Chapter

Dairy Farming Innovations for Productivity Enhancement

Vidya Nimbalkar, Harish Kumar Verma and Jaswinder Singh

Abstract

Dairy farming innovations' implementation at every farmer's farm is the present day need; during the era of scarce natural resources coupled with population explosion, putting obvious pressure for more food production. Milk, produced from every single farm at micro level, is contributing to global economy at macro level. Dairy sector is facing the challenge of low animal productivity due to ineffective and poor farm management. This provides a big window for different innovations application to enhance animal productivity in developing nations where majority dairy farms are small scale and managed on traditional practices. Farm innovations are the novel practices/products/techniques suitable for particular area, physiological stage of animals and economically viable option to enhance the animals' per diem yield. Despite the prevalence of innovations, the scenario for its applicability is very dismal, majority of them are yet to reach masses at root level. Farmers' demographic, social and economic characteristics including adoption behavior, act as major impeding factors affecting impact of innovations. In this chapter, information on low cost and user friendly dairy farming innovations suitable for all kinds of farms, maintained under rural conditions existing in different tropical countries have been detailed for enhancing the animal productivity and henceforth farmers' socio-economic welfare.

Keywords: animal productivity, dairy farming, farmers' welfare, innovation need, low-cost innovations

1. Introduction

Farming is about feeding the world population that exceeds 6.9 billion people and is estimated to be more than 9 billion by 2050 [1]. In this scenario, striving to protect the natural resources (such as soil, water, and air) needed for current and future food production is not a new endeavor, although the present-day pressures on entire Earth's resources have generated widespread interest in agricultural productivity enhancement. Modern farming practices aids tremendously in boosting the food production across the world that too on diminishing cultivable land [2]. Increase in agricultural productivity achieved with altogether application of scientific knowledge and technological innovations [3].

The dairy world has also witnessed the rising trend of production and consumption and can be depicted as globally connected, composite and fast-changing sector of food production. Along with augmented supply of milk, rapid economic growth,

population expansion, increased urbanization etc. have also boosted up the demand for dairy products. With a growing middle class population having more disposable income, consumers seeking out healthy alternatives to fit in with a more active lifestyle, and a focus on natural ingredients, so milk and dairy products are growing in popularity. Presently the dairy world is serving over 7 billion consumers and providing livelihoods for approximately 1 billion people thrive on dairy farms [4]. Rearing of dairy animals always has a complimentary, supplementary and sustainable relationship with crops under mixed farming system prevalent in majority of the countries. However, as milk found the top most agricultural commodity in value terms and ranked third by production worldwide in 2013 [5], the valuable role of dairy sector in feeding the population of this planet can be understood without neglecting the need for sustainability at dairy farms as defined by U.S. Department of Agriculture (USDA) [2].

Being the chief source of income and food for a greater part of the rural poor [6], dairying is important for food security in many developing countries; also considered as one of the important sector for alleviating poverty, unemployment and reducing income inequalities. More balanced development of the rural economy is possible through the development of this sector [7]. The increasing importance of dairy to the world economy raises the importance of competitiveness among the countries. Globalization, trade liberalization and advancement in transportation and communication have given rise to an outstanding acceleration of market competition. This assures consumers to have a variety of goods and services to choose from, for a better standard of living with encouraging lower prices and lower fluctuations too.

Milk, produced from small as well as large scale farms at micro level, is contributing to every nation's economy, consequently global economy at macro level. There is a wide disparity of dairy farms in the world ranging from less than 3 cows per farm in some countries to over 1000 cows per farm in others, highlighting that milk production is performed distinctively in different countries. Discrepancies have also been noticed in terms of farm size, housing, milking and feeding systems. However, the world's average farmer keeps 3.2 milk animals with an average annual milk yield of approximately 2.2-ton ECM/animal/year [8]. During the era of global competition, achieving maximum productivity by using scarce natural resources is the biggest challenge among the dairy farmers, which can been addressed by implementing dairy farming innovations at every farmer's farm. Application of innovations at every stage of production since from cultivation of fodder till marketing of milk is the dire need of the present day.

Farm innovations are the novel practices/products/techniques suitable for particular area, physiological stage of animals and economically viable option to enhance the animals' per diem yield. Low cost and user friendly dairy farming innovations (technologies) suitable for all kinds of farms, maintained under rural conditions existing in different tropical countries are proved to be useful in enhancing animal productivity and henceforth farmers' socio-economic welfare. The term technology explains systematic application of scientific or other organized body of knowledge to practical purposes, which includes new ideas, inventions, innovations, techniques, methods and materials [9]. A decision made by an individual or group to use an innovation in a continuous manner termed as adoption. As, dairying has become a commercial enterprise and needs technology adoption for higher milk yield and lower per unit costs [10]; Innovations applicable for increasing net returns, reducing costs and optimizing production are discussed in this chapter; so that a common dairy farmer as well as consumer can contribute to a more resilient and more sustainable future for all of us.

