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Determinants of Innovative Technologies Adoption: In Context with Livestock Holders of India

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Abstract

Objective: This study aimed to determine the determinants of innovative technology adoption that affect the farming patterns of livestock holders in India.

Research Methodology: A stratified random sampling of cattle, sheep, buffalo, and goats was used to collect data from 270 farmers sampled from rural areas in the Rajasthan and Uttar Pradesh states of India. The sampled farmers included 135 adopters (i.e. farmers who adopted the new technologies) and 135 non-ads (i.e., farmers who did not adopt the technologies). To determine the impact of various independent factors on technology adoption by livestock holders Binary Logistic Regression was used.

Findings: The statistical software SPSS was used to predict logistic regression coefficients using the ML (Maximum Likelihood Method). One of the most reliable methods for conciliation of logistic regression models is the Hosmer-Lemeshow statistic. About 77.98 % of the total predictions were correct. The Lemers-Hosmer Goodness of fit Test, derived from Chi-square distribution (d.f., $p = 0.581$), presented that the model fits the data very well. The result indicated that the null hypothesis, according to which there is no difference between the estimated and observed values for the dependent variable, was accepted.

Originality/Value: In this work various variables that affect innovative technology adoption by Indian livestock holders have been identified. A few of the study's shortcomings must be filled in and haven't received enough attention in earlier research.

Practical Implication: This research indicates that improved connectivity amongst the different livestock industry stakeholders (farmers, agricultural industry, wholesalers/retailers, policymakers/consumers, etc.) is required to guarantee the best possible uptake of new technologies.

Key Words: Livestock holders, binary logistic regression, technology adaption, Farmers.

Introduction:

Technology and innovation are transforming every sector in the world today. The livestock farming industry is no exception. Technology has the potential to revolutionize productivity, sustainability and efficiency in agricultural practices (Khan et al., 2021). The digital revolution is changing livestock farming by introducing new technologies and processes that improve efficiency and productivity (Plumecocq et al., 2018). IoT, wearables, and sensors are facilitating resource management, feeding operations, and tracking animal health, as can be shown (Karunathilake et al., 2023; Ahmadi et al., 2023).

Farmers today are gaining important insights into genetics, feed performance, herd performance etc. by utilizing artificial intelligence, data analytics and machine learning. Farmers can boost output, cut expenses and make wiser decisions when they use data to inform their decisions. To create a more promising future for livestock production and sustainable food, rural residents are searching for cutting-edge technology. Furthermore, technology is a major factor in the advancement of sustainable farming methods (Ashraf & Akanbi, 2023; Bolfe et al., 2020). For instance, it improves weather forecasting, reduces chemical inputs and optimizes nutrient management, which allows farmers to make better use of resources while reducing their environmental footprint. Livestock is an essential part of the Indian economy. India has a large number of cattle and poultry farms, which are essential for improving the standard of living of the rural population (Vijayalingam et al., 2019; Quddus 2012; Dhamale et al., 2016). According to the latest Livestock Census in India (Animal Husbandry & Dairying Report, 2022), there are 303.76 million cattle (Cattle, Bovine, Mithun, and Yak), 74.26 million Sheep, 148.88 million Goat, 9.06 million Pigs, and 851 million Poultry. The Indian Livestock industry grew at a CAGR of 7.93% between 2014 and 2021. In 2021, the livestock industry accounted for 4.90% of the total GAV (Grass Annual Value). In 2022, the livestock industry contributed 30.13% to the total GAV of agriculture and allied sectors (at constant prices), compared to 24.32% in 2014 (Husbandry & Statistics, 2022). Despite this growth, Indian livestock farmers are facing many challenges in adopting new technologies; such as high cost, lack of knowledge and technical skills, limited access to infrastructure, fear of risks etc. The adoption rate of IT among farmers remains low despite the Indian government's initiatives to promote IT adoption through various national and/or multilateral development projects (Sangameswaran et al., 2019; Kumar & Singh, 2008). This study aims to explore the possible factors that influence IT adoption in the states of Uttar Pradesh and Rajasthan India. The adoption of agricultural technology is determined by a combination of human-specific factors (social), institutional factors, technological factors, and economic factors.

Literature Review:

The secret to realizing livestock farming's full potential is innovation and technology. There are countless opportunities to improve sustainability, efficiency, and productivity. Livestock farmers can profit from innovation and technology in a variety of ways, including robotics, automation, data-driven decision-making, and precision livestock farming. Livestock farmers can improve animal welfare, make the most use of resources, better meet the needs of a changing global environment, and help to build a more sustainable agriculture sector by putting these innovations into practice (Ashraf & Akanbi, 2023; Bolfe et al., 2020).

