University of Veterinary and Animal Sciences

Mixed Dairy Farming Systems in Haryana: A Constraint Analysis

Rachna[1], Gautam[2] and Anika Malik[3]

1. Assistant Professor (Dairy Ext.), 2. Associate Professor (Vet. and AH Ext. Edu.), 3. Assistant Professor (Vet. and AH Ext. Edu.), College of Veterinary Sciences. Lala Lajpat Rai Uni. of Veterinary and Animal Sciences, Hisar, India.

Corresponding author e-mail: anikadhundwal@gmail.com

Paper Received on October 28, 2017, Accepted on November 30, 2017 and Published Online on December 22, 2017

ABSTRACT

Dairying in mixed farming situations involves millions of resource-poor farmers, for whom animal ownership ensures critical livelihood, sustainable farming, and economic stability. Attempts to help these farming systems have met with partial success in the past although their importance is well understood. We look at the problem from the farmers' perspective. Adopting the approach hired from theory of constraints an attempt is made to understand the most important bottlenecks in production enhancement in these production systems. The study was conducted on 60 randomly selected farmers practicing dairying in mixed farming situation. A list of likely constraints affecting mixed dairy farming systems was drawn and farmer's opinion was sought on these. The constraints perceived by the respondents were divided into six main areas viz. general, feeding, economic, management, health care and breeding. Management and feeding constraints were perceived as most serious. Decreasing operational land holding was seen as a major threat to these integrated systems. This, we argue, will result in delinking of rural dairying from crop husbandry. Similarly, increasing costs of animal feeds and fodders are posing significant threats. These together with poor animal health management factors are posing risks that in turn will likely compel farmers to refrain from adopting high yielding cross-bred animals. Lack of clean drinking water and ponds for animals was also perceived as important constraint. Poor reproductive efficiency of buffaloes was considered a key problem. Age, extension contact and mass media exposure were significantly and positively associated with constraint perception. Education was negatively and significantly related to the constraint perception. Steps like development of favourable market linkages, streamlining of research and development systems, broad basing livestock extension support and reforming inputs markets are suggested.

Key words: *Mixed dairy farming system; Dairy farmers; Constraints; Buffaloes;*

India, home to 17 per cent of the world livestock population, is the world's leading milk producer with annual production of about 121.8 million tonnes in the year 2010-11 *(Anonymous, 2012)*. The production system in the country is primarily smallholder with characteristic crop livestock integrated farming *(Vaidyanathan, 1998; Devendra et al., 2000)*. It is considered that almost 80 per cent of livestock products still come from small farmers with 3-5 animals and less than two hectares of land *(Rangnekar, 2001)*. These production systems evolved primarily to meet the livelihood needs of the rural families. It is estimated that the demand of livestock products will more than double by 2020 as compared to food grains whose demand is expected to rise by less than 50 per cent over the current levels *(Paroda and Kumar, 2000)*. It would seem that this increasing demand provides an excellent opportunity to the producers who are primarily smallholders. However, increasing urbanization and incomes are increasing the length and complexity of livestock value chains and the quality and safety standards demanded in livestock markets, making it more difficult for smallholders to compete in these growing markets *(Mcdermott et al., 2010)*. There is a possibility of concentrated livestock production and processing in large-scale integrated commercial companies, which

would likely displace small-scale livestock farmers and exacerbate rural poverty *(Steinfeld, 2003)*. The point of concern is the marginalization of small farmers in the face of increasing intensification and commercialization of livestock production systems. This has already happened in poultry sector (in India) to which the contribution of the rural mixed crop-animal production has become insignificant compared to the almost entirely urban commercial production systems *(Kurup, 1995)*. A similar transition in the crop-livestock systems can prove disastrous for the rural economy and livelihoods of a large majority of rural poor.

