Indian Journal of Animal Sciences **91** (6): 430–437, June 2021/Review Article
https://doi.org/10.56093/ijans.v91i6.115437

Strategies to overcome the challenges in dairy extension

KUPPUSAMY PONNUSAMY[1]✉, VIKRAM SINGH[2] and RITU CHAKRAVARTY[1]

ICAR-National Dairy Research Institute, Karnal, Haryana 132 001 India

Received: 30 July 2021; Accepted: 4 August 2021

ABSTRACT

Dairy extension ensures steady flow of information and technology to the client system. Its role in future food, nutrition, livelihood and environmental security becomes indispensable in lieu of daunting challenges especially demand for skilled manpower, resource priorities and quality final products. Research, teaching and extension reforms warrant recalibrated strategies in order to realise sustainable and profitable dairying in the years to come. Extension should play crucial role in bringing informal stakeholders who are still outside the purview of development process and suggest integrated sustainable rural approach. Further, its contribution in popularizing the commercialized dairy innovations and their impact analysis would augment the dairy productivity and vibrancy of dairy sector. This paper discusses improvements in pedagogical approaches, demand driven field extension methodologies and data analytics which would yield greater dividends for future dairy stakeholders.

Keywords: Field extension methodologies, Recalibrated extension strategy, Sustainable dairying

Dairying is an important farm enterprise from time immemorial, contributing to the livelihood of farm families and maintenance of agri-food ecosystem. Farmers are experts in breeding and maintenance of dual breeds for both draught and milk production purposes. They also use dairy animals in farming system mode by using the dung for manuring of field and by-products of crops as fodder for dairy animals (Ponnusamy *et al.* 2019). The domestic production and consumption had undergone substantial change when Britishers started cattle farm for their army. Then people moved gradually towards sale of milk in nearby urban areas and later milk products such as curd, butter, buttermilk and ghee. Commercial orientation had started when serving milk and milk products for eateries and sweet manufacturers gained significance. The emergence of dairy cooperatives, producers companies and commercial dairy farms are substantially contributing to increasing milk demand. India has stepped up its milk production of 17 million tonnes in 1950 to 198.4 million tonnes in 2019–20 (GoI 2021), with average growth rate of 4.5%. In all its endeavourer and achievements, dairy extension has played crucial role in spearheading the growth and development of dairy sector. Its role will be pivotal in future dairying too. In the context, it is essential to review its progress, achievement, challenges and work out a futuristic outlook so that dairying will be practised taking into consideration of profitability, sustainability and egalitarianism.

Present address: [1]ICAR-National Dairy Research Institute, Karnal, Haryana. [2]Indian Council of Agricultural Research, New Delhi. ✉Corresponding author email: ponnusamyk@hotmail.com

Main players in dairy extension

Dairy extension maneuvers in cooperation with various institutions and agencies. Extension activities are carried out in a pluralistic mode with several groups working together with an effort to deliver services to farmers. There are broadly five major players in dairy extension in India (Ponnusamy and Pachaiyappan 2018) namely, (i) Public extension service providers comprising State Department of animal husbandry, dairying, Agricultural Technology Management Agency (ATMA), (ii) Public research-cum-extension organizations including extension wings of ICAR and SAUs/ SVUs, commodity boards, KVK, (iii) Dairy collectives like cooperatives and producer companies, (iv) International and private entities like ILRC, Kenya; International Farm Comparison Network (IFCN), Germany; farmers association; input suppliers; commodity processors and exporters, and (v) NGOs like J.K. Trust and BAIF (Bharatiya Agro Industries Foundation). Their immense contribution despite their differing mandates played an affirmative role to expand, deepen and intensify the dairy development through various extension techniques. Extension personnel need to take a lead in fostering collaboration and networking between and among different agencies simultaneously to suitably respond to the market-driven economy.

