Indian Journal of Animal Sciences **90** (3): 383–387, March 2020/Article

Economic potential of AVIKASIL-S technology for estrus synchronization in sheep

VINAYAK NIKAM*, SHIV KUMAR, I T KINGSLY, S J BALAJI, ABIMANYU JHAJHRIA, RAJ KUMAR and DAVENDRA KUMAR

ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi, Delhi 110 012 India

Received: 4 February 2020; Accepted: 13 March 2020

ABSTRACT

The study captures the economic benefits of AVIKASIL-S, an estrus synchronization technology in sheep using an economic surplus approach in the Rajasthan state of India. The adoption of technology at the field level was at a nascent stage. Study simulated scenarios at different adoption rates of technology and discerned that technology has the economic power to enhance the income of shepherds in the state. To reap the more benefits of technology, the adoption rate needs to increase. The support of government, private sector, and public-private partnership models besides entrepreneurs are the channels for wider adoption of technology amongst shepherds.

Keywords: AVIKASIL-S, Estrus synchronization, Sheep, Economic surplus, Rajasthan

Most part of the Rajasthan state comes under the arid and semi-arid agro-climatic conditions which influence the cropping pattern and livestock production in the region (Vining 1990, Indu *et al.* 2014). In this region, livestock are often considered to be one of the most important means to sustain the livelihood of the rural population (Sejain *et al.* 2014, De *et al.* 2015). People in this region rear livestock through a pastoral system, but are constrained by the problem of low biomass availability, hot climate, high weather variability and limited water availability making it difficult to sustain the livestock (De *et al*. 2015). In such regions, reproductive efficiency of different breeds of sheep (75 to 80%) is relatively low (Arora and Garg 1998).

Anestrus is most commonly occurring reproductive disorder of sheep, causing non-pregnancy in the sheep which many times leads to slaughtering of animals causing economic losses to the farmers, mainly because of low fecundity and longer inter-lambing period (less than 1 lamb/ year) (De *et al.* 2015). The shepherds face difficulty in detection of estrus and incur extra time and labour for its detection. As income to the shepherds mainly comes from selling of lambs for meat purpose, more number of lambs per year gives more profit to them. Festival seasonal rhythm also influences the demand of lambs. Demand for lamb reaches its peak in months of Ramazan. To fulfil lambs demand in the market with adequate supply of mature lambs, with the help of estrus induction and fixed time artificial insemination techniques in sheep rearing could give better returns to the shepherds for their economic viability.

ICAR-Central Sheep and Wool Research Institute, (ICAR-CSWRI), Avikanagar (Rajasthan) has developed an estrus synchronization technology called AVIKASIL-S. In this technology, progesterone impregnated intra-vaginal sponges are inserted into the vagina of the sheep. This sponge helps in inducing as well as synchronizing the estrus among the sheep. After this process, artificial insemination is done at a time in the herd. Though this technology has been developed quite earlier but still it is in nascent stage. Despite having great potential to increase the income of the shepherds, it was not picked up or commercialized either by private sector or by government sector to exploit its full potential. In this backdrop, considering the potential and worth of the technology, the present study attempts to compute the expected economic surplus generated by the technology if adopted by farmers at varying levels.

MATERIALS AND METHODS

Study area: Rajasthan state has 56.8 million livestock population, of which 14% are the sheep. (Livestock Census 2019). Dairy and animal husbandry forms major source of income (about 35%) to the small and marginal farmers of the state. At national level, Rajasthan ranked fourth in sheep population, accounts for nearly 10% of total sheeps in India (Livestock Census 2019). For field survey, we purposefully selected Tonk district of the Rajasthan as all the beneficiaries of this technology from ICAR-CSWRI are from this district. The sheep population of Tonk district is 2 lakh (Livestock Census 2012). In this district, livestock sector forms an important source of income next to crops for the agricultural households and gross livestock income forms 4% of household income (NSSO 2013).