Crop livestock farming systems constitute the dominant land use system in the developing countries *(Iiyama et al., 2007)*. In these crop livestock systems, often referred to as mixed farming systems (*Sere and Steinfeld, 1996*), livestock and crops are produced within coordinated framework (*Van Keulen and Schiere, 2004*). Integrated crop livestock farming with dairy animals is also referred as dairying under mixed farming system or mixed dairy farming system. The importance of crop livestock systems in providing livestock and crop products, role in livelihoods of the poor, food security, poverty alleviation and sustainable resource management has long been realized *(Kristajanson and Thornton, 2004; Pell,1999; Lenne and Thomas, 2006; McIntire et al., 1992; Thornton and Herrero, 2001; Williams et al., 2004)*. However, the apparent potential appears to be still unrealised and, in many of these systems, levels of poverty are significant and crop and livestock production both remain low *(Tarawali et al., 2011)*. Understanding crop-livestock systems is enormously challenging *(Iiyama et al., 2007)*.

We attempt a slightly different method in attempting to understand the bottlenecks in production enhancement in the rural mixed dairy farming systems. Hiring from the 'Theory of constraints' (TOC), originally introduced by Dr. Eliyahu M. Goldratt in his book -*The Goal (1986),* we attempt to explore the opinion of practicing farmers on the question - what constrains the production enhancement in such (mixed farming) dairying situations? The method is based on two basic premises – a). The mixed farming systems is more of a risk coping strategy by the farmers who attempt to achieve optimum utilization of available resources in the face of dynamically changing conditions and b). There always is atleast one constraint affecting a system whose productivity would otherwise be infinite. A critical examination of such identified constraints has the potential to provide valuable inputs for formulation and implementation of support programs.

METHODOLOGY

The study was conducted on 60 farmers practicing mixed dairy farming (farmers who are practicing agriculture along with dairying) randomly selected from four villages (viz. Dabra, Mirkan, Shahpur and Dhobhi) of Hisar district of Haryana State (India). Hisar district has a large livestock population (796810), which is highest among all the 21 districts of Haryana (*Anonymous, 2007*). The 'constraints' were operationalized as certain irresistible forces (as perceived by the respondents) that acted as hindrance to the practice and growth of dairying in mixed farming systems. To begin with, constraints were picked from a variety of sources like opinion leaders, progressive farmers, veterinarians, literature, informal discussions and pilot studies. Finally, a list of 60 constraints (divided into six main areas viz. general, feeding, economic, management, health care and breeding) was selected in consultation with extension scientists and animal husbandry experts. The opinion of the respondents was sought on these constraints with each item having three degrees on a seriousness continuum ('very serious', 'serious' and 'not serious'). A weight-age score of 3, 2 and 1, was assigned to each response based on the degree of perceived seriousness. The data was collected using a pre-structured interview schedule developed solely for this purpose and by holding personal interview with the selected farmers in the year 2011-12. The sum of scores and mean percentage score of each constraint (item) was calculated. Ranks were assigned to constraints on the basis of mean percentage scores.

RESULTS AND DISCUSSION

The result of the farmers' response is summarized in Table 1. Evidently management and feeding constraints were perceived as more serious, whereas breeding and general constraints were perceived as comparatively less serious. On the whole, a majority of farmers perceived moderate degree of constraints with the mean score being 56.34 (Table 2). This, in a way, can be used to conjecture that majority of them were not averse to mixed dairy farming. This in turn allows us to suggest that there is reasonable scope for growth

Table 1. Constraint perception scores of farmers in different areas of dairy farming

Constraints	Total statements	Score obtained	MPS	Rank
General	20	1935	53.75	6
Feeding	10	1072	59.55	2
Economic	6	637	58.98	3
Management	4	466	64.72	1
Health Care	10	992	55.11	4
Breeding	10	983	54.33	5
Total	60	6085	56.34	-

of mixed dairy farming systems.