Role of extension in dairying

Extension is the practice of working among farmers to improve their livelihood by educating them on methods to enhance their yield (van den Ban and Hawkins 1996). Breeding, feeding, health and management including shelter

are four major focuses of any scientific intervention. The production and productivity were abysmally low due to low priority for commercial sale and traditional home consumption of milk products. Intensive Cattle Development programme (1964) and Key Village Schemes of 1952 had kindled the interest of farmers since the launching of Community Development programme (CDP) in 1952, followed by National Extension Service (NES) in 1953. Extension officers (Animal Husbandry) played a key role in ensuring flow of technology transfer. Extension service got fillip during the implementation of the Operation Flood Programme (OFP) which sought to forge an adequate marketing link between the rural producer and the urban consumer through the cooperative structure. The first phase of OFP lasted from 1970–71 to 1980–81 followed by the second phase from 1978–79 to 1984–85 and third phase from 1987–88 to April 1996. Large public investments were made in the milk processing and marketing infrastructure through cooperatives. The three-tier dairy cooperatives system made it possible to reach even to remotest villages by pouring milk, collection, bulk cooling, processing and packaging to serve the milk to the large number of urban consumers. The resource poor dairy farmers were facilitated for gathering quality dairy breed under the Integrated Rural Development Programme (IRDP) in 1979. Extension components were explicitly incorporated in many schemes of both central and state governments. For instance, the specific schemes like National Kamadhenu Breeding Centres (NKBC) at central level and Integrated Murrah Development Schemes in Haryana state played a crucial role in motivation of farmers.

Growth of dairying in India

Milk production provides supplementary income, employment and nutrition to 80 million rural households. The output of milk and milk products has increased faster than of the crops during the past four decades with the average growth rate of 4.5% in milk production (Fig. 1). This success story of milk production has been written primarily by the millions of smallholder producers, who dot the landscape of milk production in the country. However, despite being the world's largest milk producer (Ponnusamy and Pachaiyappan 2018) and with the highest livestock population (GoI 2019), the average annual productivity per animal in India is low, at 1777 kg per animal per year (2019–20) as against the world average of 2699 kg per animal per year during 2019 (PIB 2021). Indian dairy industry which was highly regulated till late-1990s, has been completely liberalized and exposed to world competition. The past decade has seen rapid changes in the Indian dairy sector and there have been growing concerns on the likely impacts of these changes on smallholder producers.

The tremendous progress in milk production has increased the per-capita milk availability from 130 g/day in 1950–51 to 407 g/day in 2019–20. National Dairy Development Board has also estimated that the demand for milk and milk products at 2030 will be 266.50 million

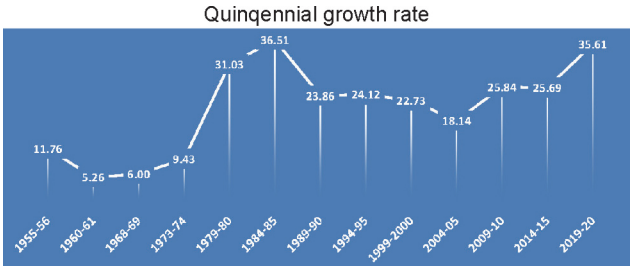

Fig. 1. Quinquennial growth rate of milk production (%) change in India from 1950–51 to 2019–20.

tonnes (NDDB 2019). Several schemes including Operation Flood and dedicated extension services had contributed to achieve this growth rate.

Factors enabling growth in dairying

Dairy sector in India has witnessed a prolific growth over the years after independence, creating positive changes in both quantity and quality. This could be broadly due to infusion of new technologies in rearing dairy animals; strengthening marketing functions; processing of milk into various products and streamlined extension system. The increase in milk production could also be attributed to the increase in the population of dairy animal (Ponnusamy and Pachaiyappan 2018). This led to competitiveness of the dairy sector which pushed growth of dairy sector in India over the years.

Factors which propelled growth in dairying are favourable factors of production, demand creation due to urbanization, disposable income, greater interest in nutrition, efficient channel of production and distribution of dairy cooperatives and private dairies; industrial support in machineries, feed and milk product preparation; regulations and programmes of government and continuous research and development support. The price elasticity for milk is high, thus demand for milk is very sensitive to price changes. So, the future of dairy extension must thrive on activities that aim at ensuring the productivity of animals and sustainability in farm income. Also, the current growth in population and increasing demand for food has created the need to produce more milk. Creating awareness among the dairy farmers on key drivers of future change would help to plan for meeting increasing demand.

