Evaluating the Factors Responsible for Slow Rate of Technology Diffusion in Livestock Sector of South Asia and Developing a Framework to Accelerate this Process: A Case Study using data analysis for Pakistan's Livestock Sector

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Abstract— South Asia boasts a large number of livestock populations and is considered as a very important region in context of global milk and meat production. The development of Livestock sector in countries such as India and Pakistan can be considered as a vital source for alleviating poverty and for developing the economy of these countries. However, large number of animal population in this region suffers from low productivity when compared with developed countries. The main reason behind low productivity of this sector is the lack of technology acceptance among farmers. The dissemination of information regarding new innovations and technologies in livestock sector is carried out through agriculture extension services. Technology or innovation diffusion is a complicated process. Many times seemingly beneficial technologies and innovations fail to get large scale acceptance or are accepted at a very slow rate. The process of technology diffusion consists of three basic elements i.e. technology or innovation, communication channel and social system. To accelerate this process it is essential to understand the attributes of both technology and social system and then to built an effective communication channel. This study attempts to identify important factors and attributes that play a vital role in farmer's decision to adopt or reject a new technology. Through this study an attempt has also been made to determine the effectiveness and reliability of current extension services (communication channel) in livestock sector of Pakistan. Data analysis carried out in different livestock farms shows that both public and private sector have failed to increase awareness about new technologies and innovations among farmers. The analysis also reveals the important role played by technology diffusion attributes such as perceived usefulness, cost, personal innovativeness and social pressure in adoption or rejection of a technology. On the basis of these findings a model has been established to accelerate the process of technology diffusion in livestock sector of South Asian countries.

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Keywords- Technology Diffusion; Technology Acceptance Model; Livestock of South Asia, Livesock Sector of Pakistan

I. INTRODUCTION

Agriculture forms the backbone of South Asian economy. The importance of agriculture sector for countries such as Pakistan and India cannot be over emphasized. According to Pakistan's economic survey 2009-10, agriculture sector in Pakistan accounts for about 21% of GDP and employs around 45% of the labor force. Agriculture sector can be divided into two major sub sectors i.e. crop sub-sector and live stock sub-sector. Livestock sector contributed about 53.2% of the agriculture value added in 2009-10. When compared with developed countries it becomes apparent that Pakistan's livestock sector suffers from low productivity. It is estimated that average productivity of dairy animal in Pakistan is about one fifth of Germany's average productivity and one third of New Zeeland's productivity [1]. Similar observations can be made about the livestock sector of other countries in this region such as India and Bangladesh. One of the main factors that contribute to this low productivity is the slow rate at which farmers adopt any new technology or innovation.

Technological improvement and innovations are a result of research and development (R&D) efforts. However, the outcome of these efforts can only be appreciated once the new technologies make their way to regular farmers. This process is known as 'technology diffusion'. No new technology can have a significant impact on a country's economy until it becomes widespread [2]. Sometimes seemingly beneficial technologies take an amazingly long time to get adopted. Many researchers have tried to explain this

phenomenon and the literature available on technology diffusion sprawls over many disciplinary boundaries [3].

For the growth of livestock sector in Pakistan it is imperative that the process of technology diffusion among farmers is accelerated. Diffusion of innovation or technology can be a complicated process. The rate of diffusion varies depending upon the nature of technology and characteristics of targeted social system. For livestock sector, it is the responsibility of agriculture extension workers to ensure that farmers are aware of new technologies that can help improve productivity in this sector.

A farmer's decision to adopt or reject a technology is affected by several factors. The main objective of this research is to establish a better understanding of these factors. For this purpose two livestock technologies were chosen and data analysis was carried out in livestock farms of Pakistan. In this research an attempt is made to understand the key factors behind the farmer's decision to either accept or reject these technologies and to measure the performance of extension services with regards to introducing these technologies to the farmers. Afterwards, a comprehensive model for accelerating the technology diffusion process in livestock sector of South Asian countries is developed which can be helpful for agriculture extension services to operate more effectively

II. Literature Review

A. *Technology/Innovation Diffusion*

Diffusion of innovation can be defined as "A process by which an innovation is communicated through certain channels over time among the members of a social system." Diffusion can be considered as a special type of communication in which messages are concerned with new ideas [4].