Innovative livestock farming can enhance animal welfare, reduce resource waste, and benefit the environment. Robotics and automation technologies are revolutionizing labour-intensive tasks in livestock farming (Dhanai, Negi & Singh, 2016). Innovative technologies include robotic milking, automatic feeding systems, and autonomous herding. Innovative livestock technologies that incorporate robotics and automation technologies improve animal welfare, lower labor costs, and boost farm productivity. The innovative livestock technologies used for this study are; Milking automation, cactus chopper, reproductive performances, automatic-waterer, feeding automation, improved barley varieties and barn environment control. Milking automation and feeding automation are the common technologies used by Indian dairy farmers. Milking automation is a kind of automated milking system that calls for a completely different management system for the feeding, milking, trafficking, and behaviour of the cows as well as their grazing (Mohanakumara & Biradar, 2018).

On the other hand, feeding automation is a sophisticated feeding system. Feeding automation is an automated system that precisely and consistently distributes the entire ration to the cattle groups, guaranteeing the animals' health and the quality of their milk. The automatic waterer system is so user-friendly and effective, it is used by various farming activities. In this system, water is automatically poured into the bowl via a pressure-controlled line. The bowl's level is regulated by a float-controlled valve. Some common water systems include; electrically heated, low energy and alternate energy. This system helps reduce the cost of crop production. Cactus plants are outspread in Rajasthan and southern areas of UP (Singh et al., 2016). The Cactus chopper system helps chop cactus plants and makes farming easy. Reproductive performance in both beef cow/calf and dairy operations can be improved by properly identifying and managing animals to carry out proactive reproductive programs. The reproductive performance system helps keep track of data that makes it possible to calculate key herd indices, like the percentage of cattle pregnancy rates, death rates, rate of corgid mortality bulls' capacity for reproduction etc. The nutritional requirements and cost-effectiveness of various classes of production animals are the main content of the reproductive performance system (Kiresur et al., 2017; Gujar et al., 2017; Tanti et al., 2022). Reproductive performance programs can be improved in both the beef cow /calf and the dairy operation by correctly identifying and managing animals (Bayan & Dutta, 2017). Barn environment control technologies are designed to provide farmers and producers with the information they need to optimize their farming system and improve the overall performance of their animals (Thakur et al., 2016; Akila & Chander, 2016). Cattle live in the starting point of animal production, and their sensitivity to the environment around them is affected by many factors. The latest technologies use sensors to collect data, which can then be analyzed to better understand system interactions and construct control systems (Mooventhan et al., 2017; Mathur et al., 2012; Kurup, 2001). Barn environment control automation can use a wide range of sensors, including temperature and humidity sensors, air velocity sensors, carbon dioxide sensors, ammonia sensors, light sensors, etc. The authors of this study have found all the above technologies useful to discuss in the context of different factors of technology adoption in the livestock farming sector of India.

Objective of Study:

Keeping in view the importance of innovative technology for livestock farming and sustainable agriculture, this study tries to find out various factors that can affect cattle farmers to adopt new technologies and pave the path to a more sustainable future for agriculture.

Research Methodology:

Research Participants & Area of Study

The research participants of this study were small farmers of Western Uttar Pradesh and Eastern Rajasthan of India. Further, in Western Uttar Pradesh- Meerut, Bijnor, Shahjahanpur, Bulandshahr, Muzaffarnagar, Ghaziabad, Baghpat, Saharanpur, Shamli, Hapur, Moradabad and in Eastern Rajasthan- Sawai Madhopur, Tonk, Chittorgarh, Bharatpur, Bundi and Kota districts were selected for the study. These states were chosen for the study due to their high concentration of rural residents, scarce natural resources and low levels of economic activity. In addition to the lack of natural resources (i.e. arable land, water), many small farmers rely mainly on barley and livestock for their family's livelihood. Sheep fattening is also a profitable business. People in these states rely heavily on income from agriculture and farming. According to Basic Animal Husbandry Statistics 2023, Uttar Pradesh produced the highest quantity of milk in the country at more than 36 million metric tons in the financial year 2023, followed by Rajasthan. In the same fiscal year, the country produced over 230 million metric tons of milk. In 2022–2023, Uttar Pradesh accounted for 15.72% of the total milk produced in the country from collected cattle milk. In this financial year, Rajasthan accounted for 47.98% of the total wool production in the country While Uttar Pradesh accounted for 12.20% of the total meat production in the country (Gulati & Juneja, 2023; Krishnamoorthy et al., 2023). Only rural areas and small farmers, having not more than seven acres of land and who were actively engaged in livestock activities included in the study.