Some interesting findings were observed in the study. Looking at the obstacles in the augmentation of production in the face of the persistently rising demand of milk, one is tempted to go by the popular assumption that lack of effective market value chains is to blame. Surprisingly, it is the input side factor(s) that appear critically limiting (Table 3). Two important constraints identified by the farmers were fragmentation of land holdings and rising input costs.

Table 2. Classification of farmers on the basis of constraint perception scores

Constraint score Category	No. (%)	Constraints (Mean per cent score) General	Feeding	Economic	Management	Health care	Breeding	Total score
Low (72-89)	10(16.7)	45.50	57.33	47.78	46.67	45.33	41.67	47.11
Medium (90-108)	34(56.7)	53.57	57.03	59.44	65.67	56.83	52.13	55.86
High (109-126)	16(26.7)	59.27	66.23	64.89	73.92	57.50	67.90	63.12
Overall	60(100)	53.75	59.55	58.98	64.72	55.11	54.33	56.34
Ranks	-	VI	II	III	I	IV	V	-

Table 3. Item wise scores of general constraints, as perceived by respondents

General constraints	TS	MS	MPS	Rank
There is already high burden of work and keeping more animals is not feasible.	111	1.85	61.67	V
Mixed dairy farming is an unprofitable enterprise.	87	1.45	48.33	XII
Lot of hardship is involved in keeping animals.	128	2.13	71.11	II
It is very risky to keep dairy animals.	93	1.55	51.67	IX
Milk requirement is not high.	112	1.87	62.22	IV
Illiteracy is a hindrance to animal management.	74	1.23	41.11	XIV
Engagement with other tasks leaves little time for animal keeping.	92	1.53	51.11	X
Wards do not like animal husbandry related work.	91	1.52	50.56	XI
Who is to do attitude' in doing work related to animals is a problem.	74	1.23	41.11	XIV
Nutritional requirements of family are met by means other than mixed dairy farming.	71	1.18	39.44	XV
Premises become unclean due to animals.	115	1.92	63.89	III
Financial requirements of family are met by means other than mixed dairy farming.	95	1.58	52.78	VIII
There is availability of milk at economical price.	98	1.63	54.44	VII
Fragmentation of land holdings is a hindrance to mixed farming.	154	2.57	85.56	I
There is lack of irrigation facilities for fodder crops.	99	1.65	55.00	VI
Shifting of cropping patterns has led to difficulties in animal keeping.	98	1.63	54.44	VII
Since male animals are not required in fields these days, there is no need to rear animals.	77	1.28	42.78	XIII
High milk yielding breeds of animals are not available.	115	1.92	63.89	III
There is lack of storage facility for dairy products.	64	1.07	35.56	XVI
Labor is a problem and keeping animals have become difficult.	87	1.45	48.33	XII

For general practices, 'fragmentation of land holdings' was perceived as most serious constraint followed by, 'hardship is involved in keeping animals.' Lack of storage facility for dairy products' was perceived as least serious constraint (Table 3). Fragmentation of land holdings occurs when land is divided amongst the family members of next generation.

The argument is well substantiated by the fact that in India about 50 per cent of all operational holdings in 1980 were less than one hectare in size which had increased to 62.3 per cent in 2000-01. About 19 per cent fell in the 1-2 hectare range, 16 per cent in the 2-4 hectare range which reduced to 11.8 per cent in 2000-01, and 11 per cent in the 4-10 hectare range which had also reduced

to 5.5 per cent in 2000-01. All India average size of the landholding has also reduced from 1.41 hectare to 1.33 hectare between 1995-96 to 2000-01 and by all probabilities the average size of landholding presently would be nearly 1.25 hectare *(Anonymous, 2010)*.

Further, the mixed farming systems get characterized by the intensified internal recycling of the nutrients. In these systems, crop residues are used to feed animals. However, fragmentation of land holding together with other factors like changing labour productivity, market access, changing demand patterns, etc have led to increased mechanization of agricultural operations and shift to commercial crops besides changes in crop patterns. It is thus posing a serious challenge to mixed farming systems. It is suggested that efforts to improve crop residues availability by encouraging such crops as may yield higher residues, changing crop rotation to facilitate fodder production, improving unconventional feed utilization, etc should be seriously considered.