Evert Roberts in his book "diffusion of innovation" defined the four elements central to this process:

- **Innovation:** An innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption.
- **Communication Channel:** Any new idea or practice reaches its potential adopters through certain communication channels.
- **Time:** An innovation's *rate of adoption,* the relative speed with which an innovation is adopted by members of a system.
- **Social System:** Social system is defined as set of interrelated units that are engaged in joint problem solving to accomplish a common goal. Diffusion occurs within the social system

B. *Technology Acceptance Model*

Many researchers have come up different models for explaining the behavior of consumers towards a new technology or innovation. Technology Acceptance Model (TAM) was proposed by Fred D. Davis in 1986. TAM initially aimed to explain computer adoption among individuals. After its introduction many researchers tried to replicate TAM with other technologies and research settings to verify its consistency. The researchers concluded that TAM maintains its consistency and validity in explaining user's acceptance of different technologies and innovations [5].

Some of the variables associated with TAM are as follows:

Perceived Usefulness (PU): Perceived Usefulness is defined as the degree to which an individual believes that using a particular technology will enhance his or her performance [6].

Perceived Ease of Use (PEOU): Perceived Ease of Use is defined as the degree to which an individual believes that the use of a particular technology will be free of physical and mental effort [7].

Personal Innovativeness (PI): Personal innovativeness can be considered as an individual trait reflecting a willingness to try out any new technology [8].

Subjective Norm/Social Influence (SN/SI): It is a measure of a person's perception that most people who are important to him think he should or should not perform a particular task [9].

Accessibility (Acc): Physical Accessibility is the measure of the extent to which someone has the physical access to the technology [10]. Information accessibility refers to the accessibility to the information regarding the usage of a technology.

III. Overview of Livestock Sector of Pakistan

Pakistan has almost 8 million farming households with a total herd size of approximately 50 million animals. The livestock sector of Pakistan has shown consistent growth in production over the years but this is mainly due to the increase in number of animals as opposed to higher productivity per animal. "Table 1" shows the livestock population of Pakistan has increased consistently over the years.

TABLE 1. LIVESTOCK POPULATION IN PAKISTAN (THOUSAND NUMBERS)

	1960	1986	1996	2006
Cattle	16624	17541	20424	29559
Buffaloes	8161	15705	20272	27335
Sheep	12378	22655	23544	26488
Goats	10046	28647	41166	53787
Total	47209	84548	105406	137169

Source: Agriculture statistics of Pakistan 2008-2009

A. *Average Milk Productivity Across the World*

A. When compared with developed countries the productivity of livestock sector of Pakistan is extremely low. "Table 2" shows a comparison between developed countries and Pakistan in terms of average milk production per animal as recorded in year 2005. One of the main reasons behind this difference in productivity is faster technology diffusion at farm level in developed countries as compared to Pakistan [1].

TABLE 2. AVERAGE MILK PRODUCTIVITY PER ANIMAL ACROSS THE WORLD

Countries	Milk Production per Animal per year (kg)
USA	8395
Germany	7117
UK	6886
New Zeeland	3947
Australia	4926
India*	1450
Pakistan*	1900

Source: FAO (Food and Agriculture Organization)
*Milk Production for Buffalo only

B. Agriculture Extension Services in Pakistan

The most important goal of extension services is to provide a reliable channel through which technology can be transferred from R&D institutes to farmers [11]. Agriculture extension in Pakistan was a sole public funded service for almost 40 years, during the period since its independence in 1947 till 1988. During this period successive governments experimented with several different models and styles of extension with the view to increase its efficiency but limited success was achieved [12]. In 1988 private sector was allowed to participate in extension activities. Currently in livestock sector of Pakistan extension services are being provided by both public and private sector through veterinary officials, doctors and marketing personnel etc.

