CURRENT SITUATION AND FUTURE DIRECTIONS FOR TECHNOLOGY ADOPTION IN INDIAN DAIRY FARMING

Abstract

The operational efficiency and productivity of the dairy industry in several Nations have significantly increased as a result of technology involvement into operations. The researches have shown that technology makes dairy farming activities easier, however not everywhere technology is adopted similarly. The purpose of this paper is to highlight the opinions of Indian dairy farmers regarding the benefits and challenges of technology adoption along with the awareness and adoption status of each type of technology to come out with current situation appropriate suggestions for future. The findings show that the current status of technology adoption among Indian dairy farmers is not satisfactory. The awareness of some good technologies even before the adoption is a concern like IoT and RFID are some technologies that most farmers were not aware about or if aware then were not responsive about its features, utility, merits and demerits. The other side shows that dairy farming in India faces other basic problems and technology adoption is still a far goal ahead. The limitation of this research work is that the data collected were in open ended responses considering the knowledge and comfort of the respondents. Therefore, this research is helpful for decision-makers and policy planners to spot the gaps in current situation and look for solutions to maximize role technology implementation. As future scope, closed ended questions may be formed and certain quantitative techniques may be applied.

Keywords: Dairy farming, Dairy business, Technology adoption

1 Introduction

According to research based evidences, agribusiness has the ability to improve performance and bring about operational efficiency with the implementation of technology. India is the largest milk producer and consumer in the world, but it faces challenges with yield per cattle, overall productivity, low rates of technology acceptance and adoption, health monitoring of milking units, recording

animal data, and the availability of dairy products on the international market. Research on innovation in agriculture has a long history, and most of these studies indicate that implementing new technologies can increase farm income, competitiveness, and productivity [1]. In the current global market, the dairy industry cannot ignore success factors such economic trends, competitive position, technical improvements, operations, and supply chain management [2]. Of all the nations, milk production and consumption are at their highest in India. The production of dairy products accounted for about 4.2 percent of India's gross domestic product as of 2020. The Indian dairy industry was said to be expanding at a 4.9 percent yearly rate in 2019 [3]. The most prevalent and lucrative livestock industry is dairy farming. India's small-scale dairy farmers view their industry as primary source of revenue [4]. 27 state run milk federations, 196,114 dairy cooperative societies and more than 17.26 million milk producers make up the bulk of the Indian dairy industry [5]. With A2 milk producing indigenous cows gradually becoming extinct, crossbred and buffalo now dominate the milch animal stock. Making tested technologies widely accessible and constructing the necessary infrastructure are the only ways to expand the dairy cows' capacity for production [6]. Despite of being the world's largest milk producer, the growth rate is not in line with the level of demand (Punjabi, 2017); the nation struggles with per cattle productivity of indigenous breeds [7] and insufficient global presence of processed dairy products [8]. The National dairy development board (NDDB) uses information, knowledge, creativity and initiative with the help of technology, to produce new ideas that may be turned into useful products and services that can be replicated and to extract more value from dairy farming processes and resources. Some of the technology initiatives to aid dairy farmers, authorities and decision makers are- e-Gopala, INAPH, GIS tracking, dairy knowledge web portal, internet based dairy information system, etc.

1.1 Technologies available for dairy farming

It is generally accepted that adopting agricultural technologies boosts profitability and competitiveness. Adopting new technology by farmers increases output while lowering expenses [9]. The technical modernization of dairy farming operations aims to boost profitability through the efficient use of cutting-edge technological solutions created on the basis of information convergence between parts of the triune animal-machine-human system, which interacts using multivariate methods for process organisation and management.

The term precision dairy farming refers to a group of technologies that include automated reading devices like sensor systems, software-based animal monitoring, tasks related to milk procurement like automated milking, and data management that measures and analyses behavioral and physiological indicators in individual milking units [10]. With the implementation of the Internet of Things, agricultural food production has advanced thanks to smart farming (IoT). Smart farming is an intelligent farming management technique supported by technology that aims to improve output levels, farm

practices, and environmental awareness [11]. The dairy farming technologies can be broadly categorized as breeding, milking and management related technologies based on ICT (Table I). Breeding technologies are provided by lab facilities, milking and ICT based management technologies are provided by technology service providers along with consultation. There are some additional technologies adopted mostly by co-operative milk supply chain such as automatic milk collection unit (AMCU), milk tester, processing, hazard analysis and critical control points (HACCP) and packaging plant, GPS tracking for cold chain management but some large scale dairy farms do have their own packaging and distribution network. Also, to keep sustainable concerns, some dairy farms use bio-gas plant.

