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Cost of conservation of indigenous dairy cattle breed—A case of Sahiwal in India

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ABSTRACT

Conservation of indigenous cattle breeds is now getting much needed attention from the Government. Understanding the perception of dairy farmers and estimation of conservation cost is very important for designing effective conservation policies. Present study attempts to address the same with specific reference to Sahiwal breed. Primary data was collected from 168 dairy farmers spread over prominent breeding tract of Sahiwal in India. Relevant secondary information was collected from ABRC, NDRI and from companies dealing with reproduction technologies. Garrett's ranking, dichotomous choice CVM and cost analysis were used for analyzing the collected data. Subsidy on purchase price, higher price for milk and ensured availability of pure breed figured out as the most essential requirement for rearing Sahiwal cattle. WTA estimates were lowest for Sri Ganganagar indicating that if *in situ* conservation is done in this area it will cost comparatively less to the Government. Cost per insemination and cost per conception in Sahiwal worked out to be ₹ 95.97 and ₹ 191.94, respectively.

Keywords: Conservation cost, Dichotomous choice CVM, Indigenous cattle, Sahiwal, WTA

It is widely recognized that biodiversity preservation is essential for sustainable future. There is no doubt that the erosion of farm animal genetic resources eventually results in irreversible damage for both present and future generations, accompanied by the loss of potential market values and environmental functions (FAO 2000, Hammond 1999). India is immensely rich in bovine diversity and possess one-ninth of cattle germplasm along with cent per cent breeds of water buffalo. It is home to some of the finest dairy cattle breeds—Sahiwal, Gir, Tharparkar, Red Sindhi—which are known all over the world for their milking prowess. These breeds are not only well adapted to the local conditions but also share strong cultural and ecological links with the native population.

But due to sole emphasis on raising the milk production in recent decades and failure of markets to account for other benefits of indigenous breeds, cattle biodiversity in India are under severe threats. One of the examples of indigenous cattle breed whose number is continuously declining in its own homeland is Sahiwal. Sahiwal originated along the Indo-Pakistan border and its breeding tract in India comprises of Fazilka and Abohar region of Punjab, Sirsa district of Haryana and Sri Ganganagar district of Rajasthan. It is the best indigenous milch breed in India and Pakistan. Due to its characteristics it has been used to develop new breeds like Karan Swiss and Frieswal. The contribution of the Sahiwal breed to adaptability is also well documented in other countries also. Despite this it forms only 2.5% of total cattle population in India and out of that also only 22% are pure and rest is graded (GoI, 2013). Though, sufficient secondary data is not available to track its population trend but experiences of various experts indicate that at field level its population has declined and it needs attention for conservation (Tomar 2004, Sharma and Niranjan 2016).

Realizing the importance of Sahiwal and other indigenous breeds, Government of India has launched 'Rashtriya Gokul Mission' for promoting conservation and development of native breeds. But, the conservation of animals that are no longer economically convenient to rear under present market conditions involves a certain cost to the community. If this cost is not met, these animal populations are faced with the threat of extinction. Thus, some policies are needed to prescribe which and how many breeds to conserve, along with the management strategies to implement so as to achieve conservation, via either *in situ* or *ex situ* approaches (Cicia *et al*. 2003). For guiding such policies a comprehensive study of the perception of dairy farmers is necessary along with the estimation of cost of conservation.

Though, there are a few past studies which partially address this issue for plant genetic resources in India but there is hardly any such study in relation to farm animal genetic resources. The present study is a modest attempt to fill this gap. The major research questions which the current study tries to answer with specific reference to Sahiwal breed are whether the farmers willing to rear Sahiwal breed? what are the hurdles that farmers face in rearing indigenous cattle? and what is the estimated cost of conserving the