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2. Innovation needs

Though developing countries like India contribute above half in world milk pail, productivity per animal is poor compared to other countries. The huge production is purely number driven rather than productivity achievement. This leads to over exploitation of resources and more waste production particularly manure, which is really harmful to the planet looking towards environmental concerns. Low animal productivity might be a result of ineffective breeding, improper feed and fodder management, deficient veterinary care, poor farm management etc. Dairy farmer has to improve the amount of milk each animal produces, thereby reducing the amount of feed, water and space needed per liter of milk resulting in less manure production. This provides a big window for different innovation application to enhance productivity in such developing nations where majority dairy farms are small scale and managed on traditional practices. It is well recognized that sustainability—in its economic, social and ecological dimensions - in milk production vary across different dairy systems categorized on the basis of relevant socio-economic and farm characteristics of milk producing households. However, the sustainability studies concluded that market oriented farms with a high degree of technology adoption was the most economically, socially and ecologically sustainable farms.

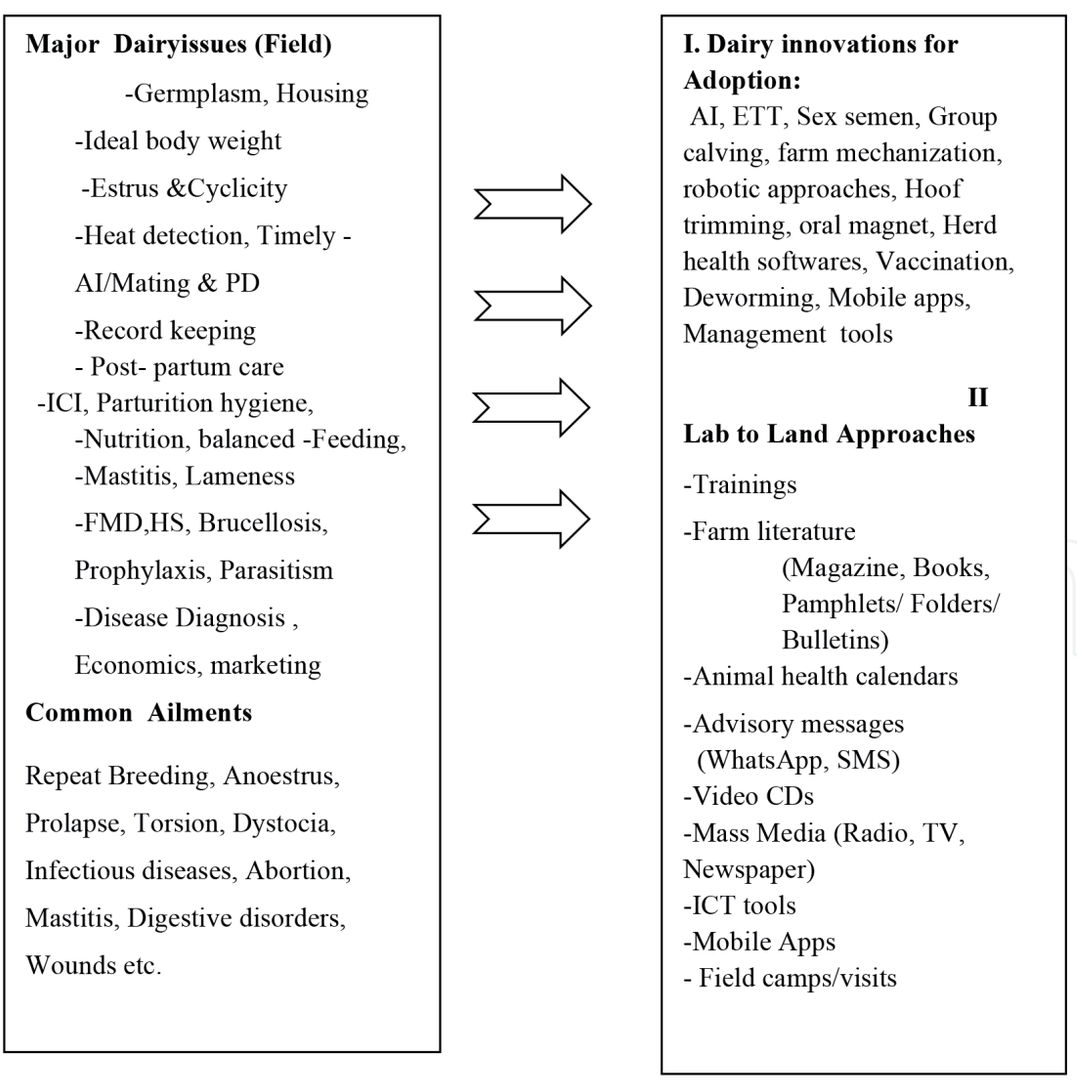

Figure 1.
Dairy farming issues, innovations and lab to land approaches.