Dairy technologies	Description	Source
Artificial insemination (AI)	This method was first used in the 1940s as a speedy diffusion process to create superior genetics, eliminate the possibility of the spread of venereal diseases, free farmers from the reliance on bulls, reduce costs while increasing profitability and increase economic advantage	Khanal and Gillespie (2013) [12]; Foote (1996) [13]; Barber (1983) [14]
Genomic testing	By using an applicator and a tissue collection device, it is yet another cutting-edge electronic herd intelligence service provided by specialized labs that maps the genetic characteristics of a newborn calf.	Schefers and Weigel (2012) [15]
OPU-IVEP	Test tube calves are created using the Ovum Pick Up and In Vitro Embryo Production (OPU-IVEP) method (surrogacy). It enables 5–10 times more male calves to be born from a single superior animal, resulting in the development of superior breeds.	Nehring et al. (2017) [16]
Sexed semen	Male and female cells are separated from the semen prior to artificial insemination. Although lower conception rates are a cause for concern, it aids in producing the intended gender of calves.	De Vries et al. (2008) [17]; Wiegel (2004) [18]

Bucket milking system	Milking is carried out via a system connected to storage buckets. Sometimes, this suction is performed manually by pushing a lever without the assistance of a motor.	Gaworski and Prieulis (2014) [19]
Milk parlor	On a high platform, the animal enters the stalls for the milking procedure and is then let out once it has been milked. Parlors can be built in a variety of ways, including swing, parallel, herringbone, polygon, side opening (tandem), carousel, and flat-barn.	Gillespie et al. (2014) [20]
Milking pipeline	In a milking pipeline, a vacuum pump is employed to help transport milk from the cow to the storage tank.	Alekseeva et al. (2021) [21]
Portable milking system	They provide a large-scale contemporary dairy farm with a solution for emerging nations with limited herd sizes. These devices can be transported separately to each cow, and milking is accomplished using suction from tiny electrically powered motors.	Čėsna et al. (2017) [22]
Robotic milking system	While the robot keeps track of the yield per cow, milking frequency, milk quality, quick problem identification, and refusals in addition to helping with the milking process, this is a fully automated method.	Hyde et al. (2007) [23]
Internet of things (IoT)	It is a system of connections between the Internet and other sensing and actuating devices that can operate information across various platforms with the aid of a unified framework like cloud computing with seamless information demonstration, data analytics, and ubiquitous sensing.	Gubbi et al. (2013) [24]

Website	Small businesses may easily and affordably share their product or brand with customers via social media sites or own websites. By examining one farmer's communication with customers increases authenticity as a farmer.	Garner (2022) [25]
Enterprise resource planning (ERP)	It is an enterprise-wide software solution that stably integrates and automates an organization's business processes. ERP gathers real-time data from cattle ranches that aids in cost-saving, milk production, animal breeding, animal health, and general efficiency improvements.	Leon (2008) [26]; Jadawala and Patel (2018) [27]
Radio frequency identification (RFID)	RFID tagging in dairy animals uses a two-way radio frequency communication chip to collect and keep health data, while also monitoring their ongoing activities even in locations without Internet connection.	Mitchell (2008) [28]

Table 1: Dairy farming technologies

2 Literature review

Industries cannot overlook success aspects like economic trends, competitive position, operations and technological advancements in the current global market [2]. Technology foresight can offer a chance to examine a possible future for the dairy farming, and then set out to achieve it through the implementation of suitable policy initiatives [29]. In a survey of 180 dairy farmers in Rajasthan's Bhilwara district, Yadav and Naagar (2021) [3] discovered that adoption of dairy farming technologies was significantly and positively correlated with age, education, family size, annual income, dairy experience, participation in organizations, ownership of land and livestock, economic motivation, and market and scientific orientation.

According to Yadav et al. (2021) [6], the management of breeding, feeding, storage, and infrastructure in dairy farming depends on the use of technology. The strategic areas for improvement include better breeds, administration of feeding, training, upgrading of policies, control of health and illness, housing, access to markets, and new opportunities. In two separate time periods, Burkitbayeva et al. (2019) [30] evaluated the level of technology use in dairy farms in Punjab state with the belief that it increases dairy productivity and enhances the welfare of poor farmers (2008 and 2015). The research findings revealed a

considerable increase in lower level farmer technology use but little improvement in medium and high level players' technology usage. The adoption of contemporary technology, such as procedures runs by equipment, enhanced farmer productivity and satisfaction. A gap in vertical coordination in the value chain was found, despite technology facilitating value-chain integration, indicating need for improvement for future technology adoption.