Innovative & Advanced Livestock Technologies:

In this study, authors have selected eight innovative livestock technologies: Milking automation, Cactus chopper, Reproductive performances, Automatic-waterer, Feeding automation, Reproductive performances, Barn environment control and Improved barley varieties. These innovative technologies have been undertaken by the Indian government under different development projects to help small farmers in different states of India. Over the past ten years, various national development projects have also been established to promote innovative technologies and for the green and white revolution in rural areas of India.

Data Collection and Sample Size:

Data from 270 farmers who were selected at random from rural regions in the Indian states of Rajasthan and Uttar Pradesh was gathered using a random stratified sampling of cattle, sheep, buffalo, and goats. The sampled farmers included 135 adopters (i.e. farmers who adopted the new technologies) and 135 non-ads (i.e., farmers who did not adopt the technologies). Table 1 shows the sample size and the distribution of farmers based on technology and location. The small farmers who were willing to participate in this research work were included. Before the survey launch, the questionnaire was tested in the intended areas. The authors tried to improve the field survey and make some adjustments after pre-testing. The authors conducted in-person interviews to get the data. The gathered information was double-checked and confirmed. After that, the data was cross-referenced and coded. Microsoft Excel and the Statistical Package for Social Sciences (SPSS) were used to analyze the data. The questionnaires used to collect the data covered the following areas: The socioeconomic circumstances of farmers, natural capital, flock size, credit availability, community involvement, awareness of emerging technologies, attitudes toward technology adoption, and attitudes toward technology transfer strategies etc.

Table 1: Location-wise Sample Distribution

Type of Farmers	Technologies Used	N (number of formers)
Farmers adopted the new technologies	Milking automation	28
	Cactus chopper	13
	Reproductive performances	21
	Automatic-waterer	24
	Feeding automation	25
	Improved barley varieties	11
	Barn environment control	13
Farmers did not adopt the new technologies	No technology used	135

Source: Authors collection from Farmers

Binary Logistic Regression: Discussion about variables and hypothesis

The objective of this survey was to better understand farmers' perspectives on technology use and the factors that influence farmers' use and adoption of technologies. Numerous socioeconomic, institutional and socio-demographic factors affect how farmers use technologies (Table 2). The model's seven explanatory variables represent the variables that are considered to influence the adoption and diffusion of innovative technologies in the research domain.

Empirical studies have demonstrated that an individual's adoption of innovation is influenced by economic, organizational, and policy factors in addition to personal beliefs. Within this framework, authors have determined the factors that significantly influence an individual's adoption and diffusion of information technology in their target area, based on thorough descriptive statistics. Among these variables are:

