

Practical approaches for doubling livestock farmers' income

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ABSTRACT

Agriculture is the backbone of rural Punjab. Around 70 percent people of the state are involved in agriculture and allied activities and more than 83 per cent of the total land in the state is under agriculture. In 2016-17, agriculture had 23.96 per cent share in State's GDP while livestock had 8.63 percent share (Statistical Abstract Punjab, 2017). In the recent past, the share of livestock GDP in agriculture increased steadily. Livestock economy including fisheries contributed 29.60 per cent of the agricultural GDP in 2000-01 while the share increased to 36.01 per cent in 2016-17. Livestock sub-sector has registered highest growth among all the sub-sectors of agriculture in India while Punjab is rated among the highest for the share of livestock output to agricultural output (Jha *et al.*, 2009). Thus, livestock sector proved to be an important growth engine for the overall development of agricultural sector in the state.

Keywords : *Approaches, Income, Livestock farmers*

As per 19th Indian Livestock Census (2012), Punjab is inhabited with 24.27 lakh cattle, 51.59 buffalo, 1.28 lakh sheep, 3.27 lakh goat, 32 thousand pigs, 41 thousand horses, ponies and donkeys and 693 camels. Nature has bestowed Punjab with many indigenous livestock breeds that include Murrah and Nili Ravi buffalo, Sahiwal cattle and Beetle goat. With only 2.53 per cent bovine population of the country, Punjab accounted for 6.89 per cent of the total milk produced in the country and stood 6th (after Uttar Pradesh, Rajasthan, M P, Gujarat and Andhra Pradesh) in milk production. The per capita availability of milk in the state is 1075 g per day as compared to national average of 352 g (Statistical Abstract Punjab, 2017).

The human population density in Punjab is 550 persons per km². It is significantly higher than the national average of 382 persons per km² (Statistical Abstract Punjab, 2012). Of the total workforce in Punjab, 68 per cent are engaged in agriculture (Statistical Abstract Punjab, 2012). Because of

division of families, the land holdings are ever decreasing. Under this scenario, livestock based rural livelihoods have become even more important. The per capita income in Punjab is ever increasing and it stood at Rs.131112 in 2016-17 (www.punjabdata.com). Because of increase in the per capita income, it becomes affordable for masses to buy livestock products easily, thereby, increasing its demand.

In spite of all these facts and figures, the farmer's income remained low as compared to income of those working in other sectors (Chand, 2017). During early 1980s, the farmer's income was almost one third of the non-agricultural worker's income. It worsened to one-fourth during the late 1990s. The Central Government paid special attention to the plight of Indian farmers by initiating different measures to double his/her income by the year 2022. These measures targeted improvements in productivity, resource use efficiency, reduction in cost of production, intensification, diversification

and value addition of the livestock output, and improvement in terms of trade for farmers (Chand, 2017).

In Punjab, the major constraints faced by livestock sector are small herd size or livestock units, lack of proper and scientific nutrition interventions for different categories of animals, insufficient prophylactic vaccination, poor value addition of the produce procured from small and marginal farmers, absence of culling policy for stray animals and male buffalo calves, poor extension services concerning livestock sector, poor linkages with consumer market etc.

Keeping in view all the above listed facts, the Veterinary University at Ludhiana recommends *Livestock Aggregation Model* for doubling the livestock farmer's (especially small dairy farmers) income in the state. This model is purely theoretical. No data is available to predict the success of this model. Still, the success of dairy farming under this model appears to be a possibility with rearing a minimum of 200 milch animals by a group of like-minded farmers. However, it is an uphill task to bring the small and marginal farmers under the umbrella of such models. Lots of efforts will be needed for building and maintaining farmers' trust in the transparency and functioning of this model. Profit distribution criteria among farmers of the Group is another facet of the problem. The effective monitoring and control over the activities of the Group is also an important aspect of the success of this model. The supportive evidence for the success of this model includes the establishment of more than 2000 commercial dairy farms in the state during the last two decades. The farmers rear crossbred cattle especially HF crosses with herd size of 30 to 300 heads or even more. These animals are of high genetic make-up. The farmers follow scientific practices related to breeding, feeding, healthcare and general management of animals. The success of such initiatives can be replicated under the suggested cluster approach.