In case of feeding practices, 'high cost of animal feeds' was perceived as most serious constraints whereas 'Non availability of seeds of high yielding varities (H.Y.V.) of fodder crops' was perceived as least serious by the respondents (Table 4).

The problem is in part a reflection of the changing agricultural practices besides changing market dynamics. Firstly, the problem can be understood from the point of view of changing agricultural practices, leading to decline in the availability of crop residues (such as wheat straws). The reduced availability has fuelled the prices of such feed stuffs in recent past. Secondly, over the last three decades there has been a marked shift in favour of concentrate feeding.

Infact, it has been argued that the higher output growth in the Indian Dairy sector since 1980s owes much to the availability of concentrate to the otherwise poorly fed animals *(Gautam et al., 2010)*. Doubts have earlier been raised on the ability to maintain a shift in favour of increasing concentrate use for animal feeding *(Delgado et al., 1999)*. Thus farmers have to cope with decreasing availability and rising prices of both crop residues and concentrates.

Among economic/ marketing related constraints, 'with high cost of input very difficult to achieve profitability' and 'high cost buffaloes', were perceived as most serious constraints whereas 'lack of insurance facilities for animals, was perceived as least serious by the respondents (Table 5). Farmer's constraint perception about rising input costs can also be seen as associated with high cost of feed and fodders.

For management practices, 'lack of clean ponds in village' was perceived as most serious constraint. 'Difficulty in management of animals during inclement weather conditions.' was perceived as least serious

Table 4. Item wise scores of feeding constraints, as perceived by respondents

Feeding constraints	TS	MS	MPS	Rank
There is lack of knowledge about balanced ration.	113	1.88	62.78	4
Pastures are not available.	101	1.68	56.11	6
Non availability of green fodder throughout the year.	120	2.00	66.67	3
Non availability of dry fodder.	81	1.35	45.00	9
High cost of animal feeds and fodders.	146	2.43	81.11	1
Non availability of seeds of high yielding varities (H.Y.V.) of fodder crops.	77	1.28	42.78	10
There is poor grain and byproduct availability for animals.	89	1.48	49.44	8
Non availability of mineral mixture in village.	108	1.80	60.00	5
Feeding of animals is a tiresome task.	94	1.57	52.22	7
Lack of clean drinking water sources for animals.	143	2.38	79.44	2

Table 5. Item wise scores of Economic Constraints, as perceived by respondents

Economic / Marketing Constraints	TS	MS	MPS	Rank
The location of market is far away.	78	1.30	43.33	4
Input costs are increasing and it's very difficult to achieve profitability.	145	2.42	80.56	1
There is lack of credit facility for dairy farmers.	75	1.25	41.67	5
There is lack of insurance facilities for animals.	73	1.22	40.56	6
The price of produce is un-remunerative.	123	2.05	68.33	3
Cost of buffaloes is very high.	143	2.38	79.44	2

Table 6. Item wise scores of management constraints, as perceived by respondents

Management constraints	TS	MS	MPS	Rank
More time is required for agriculture thus lack of time to devote to animal husbandry.	117	1.95	65.00	2
There is lack of space for animal premises.	116	1.93	64.44	3
There is difficulty in management of animals during inclement weather conditions.	106	1.77	58.89	4
There is lack of clean ponds in village. Bathing of animals in absence of ponds is a problem.	127	2.12	70.56	1