C. Social Influence on Farmers

Along with traditional extension service activities, social influences (opinions of peers and colleagues) also have a great impact on the process of technology diffusion. In Pakistan, studies reveal that farmers' attitude towards adoption of new technologies are interdependent. In other words a farmer is easily influenced by the actions and opinions of his colleagues and peers. Farmers appear to be more strongly influenced by their social peers rather than physical neighbors. Social peers are defined as farmers within the same village who share similar economic and social standing [13].

IV. DATA COLLENCTION AND ANALYSIS

As mentioned before there are three important factors that affect the process of technology diffusion. These include technology/innovation, social system and communication channel. In the context of technology diffusion in livestock sector, these factors can be replaced by more appropriate terms i.e. livestock technologies/innovations, livestock farmers and extension services.

To evaluate the factors that affect the rate of technology diffusion in livestock sector of Pakistan, two questionnaires were developed, for two different livestock technologies that were chosen in consultation with NARC experts. These technologies are:

- Balanced dairy concentrate feed
- Urea as protein source

Through these questionnaires livestock farmers' feedback was collected about the two livestock technologies and the role of extension services in introducing these technologies.

A. Questionnaire Design

The questionnaire used to collect data on two livestock technologies, social system and extension services consists of following sections:

- The general information about the farm
- Familiarity with the technology
- Actual usage of the technology
- Measure of extension service variables such as public sector extension services, private sector extension services and other channels such as TV, Radio and internet etc.
- Measure of technology variables such as Perceived usefulness, Perceived Ease of Use, Cost, Accessibility.
- Measure of Social System Variables such as Social Influence and Personal innovativeness.

The data was collected by carrying out the survey across different livestock farms located in Islamabad, Rawalpindi, Chakwal, Gujjar Khan and D.G Khan. The survey consists of direct visits and telephonic interviews. The sample size was 150 farms that were divided into small (1-6 animals) and large (>6 animals) categories. For analyzing participant's responses five-point Likert scale ranging from 'strongly agree' or 'excellent' to 'strongly disagree' or 'poor'.

A. Data Analysis: Balanced Dairy Concentrate Feed

The first technology chosen for the survey was 'balanced dairy concentrate feed'. The entire sample population showed a basic level of familiarity with the technology. "Table 3" shows the actual level of adoption for this technology. The data shows that most of the farmers have continuously rejected this technology. Large farms show a slightly better adoption rate than small farms.

TABLE 3. ACTUAL ADOPTION OF BALANCED DAIRY CONCENTRATE FEED

Level of Adoption	Small Farms	Large Farms
Continued Adoption	29%	37%
Continued Rejection	61%	58%
Discontinued Adoption	10%	5%

To better understand the decision of farmers to adopt or reject 'balanced dairy concentrate feed', the participants of the survey were asked to rate different variables associated with the technology. These variables include Perceived Usefulness, Perceived Ease of Use, Accessibility and Cost (in comparison to traditional feed). The result for small scale farmers is shown in "Fig. 1" and for large scale farmers in "Fig. 2".

The data indicates extremely low level of Perceived Usefulness of technology among farmers. Slightly better scores were recorded for Perceived Ease of Use and Accessibility of the technology. Most of the small scale farmers found the cost of 'balanced dairy concentrate feed' on the higher side when compared with the cost of traditional feed. Whereas, for most of the large scale farmers this cost was lower or normal in comparison with the traditional feed they utilize. This difference exists because traditional feed used in livestock farms of Pakistan vary from farm to farm based on the resources of farmer.