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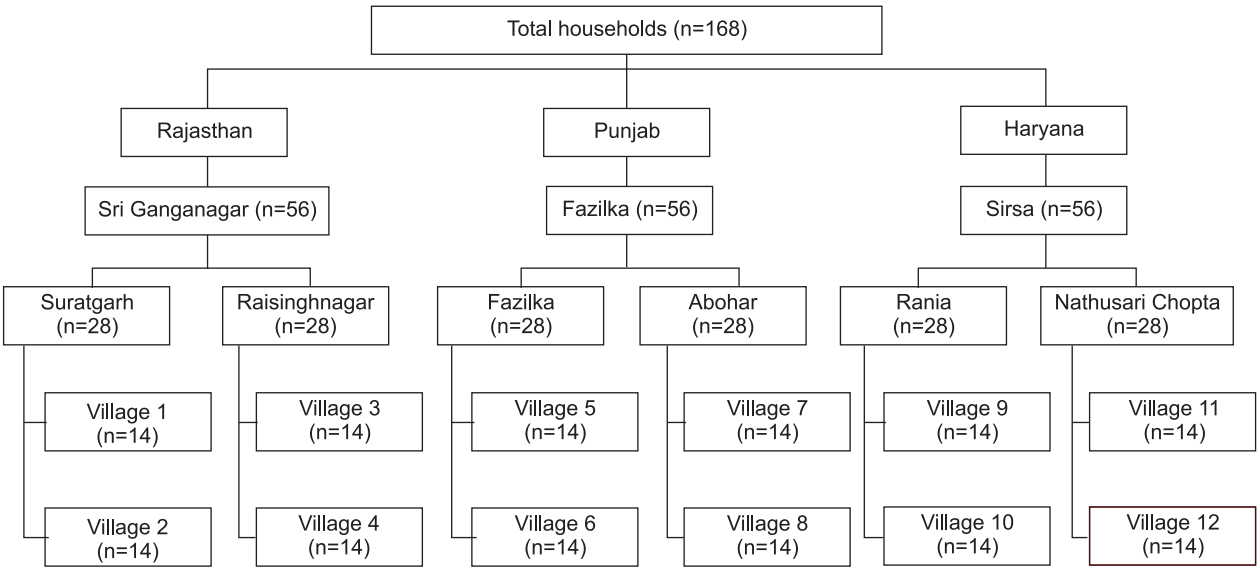

Fig. 1. Sampling framework of the study area

breed through in-situ and *ex-situ* method?

MATERIALS AND METHODS

Study area: The study was carried out in the breeding tract of Sahiwal in India comprising of Sri Ganganagar district (Rajasthan), Fazilka district (Punjab) and Sirsa district (Haryana). This region was purposively selected as due to prolonged association with the native community, Sahiwal breed is well known and forms a part of local landscape, tradition and customs. Despite this, the area has observed a major decline in the number of indigenous cattle and a subsequent rise in the population of crossbred which makes it an ideal choice for studying the conservation aspects of the Sahiwal.

Sampling framework: Multi stage sampling procedure was adopted.

At the first stage, entire breeding tract of Sahiwal in India comprising of Fazilka district (Punjab), Sri Ganganagar district (Rajasthan) and Sirsa district (Haryana) was selected purposively. After that, based on field information, two blocks having higher number of Sahiwal cattle were purposively selected from each district and from each block again, two villages were selected. From each village, 7 Sahiwal rearing and 7 non-Sahiwal rearing dairy farmers were selected randomly. Thus, a total of 168 dairy farmers comprising 84 Sahiwal rearing and 84 non-Sahiwal rearing were selected from 12 villages.

Data collection: Primary data was collected by personally interviewing the respondents using a pretested structured schedule developed for the purpose. Information related to various socio-economic parameters of the households was collected from the primary sources. Secondary information related to daily nutrient requirements of bulls and Minimum Standards Protocol (MSP) for production of bovine frozen semen was collected from Artificial Breeding Research Centre, NDRI and the relevant data related to cost of equipments and chemicals was collected from companies dealing with reproduction technologies like IMV technologies, Minitube and Sigma.