Research design and sampling: A multistage sampling procedure was followed in selection of respondents. From

*Corresponding author e-mail: vinayakrnikam@ gmail.com

Tonk district, 7 villages, viz. Indoli, Ridliya Bujurg, Chonsla, Soda, Garzeda, Deshma and Pratap Pura from Malpura block, were selected due to concentration of the beneficiaries of the technology in these villages. Total 52 adopters of AVIKASIL-S technology along with the 40 non-adopters were selected. Data about the socioeconomic status of the farmers, cost in sheep rearing and economic benefits of the technology were collected from the shepherds using a well-structured interview schedule. For economic surplus, secondary data from the institute and government sources were collected.

Economic surplus approach: Economic surplus represents difference between monetary value of the unit consumed and the monetary value of unit produced up to the equilibrium price and quantity. This is most widely used tool for evaluating the impact of technology on the economic welfare of households (Moore *et al.* 2000, Wander *et al.* 2004, Swinton, 2002). This method relies on the principle of projecting shifts in supply and demand curves based on changes in yield and input cost due to adoption of technology (Alston *et al.* 1995). It measures the cumulative social gains due to research project/technology, returns on investments by manoeuvring the change in consumer and producer surplus through a technological change due to the research. It can also be used to estimate the net present value (NPV), internal rate of return (IRR), or benefit-cost ratio (BCR) (Maredia *et al.* 2000). This approach takes into account the reduction in per-unit cost and price responses owing to research-induced supply shifts and computes the distributional effects of research benefits (Nikam *et al*. 2019a).

We assessed the aggregate level of benefits and distribution of economic benefits of AVIKASIL-S technology at state level (Rajasthan) using an economic surplus method. Changes in economic surplus that included producer and consumer surplus were calculated, then discounted (at 10%) and totalled over 26 years to provide estimates of economic benefits of the technology. Assumption of 'closed economy' was maintained as most of the sheep meat is consumed domestically. The basic economic surplus model of research benefits is described by Alston *et al*. (1995).

In Fig. 1, D represents the demand for the product, a shift in supply from S_0 to S_1 represents yield improvement or reduction in cost after the adoption of the new technology. The initial equilibrium price and quantity are P_0 and Q_0; P_1 and Q_1 represent the after the supply shift. The area beneath the demand curve and between the two supply curves (TS= area I_0abI_1) represents the total (annual) benefit from the research induced supply shift.

Total surplus is calculated by

$$\Delta CS = P_0 Q_0 Z(1+0.5Z \eta) \quad \text{... (1)}$$

$$\Delta PS = P_0 Q_0 Z (K–Z) (1+0.5Z \eta) \quad \text{... (2)}$$

$$\Delta TS = \Delta CS + \Delta PS = P_0 Q_0 K (1+0.5Z \eta) \quad \text{... (3)}$$

where ΔCS is change in consumer surplus; ΔPS is change in producer surplus; ΔTS is change in total surplus; P_0 is the price before the introduction of mobile app; Q_0 is the pre-research quantity; η is the elasticity of demand

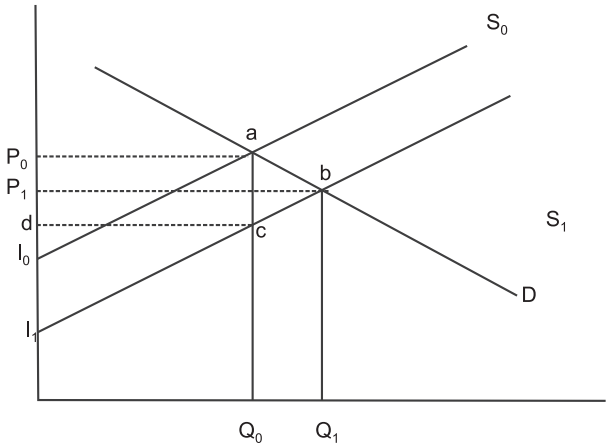

Fig. 1. Economic surplus measurement (*Source:* Alston, *et al.* 1995, pp. 209).

$$Z = K\varepsilon/(\varepsilon + \eta) \quad \text{...(4)}$$

$$K = [E(y)/\varepsilon – E(c)/1+E(y)] \, p \, A \, (1+ \partial) \quad \text{...(5)}$$

where Z is the reduction in price, relative to its initial value, due to supply shift; s is the absolute value of the elasticity of demand; ε is the elasticity of supply; K is the proportionate shift down in the supply curve due to the technology; E(y) is the expected yield change; E(c) is the expected cost change; p is the probability of research success; A is the technology adoption rate, and ∂ is the technology depreciation rate.