Meena and Jeph (2018) [31] conducted in-person interviews with 80 dairy farms in the Rajasthan districts of Jaipur and Dausa to investigate the high, medium, and low degree of influence barriers to the adoption of dairy farm technologies by farmers. It was discovered that 45 percent of farmers cited a high degree of technical competence as a barrier, followed by a high infrastructure-related constraint of 42.5 percent and a high economic constraint of 38.8 percent. According to Husain (2018) [32], Indian dairy should encourage strategic alliances with major businesses to increase technology support, particularly IoT for automation, in order to change itself to a better position of organization and drive toward innovation. As the largest producer and consumer in the world, it still falls short in terms of the productivity of milking machines that can be handled through efficient IoT adoption across dairy farms.

When combined with ERP to collect real-time data in dairy farms, new disruptive ICT technologies like RFID tags, IoT, mobile applications, payment gateways, and using GIS for land management, weather prediction, etc. help reduce costs while enhancing milk production, animal breeding, animal health, and overall efficiency. Additionally, it has the power to integrate technology into dairy farms, and by kicking off a new boom era, it can upgrade the whole Indian dairy business [27]. Deshmukh et al. (2015) [33] examined the viability and applications of a number of computer-based technologies in the modern dairy industry, including the installation of RFID tags at farms, plant automation, milk testing, MIS, computerized accounting system, computational neural network, electronic payments or e-billing, price determination, and GPS-based tracking. By bringing all federations and unions together, such as the NIN (National information network) and GIS, NDDB has begun a computerized network. The overarching goal is to promote preventative maintenance while achieving supply chain integration and traceability. According to the article's conclusion, the dairy business has a significant chance to adapt in order to fulfill its goals via customizing IT platforms.

The use of technology in precision dairy farming allows for the measurement and analysis of animal behavior, physiological data, and production indicators. It involves automation of tasks including managing feeding and milking, updating data, keeping records, reproducing, keeping track of health, and managing milching units as a whole. It provides improved methods for keeping an eye on and enhancing the welfare of the animals, which reduces the need for labour, lowers costs, and lengthens the lifespan of dairying facilities. Therefore, advancement in the dairy business will be driven by precise technologies in the future [34]. Birthal and Negi (2012) [35] came to the conclusion that the low production of India's livestock business was due to a combination of

factors including poor animal health, a lack of feed and fodder, and a low level of technological adoption.

The most popular technology is website; most of the users claim to have done so. Farmers are aware about the website for agriculture and animal husbandry was known to majority of respondents. The survey, which was performed in 21 places in the Nagpur region, involved 210 dairy producers. The five different dairy farming technologies were the subject of the investigation. The biggest obstacles to adoption or abandonment of these technologies were a shortage of services, farmers' ignorance, and the government's withdrawal of free or subsidized services [36].

3 Problem Description

A thorough examination of the literature revealed that, particularly in the context of India, the researches in the dairy sector are few and does not focus upon technology adoption related issues rather consider general dairy farm problems. Since the literature and case evidences support that technology adoption can bring improvement in the operational efficiency and performance improvement of dairy farming operation, still the technology adoption is at low pace. The emphasis of the current research is on highlighting the present status of technology adoption gathering responses through in-depth personal interviews with dairy farmers, dairy farm owners and managers in terms of their awareness, usage, opinion and satisfaction related to technology adoption and also collecting suggestions for future improvements by regulatory bodies or policy makers.

4 Methodology

Field of study and respondents

The study was carried out in the Indian states of Haryana, Punjab and Uttar Pradesh. These three states are the top milk producing states in the country. 60 dairy farms were covered from 17 districts in all. A representation of 3 respondents were taken from each farm (n=180). These respondents were either dairy farmer, employee in a dairy farm unit, dairy farm manager or owner.

Measurement of responses

The in-depth interviews were taken from the respondents. The data were collected on the basic profile of farmers/farms, awareness and agreeableness of technology in dairy farming; usage of technology, perception about ease of use; benefits and challenges of technology adoption, suggestions for converting non-adoption into adoption. Only farming or farm related technologies are taken into consideration excluding the logistics or cold chain management technologies. The findings and discussion of analysis contains some general responses related to a whole dairy farm unit, which means 60 responses while some responses indicate individual reporting of 180 respondents. Since some

of the respondents were unaware about the basic terminologies, therefore the responses were converted into generic terms by the researchers.

5 Findings

The basic profile of the 60 dairy farms understudy can be seen Table II. The profile contains the classification of dairy farms on the basis of herd size, average yield per cattle, supply areas and related business activities other than milk production.