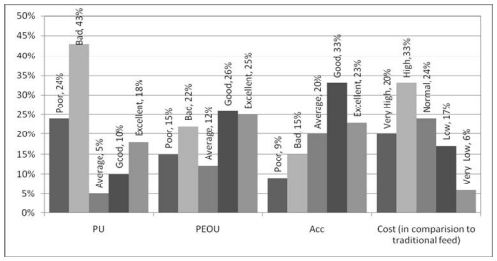

Figure 1. Scores for Technology Variables as Recorded by Small Scale Farmers

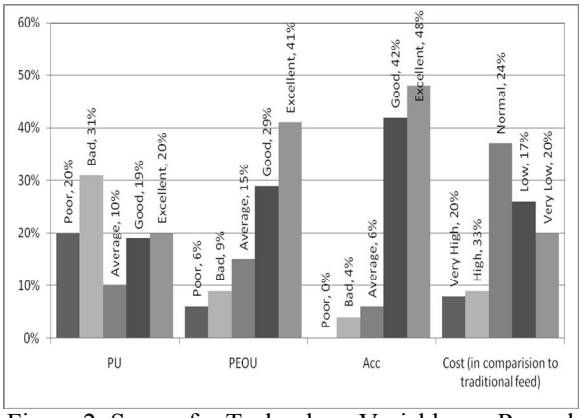

Figure 2. Scores for Technology Variables as Recorded by Large Scale Farmers

In addition to these variables related to technology, another important variable associated with social system is Personal Innovativeness. The Personal Innovativeness of the participants was measured as their willingness to try out new technologies and innovations. The result is shown in "Fig. 3".

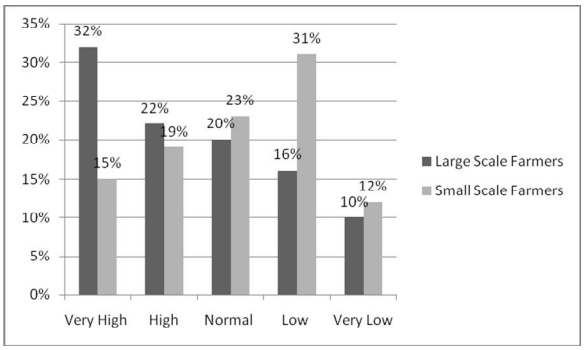

Figure 3. Personal Innovativeness of Small and Large Scale Farmers

Correlation matrix was generated to highlight the relationship among actual usage of technology and other variables used in the questionnaire. The correlation matrix for small and large farms is given in "Table 4" and "Table 5" respectively.

TABLE 4. CORRELATION MATRIX: USE OF BALANCED DAIRY CONCENTRATE FEED IN SMALL FARMS

	Usage	PU	PEOU	Acc	PI	SI/SN	Cost
Usage	1						
PU	***0.91***	1					
PEOU	0.57	0.63	1				
Acc	0.3	0.33	0.1	1			
PI	0.64	0.52	0.061	0.26	1		
SI/SN	***0.82***	***0.86***	0.49	0.25	0.56	1	
Cost	***0.81***	0.79	0.51	0.3	0.55	0.74	1

The correlation matrix shows that the variables Perceived Usefulness, Social Influence/ Subjective Norms and cost highly affect the actual usage of this technology for small farms. In other words these three factors play a decisive role in small scale farmer's decision to adopt or reject this technology.

TABLE 5. CORRELATION MATRIX: USE BALANCED DAIRY CONCENTRATE FEED IN LARGE FARMS

	Usage	PU	PEOU	Acc	PI	SN	Cost
Usage	1						
PU	***0.92***	1					
PEOU	0.59	0.52	1				
Acc	0.22	0.16	0.09	1			
PI	0.47	0.36	0.05	0.11	1		
SI/SN	0.69	0.68	0.22	0.24	0.12	1	
Cost	***0.76***	0.71	0.57	0.19	0.26	0.52	1

"Table 5" shows that factors of cost and social influence/subjective norms play a relatively small role in large scale farmer's decision to adopt or reject the technology.

B. Data Analysis: Urea as Protein Source

Only 32 out of 150 farmers showed familiarity with the second technology 'urea as protein source'. All of these farmers belonged in the category of 'large farms'. "Table 6" shows the actual level of adoption for this technology among these 32 farmers.