Assumptions and value parameters used: Table 1 gives an overview of basic parameters used in economic surplus approach. As the technology helps in estrus induction as well as synchronization, average gain in income was 25% more compared to control group. Cost-wise, no difference was observed between treated and non treated sheep except the cost of sponge. Therefore, an increase in cost for the technology was considered at 3%. Elasticity of demand and supply in relation to prices were obtained from past literature. Kumar *et al.* (2011) have estimated the demand elasticity for meat as –0.821. Supply elasticity of meat was taken as 1 since technology is at demonstration stage only. With little awareness among the shepherds about the technology, presently its adoption is less than 1% and adoption of the technology could not achieve the take-off stage as described by Rogers (2003). Nikam *et al*. (2019b) concluded that after commercialization of technology and/or *ab initio* support of government support boosted penetration of technology and distribution of gains amongst farmers.

The study projects the economic surplus over the period of time (for next 10 years) with varying rate of adoption by the shepherds. Production and price data for sheep meat of Rajasthan state were obtained from various published sources of government. Prices were obtained year wise since 1994/kg were brought at real prices using index of wholesale prices at 2019–20 base year. The production and

Table 1. Value parameters used in estimation of economic surplus

Parameter	Value	Source
Increase in yield (%)	25	Own survey
Reduction in variable cost (%)	–03	Own survey
Supply elasticity of meat	01	Review of literature
Demand elasticity of meat	–0.821	Kumar *et al*. (2010)
Adoption rate (%)	01	Consultation with various stakeholders
Probability of success	50	Expert opinion

prices series were extrapolated using regression for the next 10 years. Probability of success of the technology ranges from 0 to 1. Considering the risk involved and competition in near future, we considered the probability of success at 50%. Depreciation factor implies that how soon this technology would become depreciate or obsolete. Mathematically, it can be calculated as one minus the annual rate of depreciation. Assumption herein is that in next 10 years about 10% depreciation of the technology. It is also possible that with the increasing scale of technology adoption, the quality of the service may deteriorate. Historical cost of the research was obtained from the records of the Institute. The work for development of technology was started in the year 1994–2000 for which research cost was considered. Since 2001 technology has gone for demonstration at the shepherds' field. Therefore, from 2001 onward extension and development cost was considered. Discount rate refers to the interest rate used to determine the present value. As it is time preference concept, we have used 10% of interest rate to calculate the Net Present Value in analysis.

RESULTS AND DISCUSSION

Present scenario of low adoption rate: The technology is developed and standardized as per protocol. The technology is in demand by various other institutions and development organizations outside the state. At micro level, evidences establish credential of the technology but not adopted at a broader level due to weak financial conditions and lack of awareness among shepherds, besides poor government support in dissemination of technology. All these factors led to poor adoption of technology, which is less than 1%. The break-even point of the technology could be achieved even at adoption level of 0.02% in 2011–12. The technology beyond adoption level of 0.02% of sheep population would start generating economic surplus in the society. In the year 2019, at an adoption rate of 0.09%, this technology would generate net surplus of ` 27.31 lakh. We also projected the economic benefits till 2030, where at one per cent level of adoption, this technology would likely to generate the net benefit of ₹ 506.74 lakh, with Internal rate of return (IRR) 27% and Net present value of ₹ 1,048.59 lakh.

Internal rate of return (IRR) is one of the ways to look at the potentiality of investment and provides an idea of potential profitability and quick recovery of investment,

Table 2. Net present value, internal rate of return and benefit-cost-ratio of AVIKASIL-S

