

**DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY IN  
HARYANA: FARMERS PERSPECTIVE**



THESIS SUBMITTED TO THE  
ICAR-NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL  
(DEEMED UNIVERSITY)

IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE OF

**MASTER OF SCIENCE**

**IN**

**AGRICULTURAL EXTENSION EDUCATION**

**BY**

**LINGIREDDY HEMA VENKATA LATHA**

**B. Sc. (Hons) Agriculture**

**DIVISION OF DAIRY EXTENSION  
ICAR-NATIONAL DAIRY RESEARCH INSTITUTE  
(DEEMED UNIVERSITY)**

**KARNAL - 132001 (HARYANA), INDIA**

**2022**

**Regn. No. 20-M-DX-03**

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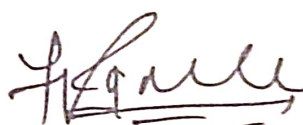
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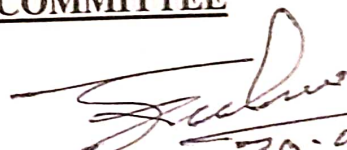
  
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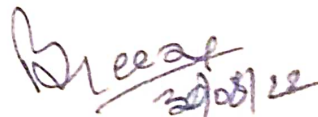
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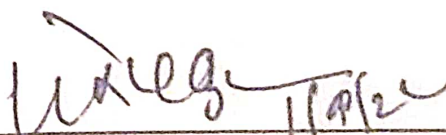
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## **CERTIFICATE**

This is to certify that the thesis entitled, “**Digital Agro-Animal Farming Technology in Haryana: Farmers Perspective**” submitted by **Ms. Lingireddy Hema Venkata Latha** towards the partial fulfilment of the requirement for the award of the degree of **Master of Science in Agricultural Extension Education** of the **ICAR-National Dairy Research Institute (Deemed University)**, Karnal (Haryana), India, is a bonafide research work carried out by her under my supervision, and no part of this thesis has been submitted for any other degree or diploma.

**Place:** Karnal  
**Dated :**

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## **ACKNOWLEDGEMENT**

*In the first place, I bow my head in reverence to God Almighty for the abundant blessing that he has bestowed upon me. It is a pleasure to convey my gratitude to all in my humble acknowledgment.*

*Foremost, I would like to avail myself the opportunity to express my heartiest gratitude to my major advisor **Dr. H. R. Meena**, Principal Scientist, Dairy Extension Division, NDRI, Karnal for his support, guidance, encouragement, valuable suggestions and critical examination of my work, without which I wouldn't have finished my research in time.*

*I owe my special gratitude to the advisory committee members, Dr. K.S. Kadian, Head of Dairy Extension Division, Dr. B. S. Meena, Principal Scientist, Dairy Extension Division, Dr. Gunjan Bandari, Scientist, DES & M Division, Dr. Rakesh Kumar, Principal Scientist, Agronomy section, ICAR – National Dairy Research Institute, Karnal, Haryana for their valuable suggestions, helpful remarks, and supports in completion of this research study.*

*I express special acknowledgement to **Dr. M.S. Chauhan**, Director, ICAR-NDRI, Karnal for his indispensable help and providing necessary facilities for carrying out this study and financial assistance in the form of Institutional Fellowship during my programme. I am also very much thankful to all the office staff members of Division for their timely help.*

*I am also grateful to **Dr. K. S. Kadian**, **Dr. Sanjit Maiti**, **Dr. K. Ponnuswamy**, **Dr. Gopal Sankhala**, **Dr. Ritu chakraborty** and **Dr. Sanchita Garai** for their full cooperation and help during the entire period of research and my study at NDRI.*

*I am also very much thankful and indebted to all my respected seniors namely, Ditty Mam, Hridya Mam, Madhu Mam, Manju sree Mam, Khushboo Mam, Shravani Mam, Priyajoy sir, Aarthy Mam, Anil sir, Manjunath sir, Alaga Niranjan sir, Gayathri Mam, Akshith sir, Saryjeeth Mam, Manish sir, Ankit sir, Manasa Mam, Mounika Mam and Apoorva Mam who helped me when I was in need of their help.*

*Collective and individual acknowledgments are also owed to my batchmates at NDRI, Pratyusha, Jagadeesh, Abhishek, Shelly, Priya, Sruthi, Subhash, Saurabh, Pushpendra, Shubham and Bikram whose presence somehow perpetually refreshed me and was helpful and memorable. I would like to say special thanks to my friends Raviteja, Shashikala, Shilpa, Vamsi, Indrajith and Aneetta from core of my heart for their constant motivation, support and belief on me throughout the research.*

*Special mentions to my juniors Guru sri, Akhila, Sreeja, Surya, Neha, Sheetal, Sreepali, Mebom, Vinay, Swathi, Anu and Athira who helped me to go through the various processes of my work.*

*I am deeply indebted to my whole family and friends for their support and understanding me in hard situations. This is possible only because of their encouragement and belief in me. I am forever grateful to them.*

*I extend my special thanks to the respondents of Haryana who have given full cooperation and support during my research work with valuable first-hand information.*