Table 7. Item wise scores of healthcare constraints, as perceived by respondents

Healthcare constraints	TS	MS	MPS	Rank
Non availability of veterinary hospital in the village.	60	1.00	33.33	8
Far away location of veterinary hospital is a problem.	62	1.03	34.44	7
Non availability of veterinary surgeons.	64	1.07	35.56	6
There is lack of doorstep veterinary health care services.	85	1.42	47.22	5
Cost of treatment of sick animals is very high	102	1.70	56.67	4
Vaccination facilities are not timely available.	62	1.03	34.44	7
There is growing problem of mastitis in lactating animals.	121	2.02	67.22	3
New born calf care is troublesome.	144	2.40	80.00	2
There are high losses due to incidence of disease.	148	2.47	82.22	1
There is economic loss due to high calf mortality rate.	144	2.40	80.00	2

Table 8. Item wise scores of breeding constraints, as perceived by respondents

Breeding constraints	TS	MS	MPS	Rank
There is lack of good breeding bulls in villages.	135	2.25	75.00	1
There is lack of A.I facility in the village.	71	1.18	39.44	8
Poor conception rates of A.I.	113	1.88	62.78	5
There is lack of knowledge regarding care of pregnant animals.	79	1.32	43.89	6
Repeat breeding in buffaloes is a problem.	133	2.22	73.89	2
There is a problem of abortion in animals.	75	1.25	41.67	7
There is growing problem of infertility in animals.	115	1.92	63.89	3
Heifers do not conceive timely.	114	1.90	63.33	4
It is difficult to detect heat in buffaloes.	69	1.15	38.33	9
Improper feeds lead to animal not coming in heat timely.	79	1.32	43.89	6

constraint (Table 6). Adequate clean water availability is a pre-requisite for dairy animal rearing. Water is required for drinking, bathing, cleaning the premises. Farmers' perceived lack of clean drinking water and ponds for animals is an important constraint The reason are not difficult to discover. The study area is adjacent to the home tract of famous Murrah buffalo. The animal primarily reared in rural dairying situations is buffalo. These are infact, water buffaloes domesticated some 5000 years back. Water availability for these animals is of high importance especially in hot climates since they need wallows, rivers or splashing water in order to reduce the heat load and thermal stress *(Wikipedia, 2013)*.

Discussion with farmers revealed that buffalo husbandry did evolve, to a certain extent, with the increasing availability of the water sources. The earlier generations of the farmers, reportedly, favoured cattle over buffaloes. With the increasing water availability and stable crops, buffaloes were favoured. Every village visited by the researcher had more than one pond specially set aside for animals. A large majority of farmers were taking their animals for drinking, bathing and wallowing in these ponds. Factors like decrease in the number of such ponds, shrinkage in size, deteriorating water quality and increasing distances (owing to horizontal expansion in the dwellings) are, perhaps, limiting the availability of water for buffaloes. Community efforts to spread awareness among people through Panchayats are recommended to improve the condition of deteriorated ponds and ensure clean drinking water to livestock.

For health care practices, 'high losses due to incidence of disease' was perceived as most serious

Table 9. Correlation coefficients between constraint perception scores and antecedent variables of respondents

Constraints	Correlation Coefficient 'r' Values						
	General	Feeding	Economic	Management	Health care	Breeding	Total Score
Age	0.088	0.009	.316*	0.149	0.23	.306*	.273*
Education	-0.114	0.019	-.367**	-0.214	-.316*	-.334**	-.324*
Family type	0.177	0.152	-0.125	-0.167	-0.018	0.165	0.11
Land holding	-0.143	0.039	-0.155	-0.117	-0.024	0.008	-0.095
Herd size	-0.114	-0.089	.290*	-0.049	.283*	0.014	0.047
Social participation	.279*	0.155	0.102	0.087	0.024	0.173	0.244
Extension contact	0.184	-0.105	.460**	0.214	.322*	.307*	.339**
Mass media exposure	.323*	0.197	.263*	0.217	0.065	.388**	.403**
Economic motivation	0.014	.264*	-0.07	-0.011	0.019	0.14	0.11
Risk orientation	-0.049	0.117	-0.073	-0.045	-0.097	0.243	0.05

*. Correlation is significant at the 0.05 level (2-tailed).; **. Correlation is significant at the 0.01 level (2-tailed)

constraint followed by, 'economic loss due to high calf mortality rate'. Whereas 'Non availability of veterinary hospital in the village' and 'non availability of timely vaccination facilities' were perceived as least serious constraints (Table 7).