Table 2: Numerous socioeconomic, institutional and socio-demographic factors

Variables	Concept	Authors
Live-Stock Experience (LEXP)	It's a numerical variable, which means it's a measure of average experience in the dairy business. It's generally interpreted negatively. Young livestock owners tend to be open to innovation, while more experienced ones are more traditional and tend to be less open to new technologies. Experienced livestock owners are more likely to adopt traditional methods of farming. They are not comfortable with new technologies.	Göncü & Güngör, (2018); Dhraief et al., (2019)
Age	It's a numerical variable. It was suggested that there would be an inverse relationship between age and propensity to adopt precision agriculture technologies. When new technologies are introduced (in agriculture or elsewhere), the conventional wisdom is that younger generations adopt them first, and older generations usually adopt them later.	Göncü & Güngör, (2018)
Active-labor force size (ALF)	It is a numerical variable. It's a measure of the active workforce. The more active the workforce, the more likely it is to adopt new technologies.	Chander & Rathod, (2015); Obiero et al., (2019)
Education (Educ)	It's a variable of quality. By increasing a household's access to information and ability to adapt, education can promote the adoption of new technologies. Adoption is expected to benefit from education.	Abdul-Majid et al., (2024); Kumar, Das & Gulati, (2022)
Cash Credit Facility (CCF)	It's a variable of quality. It measures how easy it is for livestock owners to get cash credit which can help to extend new technologies. It is expected that the cash credit facility (dummy variable) will have a positive effect on the adoption of modern technologies.	Obiero et al., (2019); Kumar, Das & Gulati, (2022)
Number of cattle heads (NCH)	It is a numerical variable. This variable refers to the number of heads of cattle. Owners of large flocks of livestock are more likely to use new farming techniques.	Kumar, Das & Gulati, (2022); Chander & Rathod, (2015)
Source of Information (SOI)	It is a qualitative variable that describes where the knowledge of the technology comes from. Direct information sharing by the project manager influences livestock owners' adoption of the technology in a favorable way.	Göncü & Güngör, (2018); Dhraief et al., (2019)
Member of an Association (MOA)	It's a variable of quality. As a member of an association, livestock owners can benefit from access to up -to-date technology and more chances to adopt new technologies than they would otherwise have as small livestock owners.	Abdul-Majid et al., (2024); Kumar, Das & Gulati, (2022)
Extension Services (EXS)	This is a qualitative factor which looks at how easy it is for livestock owners to get access to extension services. It is expected that the adoption of modern technologies to be positively affected by a dummy CCF variable.	Kumar, Das & Gulati, (2022); Chander & Rathod, (2015)
Source of Income (SOIN)	It's a variable of quality. It shows whether or not the breeder's income comes exclusively from farming (farm income), or other non -farming activities (non - farming income). The adoption of modern technologies may be affected adversely or favorably by the SOI dummy.	Göncü & Güngör, (2018); Dhraief et al., (2019) ; Seth et al., (2014)

Hypothesis:

H01: There is no difference between the estimated and observed values for the dependent variable i.e., modern technology adoption by farmers in farming activities.

Demographic Profile:

Table 3 displays the demographic profile of the study participants. The demographic profile includes 68.14% younger technology adaptors whereas 31.85% technology adaptors were above age 35. 77.77% of technology adaptors were educated whereas 22.22% of adaptors were uneducated. Among farming experience, 80.74% of technology adaptors had less than 20 years of experience. 45.92% of technology adaptors had income from farm activities and 54.07% of technology adaptors participants had off-form income. The sample description, IT Adopters, and Non-Adopters are presented in three main columns of Table 2 below.

Table 3: Demographic Profile

Demographic Profile	Farmers adopted the new technologies (N:135)	Farmers did not adopt the new technologies (N: 135)
1. Age		
Between 20-35 years	92 (68.14%)	39 (28.88%)
Above 35 Years	43 (31.85%)	96 (71.11%)
2. Education		
Educated (At least primary education)	105 (77.77%)	41 (30.37%)
Uneducated (not even primary education)	30 (22.22%)	94 (69.62%)
3. Farming Experience		
Less than 20 years	109 (80.74%)	46 (34.07%)
More than 20 years	26 (19.25%)	89 (65.92%)
4. Labor force size		
Less than 5	78 (57.77%)	69 (51.11%)
More than 5	57 (42.22%)	66 (48.88%)
5. Cash Credit Facility		
Credit facility availed	61 (45.18%)	78 (57.77%)
Credit facility not availed	74 (54.81%)	57 (42.22%)
6. Number of cattle heads		
Less than 20	52 (38.51%)	88 (65.18%)
More than 20	83 (61.48%)	47 (34.81%)
7. Source of Information		
Received from Project Manager	91 (67.40%)	53 (39.25%)
From Others	44 (32.59%)	82 (60.74%)
8. Member of an Association (Farmers Association)		
Yes	82 (60.74%)	46 (34.07%)
No	53 (39.25%)	89 (65.92%)
9. Extension Services		
Available	81 (60%)	63 (46.66%)
Not Available	54 (40%)	72 (53.33%)
10. Source of Income		
Farm Income	62 (45.92%)	76 (56.29%)
Off Farm Income	73 (54.07%)	59 (43.70%)

Source: Author's collection through questionnaire

Technology Adoption Decision Criterion:

The features of the technology have a big impact on how quickly innovations are adopted. For instance, Rogers et al., (2014) identified five factors that affect how quickly an innovation is adopted: Comparative benefit, Communication, Complexity, Divisibility and Complementarity. As discussed by Dhraief et al., (2019), farmers can learn from neighbors, from nearby agricultural extension services, as well as from their experiments. In developing countries, farmers often adopt the social learning approach. Göncü & Güngör, (2018) identifies a category of adoption based on the 'innovation decision period'. The amount of time needed to complete the innovation-decision process is known as the innovation-decision period. To better understand the importance of technology attributes in the IT adoption decision, several technology attributes were chosen for this study (Table 4). The characteristics of innovative technology adopters in the target zone were evaluated using a Likert scale (1-5 range). A score of 1 indicates "strongly disagree" whereas a score of 5 indicates "strongly agree." Among farming technologies, farmers found automatic-waterer (mean: 3.66) and Reproductive performances (mean:3.46) more useful than other technologies. Further, cactus chopper technology is easy to implement, reduces risk and is affordable. Milking automation technology is also helpful in maximizing profits by reducing risks. The Table 4 shows the farmers' different scores for the innovative technologies they adopted.