Technology adoption is associated with better milk yield and improved dairying is directly correlated with higher technology adoption, showing direct impact on income generation, poverty alleviation and animal protein availability [11] thus, to raise the milk production, improved animal husbandry techniques should be adopted in the small house hold dairy farms. To overcome the present challenges of this sector, technological innovations as well as ability to transfer these innovations from lab to field in dairy farming system is mandatory for achieving expected animal productivity, and lowering down the cost of production for greater economic returns to the farmers. The various dairy farming innovations addressed for sustainable dairy production are broadly discussed in this chapter. Various dairy farming issues, animal ailments along with dairy farming innovations and various lab to land approaches are presented jointly in **Figure 1**.

3. Breeding innovations

Breeding innovations generally known as cross breeding have resulted in profitable dairy farming with serious health and fertility concerns. Selection of good, diseases resistant and climate resilient breed coupled with adoption of scientific breeding innovations laid the strong foundation to the dairy farm to grow in future. Topography, soil type, feed and fodder availability must also be given due consideration while selecting the animals. Highly productive animal requires special care in terms of management, disease control and feeding strategies. Native breeds with quality germplasm would be more appropriate for local climatic conditions. Genetic up-gradation of non-descript animals by using local superior germplasm proves more beneficial in terms of sustainable production. However introducing exotic germplasm to a certain limit generally known as cross breeding have resulted in profitable dairy farming with serious concerns. Breeding innovations commonly introduced at field level are highlighted in this chapter.

3.1 Artificial insemination (AI) technique

Artificial Insemination (AI) is an Assisted Reproductive Technology (ART) used worldwide to deposit proven sire's stored semen directly into a cow's uterus. The technique is used as a rapid way to improve desired characteristics through intensive genetic selection. Advantages, such as facilitating the use of superior quality semen without the expense and risk of sire's ownership; reduction in the risk of introducing venereal diseases into the herd have achieved with this innovative technique. Being the quickest and most effective mean of breeding through AI, developing countries like India could witness position as the top most milk producing country of the world. Not only it exclude the need of keeping a bull for natural service but also helps in exploiting the excellent germplasm up to the fuller extent.

3.2 Progeny testing

Progeny testing is the practical and best technique, in which bulls are evaluated on the basis of their daughters' performance. When large numbers of animals are spread in many villages for a particular breed in its native tract, these villages can get AI services and progeny produced in this way is evaluated for their performance. Progeny testing is a practical and the best option for achieving genetic improvement in that breed.

3.3 Embryo transfer technology (ETT)

Embryo transfer technology (ETT) is one of the latest tools available for the faster improvement of livestock worldwide particularly for exploiting the genetic potential of high quality females and the males simultaneously. Prior to the development of this technology a limited number of off springs were achieved from a superior/high milk producing cow in her life time. Higher cost of technology with low conception rate might be the factors limiting its implementation.

3.4 Sexed semen

Sexed semen is processed semen of proven bull from where 'Y' chromosomes bearing sperm cells are removed through sorting process. Sexed semen predominant with 'X' chromosomes can ensure birth of female calf. Reduction in economic burden and production of more number of female calves as a future productive cattle are the main advantages popularizing this technology among dairy farmers. However, the higher cost of semen coupled with low conception rate are important factors to be considered before its use and that too in heifers or primiparous animals for better results.

3.5 Hormonal synchronization/protocols

Different hormone protocols are being adopted for getting group calving or desired calving in a year for efficient and controlled management. Such desired calving matches with market demand and season. It is planned administration of hormones with fixed time AI for specified calving.

In addition to this, the advanced reproductive techniques such as Multiple Ovulation and Embryo Transfer (MOET), ovum pick up technique and embryo manipulation (splitting, sexing and cloning etc.) offer possibilities for faster multiplication of superior germplasm from highly selected elite donors to achieve the target producing large number of superior bull calves/bulls and their adequate number of quality semen doses.

4. Feeding innovations (cost-effective feeding strategies)

Steady supply of quality feed and fodder assures productivity enhancement. Feeding constitutes about 60–70% of total cost of milk production in dairying. Feeding management plays a crucial role in exploiting real potential of dairy animals. Balanced feed (green and dry fodder along with concentrate ration) proves beneficial for sustainability as well as profitability of the farm. Fodder both green and dry needs to be grown inside the farm. High yielding fodder varieties like Bajra, Napier hybrids, Maize, Sorghum can be grown in fertile and well irrigated land, while Guinea/Rye grass can be grown in barren rain-fed land. In draught prone areas, planting of local fodder trees will sustain the animal production during scarcities. Some trees like *Prosopis cineraria, Leucaenale ucocephala* & *Moringa oleifera* are gaining popularity among fodder due to their high nutritional value. Further, slight improvement in animal nutritional status with additional supplementation can improve animal productivity with mere addition of cost. Different types of Animal Feed Innovations, easily applicable at every farm are discussed here in this chapter.