TABLE 6. ACTUAL ADOPTION OF UREA AS PROTEIN SOURCE

Level of Adoption	Large Farms
Continued Adoption	76%
Continued Rejection	24%
Discontinued Adoption	0%

The participants of the survey familiar with this technology were asked to rate different variables associated with 'urea as protein source'. The correlation among actual usage of technology 'urea as protein source' and other variables used in the questionnaire is given in "Table 7".

TABLE 7. CORRELATION MATRIX: FOR UREA AS PROTEIN SOURCE

表格 1

	Usage	PU	PEOU	Acc	SI/SN	Cost
Usage	1					
PU	***0.94***	1				
PEOU	***0.78***	0.61	1			
Acc	***0.71***	0.12	0.69	1		
PI	***0.76***	0.79	0.64	0.15		
SI/SN	0.45	0.51	0.06	0.2	1	
Cost	0.24	0.11	0.09	0.13	0.39	1

'Urea as protein source' can be considered as a relatively new technology when compared with 'balanced dairy concentrate feed'. The correlation matrix shows that unlike the first technology, social influence and cost do not play an important role in farmer's decision to adopt or reject this technology. Instead perceived ease of use and personal innovativeness along with perceived usefulness possess a high relationship with actual usage of the technology.

C. Data Analysis : Extension Services

This section is used to analyze the role of extension services in technology diffusion in livestock sector of Pakistan. The participants in the survey were asked about their primary source of information for the two livestock technologies mentioned above. The results are summarized in "Table 8".

TABLE 8. PRIMARY SOURCE OF INFORMATION FOR THE TWO LIVESTOCK TECHNOLOGIES

	Balanced Dairy Concentrate Feed (Small Farms)	Balanced Dairy Concentrate Feed (Large Farms)	Urea as Protein Source (Large Farms)
Private Sector	21%	41%	5%
Public Sector	11%	20%	29%
Peers and Colleagues	60%	29%	35%
Others (TV, Radio and Internet etc)	8%	10%	31%

The participants were asked if they received information regarding new technologies from either public or private sector. The result is shown in "Table 9".

TABLE 9. PRIMARY SOURCE OF INFORMATION REGARDING NEW TECHNOLOGIES FOR LIVESTOCK FARMERS

	Private Sector	Public Sector
Small Scale Farmers	30%	11%
Large Scale Farmers	45%	18%

In addition the participants of the survey were asked about their trusted sources of information regarding new livestock technologies. The results are shown in "Table 10".

TABLE 10. TRUSTED SOURCE OF INFORMATION FOR LIVESTOCK FARMERS

Sources of Information	Level of Trust among Farmers
Private Firms	15%
Public Sector Veterinary Officials	70%
Peers and Colleagues	65%
Observation	90%
Others (TV, Radio and Internet etc)	18%

D. Result and Discussion

Some of the important points that appeared after data analysis are listed below.

1) Important Factors and Variables of Technology

- The correlation matrix shows that for 'balanced dairy concentrate feed' the farmer's decision to adopt or reject the technology is influenced mostly by factors of perceived usefulness, social influence/ subjective norms and cost.
- For 'urea as protein source' (relatively newer technology) the factors of perceived usefulness, perceived ease of use and personal innovativeness are more important.

2) Important Factors of social System

- The data shows that farmers tend to be influenced by the opinions of their peers and colleagues.
- For large scale farmers the factor of social influence/ subjective norms plays a smaller role as compared to small scale farmers.

- Farmers also showed lack of personal innovativeness meaning they were unwilling to adopt new innovations and technologies on their own.

3) Role of Private Sector in Technology Diffusion

- Aside from peers and colleagues, private sector is the most important component of extension services as far as familiarizing the farmers with new technologies is concerned.
- Low familiarity with technology 'urea as protein source' is a result of lack of involvement of private sector. As most of the urea manufacturers do not see livestock sector as an important market for their product.
- But at the same time farmers showed a lack of trust on the private sector as compared to their trust on public sector veterinary officials and doctors.