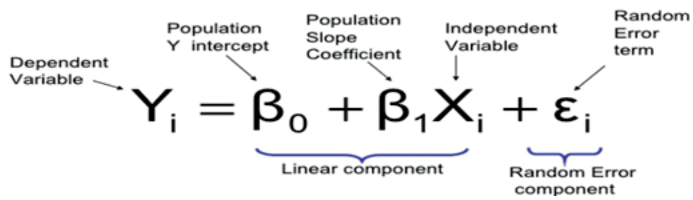
Table 4: Technology Adoption Decision Criterion

Technologies Used	Minimize production costs	Maximize profits	Divisibility	Communicability	Reduce risk	Eco-friendly	Affordable	Compatible	Easy to implement	Complex technology	Mean
Milking automation	3.4	4.0	2.7	2.3	3.6	3.2	2.8	3.1	3.2	2.9	3.12
Cactus chopper	2.8	3.1	3.1	2.8	4.1	3.8	4.2	3.9	4.6	3.7	3.61
Reproductive performances	3.2	4.2	3.6	3.8	2.7	3.5	3.4	2.8	3.6	3.8	3.46
Automatic-waterer	4.1	4.2	3.1	3.2	3.3	4.2	3.8	2.7	4.3	3.7	3.66
Feeding automation	3.4	3.2	3.1	3.9	3.2	3.3	2.7	3.8	2.6	2.4	3.16
Improved barley varieties	2.8	3.1	2.9	3.6	3.5	3.1	3.2	2.6	2.5	3.1	3.04
Barn environment control	3.3	3.4	2.8	3.5	3.6	3.1	2.5	3.7	2.9	3.2	3.20

Source: Authors' Collection

Results:

The binary logistic regression showed the importance of institutional, socio-demographic, and economic characteristics of farmers in IT adoption (Table 5). Here is the logistic regression equation:



Source: Formula proposed by Vasudev, R.(2018)

Table 5: The logistic regression parameter estimates of the variables that influence the adoption of new technologies

Factor	Beta (β)	S.E.	Wald	Significance	Exponential Beta (β)
LEXP	-0.049	.019	5.702	0.016	.951
Age	-.029	.019	2.801	0.089	.971
ALF	-0.013	.089	0.021	0.901	.991
Educ	1.802	.499	11.998	0.00	5.901
CCF	-0.129	.441	.089	.759	.881
NCH	0.121	.041	11.091	.002	1.131
SOI	1.501	.461	10.609	.001	4.459
MOA	1.015	.439	5.249	.019	2.802
EXS	1.671	.499	10.789	.002	5.291
SOIN	0.699	.409	3.051	.079	2.072
Constant	-2.399	1.229	3.901	.052	.092

(Source: Author's calculation using SPSS)

Note:

Hosmer-Lemeshow Test Result:

Chi-square: 6.599

df., 8 and Sig., 0.581;

Cox & Snell R Square, 0.451;

Nagelkerke R Square, 0.589;

The overall percentage of correct predictions, 77.98%

Discussion:

In this research work, researchers tried to find out different factors affecting farmers' farming activities. The statistical software SPSS was used to predict logistic regression coefficients using the ML (Maximum Likelihood Method). One of the most reliable methods for conciliation of logistic regression models is the Hosmer-Lemeshow statistic. Table 5 shows the model's results. About 77.98 % of the total predictions were correct. The Lemers-Hosmer Goodness of fit Test, derived from Chi-square distribution (d.f., p = 0.581), shows that the model fits the data very well. The test results of Cox & Snell R Square, (0.451) and Nagelkerke R Square (0.589) also indicate that the model is fit. This indicates that the null hypothesis, according to which there is no difference between the estimated and observed values for the dependent variable, is true. The logistic regression of the expected unit increase of the corresponding explanatory variable is called the logistic regression coefficient, or logistic beta. The logistic beta, which is the exponential of the expected value β raised to the designated value is used to compute the logistic regression.