Analytical tools

Garrett's ranking technique: Garrett's ranking technique was used to identify the major incentives required by dairy farmers for rearing Sahiwal. Garrett's formula for converting ranks into percent was used to obtain percent position which is given by,

$$\text{Percent position} = 100\times(R_{ij}-0.5)/N_j$$

where R_{ij}, rank given for i^{th} factor by j^{th} individual; N_j, number of factors ranked by j^{th} individual.

The per cent position of each rank was then converted into scores referring to the table given by Garrett and Woodworth (1969). For each trait, the scores of individual respondents were added together and divided by the total number of the respondents. These mean scores for all the traits were then arranged in descending order, ranks were given and most important incentives were identified.

Dichotomous choice contingent valuation: Dichotomous choice contingent valuation technique was used to determine farmers' willingness to accept (WTA) compensation to participate in a conservation programme for Sahiwal. During the survey, crossbred rearing farmers were asked to assume that the government was going to provide them an annual compensation amount if they replace one of their crossbred cows with a Sahiwal. After that a bid amount was presented to them and they were asked to tell whether they were ready or not to rear a Sahiwal at the given amount. The first bid amount was presented randomly to the farmers. If they replied with yes then a second bid with lower amount was presented whereas in the case of negative response a second bid with higher amount was presented. Response to both the bids was

Table 1. Bid structure for willingness to accept (WTA) elicitation

Bid 1	10,000	20,000	30,000
Bid 2 max	20,000	30,000	40,000
Bid 2 min	5,000	15,000	25,000

recorded. Table 1 shows the value of various bid amounts presented to the farmers. Bid amount was decided on the basis of rough estimates of opportunity cost of rearing Sahiwal as told by the farmers during preliminary survey.

Responses obtained from the farmers using dichotomous choice contingent valuation technique were analyzed using bivariate probit model to arrive at WTA estimate. The bivariate probit model was initially introduced by Cameron and Quiggin (1994). The probit model is applicable to CV studies with one dichotomous-choice question but by introducing a follow-up dichotomous-choice question, the statistical efficiency improves by the application of a bivariate probit model (Carson *et al*.1986). The bivariate probit (biprobit) model has two binary dependent variables that are correlated.

In the bivariate probit model, the WTP functions for an individual i can be written as:

$$\ln (WTP_{1i}) = \beta_1 Xi + \varepsilon_{1i}$$
$$\ln (WTP_{2i}) = \beta_2 X_i + \varepsilon_{2i}$$

In the study two dichotomous variables were observed, i.e. the answer to the first question and to its follow up question. This method produced four possible outcomes, i.e. 'Yes-Yes' (YY), 'Yes-No' (YN), 'No-Yes' (NY) and 'No-No'(NN). This data was then used to estimate the model by the maximum likelihood estimation technique using "biprobit" command in STATA. After obtaining the coefficients mean willingness to accept was estimated using the following formula given by Haab & McConnell (2002):

$$\text{Willingness to Accept (WTA)} = -\beta_0/\beta_1$$

Cost analysis: Cost of *ex-situ* conservation using semen doses was estimated in the present study. Minimum Standards Protocol (MSP) for production of five lakh doses of bovine frozen semen (MSP) recommended by Government of India and daily nutrient requirements of bull were used as reference and cost incurred from bull rearing till conception was estimated.

In the first step, cost incurred from bull rearing till semen dispatch was estimated. The total costs were divided into two broad categories namely Fixed costs and Variable costs

Fixed costs– The fixed cost includes salary of staff, depreciation on equipments, buildings and the animal.

Equipments– A depreciation of 5% was calculated on the cost of listed equipments. Depreciation on individual items was then added together to arrive at final figure.

Buildings– Depreciation of buildings was calculated at 5%.

Bulls– Cost incurred in purchasing bull and rearing it during growing years was accounted in the form of depreciation on bulls. Depreciation rate of 15% was used in this case.

Salary– Annual salary paid to the staff members was included in this component.

Variable costs– Variable cost was subdivided into cost incurred in semen processing and preservation and cost of bull maintenance.