The cluster network approach can also be followed for value addition of milk. Of the total milk produced in Punjab, only 18.0 per cent is processed into value added products. Value addition of milk can augment the profitability of the farmer by up to 25 per cent. There is ample scope for employment also.

The cluster approach is also beneficial for pig and goat farmers of the state. Adoption of this model will lead to remunerative employment generation for rural youth. The hygienic pig and goat meat will become available in almost all parts of the state. The potential for export of pig and goat meat will certainly rise. India earns approximately one per of aggregate export earnings through exchange of livestock products every year (Kumar *et al.*, 2007). Among various livestock products, meat and meat products provide the major chunk (> 90%) of export earnings. Besides exports, the increased consumption of meat in the state will also have a great impetus for the growth of these ventures.

Pork is the only meat that is imported in India. During 2016-17, the imports rose to 527 metric tons. Piggery in Punjab is developing at very high rate and demand of pork is increasing in the society. The Veterinary University recommends the establishment of a Nucleus Pig Breeding Unit (size: 50 breedable sows+ 5 breeding boars) preferably in government sector. This Unit will act as a breed improvement centre and it will be able to supply at least 120 breedable sows annually to potential pig breeding units. At least 300 pig breeding units having capacity of 100 females and 10 males have to be established in different parts of the state for the supply of piglets for fattening purposes. Each pig breeding unit will cost about one crore rupees. All these units combined together will be able to supply 1600 weaned piglet at two months of age in one year to ancillary units in the state. For this enterprise about 21 lac tonnes of feed will be required annually. This model will definitely boost the pig farming enterprise in the state.

Goat farming will offer an excellent economic opportunity for landless, marginal and

small farmers. India is the largest exporter of goat meat and during 2015-16, it was worth Rs 837.76 crore. Under the proposed *Livestock Aggregation Model*, a Central Unit with a capacity of 500-1000 breedable does has to be set up in Government or private sector. This Unit will help in the selection of breeding stock and it will be able to supply 32500 goats annually to secondary goat farmers. Additionally, 13,000 bucks could also be supplied to the market. In this set up, about 500 households will get benefitted. The availability of better germ plasm will definitely augment the farmer's income.

For resource poor farmers, backyard poultry (5-30 birds) especially with IBL 80 (Punjab Red) breed can also act a potential source of income and employment. There is great demand of brown shelled eggs especially in rural areas of the state and these are sold at premium. Backyard poultry can be easily managed by women, children and very old members of the family. Moreover, it requires very low initial investment with high economic returns. Major scientific advances have been made in the field of chick rearing, climate control measures, disease prevention strategies along with development of efficient marketing channels.

The south-western districts of the state (about 10,000 ha of land) are affected by salinity/ water logging. No income is drawn from such soils. This unproductive land could be put to effective use through carp and shrimp culture. Following table clearly indicates high economic returns from saline and water logged soils through carp culture.

Farmer's income can further jump to three

folds through rearing Pangas catfish resulting in productivity of 17-18 tonnes per hectare in six months. Even rearing vannamei shrimp is far more remunerative with a short culture period of 100-120 days. A net income of Rs 5.00-6.00 lakhs can be earned from one hectare pond in a short period of four months.

Some of the interventions that have potential for doubling dairy farmer's income have been enumerated below:

1. Buffalo to Cattle Ratio: Buffalo is often preferred to cattle especially in small farming set-up of the state. Buffaloes are known for high disease resistance and longer production life. Moreover, the consumers have great liking for buffalo milk owing to its higher fat content. Thus, major contribution (71%) to milk pool of the state is from buffaloes (CIRB Vision 2050). The average daily milk production in the state is 8.67 litres per buffalo per day (Livestock Census, 2012). However, improving daily milk yield in buffaloes has no significant impact on farmer's income from livestock (Saxena *et al*, 2017). However, Lal and Chandel (2017) conducted a study in Sirsa district of Haryana and found herd size and rearing of high yielding animals to have positive impact on total factor productivity in milk production.

Birth of male buffalo calf is not much condemned by the farmers since male calves also fetch some money to them. Even male calves can be reared up to few years of age for the purpose of selling them as meat source. This way the farmers' income can get significant boost (Saxena *et al*, 2017).