Extension component in schemes and programmes

Various ongoing schemes and programmes such as National Livestock Mission (NLM), National Programme for Dairy Development (NPDD), Rashtriya Gokul Mission, Animal Husbandry Infrastructure Development Fund (AHIDF) under Atmanirbhar Bharat Abhiyan, Kisan Credit Cards (KCC) to Livestock Farmers, Dairy Processing and Infrastructure Development Fund (DIDF), Supporting Dairy Cooperatives and Farmer Producer Organizations engaged in dairy activities (SDCFPO), Livestock Health and Disease Control (LH&DC) Scheme, National Animal Disease Control Programme (NADCP), Atal Innovation Mission, NewGen Innovation and Entrepreneurship Development

Centres, Venture capital Assistance promoted by SFAC, Agriculture Grand Challenge plan of Union Ministry of Agriculture and Farmers Welfare and ICT initiatives like *E-PashuHaat* play major role in the development of dairy sector in India. These schemes have inbuilt extension components like awareness campaign, training, demonstration, exposure visits, subsidies, incentives, awards, rewards, recognitions, organizing fairs and exhibitions. Besides, research institutes such as ICAR-National Dairy Research Institute, ICAR-Indian Veterinary Research Institute, various State Agricultural and Veterinary Universities, KVKs, Line Departments of both State and Central Government have been playing significant role in research, education and extension for the development of dairy sector in India over the years after independence and creating favourable environment for dairy enterprises.

Contribution of dairy extension education

Dairy extension education develops researchers and professionals who provide anchors to facilitate the growth of dairying. The commercial, business and industrial establishments utilize the benefits of the research findings with the community at large including farmers. Dairy extension contributes teaching and training of professionals with degree courses in dairy extension; incorporation of application of principles, philosophy and approaches in the curriculum of dairy extension; scientific communication of developments in the dairy industry to the stakeholders; assessment and refinement of dairy extension methodologies; tracing the reasons of non-adoption of any technology and keeping extension activities current or up-to-date changing levels of technology.

Challenges in promotion of dairy extension

There are umpteen challenges in dairy extension which are delineated below.

1. This deprives the opportunities for developing professional knowledge in dairy extension. Dairy extension is often clubbed under agricultural extension or livestock extension courses. Farmers look upon to animal husbandry departments for seeking information; however functionaries were not exposed to advisory role as they orient towards clinical aspects (Ravikumar and Chander 2011).
2. Inadequate faculty with background of dairy or livestock subject knowledge results in least consideration to cover subject matter for dairy extension (Sasidhar 2002, Rao and Sasidhar 2021). Research studies mostly use the ex-post facto research design (NAAS 2017), undertaken by researchers and post-graduate students at micro level using smaller sample size with limited funding. This could not generate adequate inputs for generalization and extrapolation, leading to rare utilization of research findings for policy making and extension planning.
3. Qualitative research methods get limited attention at post-graduate teaching. In addition, development of depth in subject matter specialization skills are also lacking at the postgraduate level (Sulaiman and van den Ban 2000). Increasing demands of highly specialized and technical services and lack of highly skilled resource persons need changes in contemporary extension teaching and research including techniques like artificial intelligence, pregnancy diagnosis, IVF, mechanization of dairy farming operations and IoT products (Ponnusamy *et al*. 2016).
4. Several ongoing advancements in the field of extension through research fail to reach the end users due to poor industry-institution linkage thus warranting further strengthening of the extension chain by converging and coordinating the institutions carrying out dairy extension activities and research.
5. Services that support gender or dairy entrepreneurship which has gained momentum in the last few years is still inadequate (Ponnusamy *et al.* 2017a, 2020).
6. Dairy extension system and extension research still primarily focus on technology transfer. The contemporary scenario demands behavioural modification through education which needs to be addressed through proper extension methodologies and application of research findings.
7. The number of indigenous breeds with better adaptability, disease-resistance and feed efficiency ratio is declining due to continued focus on exotic germplasm based cross breeding (DAHD 2021). Inadequate adaptive research and technological gap between technology recommended and technology adopted by the farmers (Ponnusamy and Padaria 2021) lead to loss of information or misinterpretation of scientific findings at the level of farmers. Due to this, the expected level of results is not seen.
8. There are no standard criteria for performance appraisal of teaching and research personnel which impede proper development of human resource in this field.
9. Beliefs and values of farming community also determine the adoption of technologies in dairy farming. The perception aspect of the end users affects the effectiveness of extension strategies. Even if a technology is worthy enough and demonstrated in an appropriate manner, the rate of adoption by farmers is poor due to difference in their school of thought. This poses an important challenge in sustainable development of dairying as people have strong sentiments for animals.
10. Declining value system on 'Dairy husbandry' as an occupation among rural community compromises prospective matrimonial arrangements for rural youth if they are retained in livestock / agriculture sector (Sudeep and Thirunavukkarasu 2016).
11. Cropping pattern changes are resulting in weakening of crop-animal interaction and dairying system becoming more intensive. A sharp decline in grazing