The findings demonstrated that age (Beta: -.029; Wald: 2.801) had a statistically significant impact on IT adoption or not adoption. The negative signal of the age of household head-coefficient indicates that a household head's adoption of IT is less likely to occur as he grows older. This is in line with the literature review that found younger farmers to be more likely to adopt newer technologies than older farmers (Göncü & Güngör, 2018). The education variable (Beta: 1.802; Wald: 11.998) is statistically significant which shows a positive effect on technology adoption. This suggests that adoption rates are higher among farmers who have completed elementary education. Education plays a major role in the adoption of innovation technologies because its Wald value is high among all values at a significance level< 0.01%. This supports the literature report findings that education has a positive impact on technology adoption (Abdul-Majid et al., 2024; Kumar et al., 2022). There is no statistically significant relationship between the labour force size variable (Beta: -0.013; Wald: 0.021) and the decision to adopt IT. The reason for this is probably that farmers don't need a lot of labour, especially with mechanized technologies. At the level of 5% significance, results also indicated a significant farmer experience (Beta: -0.049; Wald: 5.702) coefficient and inversely correlated with adoption choice. This supports the idea that younger cattle owners are more inclined to adopt new technologies, while experienced farmers stick to traditional farming methods and are less inclined to adopt modern innovations (Göncü & Güngör, 2018; Dhraief et al., 2019). Off-farm income (Beta: 1.501; Wald: 10.609) plays a statistically significant role in the adoption of IT concerning farm income. Cattle ownership (Beta: 0.121; Wald: 11.091) has a statistically significant effect on IT adoption in India. With a one-unit increase of variable NCH, the likelihood of IT adoption increases by 1.131 times. At the level of significance of 10%, the extension services variable (Beta: 1.671; Wald: 10.789) also showed a significant and positive correlation with adoption choice. This indicates that when farmers can access extension services, their adoption rates increase. There was a statistically significant correlation between the association member (MOA) variable (Beta: 1.015; Wald: 5.249) and India's adoption of IT. The results also demonstrated that institutional elements like credit availability (CCF) (Beta: -0.129; Wald: .089) had no bearing on an organization's choice to implement IT. Therefore, obtaining credit presents numerous difficulties for Indian farmers. The adoption of IT in India is significantly impacted by the technology knowledge source variable (SOIN) (Beta: 0.699; Wald: 3.051). IT adoption increased when project managers provided direct access to technology information.

Conclusion:

Decision-makers in agriculture have long been troubled by the diffusion of technology, particularly in the livestock industry where productivity is still very low. In this study, the authors sought to gain a deeper understanding of the factors that influence innovation adoption in India. Education plays a major role in the adoption of innovation technologies (Beta: 1.802; Wald: 11.998; sig:0.00). This study suggests that decision-makers should pay more attention to farmers' educational backgrounds and design techniques that are suitable for better-educated farmers, which could lead to an increase in innovation adoption. The study also found that farmers who were members of an association were more likely to adopt IT. By working on a three-pronged approach farmers, researchers and policymakers this type of organization can provide its members with access to credit and information on modern technologies, as well as support the sector's development. The study found that to improve the farmers' adoption decision the project manager had to focus more on their training. One of the most significant lessons we learned is the need to focus on the younger generation of farmers when promoting new technologies. To this extent, one of the key success factors for technology adoption is working in parallel and partnering with younger farmers in the early stages and older farmers in the later stages. In addition, farmers face a lot of challenges, such as bad weather, high input costs, poor productivity, low sales, etc., which causes young people to quit farming. The government should strongly support young farmers to keep farming and then speed up the adoption of technology.

Limitation of Study:

This study has a few limitations. Firstly, the study included a sample from UP and Rajasthan states of India only, which may not be generalized to other states of India. Secondly, the study included only a few demographic categories of respondents whereas profiles like marital status, family structure etc. could also be considered in future research. Further, this research has a small sample size and questionnaire statements have their limitations. Researchers will overcome all these limitations in future research.

Practical Implication: This research indicates that improved connectivity amongst the different livestock industry stakeholders (farmers, agricultural industry, wholesalers/retailers, policymakers/consumers, etc.) is required to guarantee the best possible uptake of new technologies. The better way to reduce tech development costs while increasing the adoption of disruptive technologies might be to adopt an open innovation approach that includes all stakeholders at every stage of the idea-generation process.

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