Table 2 Basic profile of 60 dairy farm units

Herd Size		
Number of animals	*Frequency*	*Percentage*
Less than 50	14	23.33
50-300	41	68.33
300-1000	4	6.67
1000 and above	1	1.67
Average yield per cattle		
textitYield range	*Frequency*	*Percentage*
5-10 ltrs	13	21.67
11-16 ltrs	19	31.67
17-22 ltrs	11	18.33
23-28 ltrs	6	10
29-34 ltrs	3	5
35-40 ltrs	6	10
More than 40 ltrs	2	3.33
Milk or milk products supply		
Supply to	*Frequency*	*Percentage*
Local and nearby regions	52	86.67
Food joints	9	15
Self-consumption	7	11.67
Food processing companies	4	6.67
Institutional	4	6.67
Engagements in business activities		
Business Activity	*Frequency*	*Percentage*
Milk selling	57	95
Milk products	29	48.33
Animal selling	13	21.67
Organic farm products	8	13.33
Breeding services	6	10
Animal by-products	4	6.67
Bio gas plant	3	5
Ayurvedic medicines	2	3.33
Animal husbandry	2	3.33
Consultancy	2	3.33
Farm Eco-Tourism	1	1.67

Fig. 1 shows response related to status of adoption of various technologies in selected 60 dairy farms. The frequencies are represented graphically. It was found that artificial insemination is the mostly used technology form constituting 91.67 percent dairy farms (55 dairy farms) using it to ensure better

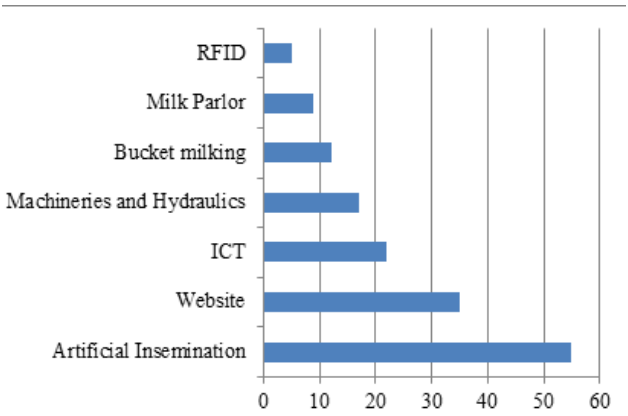

Fig. 1 Type of technology adopted

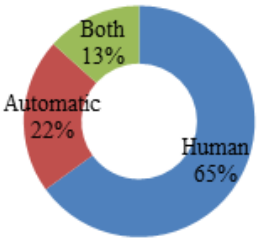

Fig. 2 Milking process

breeding quality and breed improvement that ultimately affects health of born calves, yield and productivity of milching units. This is followed by making a website of a dairy farm for communicating the best practices, size of farm, quality commitment, vision/mission, technologies usage, order collection of milk or milk products, providing consultancies, handling queries, animal selling, breeding services, mentoring etc. The website has been quoted by most of the respondents as an important form of technology for establishing contact and relationships with the customers primarily order collection. The ICT includes primarily the database management or any sort of computer, mobile and internet usage for record keeping or herd management. The machineries and hydraulics includes silage preparation machine, automatic water supplier, and hydraulics for sanitation management.

After analyzing the method of milking process (Fig. 2), 65 percent of dairy farms rely on human based milking followed by 22 percent performing automatic milking either through bucket milking or milk parlors and 13 percent adopted hybrid of both methods. The reasons for hybrid mode were firstly to ensure availability of labor in case of equipment failure and secondly where herd was composed of cows and buffaloes both. The automatic milking in most cases is not suitable for buffaloes.

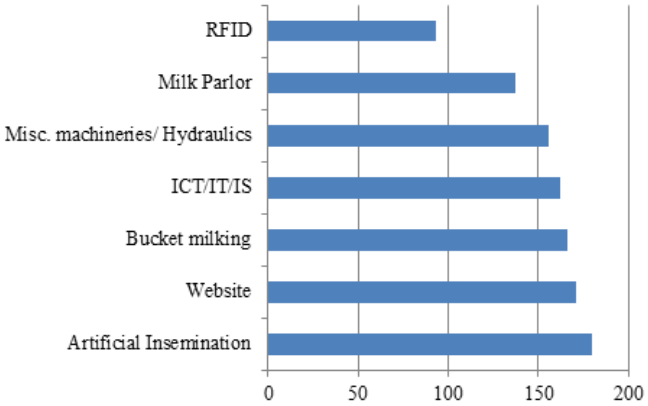

Fig. 3 Awareness of dairy farming technologies among respondents

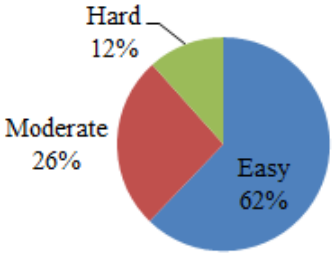

Fig. 4 Ease of use perception

Fig. 3 contains responses with graphical representation of awareness, general perception related to ease of using technology and respondent's willingness to continue the usage or adopt any other or new technology if not using currently. In this regard, it was found that 100 percent respondents were aware about artificial insemination technology followed by the awareness of using websites for dairy farm business activities. The least awareness was found for RFID technology i.e. 51.67 percent.