lands across India (Birthal and Negi 2012, Ponnusamy and Devi 2017) accelerate this process.

12. The increasing demand is expected to push up intensification in mixed / crop-livestock farming system (Ponnusamy 2006). In India intensification process takes in the form replacement of stock, purchase of feed, health and breeding services etc. Shift from traditional approach to moderate intensive systems of production through breaking of relationship with crop husbandry activities is being initiated and tried by farmers at a moderate level.
13. Unlike the processing capacities created by cooperatives, there has not been any comprehensive data on the milk processing capacities of the organised private sector. It is estimated that the capacity created by private dairies in the last 20 years is more than the capacity set up by the cooperatives in over 30 years (FICCI 2020).
14. It is a daunting task to transfer dairy farming technologies compared to crop technologies for a variety of reasons which emanate basically from the differences in crop and animals itself. The dairy owners depend upon the technical persons for adopting technologies/ practices which include Artificial Insemination (AI), pregnancy diagnosis, vaccination, de-worming, diagnosis and treatment of animals. This means the dairy owner needs to take the animals to the technical person (veterinarian or livestock assistant) or the latter have to be brought to the animal for services/adoption of practices. As a sequel not only the distance between livestock owner and the technical person but also the attitude and skill of the technical persons also come into the picture.
15. As per the 19th Livestock census, there are 88 million 'In-Milk' animals whose records are unavailable on an annual basis. Records of those in breeding stage, their productivity, treatment and vaccination are also not properly maintained by State Animal Husbandry Departments.