4.1 Baled silage

Silage, method of preserving surplus green fodder, predominantly adopted on large dairy farms as far as tropical countries are concerned. It is the product of controlled fermentation of green fodder retaining high moisture content. Many countries are propagating tube silage or bag silage, as one of the innovative technique of silage making, introduced for a marginal dairy farmer possessing one-two dairy animals and limited fodder acreage. Standard plastic tube/polythene bags of recyclable material are available in markets in India with a capacity of producing 500–1000 kg of silage. Baled silage is the latest upgraded innovation of fodder conservation. In this, forage is baled at higher moisture than forage to be stored as dry hay. The sealed airtight plastic bales remain sealed until they are required. The high moisture and lack of air promote fermentation within the sealed bale that preserves forage quality. Such baby corn silage bales of 50 kg are available for sale at a reasonable price on online portals like Indiamart.com.

4.2 Rumen inert protein (bypass protein)

Protein meals are subjected to suitable physical/chemical treatment, energy and nitrogen balance gets improved with only marginal increase in treatment cost. Chemical or heat treatments are the main methods used for protecting proteins. In this technique, part of the protein is not degraded in the rumen and it can be utilized more efficiently in the small intestine. This rumen inert protein commonly known as Bypass protein, that is a misnomer. This protein supplies more essential amino acids at the intestinal level, which can lead to increase in milk yield by 10–15% and growth rate by 20–25%.

4.3 Bypass fat

Dietary fat, that resists lipolysis and bio-hydrogenation in rumen by rumen microorganisms, but gets digested in lower digestive tract, is known as bypass fat or rumen protected fat or inert fat. Among all forms of bypass fat, calcium salts of long chain fatty acids (Ca-LCFA) has highest intestinal digestibility and act as an additional source of calcium. A simple cost effective indigenous technology has been developed for the preparation of bypass fat (Ca-LCFA) using vegetable fatty acids. Ration of the high producing animals should contain 4–6% fat, which should include fat from natural feed, oil seed and bypass fat in equal proportions. Bypass fat supplementation has proved beneficial without any adverse effect on the rumen fermentation, feed intake, digestibility of nutrients and different blood parameters of the dairy animals. Rise in milk is recorded by 5.5–24.0%. Improvement in post-partum recovery and reproductive performance of dairy animals are the added advantages of this innovation.

4.4 Total mixed ration

The term total mixed ration may be defined as, "The practice of weighing and blending all feedstuffs into a complete ration which provides adequate nourishment to meet the needs of dairy cows." Each bite consumed contains the required level of nutrients (energy, protein, minerals and vitamins) needed by the cow. A 4% increase in feed utilization, greater accuracy in formulation and feeding, masking of the flavor of less palatable feeds (urea, limestone, fats, and some by-pass protein sources) and use of commodity ingredients can be expected while using TMR. While blending all the feeds together in a TMR, over mixing and under mixing of ingredients need to be avoided.

4.5 Buffers

Dietary changes like shift from hay to silage, feeding high level of grains/concentrate mixture cause increased acidity in rumen which may become detrimental for rumen microorganisms thereby affecting not only digestion but production and reproduction too. Buffers like Sodium bicarbonate, Magnesium oxide neutralize the acids produced by metabolism or fermentation. They are particularly required during hot weather when forage intake is lower and due to less chewing action natural buffer produced i.e. saliva is produced less.

4.6 Probiotics (prebiotics/synbiotics)

Probiotics are the live microorganisms that may beneficially affect the host upon ingestion by improving the balance of the intestinal microflora. Lactobacillus spp. is the most prevalent probiotic bacteria, known as lactic acid producing bacteria (LAB). Control of diarrhea in calves, increased milk production and better composition, control of ruminal acidosis, control of growth of pathogens in rumen, reduced pathogen load are the advantages of the technology. The appropriate level of 20 g probiotic per day per animal is found effective. Prebiotic are the ingredients (like Fructo-Oligosaccharides (FOS), Mannan Oligosaccharises (MOS) etc) used to enhance the population of already present good bacteria and synbiotic pertains to combination of pre and probiotic.

5. Management innovations

Building a hygienic cow shed is another important aspect to be considered among the many factors that lead to the success or failure of dairy farms. Housing systems that require less labor, which provide a comfortable and healthy environment to animals, manage space including storage efficiently and take care of bio-security measures with easy modification and expansions are more profitable than heavy structures with huge capital investment. Sufficient sunlight, proper ventilation, clean, and dry flooring along with sufficient space for lying down and protection from adverse weather conditions are the basic necessities of animal housing. Further, an effective management program has to be developed, so that animals are prevented from falling ill and there is no need for antibiotics/medicines. The direction and orientation of shed plays an important role in keeping the animals healthy as well as reducing laborious work. Considering these factors, loose housing barn with open cattle shed are recommended here, as that can be easily adapted at small as well as marginal dairy farms.