Regarding the ease of use perception about technologies (Fig. 4), 62 percent of respondents find that technology is easy to use depending upon the training, continued practice and positive learning attitude whereas 12 percent find it difficult to use due to lack of knowledge, awareness of technology engagement in dairy farming activities and background or geographical location where a dairy farm is located like rural areas. 26 percent of respondents have the opinion that some technologies are easy to use and implement whereas some high end technologies are dependent upon the basic digital literacy. Therefore cumulatively it can be interpreted that technology ease of using technology is moderate.

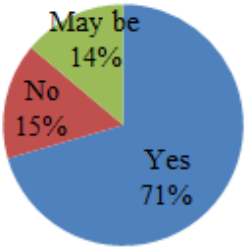

Fig. 5 Desirability to adopt or continue technology usage in future

Fig. 5 shows that 71 percent respondents illustrated potential to continue using technologies or adopt new technologies whereas 15 percent are not willing to do so and then followed by 14 percent those who are not sure about it.

Table 3 highlights the challenges in adoption of technology. In Fig. 5, 71 percent displayed willingness to adopt or continue using technologies and some clearly denied the adoption. Therefore, all 180 respondents were asked about the issues or problems that they find in technology adoption into dairy farm operations. These issues and problems are framed as the obstacles or challenges of technology adoption. A large proportion of respondents (51.67 percent) considered that high cost of acquiring technology and maintenance cost is a major problem. In this regard, some respondents did not find the cost as a problem rather a requirement to earn future gains, betterment and development of dairy farm business. The availability of skilled and trained labor to operate and manage technology in remote, rural or even semi urban areas came out as the next vital challenge. The lack of technology awareness has also been highlighted as a challenge next to the labor availability. Lastly, the dairy farms processing technology based high quality milk and milk products, highlighted that consumer's willingness to pay against technologically processed food item is also a challenge since the prices are relatively higher than the ordinarily or manually obtained milk and other items.

Table 3 Challenges of technology adoption

Challenge	*Description*	*Frequency*	*Percentage*
Cost set-up	The cost of acquiring and maintaining technologies, mainly high end technologies such as RFID and automatic milking systems and to adopt complete smart farming methods. Also the cost of basic inputs like feed and fodder	93	51.67
Labor availability	Availability of expert, skilled and trained labor for managing technology	87	48.33
Awareness	Awareness about technology options available, using technologies, do's and don'ts, merits and demerits	83	46.11
Herd size	Big herd size is necessary to cover acquisition and maintenance cost. Unsuitable for small herd sizes	75	41.67
Government support	Financial (loans/subsidies/funds), insurance, infrastructure, awareness and motivational support for some high end technologies is lacking	74	41.11
Federation pricing policy	Milk pricing policy by state federation	59	32.78
Educational opportunities	Less number of educational opportunities/institutions for enhancing dairy based education and skill development	42	23.33
Technology Acceptance	Low acceptance for technology for dairy animals (especially cows) due to ethical and socio-cultural beliefs	39	21.67
ROI	Long term or low returns against investment in technology	22	12.22
Willingness to pay	The low affordability or consumer's willingness to pay against technology processed milk and related products	17	9.44

Table 4 comprehends the responses related to benefits of technology adoption. 76.67 percent respondents affirm that technology saves time followed by reduction in the human efforts or say human involvement into the activities and quality management (66.67 percent). The other benefits reported by respondents along with the frequencies and percentages.

Table 4 Benefits of technology adoption

Benefit	*Description*	*Frequency*	*Percentage*
Time	Saving the time through technology run operations either partially or fully technology based.	138	76.67
Human efforts	Reduce human efforts and dependency upon the labor with the help of some technologies	120	66.67
Quality management	Technology ensures the operations and product quality management.	120	66.67
Hygiene	Technology such as automatic milking ensures human contact/bacteria free milking process.	90	50
Farm management	Large scale, ease of work	57	31.67
Real time monitoring	Data has become an essential requirement in dairy business where feeding, heat, health, yield, milking etc. related records of animals can be tracked and maintained with the help of technology	42	23.33
Resource utilization	Proper and optimum resource utilization helps to reduce wastages, thus saves cost and ensures sustainability	39	21.67
Global standards	Technology involvement helps dairy businesses to reach and match global standards of processing and product quality	18	10
Standardized and streamline operations	The technology involvement helps to systematically channelize the operations and avoid bottlenecks.	6	3.33