Strategies to promote the proactive role of dairy extension

- Quality of education would improve with strong research base in the academic institutions (Agrawal *et al.* 2013). The challenges identified in the teaching and research can be turned into opportunities for further development in dairy extension.
- There should be periodic workshops and seminars as well as CAFT/ summer school/ winter school/ short courses of ICAR on specialised and advanced technologies like AI, IVF, silage, smart and precision dairy farming technologies etc (Dillon *et al.* 2016).
- Regular impact assessment studies would help in finding out the best possible ways for the communication of changing technologies and practices in alignment with interests of the end receivers.
- Doubling farmers' income, climate change, gender mainstreaming and dairy entrepreneurship should be properly understood in client's perspective. The findings can be used to develop to improve extension methods which can be converted into teaching courses.
- Research is needed for development of extension strategies to promote technologies like vaccination, deworming among farmers as convincing them to adopt such technologies is still a formidable challenge.
- Depending on locale of the extension activity, different communication and dairy extension methods should be devised taking into consideration belief systems of different socio-economic communities including SC & STs.
- Dairy extension is being carried out by a variety of stakeholders including NGOs like BAIF, JK Trust, private dairy processing companies *etc*. Therefore, education focusing on converging and coordinating the dairy extension activities from different agencies would provide fruitful dividends.
- Extension system has to embrace contrasting pedagogical approaches, multi-disciplinary allegiances and contemporary skills and capabilities for bringing overall system efficiency in dairy production system. New models like public private partnership (Ponnusamy *et al.* 2017a), contract dairy farming (Ponnusamy and Walli 2007), expert system (Ponnusamy *et al*. 2016) and client centric Pasu Sakhie women empowerment model (Ponnusamy *et al*. 2017b) would foster quick technology diffusion in rural India. Technologies must be tailored to new contexts if they are to be effective for promoting sustainable dairy farming.
- Developing technical knowledge on use of ICT and data analytics becomes essential due to rise in use of data in extension intervention. This warrants further strengthening of teaching and research for efficient use of such ICT products.
- The launch of the 'Start-up Challenge' to appreciate innovations coming from the villages would nurture the growth of dairying.
- Understanding the consumer behaviour to the dairy products is a key. Studies on the consumption pattern would help in understanding the major preferred product in each area and encouraging farmers to take up such enterprise would help them to sustain in the market.
- The actual growth of science and technology in a country depends upon the working of the patents rather than the number of patents granted in that country (Singh *et al.* 2015). Historically, patents were granted with an intention to encourage local application of the invention, through its industrial application (Singh and Chakraborty 2019). An analysis of ICAR's intellectual assets transfer (2015–16 to 2019–20) revealed that 31 licensing agreements

Table 1. Addressing challenges through fixing goals

Challenge	Short-term goal	Medium-term goal	Long-term goal
Development of innovative extension approaches for strengthening inter-linkages between various stakeholders for technology dissemination and adoption	Assessing constraints, needs and deciding supportive interventions for technology dissemination utilization. Enhancing access to scientific dairy information among stakeholders at grass root level.	Developing integrated extension model for technology generation and utilization	Dissemination of standardised enabling extension approaches through a network of stakeholders with dairy extension division performing leadership role.
Enhancing skill of stakeholders for playing multifarious roles in the innovative extension approaches	Providing extension support in technical, organizational, marketing and entrepreneurial aspects.	Technology refinement through field level key players in dairying.	Dairy farming through producer companies
	Need assessment of stakeholders under innovation system	IT enabled technology transfer	Establishment of integrated Extension model for socio-economic development
	Capacity building of stakeholders for innovation management	Gender mainstreaming and gender centric programmes	Promotion of smart dairying farming approaches.
		Strengthening commodity groups in dairying.	

were signed with 12 licensees for nine major dairy research innovations. These innovations are distributed through the marketing channel of public/ private organizations, and having their existence in seven Indian states. These innovations can be classified as Milk Adulteration Detection Technologies, Dairy Food Processing, Dairy Farming Technologies, Animal Nutrition, and Animal Food Products (Singh and Singh 2015). To protect these innovations for their better utilization in research and maintain their uniqueness to satisfy the consumers taste, ICAR's National Dairy Research Institute (NDRI), Karnal has taken vigorous efforts to protect its innovations by filing many product/process patents and commercialized them to the different public and private organization. In last five years (2015–16 to 2019–20) eight high ended research innovations which were protected by patents at Indian Patent Office (IPO) of this institute were generated 30 licensing agreements, and reached to the market. Extension should take a proactive role in creating awareness about these innovations for their better application in the field of dairying.

- Harnessing the potential of lead farmers in dairy extension, and tapping Corporate Social Responsibility (CSR) for funding agricultural extension activities could reduce the strain on public extension services, while strengthening pluralism in delivery of extension services.

Fixing targets in lieu *of challenges in dairying*

Demand for quality inputs, information and assured market is likely to increase tremendously from different stakeholders. Farmers have to be oriented to respond instantly through development of appropriate institutional mechanisms. Need specific extension models, gender mainstreaming, farming system research and extension, technology assessment and refinement from farmers' perspective, stakeholder linkage mechanisms and smart farming technologies will be the approaches to enhance the adoption of scientific dairy production and processing technologies in the years to come (Table 1).