5.1 Health tracking devices

Digital animal health tracking devices are getting attention now a days as they help farmers in tracking, monitoring and managing animal's health, nutrition, behavior, pregnancy, milking frequency, milk production anomaly and activity level in real-time. These smart animal wearing gadgets can be implanted in the cattle's ears, tail, legs, neck or any part of the body. For tracking the health and early diagnosis of medical condition in dairy animals, GPS-enabled digital chips have been implanted widely in India. A huge database will be generated if these devices are used efficiently. Accuracy in such data will guide in formulating strong and concrete policies for welfare of both human and animals.

5.2 Heat detection systems

Detection of heat is very important aspect of management for performing timely AI with successful animal conception. **Heat Detection System** is heat management software which monitors the cow's activity for the whole day, predicting heat on the basis of unrest and hyperactivity along with other features to check milk flow, conductivity for suspected mastitis. It has obvious advantage over visual heat detection which is based on observation, behavior and miss heats or false negatives leading to huge economic losses. Further, these gadgets help the farmers for fertility management to get the target of a 'calf at foot every year'.

5.3 Robotic milking machines

Innovation of robotic milking machines is useful in eliminating the pressure on physical labor and maintaining a hygienic milking process with remarkable improvement in milk production. These machines have cups with sensors that can be attached individually to cows' teats. The sensors play important role in detecting readiness of teats for milking and also identify impurities, color and quality of milk. Milk not fitted for human consumption, is diverted to a separate container. The machines automatically clean and sanitize the teats once the task is over. Few models of low-cost, non-electric milking machines are also developed considering locality and need of dairy farms. Innovation of mobile milk collection unit installed with Robotic milking machines and bulk coolers will introduce a way to produce clean and quality milk from small and marginal farms.

5.4 Waste disposal and management

Scientific disposal of excreta (Dung, Urine), other organic waste (aborted fetuses, dead calf/animals, placenta) demands utmost attention. Presently, there is not a clear cut policy for dung and carcass disposal. In majority of Asian countries, both these are disposed in open, which is a serious concern from zoonotic and infectious diseases point of view. Electric incinerator and community biogas plants can provide the tangible solution.

Technology of dung cleaning robot or manure robot is available for barn cleaning and scrapping the dung in slatted floors beneath the barn. Recently Manure eating robot has been launched for cow garden cleaning that cleans the barn/cow gardens.

5.5 Digital farm management

Completion of farm management includes accounting, finance, labor management and supply chain management. Dairy farm management softwares are the innovative tools available in markets for atomizing and digitalizing end-to-end production and operations activities. It provides a holistic view for entire farm activities, manage records, generate reports and detect inefficiencies; assuring profitable dairy farming.

6. Health care innovations

Reduction in milk production is the first sign of animal discomfort and illness; whereas getting back to this production is one of the major challenge and costly affair for small as well as marginal farmer. Also there is reduction in per lactation as well as life time production of that animal. Any kind of disease treatment compels

to use antibiotics. This part is of a global conversation about antibiotic resistance, which is a serious public concern shared by animal and human health experts. So, it's always better to prevent the occurrence of diseases rather to treat. This could be possible only through application of healthcare management innovations.

6.1 Vaccination

Livestock vaccination is considered an emerging innovation of socio-economic importance in the Indian dairy industry [12] and reported more profitable and sustainable than artificial insemination [13].

Majority of tropical countries like India are endemic to many diseases that cause severe economic losses due to drastic reduction in the production capacity. Some of the diseases are even highly fatal. Fortunately, vaccines are available for most of these diseases and can be easily controlled if timely vaccination is carried out in a mass scale, covering a large proportion of the susceptible population (at least 80%) [14]. Farmers must stick to the standard vaccination protocol recommended by the Government following all precautions and regularity in inoculations.

6.2 Teat dip

The teats of all the lactating dairy animals and dry cows (during first 10–14 days of dry period) are dipped regularly after every milking in a germicidal solution. The recommended teat dips are

1. Iodine (0.5%) solution 5 parts + Glycerine 1 part

2. Chlorhexidine (0.5%) solution 1 L + Glycerine 60 ml

The iodine teat dip is the best as it treats various types of teat lesions and injuries also. Post-milking teat dipping with 'Iodine-glycerine teat dip' for prevention of new mammary infections is also recommended by many research institutes. Studies have reported that the treatment applying the post-milking teat dip automatically via milking machines had the lowest number of new intra-mammary infections (IMI).

6.3 Mastitis diagnosis kit

Mastitis, one of the expensive diseases, affects economic returns of dairy farms heavily. Farmer has to suffer with huge financial burden due to sub-clinical mastitis (SCM) as it incur heavy losses related to culling, decreased production, decreased fecundity, and treatment costs. Diagnosis of mastitis at sub clinical stage and its management results in milk production rise with quality milk and safety to consumer health [15].