6 Discussion

After portraying the findings of the responses collected, following points of discussion can be established:

- The researchers tried to look for each category of dairy farm on the basis of herd size, but only 1 dairy farm was found from large dairy farm (1000+ herd size) category. This implies that there is less number of dairy farms existing in this category. The reasons are ineffective health detection leading to deceases of milching units, low genetic productivity and milk producing capacity.
- Nearly 50 percent of dairy farms contain such milching units, whose average yield per cattle ranges from 5 to 16 liters per day, which is quite less as compared to other countries such as the US and Japan. The reason behind it is low yield of indigenous breeds found in India but still some farmers and consumers prefer milk and ghee provided by indigenous or their crossbreeds as these milching units produce A2 quality of milk known for controlling diabetes, cholesterol and ensure good health of heart.

- Most of the dairy farms (52 out of 60) supply milk and milk products to local and nearby regions either loosely, packed or with their own brand name. Along with supplies to this category, some of the dairy farms supply to food joints, restaurants, cafes, institutions such as schools, hospitals, contractual supplies to food processing companies. Few of the dairy farm units consume remaining milk by self and family.
- In terms of milk selling, 57 dairy farms are engaged in milk selling, the business motive of remaining lies in selling different breeds of milking units or bulls to other farmers or dairy farms. During the response collection it was found that now the dairy farms have explored some additional business opportunities other than conventional milk and milk products selling such as generating bio-gas through a plant, providing breeding services and consultancies to educate and provide step-wise guidance to operate dairy farms and maintain the animals against a fee amount. Also, some farms extend their animal husbandry business to poultry, fish, goat, sheep, bee keeping etc. India is rich with the Ayurveda medicines and some herbs, milk and byproducts of animals help to make these medicines to sell. 1 unique response was collected related to farm eco-tourism, where the particular dairy farm has a large land for organic and dairy farming and they have small cottages for tourists who can make online booking and enjoy their stays in natural environment with farm visits.
- The efforts of dairy development board in promotion of artificial insemination have been quite visible as 100 percent of respondents were aware about it and 55 dairy farms use this breeding technology but RFID that is referred as one of the most advanced and high end technology has displayed very low adoption number of only 5 dairy farms with only 51.67 percent respondents aware about it marking the lowest awareness. Overall, the awareness level as compared to usage seems quite better. As the usage of RFID is among 8.33 percent of dairy farms but awareness is among 51.67 percent respondents.
- Majority of dairy farms (39) perform milking by human hands and only 13 perform full automatic milking either through milk parlor or bucket milking. 8 dairy farms have engaged hybrid method of both ways of milking. This shows that the adoption of milking technologies is less.
- The response about general perception related to ease of using technologies was majorly easy (62.22 percent respondents) followed by moderate and then hard. Since most of the respondents put technology ease of usage in easy or moderate category, better awareness, training and exposure to use can be a scope for improvement in technology adoption levels. Further 127 respondents said yes for continue using technology, adopt any technology for first time or adopt new technology in future. This indicates that there is scope for demand and willingness among the dairy farmers to adopt technologies.
- Challenges create hurdles in the sense that they obstruct the demand created to get convert into actual adoption. The high cost of acquiring and maintaining technology has been highlighted as the most crucial challenge. The farmers reported shortage of funds, insurance, loan and subsidies for

technological advancements in the dairy operations. The expert labor availability in remote areas; small herd size leading to more fixed cost against investment in technology; support of government in awareness, assistance and funding; low and sometimes rigid pricing policy leading to less margins against technologically produced and processed dairy products; low dairy educational opportunities creating less digitally advanced youth to come forward in dairy business; socio-cultural beliefs denying acceptance for adoption of technology for cows, low ROI against investment in technology due to low yield, low price or small herd size; consumer's willingness to pay eventually higher prices against technologically produced dairy products; are some of the challenges highlighted by respondents.

- The respondents during the interview were allowed to express the benefits of using technology. The responses include that technology saves time as human efforts and inefficiencies are minimized. It brings quality improvement and management ensuring less wastage, effective utilisation of resources contactless hygienic production and processing, and good heath of milking units. Technology helps in smooth manage dairy farm especially large farms having big herd size and large milk producing ones. The real-time monitoring of animals through IoT, RFID etc. can help the farmers to timely detect any arising health problems. In addition to all these benefits, the technology helps to match global standards and best practices along with certain degree of standardization and streamlined operations.