Enabling growth through dairy extension research

Understanding extension research in cutting edge areas of dairying would enhance the value, prestige and respect of the discipline. Kale *et al.* (2016) analysed the disparities in dairy development across the country by developing a composite Dairy Progressiveness Index (DPI). They suggested organized marketing network along with reforms in dairy cooperatives as well as producers companies in Punjab, Haryana, Himachal Pradesh, Bihar, Madhya Pradesh and Odisha. Since fodder, pasture and irrigation resources in Himachal Pradesh, Andhra Pradesh, Madhya Pradesh, Odisha, Kerala and Gujarat are poor, policy intervention like restriction on export of oilseed cake and ban on harvesting using combine harvester without straw ripper, establishment of fodder bank network could address the fodder scarcity. Transfer of technologies such as hydroponics, azolla, silage, urea treatment, use of mineral mixtures to field in resource poor states need attention. Poor genetic potential in the low performing states demand proper breeding strategies, conservation and spread of elite indigenous breeds such as *Sahiwal, Gir*, and *Tharparkar.* Improvement in veterinary infrastructure would reduce the imbalanced progress. The policy interventions on identified gaps would pave the even development of dairy farming and to reduce future demand gap. In order to reorient the dairy extension, following thematic areas are suggested for future research (Table 2).

Table 2. Suggested thematic research areas of dairy extension

Major theme/domain	Possible research area
Extension Models	1. Developing new models of extension 2. Testing existing models and refinement of models 3. Validation of tested models in institutional perspective 4. Farmer to farmer extension model Examples of models pertaining to dairy extension: • Dairy Extension Education at farmer's doorstep • Para extension worker model • Specialists directly working with farmers • NDRI-village panchayat linkage model • Key informant knowledge dissemination Model • ATMA based commodity group models • NGO/VO linkage Models • Corporate social responsibility in dairying • Contract dairy farming • Dairy Cooperatives, farmer associations • New Generation Cooperatives (FPOs) • Public Private Partnership • Market led extension • Carbon footing/trading in dairy extension • Case studies on small scale and commercial dairy farms • Dairy start-ups; Agri-Clinic & Agri Business Centre
Farming system research and extension (FSR&E)	1. Performance of dairying vis-a-vis other farm enterprises 2. Sustainability indicators for dairy based farming system 3. Support systems enabling dairy inclusive farming system 4. Effect of diversification of farming system with dairying 5. Model on feed and fodder production 6. Effective usage of common property resources for dairying 7. Characterisation of socio-economic and technological environment for profitable dairy farming 8. Vulnerability assessment in dairy based farming system
e-Extension	1. ICT Models and information kiosks 2. m-extension 3. Expert System / mobile apps, farm data analytics 4. Web enabled information portals and spatial decision support systems 5. Artificial Intelligence and ANN based IoT products 6. Role of geo-informatics towards digital dairy farming 7. Satellite based communication and applications like Geographical Information System (GIS), Global Positioning System (GPS), Remote Sensing (RS) and other technology driven initiatives
Dynamics of social change and role of youth	1. Current status of participation of youth in dairying 2. Impact of youth oriented programmes 3. Aspirations of youth in dairying 4. Attracting farm youth for dairy entrepreneurship 5. Attitude of youth towards dairy based entrepreneurship 6. Factors influencing youth towards farming 7. Stakeholders analysis to assess dynamics in dairying 8. Health and lifestyle problems of rural population and their link with dairying 9. Interlinkages on problems of other farm enterprises vis a vis dairying
Gender mainstreaming in dairying	1. Gender issues in dairying 2. Drudgeries and their reduction strategies in dairying 3. Women's role in dairying 4. Entrepreneurship for women in dairying 5. Impact of women specific schemes in dairying 6. Gender composition in dairy extension set up in the country 7. Gender database in dairying 8. Gender mainstreaming approaches 9. Gender Planning 10. Gender auditing & budgeting
Dairy entrepreneurship	1. Standards for defining entrepreneurship in dairying 2. Structural variation of dairy entrepreneurship across the country/class 3. Impact of existing policies and programmes impacting entrepreneurship 4. Mechanism to enable small dairy holders as entrepreneurs 5. Issues in group based entrepreneurship in dairying 6. Dairy tourism
Technology assessment and refinement in dairying	1. Assessment of technology at farmer's field 2. Adoption and diffusion studies 3. Technology refinement with farmer's perspective 4. Inter-linkages in technology application 5. Blending Indigenous Technical Knowledge (ITK) with modern technology
Impact evaluation	1. Evaluation of technologies 2. Evaluation of programmes/schemes/projects 3. Tools and techniques in impact evaluation 4. Technology commercialization of dairy institutions & its impact 5. Consumer perspectives on dairy technologies/ products 6. IPR, patents, copy rights and their implications in promotion of dairying 7. Climate change & adaptive strategies for different classes of farmers