Table 1: Economic returns from various crop combinations and aquaculture in normal and salt affected soils

(Rupees per hectare)

Particulars		Rice-Wheat	Wheat-Paddy-Potato	Bt Cotton-Wheat	Desi Cotton-Wheat	Carp Culture
Returns over variable costs	Normal Soils	95,806	1,18,535	85,131	78,991	2,05,500
	Water logged/ Salt affected Soils	Nil	Nil	Nil	Nil	94,750

2. Herd size for Economic Viability: Majority of farmers in rural Punjab rear 2-3 milch animals in mixed farming system (Anonymous, 2013). It may not be a viable option for the farmer, but, they are simply following the trend. The economic viability of a dairy farm depends upon many factors including area under fodder cultivation, layout of animal shelter, production potential of animals, method of milking, type of milking area and labour availability.

For sustaining a dairy venture, the farmer must get at least 50 per cent profit over different costs. This could be possible only when he maintains a dairy farm of medium size i.e. a farm with at least 8 adult units (Kaur *et al.*, 2012).

3. Rearing Male Buffalo Calves: Most of the male buffalo calves are either sold to middlemen immediately after weaning or they are left to die because of hunger. The male buffalo calf at three month of age usually weighs around 40-50 kg and it can fetch only Rs 1,500/- . At nine month of age, the calf usually weighs around 100-120 kg and it can fetch Rs 4,000/- . If the same calf is well fed and reared for 18 months, it usually acquires a body weight of 400 kg. Such a bull calf can fetch the farmer Rs 24,000/- . Thus, rearing male buffalo calves for meat purposes is very lucrative venture for doubling the farmer's income.

There is an assured market for selling male buffalo calves. The farmers can make a contract with a Pune based NGO for selling the male buffalo calves of 18 month age at a predetermined price. The NGO runs the scheme known as Swadhan in which vaccination and deworming of male buffalo calves is done free of cost. The balanced feed is made available to the farmer at Rs 20 per kg. During 18 month period, a bull calf can consume a total of 560 kg feed costing around Rs 11,200. Around 2000-4000 rupees will be spent on green fodder/ dry fodder and medicines. The NGO buys back the bull calf at Rs 60 per kg live weight. Thus, one buffalo bull of 400 kg body weight can provide the farmer net returns to the tune of Rs 10,000/-.

4. Breed Improvement: Milk yielding potential of cows on small and marginal farms is quite low as compared to those on large sized farms. If these gaps are narrowed down through improvement of milk yield and adoption of scientific management practices at small and marginal farms, it will certainly boost dairy sector in the state. The income of dairy farmers will automatically rise.

The strategy of cross-breeding of dairy cattle has significantly improved the milk production potential especially in central districts of Punjab where green fodder is available in plenty. Under prevailing climatic conditions of Punjab, it is advisable to keep the exotic blood level between 50.0 and 62.5 per cent. This can be maintained through *inter-se* mating with genetically superior progeny tested cross-bred bulls. However, the exotic inheritance level can be further raised in farms having superior management strategies (Anonymous, 2012).

Non-descript, low producing buffaloes and even buffaloes of recognised breeds can be improved through selective breeding with elite buffalo bulls. It is expected that introduction of germplasm of high producing buffalo bulls in farmer's herd can result in 8-10 per cent genetic improvement per annum (Bhat, 1999).

Under prevailing circumstances in Punjab state, it is obvious the worth of female cow calf is much more than the male cow calf. Most of the farmers do not intend to raise male cow calf at all. Under such scenario, the cattle farmers can take advantage of using sexed semen. However, its use is not constraint free. First, sexed semen costs more than the conventional semen. Second, there is risk of reduced conception. The fertility of sexed semen is lower to the tune of 20 to 30 per cent than the fertility of conventional semen in virgin heifers (DeJarnette *et al.*, 2007). The economic gains with employment of sexed semen includes higher value of female cow calf, increased genetic gain from dam side and lower expected dystocia related costs (Fetrow *et al.*, 2007).

5. Control of Reproductive Problems : Milk

production begins only after completion of the process of calving. However, the animal needs to get pregnant and follow normal gestation before calving. Anoestrus and repeat breeding are two reproductive problems which are very common in bovine population of Punjab. Dua (2003) reported an incidence of anoestrus in 43.0 per cent cattle and 55.5 per cent buffalo while Karwani and Sharma (2003) reported repeat breeding in 37.2 per cent cattle and 15.63 per cent buffalo. Anoestrus causes annual losses per animal to the tune of Rs 27511 in cattle and Rs 27038 in buffalo while repeat breeding costs Rs 22595 in cattle and Rs 12922 in buffalo in annual losses per animal (Malik, 2018). Both these diseases can be tackled easily by following scientific management practices of housing, feeding and breeding. The artificial insemination by a well-qualified veterinarian/ technician will result in higher chances of getting the animal pregnant, thereby, reducing the redundant costs.