7 Conclusion

The major issue surrounding the Indian dairy farming is the low yield of milching units, mainly indigenous cows and ineffective health detection mechanism of these units. In the US, the average yield per head per day is 27.8 liters whereas in Japan it is 22.5 liters but in case of Indian cows, the average is 4 liters and for buffaloes it is 5.2 liters. The huge gap can be noted here. Researches and global practices do indicate that effective and appropriate technology implementation can bring out the positive changes in yield output and provide health detection related solutions. Overall, the status of technology adoption in dairy farming of the Indian states understudy shows low levels. The awareness of some good technologies even before the adoption is a concern like IoT and RFID are some technologies that most farmers were not aware about or if aware then were not responsive about its features, utility, merits, demerits etc. The other side shows that dairy farming in India faces other basic problems and technology adoption is still a far goal ahead. The issue of socio-cultural beliefs leading to acceptance for involvement of technology into dairy farming is also a concern. The high pricing of dairy inputs such as feed/fodder, petrol/diesel is a first-hand problem to deal with. The herd needs fodder and transportation of inputs or outputs is dependent upon petrol/diesel prices. India is known worldwide for its popular cooperative society based milk supply chain but price restriction by concerned state federations with such farmers

who use some good technologies in dairy farming is again a problem. Therefore some farms prefer their own branding and supply chain eliminating their contribution to milk unions and supplies to affording consumers, food joints, food processing companies etc. The need of an hour is to attract youngsters to come forward having more inclination and awareness towards technology. As such, the requirement for more dairy education based programmes is crucial to ensure availability of skilled workforce focusing more upon digital literacy. Overall, the potential lies in the market regarding adoption of technology in dairy business as some farmers do understand the benefits of technology adoption but the role and impact of challenges should be under consideration by the policy planners to provide support seen as holistic dimension. The limitation of this research work is that the data collected were in open ended responses considering the knowledge and comfort of the respondents. As future scope, closed ended questions may be formed and certain quantitative techniques may be applied.

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References

[1] Feder, G., Just, R.E., Zilberman, D.: Adoption of agricultural innovations in developing countries: A survey. Economic development and cultural change **33**(2), 255–298 (1985)

[2] Mor, R.S., Bhardwaj, A., Singh, S.: A structured-literature-review of the supply chain practices in dairy industry. Journal of Operations and Supply Chain Management **11**(1), 14–25 (2018)

[3] Yadav, C., Naagar, K.: Dairy farming technologies adopted by the farmers in bhilwara district of rajasthan. Indian Res. J. Ext. Edu **21**(1), 7–11 (2021)

[4] Singh, A.K., Bhakat, C., Mandal, D., Mandal, A., Rai, S., Chatterjee, A., Ghosh, M.: Effect of reducing energy intake during the dry period on milk production, udder health, and body condition score of jersey crossbred cows in the tropical lower gangetic region. Tropical Animal Health and Production **52**, 1759–1767 (2020)

[5] NDDB: National Dairy Development Board: Annual report 2020-2021. https://www.nddb.coop/about/report. Accessed: 2022-12-26

[6] Yadav, R., Yadav, S.K., Singh, A.K., Singh, P.: Constraints and way forward for boosting income from dairy farming in india: A review. J Sci Res Rep **27**(8), 55–64 (2021)

[7] Nozaki, Y.: Future trends of growing demand for milk and dairy products and milk supply in india. Mitsui and Co Global Strategic Studies Institute monthly report. Mitsui & Co Global Strategic Studies Institute (2017)

[8] Mishra, L., Mudgil, S.: India heading towards medium-scale dairy farms. https://www.thehindu.com/news/cities/mumbai/business/india-heading-towards-mediumscale-dairy-farms/article8444336.ece. Accessed: 2022-12-26

[9] Simões, A.R.P., Nicholson, C.F., Novakovic, A.M., Protil, R.M.: Dynamic impacts of farm-level technology adoption on the brazilian dairy supply chain. International Food and Agribusiness Management Review **23**(1), 71–84 (2020)

[10] Hogeveen, H.: The value of precision dairy farming: Going beyond labor savings. In: Conference on Precision Dairy Farming Held at Hyatt Regency, Lexington, KY During, vol. 112 (2017)

[11] Vate-U-Lan, P., Quigley, D., Masouras, P.: Internet of things in agriculture: a case study of smart dairy farming in ontario, canada (2017)

[12] Khanal, A.R., Gillespie, J.: Adoption and productivity of breeding technologies: evidence from us dairy farms (2013)

[13] Foote, R.H.: Dairy cattle reproductive physiology research and management—past progress and future prospects. Journal of Dairy Science **79**(6), 980–990 (1996)