Year	Adoption rate (%)	Change in total surplus (Lakh ₹)	Research and extension cost (Lakh ₹)	Net benefit (Lakh ₹)
1 (1994)	0.0000	0	0.253	–0.253
2 (1995)	0.0000	0	0.290	–0.289
3 (1996)	0.0000	0	0.305	–0.304
4 (1997)	0.0000	0	0.307	–0.306
5 (1998)	0.0000	0	0.299	–0.298
6 (1999)	0.0000	0	0.306	–0.305
7 (2000)	0.0000	0	0.308	–0.307
8 (2001)	0.0002	0.879	1.40	–0.520
9 (2002)	0.0002	0.824	1.611	–0.787
10 (2003)	0.0002	1.249	1.643	–0.394
11 (2004)	0.0002	1.153	1.647	–0.500
12 (2005)	0.0002	1.153	1.648	–0.495
13 (2006)	0.0002	1.329	1.648	–0.319
14 (2007)	0.0002	1.333	1.649	–0.316
15 (2008)	0.0002	1.649	1.649	–0.005
16 (2009)	0.0002	1.472	1.649	–0.178
17 (2010)	0.0002	1.563	1.650	–0.087
18 (2011)	0.0002	2.591	1.650	0.940
19 (2012)	0.0002	3.256	1.650	1.605
20 (2013)	0.0002	3.661	1.651	2.009
21 (2014)	0.0002	4.093	1.651	2.441
22 (2015)	0.0002	4.766	1.653	3.112
23 (2016)	0.0002	5.899	1.653	4.246
24 (2017)	0.0002	6.012	1.656	4.356
25 (2018)	0.0002	5.603	1.656	3.946
26 (2019)	0.0009	28.967	1.656	27.312
27 (2020)	0.0015	51.311	1.657	49.653
28 (2021)	0.0020	72.636	1.657	70.979
29 (2022)	0.0030	113.056	1.658	111.401
30 (2023)	0.0038	149.721	1.658	148.062
31 (2024)	0.0047	193.151	1.659	191.491
32 (2025)	0.0056	239.526	1.660	237.866
33 (2026)	0.0065	288.789	1.660	287.129
34 (2027)	0.0074	340.882	1.661	339.221
35 (2028)	0.0083	395.742	1.662	394.080
36 (2029)	0.0092	453.303	1.662	451.640
37 (2030)	0.0100	508.413	1.663	506.750
Net present value (NPV) (lakh ₹)				1,048.59
Internal rate of return (IRR) (%)				27.00
Producer surplus (lakh ₹)				56.90
Consumer surplus (lakh ₹)				69.30
Total surplus (lakh ₹)				126.20

*Past values adjusted through WPI index with base year 2019; discount rate of 10%.

Table 3. Sensitivity analysis of estimates for different adoption rates

Maximum adoption by 2030 (in %)	NPV (lakh ₹)	IRR (%)	Total surplus (lakh ₹)
05	4,645	33	998
10	9,270	37	1,972
20	18,680	40	3,969
30	28,059	42	5,952

which must be more than 30% as benchmark value. In this case IRR is 27% only at 1% level of adoption. From financial institutions point of view, to recover quick investment on technology, there is need to increase the scale of adoption.

Scenario where either government or private player takes up the technology: If state government adopts this technology and distributes it through veterinary dispensary, adoption rate of the technology would be increased. Other option is the of private firm signs memorandum of understanding with the CSWRI to commercialize the technology, in that case also adoption rate of technology will increase. We expected maximum adoption of the technology at 30%. A sensitivity analysis was performed for a range of values of adoption rate. Table 3 shows the estimated economic surplus at 5%, 10%, 20% and 30% adoption rate. With the increase in adoption rate to 5%, IRR would be 33%, and total gain would be ` 4,645 lakh. At 30% level of adoption, NPV would be ` 28,059 lakh, total surplus of ` 5,952 lakh and IRR of 42%. The economic appraisal parameters of technology decipher that if efforts are made to increase the adoption of the technology at larger scale, economic agents of the society would be benefited a lot.

In conclusion, the present adoption status of technology is minuscule. There is urgent need to bring awareness amongst shepherds, policy makers and planners using different means of dissemination of knowledge. The awareness of technology would generate more demand. This could be possible by different channels. Firstly, line department may take up this technology for wider adoption using a string of prevailing different government schemes like Rastriya Kirishi Vikas Yojana and other livestock related missions. Second, the grassroots entrepreneurs and others in private sector may take this technology forward through start-ups and commercialization in public–private partnership using financial and venture capitals with the help of Start-up India program. Once the technology covers a scale, i.e. (1% adoption level) started generating promising returns and economic surplus. State line department using pedestals of its existing infrastructure and other paraphernalia can bring a leap and bound progress in dissemination, adoption and uptake of technology on larger areas to realize the scale of economy. Wider dissemination and adoption over a time horizon would help shepherds to get enhanced income as well as consumers to get meat at economic rate.