6. Early Diagnosis of Pregnancy: Inter-calving period has to be minimum for getting better economic returns from dairy animals. Reducing inter-calving period by one month through early diagnosis can lead to expected gain of 132 productive days for whole life in a cross-bred cow. In economic terms, the benefit comes out to be Rs 48,466/- (Abdulla *et al* 2014). Pregnancy diagnosis in cattle is usually done at two months of gestation through per rectal examination. It can be reduced by one month if gravid status is determined through ultrasonography at day 30 of gestation. Even the per rectal examination can be successfully done at day 45 of gestation.

Early submission (at day 45 of apparent gestation) of non-pregnant animal to artificial insemination can prevent substantial losses. Increase of one open day causes a loss of Rs 281 and Rs 368 in Sahiwal and cross-bred cow (Abdulla *et al* 2014). Thus, early diagnosis of pregnancy substantially improves the net return from a dairy venture.

7. Balanced Feeding and Dry Matter Intake:

Feeding balanced ration that too in sufficient quantity to milch animals is essential to realise their full milk production potential. A balanced ration should provide energy, protein, minerals and vitamins in appropriate amounts. Lal and Chandel (2017) reported negative impact of concentrate-productivity ratio on total factor productivity in milk yield in cattle as well as in buffalo in Haryana.

National Dairy Development Board generated data on 11500 animals in Gujarat state. This data clearly indicates that by shifting to balanced feeding one can improve the milk production efficiency of cattle from 0.58 to 0.78 kg Fat Corrected Milk for every kilogram of feed dry matter intake. The corresponding improvement in buffaloes is from 0.53 to 0.66 kg/kg. This improved milk yield can lead to 10-15 per cent increase in net daily income of the farmer who possesses one to two adult heads (FAO, 2012). In Punjab too, ration balancing intervention had a positive impact on milk productivity in crossbred cattle (Sirohi et al., 2017). However in buffaloes, productivity gains are not so significant but reduction in feed cost is quite evident. Still the farmer's income can get doubled if at least 11 per cent feed cost reduction is achieved with 5 per cent gain in milk productivity (Sirohi et al., 2017). This is possible where buffaloes produce at least 5.0 litres of milk daily. In low producing buffaloes, other interventions are also needed along with balanced feeding (Sirohi et al., 2017).

Feeding balanced rations to medium producing ruminants also lead to better synthesis of ruminal microbial proteins as indicated by higher level of allantoins in urine of cows (Makkar, 2004, Ramgaokar, 2008). Thus, increased microbial protein synthesis can save valuable feed protein (Dipu et al., 2006).

In Punjab, the availability of dry matter (both dry roughages and green fodder) is 24.23 million tonnes against the demand of 14.94 million tonnes for 5.84 million Adult Cattle Units (ACU). The demand supply gap of dry matter is quite variable in different

districts owing to variable number of ACUs (Tanwar and Verma, 2017). Thus, milk yield of milch animals can be improved significantly by simply making dry matter available uniformly throughout various districts of Punjab.

8. Comfortable Housing Management: Comfortable housing management is also very essential for realizing the full production potential of a dairy animal. Ideal housing and gentle treatment of crossbred cows can lead to one kg improvement in their daily milk yield. At the same time, clinical cases of lameness are reduced to minimum owing to ideal housing management. At a farm of 100 milch crossbred cows in Punjab, the total losses due to clinical lameness is Rs 1,99,800/- . For a similar farm of buffaloes, the expected losses are Rs 42,800/- . Subclinical lameness accounts for total losses of Rs 1,62,000/- per 100 cows and 100 buffaloes. The losses due to lameness can be kept under check by feeding biotin and zinc sulphate to animals, by giving foot bath of formalin and trimming of overgrown hooves. These measures can lead to a net profit of Rs 1103/- per animal per year (Randhawa, 2018)

9. Animal Healthcare and Preventive Vaccination: Animal health is basic to the livestock production. There are many infectious diseases which pose serious threat to the livestock sector. Foot and mouth disease (FMD), Haemorrhagic septicaemia (HS), Tuberculosis (TB), Johne's disease (JD), Brucellosis, PPR, Enterotoxaemia, Swine fever and Rabies are among the major infectious diseases prevalent in the state that cause huge economic losses in the form of animal morbidity, mortality, abortion, infertility, reduced milk yield and constraints in meat exports.