Semen processing and preservation

Consumables– The cost of consumables like chemicals, latex liner, gloves, straws, tags, flag, syringe, forceps, slides, cover slip, paper roll, cartridge etc. was collected and included in this component.

Liquid nitrogen– Semen doses are stored in liquid nitrogen and it has to be replenished continuously. Market price of liquid nitrogen was used to estimate the total cost of liquid nitrogen used.

Miscellaneous– Annual cost of electricity, water, fuel, transportation, repair and maintenance were estimated based on the information collected from Artificial Breeding Research Centre (ABRC) of NDRI.

Bull maintenance

Feed– Feed cost was calculated based on the recommended daily nutrient requirement for the growing bulls (Appendix) and market price of the feed.

Health care– Health care cost was estimated based on the inputs from Artificial Breeding Research Centre (ABRC), NDRI.

Total costs– The total costs included both variable costs and the fixed costs.

Cost of artificial insemination was estimated in the second step. It includes depreciation of AI gun, consumables (gloves, sheath, lube, towel etc.) and wages of AI technician. Cost estimates obtained from step 1 and 2 were used to arrive at total cost per insemination which was then multiplied by number of artificial inseminations required per conception to arrive at total cost per conception.

RESULTS AND DISCUSSION

Characteristics of sample households: Table 2 presents the various socio-economic characteristics of sample households. The average age of household head was 45.13 years and the average family size was 5.65. There was no major difference between different areas with respect to age and family size. As parts of Sri Ganganagar fall under dryland area, the average landholding size as expected was comparatively more in the district than Sirsa and Fazilka. Households in Fazilka were rearing highest number of livestock followed by Sri Ganganagar and Sirsa. In earlier times, huge number of livestock was kept by nomads who use to seasonally migrate in search of fresh pastures. Now, most of these people have settled down in and around Fazilka but the herd size maintained by them still ranges from 50 to 200 which explain the higher herd size in this area. Also as livestock rearing is the main source of livelihood for this community and they generally do not own any agricultural land thus the average land holding

Table 2. Socio-economic characteristics of sample households

Particular	Unit	Sri Ganganagar	Fazilka	Sirsa	Overall
Age	Years	47.27	42.41	45.71	45.13
Family size	Number	5.91	5.55	5.50	5.65
Land holding	Acres/household	23.00	7.90	12.93	14.50
Livestock*	Number/household	13.39	39.84	4.72	19.32
Annual household Income	₹/year	5,53,429.00	6,81,429.00	8,15,393.00	6,85,203.00

*Includes cattle, buffalo, goat and camel.

size was lower in Fazilka. Household income was found to be highest in Sirsa and lowest in Sri Ganganagar.

Breed preference of sample farmers: Conservation of indigenous breeds at farmer's field offer several advantages. But most of the farmers now hesitate in rearing indigenous breeds due to high opportunity cost. Almost all of the Sahiwal rearing farmers in the study area were willing to rear the same breed in near future. This indicates that the farmers were content with their breed choice. Most of the farmers who were rearing Sahiwal in Sri Ganganagar and Fazilka have been rearing them for ages. They have rich experience and indigenous knowledge of rearing these breeds. Thus, due to the prolonged association with Sahiwal these farmers value them highly. Moreover, these farmers maintain big herd size which compensates for low milk yield to some extent. In the case of Sirsa, farmers started rearing Sahiwal few years back. Most of these farmers did extensive research before buying the Sahiwal breed and were convinced with its benefits. These farmers were much more concerned about quality milk and health advantages rather than milk yield. Thus, they want to continue rearing Sahiwal. Some of the farmers in Sirsa had availed the incentives provided by Government for Sahiwal rearing and thus were willing to keep them in future also.