4) Role of Public Sector in technology Diffusion

- Farmers showed a willingness to adopt new technologies if they were advised by public sector veterinary officials and doctors.
- But at the same time data analysis shows that public sector extension services have failed to reach most of the farmers.

V. Model for Accelerating Technology Diffusion Process

In this section a model has been proposed that can be used to accelerate the process of technology diffusion in livestock sector of South Asian countries. This model is based on data analysis carried out in livestock farms of Pakistan but in the opinion of these authors it is also applicable in other developing countries with similar conditions to Pakistan such as India and Bangladesh.

The process of technology diffusion consists of three fundamental elements i.e. social system, innovation or technology and communication channel. For accelerating the process of diffusion in any sector all of these three elements need to be examined and managed simultaneously. The case of livestock sector is not any different. "Fig. 1" shows the basic framework for accelerating the process of technology diffusion in livestock sector.

Figure 1. Basic Model for technology Diffusion in Livestock Sector

A. Organizing Livestock Technologies

Technology or innovation can be a result of either local R&D efforts or it can be imported from foreign sources. In either case it is essential to categorize the technologies according to their key features. Some livestock technologies might be too complicated or expensive for an ordinary farmer. For effective transfer of technology to the farmers, livestock technologies can be arranged according to their benefits, cost and complexity as shown in "Fig 2".

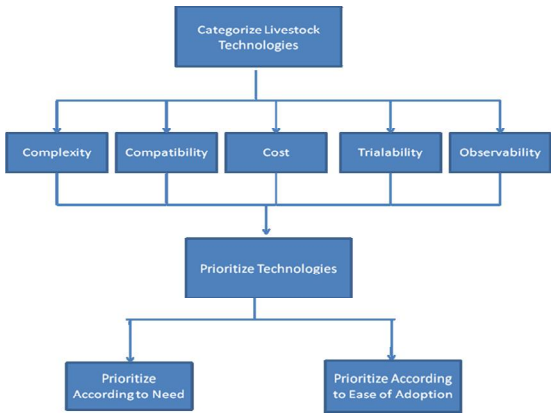

Figure 2. Organizing Livestock Technologies

B. Managing Social System

Social system is formed by the targeted users of any technology. Each social system has its own characteristics which should be understood for effective technology diffusion. The social system that is the target for livestock technologies consists mainly of farmers with limited resources that possess low level of personal innovativeness and are highly influenced by subjective norms. "Fig. 3" shows the steps that can be taken to better prepare the social system for technology adoption.

- **Identify Clusters:** The first step in managing the social system is to identify clusters where large numbers of farming households are located. These clusters of farmers should be the high priority target for technology diffusion activities. Through this approach the official extension workers or private marketing staff can reach more farmers by utilizing relatively less resources.
- **Form Groups of Farmers:** Through the survey conducted in this research paper, it can be concluded that most of the small holding farmers are strongly influenced by opinions of their peers and colleagues. This means that most of the farmers refrain from adopting any new innovation on their own initiative and wait until their colleagues also show some sort of interest in that innovation. To overcome this

obstacle, groups can be formed consisting of farmers in same vicinity that share similar farming practices.

- **Identify HR Needs:** After forming groups of farmers, the number of extension workers needed for effective communication can be identified.
- **Assess Technology Needs for each Group:** Technology needs of livestock farmers in Pakistan vary vastly throughout the country. These variations exist because of difference in land structure and climate, available resources and level of awareness. But it is unfeasible for extension services to focus on each farmer separately according to his unique circumstances. Instead the extension workers can consider a group of farmers with similar needs as a distinct unit for technology diffusion activities.
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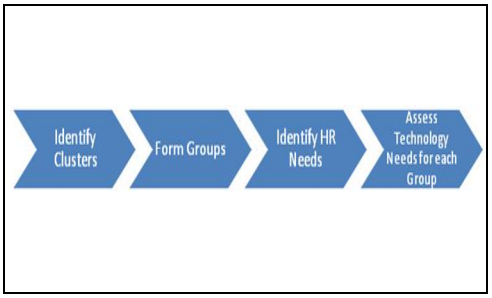