FMD is the most contagious infectious disease of cloven footed animals causing huge economic losses due to morbidity and mortality in young animals and production losses in older animals. The morbidity and mortality losses are usually about 97.6 and 2.4 per cent, respectively (Singh *et al.*, 2013). Component-wise, almost half of

the losses are due to milk loss (49.8%), followed by opportunity cost (16.2%) and reduction in growth (12.2%). Species-wise, FMD causes a total loss of Rs 12,532 and Rs 21,682 per animal, in cattle and buffalo respectively. Smaller herds have higher incidence risk of FMD (Malik, 2018). Systematic vaccination programme is an effective method of controlling this disease (Sharma *et al.*, 2017).

Haemorrhagic septicaemia is another disease of high economic importance. It is endemic in India (Venkataraman *et al.*, 2005). Its presence in a herd can cause direct losses in the form of mortality and severe milk reduction and indirect losses in the form of abortions, infertility and treatment costs. The morbidity accounts for 23 per cent of the total losses while the rest are because of mortality. In individual animal, the loss is estimated to be around Rs 6,816 in cattle and Rs 10,901 in buffalo (Singh *et al.*, 2014). A recent study (Malik, 2018), however, estimated the losses on lower side.

Mastitis is the inflammatory disease of mammary tissues of animals quite common in Punjab. It occurs both in clinical and sub-clinical form. Kaur and her associates (2015) reported an incidence of 20.4 per cent sub-clinical mastitis in buffaloes in Doaba region of Punjab. The disease causes economic losses in the form of increased cost of production, reduced milk production, culling of chronic cases, replacement costs of culled animals etc. Mastitis causes annual loss of Rs 13,871 in individual animal in Punjab (Malik, 2018) while the whole state witnesses a loss of Rs 503 crore annually.

Through effective vaccination programme, the prevalence of brucellosis can be brought to approximately 2-3 per cent after 20 years. The cost benefit ratio is 10.62 for cows and 21.27 for buffaloes (Singh *et al.*, 2018).

Thus, adoption of approved scientific practices will check losses due to infectious diseases, thus, improving farmer's net profits.

10. Early Diagnosis of Disease: Many infectious

diseases are prevalent in dairy animals in Punjab. Perhaps, the most important of all of them is haemorrhagic septicaemia followed by FMD. Brucellosis had very low prevalence in the previous century (Saini *et al.*, 1992), however, it shot up recently (Sandhu *et al.*, 2001). Tuberculosis is present in 3.0-5.0 per cent dairy animals (Joshi *et al.*, 1976, Kulshreshtha *et al.*, 1980). Actinomycosis was reported in sporadic cases in Punjab (Ray, 1976).

Early diagnosis of these infectious diseases through better diagnostic facilities will definitely reduce the anticipated losses. The losses could run in complete elimination of livelihoods in cases of severe outbreaks of certain diseases.

11. Development of Rendering Units : Around 8 per cent of total bovine population is lost every year due to natural death. Besides this, 60 per cent sheep and goat, 85 per cent pigs and 95 per cent poultry are slaughtered. This leads to huge production of by products (1.0 metric tonnes). However, due to non-availability of rendering units at village, block and district level, there is tremendous loss of revenue of livestock farmers. Establishment of around 20 By-product Processing Units in the state will fetch around Rs 600 crore annually. Thus, there is huge scope of improving farmer's income through organised carcass disposal and by-product utilization.

12. Quality inputs: Farmer's access to quality inputs like animal feed ingredients, mineral mixture, vaccines, dewormers and other medicines also have significant impact on his farm income.