Innovation of mastitis diagnosis kit includes Sodium Lauryl Sulphate (SLS) Paddle with reagent and Bromothymol Blue (BTB) card. Such innovations can be used by the farmers at their own for early diagnosis and reducing the further incidence diseases for improving productivity [16].

6.4 Lameness management

Lameness is reported as the third most economically important disease in world after infertility and mastitis [17]. It is a major cause of involuntary culling after mastitis. About 90% of lameness in dairy cattle and buffaloes occurs due to foot lesions. Recommended guidelines for prevention of lameness include hoof

trimming of all the animals at every 6 months and footbath of size 3 m long, 1 m wide and 15 cm high. Formalin (39–40%) should be preferred for foot bathing as a 4% solution (120 L water +5 L of formalin) in the footbath. Concrete footbaths are best and cheaper. In case there are few animals (unorganized farms), formalin spray (40 ml per liter of water) can be used on 1st, 2nd, and 3rd day of every fortnight along with close monitoring of animal gait at the time of walking.

6.5 Oral magnet feeding

Hardware disease is a common term for *bovine traumatic reticulo-peritonitis,* which is usually caused by the ingestion of a sharp, metallic object. Due to industrialization and urbanization, it is commonly found in dairy cattle, than any other ruminants. It can be difficult to conclusively diagnose, but can be prevented by the oral administration of a magnet around the time that the animal reaches the age of 1 year. This innovative technology is beneficial to control Traumatic Reticulo-Peritonitis (TRP) that occurs due to the intake of any sharp foreign object such as nails, blades etc. along with feed by the animal.

7. Communication innovations

In this competitive world, farmers are not only looking for various information sources for carrying out their production and marketing tasks efficiently but also for ensuring delivery of safe and quality products to the consumers. Food safety for consumers is at greater risk because of the increasing globalization of food systems. Information and Communication Technology (ICT) has potential to mitigate the needs of both ends by introducing virtual platform for dairy product production and marketing. ICT based information delivery to dairy sector can significantly improve the quality of decision-making in dairy farming system. Mobile phones with internet facility have been one of those successful innovations which benefit a large number of people in the developing world. As worldwide acceptance for mobile phones has improved among all users, it can be used as a major tool for communication and dissemination of information for quality decision making. Different mobile apps, web portals such as epashupalan.com and expert systems are being used by dairy farmers. The mobile application for dairy farmers, named 'Pashu Poshan', is available on both web and android platform, can be accessed by registering on the INAPH portal (http://inaph.nddb.coop). Guru Angad Dev Veterinary and Animal Sciences University, Punjab, India has launched 'Precision Dairy Farming' mobile application dealing with important aspects of dairy farming including important milch breeds, breeding, feeding and housing management, record keeping, health management and economics.

7.1 Product traceability in dairy sector

Traceability is commonly defined as the ability to trace products back and forth throughout the supply chain, from farm or point of production to the end user. The growing complexity of food supply chains, the heterogeneity in food safety regulations across countries, and lack of uniform requirements from one commodity to another are some factors that explain why greater efficiency in food traceability systems has increased in recent years. Block chain technology to give real-time data about the products to customers has been introduced among dairy manufacturers, suppliers and other stakeholders. QR code provided on the packaging of the product can be scanned on personal mobile devices to get information on the origin

of the milk. Information about, how and where from the product has collected and packed, how old it is, what kind of transportation and cold milk chain facilities are used, is being provided on internet. However, scattered, diversified and unorganized dairy farming is the major barrier for deep penetration of this innovation at grass roots of the sector.

The application can be highly useful in organic milk production as demand for organic milk is increasing in the market. Organic milk is considered as the ultimate milk with almost nil risk of chemicals, drugs and also free from stress factors. However its production is quite cumbersome as it needs a lot of efforts, monitoring and adhering to the organic standards for a branded product. It fetches good value in the market and the product traceability is quite easy as its each and every production component is documented.

8. Marketing innovations

E-commerce market places have played revolutionary role in input availability and product sales in dairy sector. Modern equipment and advisory services have been made available at the doorstep to farmers and dairy manufacturers on their smart phones through online Business-to-Business (B2B) market places. Many Business-to-Customers (B2C) platforms have also emerged at a rapid pace. They have major role in picking fresh produce from farms and delivering them to the doorsteps of end users. These marketing innovations have reduced spacial barriers for both producers as well as consumers. Online portals like Indiamart.com, amazon.in, reliance fresh at relianceretail.com are the successful examples of innovative online marketing of various dairy products.

9. Factors impeding innovations

Despite the prevalence of innovations, the scenario for its applicability is very dismal, widening the gap between innovations developed and available; and innovations actually being adopted or used by the end users. Recommended innovations in dairy farming sector have not been adopted as widespread as it is anticipated and the correct level of adoption is far from desired. Though large scale innovative digitalization is happening in dairy sector considering the present need of time, it has yet to reach masses at root level. Factors like low socio-economic status, disrupted electric supply, and unavailability of reliable internet facilities in rural areas might be the cause of poor outreach of the innovations. Adoption is defined as a decision to make full use of an innovation as the best course of action available and the process starts with awareness of the new product and ends with routinized use of the new product by consumer [18]. So for increasing the adoption of innovation, it has to be diffused widely as, diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system.

