefit-cost ratio) is sufficiently high to motivate the farmers to invest in controlling measures to increase their economic returns.
- The 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 important for the 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.
- A high number of the surveyed farmers were using traditional methods of treatment for livestock diseases. These methods are not reliable and very often result in significant economic losses before the farmers finally seek advice from a veterinary doctor.

Recommendations

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

- As it is well-known 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 a 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 disease is relatively higher among cows than in 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 a 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 platform of the Farmer's Organization already being established in many rural areas.
- Mobile health services could be provided by the government to help control 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.

Future Research

The current research project was completed in only one district due to time and resource limitations. Based on the results of study, and field observations, the following are potential areas of future research;

- Studies should be carried out in various agro-ecological zones of Punjab, particularly in marginal and rain fed areas where livestock rearing is the main source of livelihood and where poverty prevails.
- The climate of Punjab seems unfriendly to European breeds of cows due to seasonally more hot and humid environmental conditions. Other significant reasons for less adoption/failure of European breeds are the prevalence of diseases and poor nutrition. What is the interaction of disease control, nutrition, and a shift to very high producing Europe breeds? What is the timeline that might be involved? What set of polices with what priorities deal with this issue? These are the important questions that need to be addressed for the livestock sector in the Vision 2025 of the government of Pakistan.
- Based on the results of this study, it is striking how little the large farmers are following what are known as the correct practices. Thus, follow-up research is needed as to why they are not universally inoculating for FMD. It would seem cost effective for the government to run a major campaign to reach the large farmers for preventive vaccination. Research is needed as to the most cost effective way of achieving this.

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