Reduction of risk by way of insurance support should be given a serious thought. Although, science has made rapid strides into the diagnosis and treatment of animal diseases especially the infectious diseases, yet the animal diseases (and the resulting economic losses) still remain a major risk factor in the rural mixed farming situations. It is generally agreed that a large number of animal diseases have been brought to a stable endemic level with the development of vaccines, knowledge about their vectors, better hygiene, and other management practices.

Some other workers have reported that farmers consider high cost of veterinary treatment as a serious constraint *(Khandi et al., 2011; Sharma et al., 2010)*.

The respondents also considered constraints associated with calves rearing as serious. To be very specific both the items i.e. new born calf care is troublesome and elevated economic loss due to high calf mortality rate reflect an underlying problem about calf rearing. This is rather worrisome to note that despite the growth in number of veterinary institutions in the state the calf mortality remains high. Conjecturally it can be opined that poor knowledge of calf management practices (including feeding) and inadequate veterinary attention are to blame. Even if they are not seen as the reasons unto themselves, strengthening on both the accounts will bear positive fruits. Tools like extension campaigns on calf management can work wonders in this situation. However, in the present study the respondents considered non availability of veterinary hospital in the village as least serious constraint followed by non availability of timely vaccination facilities. Also, items like far away location of veterinary hospital and non availability of veterinary surgeons scored low. This is an indication of the fact that considerable expansion in veterinary services has occurred. Statistics of the department of Animal Husbandry and Dairying, Government of Haryana also support the contention. The number of veterinary institutions in state has increased to 2789 in year 2009-10 *(Anonymous, 2010a)*. There is, perhaps, now a case for qualitative improvement in the services rendered by these institutions.

Among breeding practices, farmers considered 'lack of good breeding bulls' and 'repeat breeding' as most serious constraints.'Difficult to detect heat in buffaloes' and 'lack of A.I facility in the village' were perceived as least serious by the respondents (Table 8).

It appears that the farmers continue to rely on natural mating instead of preferring artificial insemination. Similarly infertility, delayed puberty attainment and poor conception rates with AI were perceived as serious. It appears that farmers are concerned with poor reproductive efficiency of buffaloes. *Barile (2005)* considers that reproductive efficiency is the primary factor affecting productivity and is hampered in the female buffalo by a delayed attainment of puberty, seasonality, long post-partum anoestrus and subsequent calving interval, and poor oestrus expression. All these factors affecting reproductive efficiency have been identified and discussed earlier by many workers (*Dobson and Kamonpatana, 1986; Madan et al., 1996; Zicarelli, 1997; Oswin, 1998)*.

Hacker et al. (2009) suggest that the continued evolution of mixed farming systems will depend on the development of technology which addresses the basic biophysical constraints of the agro ecological zone within which these systems have developed. However, the application of these technologies will increasingly depend on the extent to which they address all dimensions of the social–economic–environmental system within which mixed farmers operate.

To understand the association of socio-personal characteristics with the constraint perception of the respondents, their correlation coefficients were worked out (Table 9). A majority of the antecedent variables except education and land holding were positively associated with constraint scores. Education was significantly and negatively related, whereas others like age, extension contact and mass media exposure were positively associated with constraint perception score.