Demographic, social and economic factors along with adoption behavior of farmers affect application of innovations in dairy sector. Farmer's education, knowledge, attitude, risk orientation, and innovation proneness controls adoption behavior [19, 20]. Constraints faced by the farmers such as lack of awareness, knowledge and skill of application can be considered as the major impeding factors in dairy technology adoption [21–23].

Attributes of innovation, known as characteristics of the innovation, also play influential role on farmers' technology adoption and usage decisions [24]. Five characteristics of innovations *viz.* relative advantage, compatibility, complexity,

divisibility (triability), and communicability (observability) have identified as factors affecting the rate of innovation adoption [25]. Relative complexity and profitability, risk and investment, technicality and reversibility of innovation can also significantly affect its diffusion and adoption. Majority farmers prefer adopting the only practice which needs no investment and technicality.

Low government policy support, insurance complexities and market fluctuations act as major barriers in adoption-decision making process; reducing the interest of young generation in dairy sector. Poor collective actions, low financial policy support and absence of fixed pricing assurance to milk are remained the major constraints and demotivating factors in moving this sector towards sustainability.

10. Policy barriers

Majority of policies and government schemes are suited for medium and large farmers as they are knowledgeable and can invest more in their farms. Small and marginal farmers are resource poor, less knowledgeable, low risk bearer and investor; possessing only 2–3 animals for family sustenance rather than income generating activity. However, their proportion as the dairy stake holders means a lot to the economy when it comes to scarce resources, as it is more than medium and large farmers. Hence the policies should focus more on such group of producers to change their attitude, knowledge and skill for introducing innovativeness among them and for motivating them towards sustainable dairy farming. The resistance against policy reforms in the northern Pakistan has been reported under the Dairy Science Park (DSP) as a conflict of interests among the weaker and power stakeholders across food value chain, and DSP has come up with the idea of the Triple Helix Model of Academia-Industry-Government Nexus of good governance [26].

11. Conclusions

This chapter entitled 'Dairy farming Innovations for productivity enhancement' has focused light on today's dairy sector all over the world, describing the similarity and diversity in production and production performance. The innovation needs are justified for making the farming profitable for welfare of farmers and providing customer satisfaction by offering healthy, qualitative milk and milk products. Innovations from breeding, feeding, animal management, health care and preventive measures, waste disposal, product traceability and marketing features are discussed and explained with examples and success stories. Factors impeding innovations are discussed from point of innovation generation, diffusion till its adoption. Removal of these barriers and application of suitable extension approach with policy support will lead to more and more adoption for productivity enhancement and quality production. Recommendations have given for not only technology generation but also for its implementations.

12. Recommendations

In this innovative world, there is no single perfect technique or innovation which can cater to all the needs of farmers. Innovations must be considered with regards to their total cost for owner and end user. User friendly, economical, easily updated, accessible and locally available innovations, termed as 'fit in situation innovation', will be adopted at once and has more chances of popularization compared to the

one which has complex or more steps for executions. There is need for local and region specific technology generation and further its vast diffusion among similar socio-geographic regions. Innovation must reach the target people at right time; otherwise they are lying on shelves or in the books. The impacts of innovation application on the farmers' livelihoods should be adequately addressed and documented for different agro-ecologies of the world. There is a need for greater follow-up in tracking the adoption of technologies for sustainable farming systems and in the accountability of research efforts and policies for technology dissemination and adoption. Targeted efforts should be made in changing and building farmers' awareness, attitude and perceptions through training, demonstration, field visits, experience sharing etc. Already, huge dairy innovations have been made around the globe, but still they lack to be in rationale people for their usage. For that, strong extension is the need and call of the hour for getting more successful and sustainable farms, to break the ongoing trend of closure of dairy farms.

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Conflict of interest

"The authors hereby declare that there is no conflict of interest."

Author details

Vidya Nimbalkar[1*], Harish Kumar Verma[2] and Jaswinder Singh[3]

1 KNP College of Veterinary Science, Satara, Maharashtra, India

2 Extension Education, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India

3 Department of Veterinary and Animal Husbandry Extension Education, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India

*Address all correspondence to: vgnimbvet2002@yahoo.co.in

References

[1] U.S. Department of Commerce. U.S. Census Bureau. International Database [Internet]. 2008. Available from: http://www.census.gov/population/international [Accessed: June 6, 2021]

[2] USDA/NAL. Sustainable Agriculture: Definition and Terms [Internet]. 1999. Available from: http://www.nal.usda.gov/afsic/pubs/terms/srb9902.shtml [Accessed: May 15, 2021]