Figure 3. Steps for Managing Social System

C. Developing Communication Channel

To ensure effective transfer of technology to farmers, a proper communication channel needs to be developed. This channel should ensure continuous communication between livestock development agencies and farmers. "Fig. 4"shows an effective communication channel developed by the authors that can be utilized for transferring livestock technologies to farmers. Public sector extension services consisting of livestock doctors and assistants should form the backbone of this channel as farmers show more trust on public sector as compared to private sector.

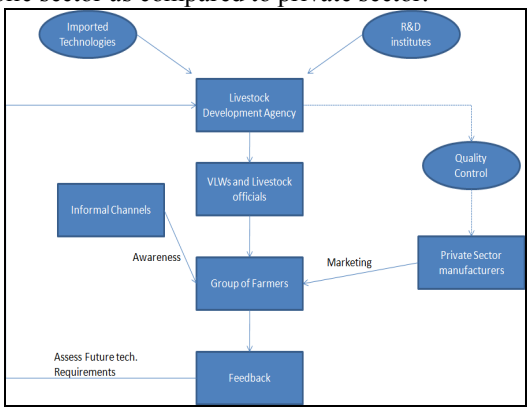

Figure 4. Elements of Communication Channel for Technology Diffusion in Livestock Sector

VI. Recommendations And Conclusion

A. Recommendations

The enormous livestock population in the region of South Asia suffers from low productivity. Technology diffusion at a faster rate is the best solution available for ramifying this situation. The responsibility for increasing the productivity of livestock sector mainly lies with the many Govt. institutions and departments that are operating at federal or provincial level in these countries. The authors recommend the following steps that can accelerate the process of technology diffusion in livestock sector.

1) Redefine the Roles of Public and Private Sectors

- Farmers show lack of trust on private firms.
- It is difficult for private sector to convince farmers into adopting any new technology or innovation.
- Public sector extension workers (veterinary officials) usually possess farmer's trust.
- Veterinary doctors that have an ongoing contact with farmers should encourage them to adopt a new technology.
-

2) Quality Control

- Almost 10% of sample population discontinued the use of 'balanced dairy concentrate feed' because of poor results.
- The main reason behind it is the lack of quality control on livestock products.
- The provincial livestock and agriculture departments should ensure strong quality control on all livestock technologies.
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3) Carry out Trials for Farmer's Observation

- Carryout trials of new technologies by selecting small number of animals from each group.
-

4) Understanding the Different Aspects of Technology

- For new innovations and technologies the variables such as 'perceived ease of use' and 'accessibility of information' become very important.
- It is imperative that all the personnel participating in extension activities completely understand the use of technology.
-

5) Utilize Mass Media

- Use of radio and TV programs to create awareness among farmers.
- Can be extremely useful in the case of new technologies such as 'urea as protein source'.
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B. Conclusion

The true potential of livestock sector of South Asia is yet to be realized. Most of the farmers in countries like Pakistan and India are still utilizing traditional farming approach and are continuously rejecting new technologies and innovations.

Currently both private and public sectors are involved in extension activities in Pakistan. This research highlights the shortcomings and inefficiency of extension services in Pakistan. The extension activities of private firms are the main source of information about new technologies for the farmers. On the other hand, public sector veterinary officials and doctors have more influence on farmer's decision. The rate of technology diffusion among farmers can be increased if information regarding new technologies reaches the farmers through proper channel.

There are many important factors that influence a farmer's decision to adopt or reject any new technology such as perceived usefulness of a technology, perceived ease of use, cost, personal innovativeness of the farmers and subjective norms. It is imperative for both public and private sector to understand the importance of these factors while introducing any new livestock technology to farmers.

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