13. Development of Value Chains: The concept of value chain emerged during the last decade of the previous century (Kaplinsky and Morris, 2001). Before a livestock product reaches the end user, it changes various hands during processing. At each step, some value is added to its price. All these activities when clubbed together in a specific order forms a value chain for that particular commodity. A value chain often links different businesses through various activities like processing, quality checks,

packaging, storage, transportation, distribution etc. Along with flow of product, the value chain also involves transfer of knowledge and information, and support through finances. The profit generated is shared at each stage of this value chain (Gereffet *et al.*, 2001). The livestock farmers can generate their own value chains to uplift their farming business. This is especially true for smallholder production systems. They can even be a part of the value chain established by bigger players in the market. Many farmers who are engaged in layer farming have established linkages with retail chains in Punjab for the supply of eggs. Formation of Self Help Groups (SHGs) or Common Interest Groups (CIGs) can also lead to higher jumps in the revenue generation. As an example, the goat and pig farmers of *kandi* area of Hoshiarpur district have formed a CIG named as *Sunrise Farmer Producer Association*. This Group consists of a total of 80 farmers (30 male and 50 women farmer). The principal activity of the Group is to produce pickle from pig and goat meat. This pickle is sold at premium at various forums. This way, the Group is earning handsome profit. Technical support for such groups is often provided by State Veterinary University while financial support is provided by NABARD. Krishi Vigyan Kendras can also help in the formation of SHGs for developing effective marketing channels in dairying (Shrivastava *et al.*, 2010). Development of a production cluster in an easily approachable area is another approach for upscaling benefits from livestock farming.

14. Reducing Calf Mortality: Calf is the future asset of the dairy farm. In India, majority of calf deaths occur during first two months of their life. Gastroenteritis, worm infestation, pneumonia and bloat are the major causes of mortality in calves (Shrivastava *et al.*, 2014). Adoption of better management practices lead to survival of calves and they turn into future heifer. This way, a farmer can save the value of purchasing a heifer for replacement.

15. Deworming : Regular deworming of calves leads to better growth rate to the tune of 100 – 400 g daily.

This gives farmer a minimum benefit of Rs 13,500 per year. Similarly, deworming of milch animals improve their milk production efficiency and the farmer gains at least Rs 4000 per animal in a year. It would be better if farmers undertakes deworming first getting faecal test of the animals and consulting the vet for the combination of drugs. Resistance is a big problem and it can be tackled with rationale deworming and changing the drug(s).

16. Ectoparasite Control: Ticks pose great threat to cattle especially crossbred cattle. They are responsible for producing anaemia, transmitting blood protozoans, reducing growth rates. Ticks also lead to production losses. In an African study, tick control measures led to a higher growth rate in calves (211.69 vs 170.84 gm/ day) and slightly higher milk yield (0.46 vs 0.40 litres per day)(Pegramet *al.*, 1988). The economic measures rural people use to adopt were keeping backyard poultry birds and let them free to move around the animals.

17. Integrating farming systems : Integrating farming in livestock sa fish with poultry, fish with pig or goat and fish with duck yields better benefits and increases the income many folds. Raising of pedigree dogs and pups along with dairy farm can further push the economy of the farm.

18. Waste management activities : Setting up of biogas plant at the dairy farm (n=250) can effectively utilize the waste resources which can save upto Rs 89250/ month in a dairy herd producing 50 quintal of dung. For such plant the initial fixed cost can be 10 lakh (After getting 40% subsidies) having Capacity of $90 \times 2 = 180$ cum with power generation and is a step towards clean environment. (Malhotra, 2017).

19. Sundries activities : Vermicomposting, dung cakes, incense sticks like activities can fetch petty income to farmers which at the end of financial year can push the economics of farm.

Doubling of farmers income can not be achieved overnight but it needs combined and constant efforts. The above listed measures can singly

or in totality can improve the livestock farmer's income, however it needs a lot of animal husbandry activates as campaigns, capacity building, field activities, welfare cum medical camps, mass media approach along with suitable ICT methods, so that scientific rearing is done for managing the animals along with rationale approach at every intervention for necessary savings.