Conclusion

Dairy extension needs to infuse professionalism to accelerate the flow of recent advancements and to respond to the emerging farming scenario at the micro agro situations for increasing the productivity and better livelihood prospects of farmers. The existing role of the Dairy Extension is focused on the dissemination of the technologies generated in the fields of dairy production, processing and management to the dairy farmers and obtaining their feedback including constraints in adoption of these technologies. Now, with the changing scenario of dairy farming, the farmers require extension support in wider perspective, encompassing technical, organizational, marketing and entrepreneurial aspects. Technologies can be accessed through various media but their adoption will be a function of the integrated support provided by the Dairy Extension. It should now have to assume a leadership role in converging the services and efforts of all the stakeholders involved in dairying in order to have an efficient and effective Transfer of Technologies. Duplicacy of efforts on the part of multiple agencies functioning for the cause of TOT should be avoided, on account of the system being integrated in nature. Overall improvement in quality of life of the clientele, especially in terms of their socio-economic upliftment, as well as livelihood sustainability & nutritional security becomes very essential. For performing this new role, as a facilitator in the multi-stakeholder system, capacity building for multi-dimensional skills and expertise, thus assumes prominence in future dairy extension.

REFERENCES

Agrawal R, Rao D R, Rao B V L N, Nanda S K and Kumar I. 2013. Forecasting manpower requirement in Indian veterinary and animal husbandry sector. *Indian Journal of Animal Sciences* **83**(7): 667–72.

Birthal P S and Negi D S. 2012. Livestock for higher, sustainable and inclusive agricultural growth. *Economic Political Weekly* Supplement **47**: 89–99.

DAHD. 2021. An overview of Bovine breeding Sector in India. Department of Animal Husbandry & Dairying. Ministry of Fisheries, Animal Husbandry & Dairying, New Delhi. Retrieved from: http://dahd.nic.in/about-us/divisions/cattle-and-dairy-development.

Dillon, E J, Hennessy T and J Cullinan. 2016. The role of agricultural education and extension in influencing best practice for managing mastitis in dairy cattle. *Journal of Agricultural Education and Extension* **22**(3): 255–70.

FICCI. 2020. FICCI Paper on Development of Dairy Sector in India. Retrieved from: https://ficci.in/spdocument/23304/Development-Dairy-Sector.pdf.

GoI. 2019. 20th Livestock Census Key Results [Provisional]. Ministry of Fisheries, Animal Husbandry & Dairying, Government of India, New Delhi. Retrieved from: https://epashuhaat.gov.in/documents/ProvisionalKeyResultsof20thLivestockCensus.pdf

GoI. 2021. Economic Survey 2020–21. Statistical Appendix. Ministry of Finance, Government of India, New Delhi. Pp 1–353.

Kale R B, Ponnusamy K Chakravarty A K, Sendhil R and Mohammad A. 2016. Assessing resource and infrastructure disparities to strengthen Indian dairy sector. *Indian Journal of Animal Sciences* **86**(6): 720–25.

NAAS. 2017. Strengthening Agricultural Extension Research and Education-The Way Forward. *Strategy Paper* No. 5. National Academy of Agricultural Sciences, New Delhi. pp 12.