Among crossbred rearing farmers, only around 30% farmers were interested in rearing Sahiwal. Percentage of these farmers varied from 3.57% in Fazilka to 67.86% in Sri Ganganagar. A very high proportion of the crossbred rearing farmers in Sri Ganganagar were interested in rearing Sahiwal breed. Presence of Saras Dairy in Suratgarh area of Sri Ganganagar played main role in changing the breed preference among crossbred rearing farmers. Few years back Saras Dairy started Sahiwal Breed Improvement Project under which it provides special benefits like higher price and free artificial insemination facility to the farmers and selling Sahiwal milk. This has encouraged the farmers to move back from crossbred to Sahiwal. Around 18% of the farmers in Sirsa also showed interest to rear Sahiwal breed mainly due to the government incentives and growing demand for indigenous milk. Percentage of crossbred rearing farmers willing to rear Sahiwal breed was very less in Fazilka as they believed profit from milk of indigenous breed can be either less or equal to the crossbred but in no case it will turn out to be more profitable than crossbred.

Incentives required by dairy farmers for rearing of Sahiwal: Though, some crossbred rearing farmers were willing to keep Sahiwal breed but due to one or the other reason they were not able to do so. A list of incentives was presented to the farmers and they were asked to rank them in order of their importance for ensuring rearing of Sahiwal cattle on their farm. Garrett technique was used to arrive at the final ranks (Table 3).

Subsidy on purchase price, higher milk price and ensured availability of pure animal figured out as the most essential requirement for rearing Sahiwal cattle. Price of Sahiwal has increased manifold in the past few years as less number of Sahiwal animals are left and the demand has been increasing. This is one of the main reason because of which now many farmers are not able to purchase Sahiwal cattle even if they are willing to do so. A good Sahiwal cow costs between ₹ 70, 000 to ₹ 1, 00,000. Haryana government is providing 50% subsidy on the purchase price still small farmers find buying Sahiwal cattle difficult. Milk yield of Sahiwal is less in comparison to the crossbred but the locals believe its milk has various health benefits. The farmers find commercial rearing of Sahiwal cattle profitable only

Table 3. Garrett scores and ranks for various incentives required for rearing of Sahiwal

Facilities	Sirsa		Fazilka		Sri Ganganagar		Total	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Availability of pure germplasm for AI	50.68	V	51.43	V	50.21	V	50.77	V
Subsidized feed	37.57	VI	33.21	IX	35.32	VII	35.37	VII
Medical facilities	28.71	IX	34.57	VII	31.18	IX	31.49	IX
Higher milk price	68.04	III	75.43	I	71.89	II	71.79	II
Subsidy on cattle shed	33.29	VIII	34.00	VIII	41.21	VI	36.17	VI
Subsidy on purchase price	70.21	II	73.14	II	73.29	I	72.21	I
Higher insurance subsidy	35.79	VII	35.21	VI	31.64	VIII	34.21	VIII
Facilities for selling calves	55.64	IV	55.61	IV	56.25	IV	55.83	IV
Ensured supply of pure animal	71.07	I	57.96	III	59.57	III	62.87	III

if they can get higher price for the milk. The case of villages of Sri Ganganagar also shows that higher milk price can act as a good incentive for the farmers to rear Sahiwal breed. Even the farmers rearing crossbred were keen to replace it with Sahiwal in this area as the milk of Sahiwal was fetching higher price. Dairy farmers in Suratgarh were getting ₹ 25/ litre for crossbred milk and ₹ 30/litre for the milk of Sahiwal.

Getting pure breed cow is another issue in rearing Sahiwal breed. Only few Sahiwal are left in India and most of them are not pure. There is a significant difference between pure and mix Sahiwal in terms of milk yield and other characteristics. But most of the farmers now are not able to visually identify pure animal as along with the Sahiwal breed the traditional knowledge of physical characteristics of the breed have also gradually disappeared. Traders take advantage of this situation and often sell mix breed (mainly Rathi breed) to the farmers at the price of pure animal. Farmers reported that they pay hefty amount for Sahiwal breed only to find later that they have got an animal of mix breed instead. This acts as a major deterrent for the farmers willing to rear Sahiwal. Apart from these, farmers were interested in getting good options for selling Sahiwal calves and pure germplasm for artificial insemination services.