REFERENCES:

- Abdullah M, Mohanty T K, Kunaresan A, Mohanty A K, Madkar A R, Baithalu R K and Bhakat M. (2014) Early pregnancy diagnosis in dairy cattle: Economic importance and accuracy of ultrasonography. *Advances in Animal and Veterinary Sciences* 2 (8): 464-67.
- Anonymous (2012) Annual Report 2011-2012. Department of Animal Husbandry and Dairying, Ministry of Agriculture, Government of India. New Delhi.
- Anonymous. (2013) Agriculture policy for Punjab.
- Bhat P N. (1999) Buffaloes. In: An introduction to Animal Husbandry in the Tropics (eds. William JA Payne and R Prades, Trevor Wilson). Blackwell Science, USA. Pp. 325-404.
- Chand R. (2017) Doubling farmers' income. Rationale, strategy, prospects and action plan. *NITI Policy Paper No. 1/2017*. Government of India.
- CIRB (Central Institute for Research on Buffaloes) (2015) ICAR-CIRB Vision 2050. Central Institute for Research on Buffaloes (Indian Council of Agricultural Research) Hisar, Haryana.
- DeJarnette J M, Nebel R L, Meek B, Wells J and Marshall C E. (2007) Commercial application of sex-sorted semen in Holstein heifers. *Journal of Dairy Science* 90 (Suppl. 1):228 (Abstract).
- Dipu M T, George S K, Singh P, Verma A K and Mehra U R. (2006) Measurement of microbial protein supply in Murrah buffaloes (*Bubalus bubalis*) using urinary purine derivatives excretion and PDC index. *Asian-Aust. Journal of Animal Science*, 19: 347–355.

- Dua K. (2003) Comparative disease susceptibility of cattle and buffalo in Punjab (India). In: Proceedings, 10th International Symposium on Veterinary Epidemiology and Economics. Vina del Mar, Chile, South America.
- [http://esaPunjab.gov.in/Data/StateStatisticalAbstract/Statistica lAbstract\(2011-12\).pdf](http://esaPunjab.gov.in/Data/StateStatisticalAbstract/Statistica lAbstract(2011-12).pdf).
- FAO. (2012) Balanced feeding for improving livestock productivity—Increase in milk production and nutrient use efficiency and decrease in methane emission, by M.R. Garg. *FAO Animal Production and Health Paper No. 173*. Rome, Italy.
- Fetrow J, Overton M and Eicker S. (2007) Sexed semen: economics of a new technology. Proceedings Western Dairy Management Conference, March 7-9, Reno, NV. Available at
<http://www.wdmc.org/2007/fetrow.pdf>
- Gereffi G, Humphrey J and Kaplinsky R. (2001) Introduction: globalization, value chains and development. *IDS Bulletin*, 32(3), 1-8.
- Jha B, Kumar N and Mohanty B. (2009) Pattern of agricultural diversification in India. *IEG Working Paper Series No. E/302/2009*. Institute of Economic Growth, New Delhi, pp1-56.
- Joshi D V, Sharma D R, Sodhi S S and Dhillon S S. (1976) Survey of tuberculosis at a buffalo farm. *Indian Journal of Animal Health* 15: 27-28.
- Kaplinsky R and Morris M. (2001) A Handbook for Value Chain Research (113). IDRC, Ottawa.
- Karwani A and Sharma J K. (2003) Incidence and epidemiology of abortions and repeat breeding in bovines at Dairy Farms in Punjab, India. 11th International Symposium of World Association of Veterinary Laboratory Diagnosticians and OIE Seminar on Biotechnology. Nov 9-13, 2003. Bangkok, Thailand.
- Kaur I, Singh V P, Kaur H and Singh P. (2012) Cost of milk production in Punjab: A pre-requisite for pricing policy. *Indian Research Journal of Extension Education*, Special Issue (Vol I): 313-21.
- Kaur M, Ramneek, Bansal B K, Mukhopadhyay C S and Arora J S. (2015) Status of sub-clinical mastitis and associated risk factors in Indian water buffalo in Doaba region of Punjab, India. *Indian Journal of Dairy Science* 68(5): 483-87.
- Kulshrestha R C, Singh J, Chandiramani N K (1980) A study on the prevalence of tuberculosis and Johne's disease in cattle and buffaloes in Haryana state. *Haryana Vet* 19: 139-41.
- Kumar A, Stall S J, Singh N P and Singh D K. (2007) Livestock sector trade of India: Surging momentum in the new liberalised regime. *Indian Journal of Agricultural Economics* 62(3): 395-410.
- Lal P and Chandel B S. (2017) Total Factor Productivity in milk production in Haryana. *Agricultural Economics Research Review* 30 (2) 279-284.
- Makkar H P S. (2004) Estimation of microbial protein supply in ruminant livestock through quantification of urinary purine derivatives. In: Makkar, H.P.S. and Chen, X.B. eds., Kluwer Academic Press, Dordrecht, The Netherlands, pp. 212.
- Malik M H. (2018) Economic losses due to selected diseases of dairy animals in Punjab. Ph.D Thesis. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India.
- Malhotra P. (2017). Economics of setting a biogas plant at dairy farm, personal communication.
- Pegram R G, James A D, Killorn K J, Oosterwick G P M, Lemche J, Ghirotti M, Tekle Z, Chizyuka H G B, Mwase E T and Chizyuka F. (1988) Studies on the economic impact of ticks in Zambia, Phase II: Analysis of the impact of tick control on herd productivity. Report prepared for the Government of the Republic of Zambia. Food and Agriculture Organization of the United Nations, Rome, (50 pp.)
- Ramgaokar J S, Verma A K, Singh P and Mehra U R. (2008) Effect of dietary protein levels on urinary excretion and plasma concentration of purine derivatives in crossbred bulls. *Animal Nutrition and*