CONCLUSION

There is a strong case for proactive approach in favour of mixed dairy farming systems given the dependence of rural poor on these and the environmental consequences of commercial systems. Such an approach should include favourable market access and linkages, streamlining of research and development systems, dis-incentivizing the commercial dairying by way of regulatory and policy measures, broad basing livestock extension support and reforming inputs markets. It is concluded that input side factor(s) were perceived as critically limiting by the farmers. There is a need to look at the problems perceived as serious by farmers. These include fragmentation of land holdings, high input and animal costs, infertility and repeat breeding, calf mortality, etc., among others. Age, extension contact and mass media exposure were significantly and positively associated with constraint perception. Education was negatively and significantly related to the constraint perception. Sensitization of research and development systems about the problems of farmers is also advised. Accordingly, attempts to improve feed and fodder supply, farmer's risk coping strategies (like animal insurance), water availability and better reproductive management will likely prove critical in sustaining and promoting mixed crop livestock dairying in rural areas.

REFERENCES

Anonymous (2007). Livestock census 2007, Department of Animal Husbandry and Dairying, State Government of Haryana. Available athttp://pashudhanharyana.gov.in/html/livestockcensus. htm. Accessed on May 6, 2012.

Anonymous (2010). Population growth and Agriculture in India. Available at http://indiamicro finance.com/population-growth-agriculture-india.html accessed on April 6, 2012.

Anonymous (2010a). District-wise veterinary institutions as on 25.02.2010, Department of Animal Husbandry and Dairying, State Government of Haryana. Available at http://pashudhanharyana.gov.in/html/farms.htm accessed on May 6, 2012.

Anonymous, (2012). Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India. Available at http://dahd.nic.in/dahd/division/dairy-development.aspx Last accessed 24.09.2013.

Barile, V.L. (2005). Improving reproductive efficiency in female buffaloes. *Livestock Prod. Sci.*, **92**: 183-192.

Delgado, C.; Rosegrant, M.; Steinfield, H.; Ehui, S. and Courbois, C. (1999). Livestock to 2020; The next food revolution, IFPRI, Food, Agriculture and Environment Dicussion Paper 28, International Food Policy Research Institute, Washington DC, USA.

Devendra, C., Thomas, D., Jabbar, M. and Zerbini, E. (2000). Improvement of livestock production in crop-animal systems in agro-ecological zones of South Asia. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Dobson, H. and Kamonpatana, M. (1986). A review of female cattle reproduction with special reference to a comparison between buffaloes, cows and zebu. *J. of Reproduction and Fertility*. **77**: 1–36.

Gautam; Dalal, R.S. and Pathak, V. (2010). Indian dairy sector: Time to revisit operation flood. *Livestock Sci*.. **127**: 164–175.

Goldratt, E.M. (1986). The goal: a process of ongoing improvement. North River Press, New York.

Hacker, R.; Robertson, M.; Price, R. and Bowman, A. (2009). Evolution of mixed farming systems for the delivery of triple bottom line outcomes: a synthesis of the grain & graze program. *Animal Prod. Sci.*. **49**: 966–974.

Iiyama, M.; Kaitibie, S.; Kariuki, P. and Morimoto, Y. (2007). The status of crop–livestock systems and evolution toward integration. *Annals of Arid Zone*. **46** (3-4): 1-23.

Khandi, S.A.; Hamdani, S.A.; Gautam.; Kumar, P. and Bhadwal, M.S. (2011). Constraints perceived by Gujjars (Pastoralists) in adopting improved animal husbandry practices. *J.of Res.*, SKUAST-J. **10** (2) : 17-24.

Kristjanson, P. M. and Thornton, P. K. (2004). Methodological challenges in evaluating impact of crop–livestock interventions. In: Williams, T. O., S. A. Tarawali, P. Hiernaux, and S. Fernández-Rivera (Eds). Sustainable crop-livestock production for improved livelihoods and natural resource management in West Africa. Nairobi, International Livestock Research Institute, Kenya pp160-172.

Kurup, M.G.P. (1995). India- Livestock Sector Perspectives 1995-2020, Project Report of Govt. of India, Dept. of Animal Husbandry, Ministry of Agriculture in collaboration with Swiss Development Corporation.