Willingness to accept (*WTA*) *compensation for rearing Sahiwal:* During the survey, crossbred rearing farmers were asked to assume that instead of all the above mentioned incentives the government was going to provide them an annual compensation amount and for that they had to replace one of their crossbred cows with a Sahiwal. After that bid amounts were presented and responses obtained from the farmers were analyzed using bivariate probit model to arrive at Willingness to Accept (WTA) estimate. Regression coefficients from bivariate probit model and willingness to accept values are shown in Table 4.

Value of WTA estimates was quite different in the three areas. It was fairly high at ₹ 23,248/animal/year in the case of Sirsa and remarkably low in the case of Sri Ganganagar (₹ 13,057). Fazilka followed Sirsa with a WTA of ₹ 20,652. Traders have to bring Sahiwal cattle from Rajasthan for selling in Sirsa which adds to its price. Whereas in Suratgarh area of Sriganganagar district good Sahiwal animals are locally available and they still have pastures for cattle grazing. Moreover, Sahiwal farmers in Sriganganagar are already fetching better price for milk of Sahiwal. These factors partially explain the difference in WTA in the two areas. Presence of high milk yielding crossbreds and buffaloes in Sirsa and Fazilka as an alternative to Sahiwal might be another reason for high WTA. This shows that if *in situ* conservation is done in Sri Ganganagar it will cost comparatively less to the Government. On the other hand, higher amount of incentives will be required if the conservation is to be done in Fazilka or Sirsa. Overall the WTA estimate was ₹ 19,074/animal for all the three areas taken together.

Table 4. Estimated willingness to accept (WTA) compensation for rearing Sahiwal

Region	β_0	β_1	WTA (₹/animal/year)
Sri Ganganagar	–1.38146	0.00011	13,057
Fazilka	–3.88254	0.00019	20,652
Sirsa	–4.87979	0.00021	23,248
Overall	–2.59609	0.00014	19,075

Ex situ cost of conservation: Ex situ conservation or off-site conservation refers to the process of protecting an endangered species, variety or breed, of plant or animal outside its natural habitat. There are various methods available for *ex-situ* conservation of livestock which includes storage of embryos, semen, ovule, DNA, somatic cells or captive breeding. Out of all these methods, semen cryopreservation is most common.

If we look into the individual cost components then again salary (40.86%) accounts for the highest share in total cost followed by feed (18.28%) and consumables (15.28%). Expenditure on liquid nitrogen was only 3% of the total cost. Annual cost of producing 5 lakh straws was ₹ 99,84,858. Thus, cost per straw came out to be ₹ 19.97. This indicates that ₹ 20/semen straw is no profit no loss point for a semen station following Minimum Standard Protocol and producing 5 lakh straws. But the average cost per straw will rise if the number of straws produced is less than 5 lakh. However, Thirunavukkarasu (2009) estimated the annual cost of frozen semen straw production lower at ₹ 5.13 to ₹ 9.01 in different semen stations. Major difference was in the estimated fixed cost. Inclusion of depreciation on bulls and buildings in our study might be the reason for

Table 5. Annual cost of producing and maintaining semen straws

Particular	Cost (₹/year)	Percentage to total cost
Fixed cost	5,912,160	59.21
Equipments (Depreciation @ 5%)	932,160	9.34
Buildings (Depreciation @ 5%)	150,000	1.50
Bulls (Depreciation @ 15%)	750,000	7.51
Salary	4,080,000	40.86
Variable cost	4,402,698	44.09
Semen processing and preservation	2,356,031	23.60
Consumables	1,526,031	15.28
Liquid nitrogen for preservation	330,000	3.31
Miscellaneous (Repair and Maintenance, Electricity, Water, Fuel and Transport charges)	500,000	5.01
Bull maintenance	2,046,667	20.50
Feed	1,825,000	18.28
Health care	121,667	1.22
Miscellaneous	100,000	1.00
Total Cost	9,984,858	
Total straws produced	5,00,000	
Cost per dose	19.97	

Table 6. Cost of artificial insemination using semen straws

Particular	Cost (₹/insemination)
Depreciation (AI gun @ 0.05% per use)	6
Consumable (Gloves, sheath, lube, towel)	50
Wages of AI technician	20
Total cost	76

higher fixed cost. Also in his study cost estimation was done in general for any bovine whereas we confined our study to Sahiwal which might have again led to differences in estimates.