NDDB. 2019. Study on demand of milk and milk products in India. Final Report for National Dairy Development Board (NDDB). The World Bank, IBRD-IDA. Pp 1–181.

PIB. 2021. Productivity of Dairy Animals. Press Information Bureau (PIB). Ministry of Fisheries, Animal Husbandry & Dairying, New Delhi. Retrieved from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1707187.

Ponnusamy K and Pachaiyappan K. 2018. Strengthening extension research in animal husbandry: review of issues and strategies. *Indian Journal of Animal Sciences* **88**(2): 137–43.

Ponnusamy K and Padaria R N. 2021. Research in agricultural extension: Review of its contribution and challenges. *Indian Journal of Agricultural Sciences* **91**(5): 659–65.

Ponnusamy K and Devi M. K. 2017. Impact of Integrated Farming System Approach on Doubling Farmers' Income. *Agricultural Economics Research Review* **30**: 233–40.

Ponnusamy K, Binoo P Bonny and Manju Dutta Das. 2017a. Impact of public private partnership model on women empowerment in agriculture. *Indian Journal of Agricultural Sciences* **87**(5): 613–17.

Ponnusamy K, Chakravarty R and Singh S. 2019. Extension interventions in coping of farmers against effect of climate change in dairy farming. *Indian Journal of Dairy Science* **72**(4): 430–36.

Ponnusamy K, Chauhan A K and Meena S. 2017b. Testing the effectiveness of Pasu Sakhi: An innovation for resource poor farm women in Rajasthan. *Indian Journal of Animal Sciences* **87**(2): 229–33.

Ponnusamy K, Sabikhi L and Meena G S. 2020. An appraisal of scope for women-led entrepreneurship in dairying. *Indian Journal of Dairy Science* **73**(6): 608–13.

Ponnusamy K, Sriram N, Prabhukumar S, Vadivel E, Venkatachalam R and Mohan B. 2016. Effectiveness of cattle and buffalo expert system in knowledge management among the farmers. *Indian Journal of Animal Sciences* **86**(5): 604–08.

Ponnusamy K. 2006. 'Multidimensional analysis of integrated farming system in the coastal agro-eco system of Tamil Nadu'. PhD Thesis. NDRI (Deemed University), Karnal, Haryana.

Rao S and Sasidhar P V K. 2021. Blog 126-Revamping Veterinary and Animal Husbandry Extension in India. Welcome to AESA. [online] Aesanetwork.org. Available at: <https://www.aesanetwork.org/blog-126-revamping-veterinary-and-animal-husbandry-extension-in-india/> [Accessed 21 July 2021].

Ravikumar R K and Chander M. 2011. Livestock extension education activities of the State Departments of Animal Husbandry (SDAH) in India: A case of Tamil Nadu state. *Indian Journal of Animal Sciences* **81**(7): 757–62.

Sasidhar P V K. 2002. Revitalizing veterinary and animal science education for the future in India–Issues and approaches. *Journal of Agricultural Education and Extension* **8**(3): 139–49.

Singh V and Chakraborty K. 2019. Transfer of innovations: A case of working of patents in India. *Current Science* **117** (6): 1032–44.

Singh V and Singh A K. 2015. Intellectual property and technology management in dairy sciences. *Indian Journal of Dairy Science*

68 (04): 395–98.

Singh V, Kumar P, Datt S and Ponnusamy K. 2015. Intellectual assets management and transfer in animal science sector at the Indian Council of Agricultural Research. *Indian Journal of Animal Sciences* **85**(9): 1051–55.

Sudeep Kumar N K and Thirunavukkarasu D. 2016. Reorienting dairy extension to meet changing needs of smallholder dairy production system. *Journal of Experimental Biology and Agricultural Sciences* **4**: 18–22.

Sulaiman R V and Van den ban A W. 2000. Reorienting agricultural extension curricula in India. *Journal of Agricultural Education and Extension* **7**(2): 69–78.

van den Ban A W and Hawkins H W. 1996. *Agricultural Extension*, 2nd Edition, Blackwell Science, London.