Lenné, J.M. and Thomas, D. (2006). Integrating crop livestock research and development in sub-Saharan Africa. Option, imperative or impossible? *Outlook on Agri.*, **35**: 167–175.

Madan, M.L., Das, S.K. and Palta, P. (1996). Application of reproductive technology to buffaloes. *Animal Reproduction Sci.*, **42**: 299–306.

McDermott, J.; Staal, S.J.; Freeman, H.A.; Herrero, M. and Van de Steeg, J.A. (2010). Sustaining intensification of smallholder livestock systems in the tropics. *Livestock Sci.*. **130**: 95–109.

McIntire, J.; Bourzat, D. and Pingali, P. (1992). Crop-Livestock Interaction in Sub-Saharan Africa. World Bank Regional and Sectoral Studies. The World Bank, Washington, DC.

Oswin, P. B. (1998). Reproduction in water buffalo: comparative aspects and implications for management. *J. of Reproduction and Fertility*, **54** (Suppl.), 157–168.

Paroda, R.S. and Kumar, P. (2000). Food production and demand in South Asia. *Agril. Eco. Res. Review*. **13**: 1-24.

Pell, A.N. (1999). Integrated crop-livestock management systems in Sub-Saharan Africa. *Envi., Dev. and Sustain.*, **1**: 337-248.

Rangnekar, D.V. (2001). Livestock production in rural systems and expected impacts of free trade, Vision 2020: food security from the grassroots perspective. Forum Umwelt und Entwicklung, Bonn, Germany.

Seré, C. and Steinfeld, H. (1996). World Livestock Production Systems: Current Status, Issues and Trends. FAO Animal Production and Health Paper 127. FAO, Rome.

Sharma, K.; Singh, S.P and Gautam. (2010). Constraints perceived by dairy farmers in adoption of recommended buffalo husbandry practices. *Indian J. Dairy Sci.* **63** (3).

Steinfeld, H. (2003). Economic constraints on production and consumption of animal source foods for nutrition in developing countries. *J Nutr*. 133: 4054-4061.

Tarawali, S.; Herrero, M.; Descheemaeker, K.; Grings, E. and Blummel, M. (2011). Pathways for sustainable development of mixed crop livestock systems: Taking a livestock and pro-poor approach. *Livestock Sci.*. **139**: 11-21.

Thornton, P.K. and Herrero, M. (2001) Integrated crop-livestock simulation models for scenario analysis and impact assessment. *Agril. Systems.* **70**: 581-602.

Vaidyanathan, A. (1998). Programme for research on mixed crop-livestock systems in South Asia: A tentative outline. Report submitted to the ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Patancheru, India.

Van Keulen; H. and H. Schiere. (2004). Crop-Livestock Systems: Old Wine in New Bottles? In New directions for a diverse planet. Proceedings of the 4th International Crop Science Congress, Brisbane, Australia, 26 September-October 2004.

Wikipedia. (2013). Water Buffalo. Available at http://en.wikipedia.org/wiki/ Water_buffalo Last accessed 25.08.2013.

Williams, T.O.; Tarawali, S.A.; Hiernaux, P. and Fernandez-Rivera, S. (Eds.), 2004. Sustainable crop livestock production for improved livelihoods and natural resource management in West Africa. International Livestock Research Institute), Nairobi, Kenya and CTA (Technical Centre for Agricultural and Rural Cooperation, ACP-EC), Wageningen, The Netherlands.

Zicarelli, L.; Filippo, C. D.; Francillo, M.; Pacelli, C. and Villa, E. (1997). Influence of insemination technique and ovulation time on fertility percentage in synchronized buffaloes. In: Borghese, A.; Failla, S.; Barile, V. L. (Eds) Proceedings 5th World Buffalo Congress, Royal Palace, Caserta, Italy pp.732-737.

• • • • •