ACKNOWLEDGEMENT

Authors are thankful to the Director and Scientists of CSWRI Avikanagar, Rajasthan for providing logistic help to complete the study.

REFERENCES

Alston J M, Norton G W and Pardey P G. 1995. Science under scarcity: principles and practice for agricultural research evaluation and priority setting. Cornell University Press, Cornell, Ithaca NY.

Arora C L and Garg R C. 1998. Sheep production and breeding (International Book and Distribution Company, Lucknow).

De Kalyan, Kumar D, Sethi D, Gulyani R and Naqvi S M K. 2015. Estrus synchronization and fixed-time artificial insemination in sheep under field conditions of a semi-arid tropical region. *Tropical Animal Health Production* **47**(2): 469–72.

Indu S, Sejian V and Naqvi S M K. 2014. Impact of simulated heat stress on growth, physiological adaptability, blood metabolites and endocrine responses in Malpura ewes under semi-arid tropical environment. *Animal Production Science* **55**(6): 766–776.

Kumar P, Kumar A, Shinoj P and Raju S S. 2011. Estimation of demand elasticity for food commodities in India. *Agricultural Economics Research Review* **24**: 1–14.

Livestock Census. 2012. 19 Livestock Census-2012 All India Report. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India, Krishi Bhawan, New Delhi.

Livestock Census. 2019. 20th Livestock Census-2019. All India Report. Ministry of Fisheries, Animal Husbandry & Dairying, Government of India, New Delhi.

Maredia M K, Byerlee D and Anderson J. 2000. Ex-post evaluation of economic impacts of agricultural research programmes: a tour of good practice. Paper presented at the Workshop on The Future of Impact Assessment in CGIAR: Needs, Constraints, and Options, Standing Panel on Impact Assessment (SPIA) of the Technical Advisory Committee, Rome, 3–5 May.

Moore Michael R, Gollehon Noel R and Hellerstein Daniel M. 2000. Estimating producer's surplus with the censored regression model: an application to producers affected by Columbia river basin salmon recovery. *Journal of Agricultural and Resource Economics* **25**(2): 325–46.

Nikam V, Bisen J, Kingsly I M, Kumar S and Jhajhria A. 2019a. Economic surplus approach. *Quantitative methods for social sciences*. (Eds) Vinayak Nikam, Abimanyu Jhajhria and Suresh Pal. Published by Director, ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi. ISBN number: 978-81-940080-2-6.

Nikam V, Kumar S and Kingsley I T. 2019. Impact of mobile app using economic surplus method. *Indian Journal of Agricultural Sciences* **89**(6): 1039–43.

NSSO. 2013. 70th Round, Situation assessment survey of agricultural households: all India debt and investment & land and livestock holdings in India (January 2013–December 2013), Ministry of Statistics and Programme Implementation, Government of India.

Rogers E M. 2003. Diffusion of innovations (5th edn). Free Press, New York.

Sejian V, Maurya V P and Naqvi S M K. 2010. Adaptability and

growth of Malpura ewes subjected to thermal and nutritional stress. *Tropical Animal Health and Production* **42**: 1763–70.

Swinton S M. 2002. Integrating sustainability indicators into the economic surplus approach for NRM impact assessment. *Methods for Assessing the Impacts of Natural Resources Management Research*. A summary of the proceedings of the ICRISAT-NCAP/ICAR International Workshop. (Eds) B Shiferaw, H A Freeman, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad, 6–7 December.

Vining K C. 1990. Effects of weather on agricultural crops and livestock: an overview. *International Journal of Environmental Studies* **36**(1–2): 27–39.

Wander A E, Magalhaes M C, Vedovoto G L and Martins E C. 2004. Using the economic surplus method to assess economic impacts of new technologies—Case studies of EMBRAPA, Rural Poverty Reduction through Research for Development —Conference on International Agricultural Research for Development, Deutscher Tropentag, Berlin, 5–7 October.