[3] Elam T. Is organic beef and dairy production a responsible use of our resources?. In: Proceedings of the 22nd Annual Southwest Nutrition & Management Conference; 22-23 February 2007; Tempez. Tucson: The University of Arizona. pp. 66-75

[4] Wyrzykowski L, Reincke K, Hemme T. IFCN Long-Term Dairy Outlook – The IFCN Vision of the Dairy World in 2030 [Internet]. 2020. pp. 1-5. Available from: https://www.researchgate.net/publication/339508626 [Accessed: June 5, 2021]

[5] FAOSTAT. Statistics Division, Food and Agriculture Organization of the United Nations, Rome, Italy. The Global Dairy Sector: Facts [Internet]. 2016. Available from: http://www.fao.org/3/cb2992en/cb2992en.pdf [Accessed: May 15, 2021]

[6] FAO. World Livestock 2011 – Livestock in Food Security [Internet]. 2011. Available from: http://www.fao.org/3/i2373e/i2373e.pdf [Accessed: May 15, 2021]

[7] FAO. The State of Food and Agriculture – Livestock in the Balance [Internet]. 2009. Available from: http://www.fao.org/3/i0680e/i0680e.pdf [Accessed: May 15, 2021]

[8] Bijla S, Khalandar S. Competitiveness of milk production: Global scenario. International Journal of Livestock Research. 2019;**9**(12):158-168. DOI: 10.5455/ijlr.20190322065456

[9] Akubuilo CJC, Umebali EE, Mgbada M, Ugwu DS, Egwu WE, Awoke MU. Readings in Agricultural Economics and Extension. Enugu: Computer Edge Publishers; 2007. pp. 45-89

[10] Hisham El-Osta S, Mitchell JM. Technology adoption and its impact on production performance of dairy operations. Review of Agricultural Economics. 2000;**22**(2):477-498. DOI: 10.2307/1349806

[11] Quddus M. Adoption of dairy farming technologies by small farm holders: Practices and constraints. Bangladesh Journal of Animal Science. 2013;**41**(2):124-135. DOI: 10.3329/bjas.v41i2.14132

[12] Rathod P, Chander M. Adoption status and factors influencing adoption of livestock vaccination in India: An application of multinomial logit model. Indian Journal of Animal Sciences. 2016;**86**(9):1061-1067

[13] Lal K. Foot and mouth disease: present status and future strategies for control in India. Indian Farming. 2000;**50**:28-31

[14] NDDB. Handbook of Good Animal Husbandry Practices [Internet]. 2015. Available from: www.dairyknowledge.in/article/handbook-good-dairy-husbandry-practices [Accessed: May 15, 2021]

[15] Wattiaux MA. Mastitis: The Disease and Its Transmission. Dairy Essentials, Babcock. 2011. Available from: https://www.yumpu.com/en/document/read/29801928/23- [Accessed: May 15, 2021]

[16] Nimbalkar V, Verma H, Singh J, Kansal S. Awareness and adoption level of subclinical mastitis diagnosis among dairy farmers of Punjab, India. Turkish Journal of Veterinary and Animal Sciences. 2020;**44**:845-852. DOI: 10.3906/vet-2001-42

[17] Enting H, Kooij D, Dijkhiuzen AA, Huirne RBM, Noordhuizen-Stassen EN. Economic losses due to clinical lameness in dairy cattle. Livestock Products Science. 1997;**49**:259-267

[18] Rogers EM. Diffusion of Innovations. New York: Free Press; 2003. p. 551

[19] Bhople RS, Thakare SM. Farm information source utilization, adoption and transfer behaviour of farmers. Rural India. 1994;**57**(7):153-154

[20] Kunzru ON, Tripathi H. A comparative study of adoption of dairy farm technologies between non-members and members of dairy co-operative villages. Indian Journal of Animal Sciences. 1994;**64**(5): 501-507

[21] Borate HV, Mahadik RP, Mahadik SG, Mane AV, Hake AD, Malashe KV. Knowledge level of the farmers trained by DBSKKV, Dapoli—An action research. Journal of Community Mobilization and Sustainable Development. 2011;**6**(2):205-208

[22] Dhaka BL, Meena GS, Meena NL, Bairwa RK, Nagar BL. Constraints analysis in adoption of improved dairy farming practices in Bundi district of Rajasthan. Chemical Science Review and Letters. 2017;**6**(22):995-999

[23] Nimbalkar VG. Adoption and impact of dairy farming technologies in Punjab [thesis]. Ludhiana: Guru AngadDev Veterinary and Animal Sciences University; 2020

[24] Adensina AA, Zinnah MM. Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. Agricultural Economics. 1993;**13**(1):1-9

[25] Rogers EM. Characteristics of agricultural innovators and other adopter categories. Wooster: Ohio Agricultural Experiment Station Research Bulletin; 1961:882

[26] Dairy Science Park. Policy Reforms [Internet]. Available from: https://dairysciencepark.org/policy-reforms/ [Accessed: October 24, 2021]