Table 6 depicts the estimated cost of artificial insemination. Total cost per insemination (cost of semen straw + cost of artificial insemination) worked out to be ₹ 95.97. As in Sahiwal generally two artificial inseminations are required per conception thus total cost per conception will be ₹ 191.94. Our estimates were slightly lower than the estimates of Pandit *et al.* (2003). Average cost per artificial insemination in the case of cow in their study was ₹ 100.51 and average cost per conception was ₹ 203.03. This minor difference can be due to different time period of the study.

It is evident from the study that most of the dairy farmers rearing Sahiwal were content with their breed choice. They preferred it more either because of its suitability to their low input system or due to their prolonged association with the breed. It was also preferred for getting milk for domestic consumption. But the others farmers were ready to rear Sahiwal only if they can get better milk price, subsidy on purchase price, ensured availability of pure animal and pure germplasm for AI. Introduction of these incentives can help in encouraging dairy farmers who at present are reluctant in switching from crossbred to Sahiwal. Cost for *in-situ* conservation was lowest in Sri Ganganagar which indicates that farmers of this area can more readily switch to Sahiwal than the crossbred farmers of Fazilka and Sirsa. Though, annual cost of maintaining semen doses through cryopreservation worked out to be quite cheaper than maintaining same number of live animals, a mix of both *in-situ* and *ex-situ* conservation should be practiced as Sahiwal breed also holds indirect value for the local people.

REFERENCES

Cameron T A and Quiggin J. 1994. Estimation using contingent valuation data from a dichotomous choice with follow-up questionnaire. *Journal of Environmental Economics and Management* **27**: 218–34.

Carson R T, Hanemann W M and Mitchell R C. 1986. Determining the demand for public goods by simulating referendums at different tax prices. Manuscript, University of California, Department of Economics, San Diego.

Cicia G, D' Ercole and Marino D. 2003. Costs and benefits of preserving farm animal genetic resources from extinction: CVM and Bio-economic model for valuing a conservation program for the Italian Pentro horse. *Ecological Economics* **45**: 445–59.

Food and Agriculture Organization. 2000. World Watch List for Domestic Animal Diversity. 3rd edition, FAO, Rome.

Garrett E H and Woodworth R S. 1969. Statistics in psychology and education. Vakils, Feffer and Simons Pvt. Ltd., Bombay.

Government of India. 2013. Estimated livestock population breed wise based on breed survey-2013, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmer's Welfare, New Delhi.

Haab T C and Mc Connell K E. 2002. Valuing Environmental and Natural Resources: The Econometrics of Non-market Valuation, Cheltenham: Edward Elgar.

Hammond K. 1999. Management of farm animal genetic resources. Proceedings of an FAO/ILRI Workshop held at FAO Headquarters, Rome, Italy, 15–17 March.

Kumar P and Singh K. 2018. Role of different factors in economics of a bovine semen station. *International Journal of Current Microbiology and Applied Sciences* **7**: 4573–80.

Pandit A and Jain D K. 2003. Cost of artificial insemination using frozen semen. *Journal of Dairying, Food and Home Sciences* **22**: 88–94.

Sharma A and Niranjan S K. 2016. National action plan for management of animal genetic resources. Compendium of 13th Convention and Symposium of Society for Conservation of Domestic Animal Biodiversity. Feb, 2016. Jammu, India 8–23.

Thirunavukkarasu M. 2009. Cost of artificial breeding in bovines. *Indian Journal of Animal Sciences* **79**(12): 1245–51.

Tomar S S. 2004. *Textbook of Animal Breeding*. Kalyani Publishers, New Delhi, India. pp 59–75.