[14] Barber, K.: Maximizing the impact of dairy and beef bulls through breeding technology. Journal of Dairy Science **66**(12), 2661–2671 (1983)

[15] Schefers, J.M., Weigel, K.A.: Genomic selection in dairy cattle: Integration of dna testing into breeding programs. Animal Frontiers **2**(1), 4–9 (2012)

[16] Nehring, R., Barton, R., Hallahan, C.: The economics and productivity of us dairy farms that use crossbred vs non-crossbred breeding technology (production systems). Agricultural Finance Review (2017)

[17] De Vries, A., Overton, M., Fetrow, J., Leslie, K., Eicker, S., Rogers, G.: Exploring the impact of sexed semen on the structure of the dairy

industry. Journal of dairy science **91**(2), 847–856 (2008)

[18] Weigel, K.: Exploring the role of sexed semen in dairy production systems. Journal of Dairy Science **87**, 120–130 (2004)

[19] Gaworski, M., Priekulis, J., *et al.*: Analysis of milking system development on example of two baltic countries. In: Proceedings of 13th International Scientific Conference Engineering for Rural Development, May, pp. 29–30 (2014)

[20] Gillespie, J., Nehring, R., Sitienei, I.: The adoption of technologies, management practices, and production systems in us milk production. Agricultural and Food Economics **2**, 1–24 (2014)

[21] Alekseeva, Y.A., Garmaev, D.T., Khoroshailo, T., Serdyuchenko, I.: Automated systems application for the advanced cow milking technologies development. In: AIP Conference Proceedings, vol. 2402, p. 070036 (2021). AIP Publishing LLC

[22] Čėsna, J., Medvedskyi, O., Golub, G., Kukharets, S.: The estimation of the structural elements of conductivity of the vacuum system of a portable milking machine. In: International Scientific Conference RURAL DEVELOPMENT 2017, pp. 237–242 (2017)

[23] Hyde, J., Dunn, J.W., Steward, A., Hollabaugh, E.R.: Robots don't get sick or get paid overtime, but are they a profitable option for milking cows? Applied Economic Perspectives and Policy **29**(2), 366–380 (2007)

[24] Gubbi, J., Buyya, R., Marusic, S., Palaniswami, M.: Internet of things (iot): A vision, architectural elements, and future directions. Future generation computer systems **29**(7), 1645–1660 (2013)

[25] Garner, B.: Using social media to establish authenticity: An analysis of a small dairy farm's use of facebook. Journal of Promotion Management **28**(6), 826–842 (2022)

[26] Leon, A.: Enterprise Resource Planning. McGraw-Hill Education (India) Pte Limited, ??? (2014)

[27] Jadawala, R., Patel, S.: Implications of disruptive ict base erp in dairy industry (in the aspects of milk co-operatives and cattle farms). Journal of Emerging Technologies and Innovative Research **5**(10), 331 (2018)

[28] Mitchell, R.L.: Dairy farmers are milking wireless, rfid and sensor technologies to keep herds fat, happy and profitable. Computer world magazine article, 22–24 (2008)

[29] Mor, R.S., Bhardwaj, A., Singh, S.: Benchmarking the interactions among barriers in dairy supply chain: An ism approach. International Journal for Quality Research **12**(2), 385 (2018)

[30] Burkitbayeva, S., Janssen, E., Swinnen, J.: Technology adoption and value chains in developing countries: Panel evidence from dairy in punjab. LICOS Discussion paper series, 1–51 (2019)

[31] Meena, O., Jeph, N., *et al.*: Constraints perceived by dairy members in adoption of new technologies in dairy farming in rajasthan. Veterinary Practitioner **19**(2), 317–319 (2018)

[32] Husain, B.: How IoT can help transform India's huge dairy market. https://www.livemint.com/AI/7hcxugZ6qxMi6uJXPvwCwO/How-IoT-can-help-transform-Indias-huge-dairy-market.html. Accessed: 2022-12-28

[33] DESHMUKH, M., CHOPDE, S., KALYANKAR, S., KELE, V.: Computer applications in dairy industry (2015)

[34] Schroeder, J.W.: Dairy Focus: Technology Will Drive Dairy Industry Progress. https://www.agweb.com/article/dairy-focus-technology-will-drive-dairy-industry-progress-naa-university-news-releas Accessed: 2022-12-30

[35] Birthal, P.S., Negi, D.S.: Livestock for higher, sustainable and inclusive agricultural growth. Economic and Political Weekly, 89–99 (2012)

[36] Basunathe, V., Sawarkar, S., Sasidhar, P.: Adoption of dairy production technologies and implications for dairy development in india. Outlook on Agriculture **39**(2), 134–140 (2010)