- Feed Technology 8(1): 18–25.
- Randhawa S S. (2018) Personal communication.
- Ray S K. (1976) Ph.D. Thesis, Punjab Agric. Univ. Ludhiana, India.
- Saini S S, Sharma J K and Kwatra M S. (1992) Assessment of some management factors responsible for prevalence of brucellosis among traditionally managed animal population of Punjab. *Indian J. Anim. Sci.* 62 (9): 832–834
- Sandhu K S, Filia G, Sharma D R, Dhand N K, Singh J and Saini S S. (2001) Prevalence of brucellosis among dairy animals of Punjab. *Indian Journal of Comparative Microbiology Immunology Infectious Diseases* 22: 160-61.
- Saxena R, Singh N P, Choudhary B B, Balaji S J, Paul R K, Ahuja U, Joshi D, Kumar R and Khan N A. (2017) Can Livestock Sector be the Game Changer in Enhancing the Farmers' Income? Reinvesting Thrust with Special Focus on Dairy Sector. *Agricultural Economics Research Review* 30: 59-76.
- Shrivastava D C, Singh N K, Bhandarkar A P, Bisen N K, Deshmukh K K, Chourasia S K and Chand P. (2010) Dairy value chain model in Seoni district of Madhya Pradesh: an innovative approach by SHG. *Agricultural Economics Research Review* 23 (Conference Number) 559.
- Shrivastava M, Nanavati S and Mishra A K. (2014) Studies on factors influencing mortality rate in buffalo calves. *International Journal Agricultural Sciences and Veterinary Medicine* 2 (4): 41-46.
- Sharma G K, Mahajan S, Matura R, Biswal J K, Ranjan R, Subramaniam S, Nisri J, Bambal R G and Pattnaik B. (2017) Herd immunity against foot-mouth-disease under different vaccination practices in India. *Transboundary and Emerging Diseases* 64 (4): 1133-47.
- Singh B, Prasad S, Sinha D K and Verma M R. (2013) Estimation of economic losses due to FMD in India. *Indian Journal of Animal Sciences* 83: 964-70.
- Singh B, Prasad S, Verma M R and Sinha D K. (2014) Estimation of Economic Losses due to Haemorrhagic Septicaemia in Cattle and Buffaloes in India. *Agricultural Economics Research Review* 27 (2) 271-279.
- Singh B B, Kostoulas P, Gill J P S, Dhand N K. (2018) Cost-benefit analysis of intervention policies for prevention and control of brucellosis in India. *PLoS Neglected Tropical Diseases* 12(5): e0006488. <https://doi.org/10.1371/journal.pntd.0006488>
- Sirohi S, Sridhar V, Srivastava A K, Kalamkar S S, Sharma D and Boyal V. (2017) Ration Balancing: Promising option for doubling income from dairying. *Agricultural Economics Research Review* 30 (Conference Number) 193-203.
- Statistical Abstract Punjab (2012) Government of Punjab.
- Statistical Abstract Punjab (2017) Government of Punjab.
- Tanwar P S and Verma H K. (2017) Feed and fodder availability in Punjab state vis-a-vis livestock population -An estimate. *Indian Journal of Animal Sciences* 76(9): 720–26.
- Venkataraman R, Bandyopadhyay S K and Oberoi M S. (2005) Present status and strategies for the control of transboundary and economically important animal diseases in India: A review. *Indian Journal of Animal Sciences* 75: 456-64.