*In spite of my modest attempt to enlist every name, I would like to pay my gratitude, if any person who has helped me in one or the other way and has not been included in this list were greatly acknowledged by me for their help.*

*Finally, I would like to thank everybody who was important to the successful realization of the thesis, as well as express the apology that I could not mention personally one by one, none of them are forgotten too.*

*Place: NDRI, Karnal*

*L.H.V. Latha*  
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## **Digital Agro-Animal Farming Technology in Haryana: Farmers Perspective**

### **Abstract**

The increasing demand for food, poor productivity, unpredictable climate, shrinking resources necessitate the change in pattern of farming. Use of digital technology could provide solutions to most of these issues. Digital farming is the complex accumulation of several technologies like computers, sensors, satellite and drone imagery packages, smartphones for information access, grouping and analysis of data. In addition to this, it uses robots and machine learning to substitute manpower. The present study was carried out purposively in Haryana state. Haryana is one of the Indian states on which government is focusing for improving digital agriculture by signing MoU's with different digital technology service providers and by establishing INDO-ISRAELI centres. The study was conducted in Haryana, out of 22 districts in the state, two districts namely Karnal and Sonapat were selected randomly. From each district, 3 blocks and from each block, 10 dairy farmers and 10 crop farmers were selected randomly and a total of 120 respondents were interviewed. The criteria for selection of respondents was dairy farmers should have at least 10 animals and crop farmers should have at least 2 acres of land and both type of respondents should be using 2 digital technologies at the time of investigation. *Perception scale* was developed to measure the farmers perception regarding digital farming technology. Data were collected through semi-structured and structured interview schedule. In case of digital agriculture technologies, majority (55.00%) of agriculture farmers used laser land leveler. While automated machineries and humidity sensors were adopted by only 10.00 percent of respondents. In case of dairy farmers, Cent percent respondents had yellow QR code tags for their animals. This was followed by adoption of Bulk milk coolers by 30.00 percent of respondents. Among digital service technologies most (99.17%) of farmers were using online resources for obtaining updates to related to crop/dairy farming. The respondents strongly agreed that digital farming technologies improves the decision-making capability of the farmer with mean value of 4.08. About 45.00 percent of the respondents agreed that digital technology aids in knowing pH, temperature, and weather information instantly. Whereas 28.33 percent of respondents strongly disagreed that digitalization in agricultural sector ensures unadulterated products. Majority (53.33%) of the respondents were having medium level of perception. It was revealed that the farmers were having low awareness on digital agriculture and animal farming technologies. It was also observed that majority of the farmers were less confident to use digital technologies. However, they are ready to learn new skills and upgrade themselves. So, necessary interventions should be taken to train the farmers and strengthen the adoption of digital farming technologies.

# हरियाणा में डिजिटल कृषि-पशु खेती प्रौद्योगिकी: किसान परिप्रेक्ष्य

## लघु सारांश

भोजन की बढ़ती मांग, खराब उत्पादकता, अप्रत्याशित जलवायु, सिकुड़ते संसाधनों के लिए खेती के नमूने में बदलाव की आवश्यकता है। डिजिटल प्रौद्योगिकी का उपयोग इन मुद्दों में से अधिकांश के समाधान प्रदान कर सकता है। डिजिटल खेती कई प्रौद्योगिकियों का जटिल संचय है जैसे कंप्यूटर, सेंसर, उपग्रह और ड्रोन इमेजरी पैकेज, सूचना पहुंच के लिए स्मार्टफोन, समूहीकरण और डेटा का विश्लेषण। इसके अलावा, यह जनशक्ति को प्रतिस्थापित करने के लिए रोबोट और मशीन सीखने की तकनीक का उपयोग करता है। ये अध्ययन हरियाणा राज्य में उद्देश्यपूर्ण रूप से किया गया है। हरियाणा उन भारतीय राज्यों में से एक है जिस पर सरकार विभिन्न डिजिटल प्रौद्योगिकी सेवा प्रदाताओं के साथ समझौता ज्ञापन पर हस्ताक्षर करके और भारत-इजरायल केंद्रों की स्थापना करके डिजिटल कृषि में सुधार के लिए ध्यान केंद्रित कर रही है। यह अध्ययन हरियाणा में किया गया था, राज्य के 22 जिलों में से, करनाल और सोनीपत नामक दो जिलों को यादृच्छिक रूप से चुना गया था। प्रत्येक जिले से, 3 ब्लॉक और प्रत्येक ब्लॉक से, 10 डेयरी किसानों और 10 फसल किसानों को यादृच्छिक रूप से चुना गया था और कुल 120 उत्तरदाताओं का साक्षात्कार किया गया था। उत्तरदाताओं के चयन के लिए मानदंड यह था कि डेयरी किसानों के पास कम से कम 10 जानवर होने चाहिए और फसल किसानों के पास कम से कम 2 एकड़ भूमि होनी चाहिए और दोनों प्रकार के उत्तरदाताओं को जांच के समय 2 डिजिटल प्रौद्योगिकियों का उपयोग कर रहे हो। डिजिटल कृषि प्रौद्योगिकी के बारे में किसानों की धारणा को मापने के लिए धारणा पैमाने को विकसित किया गया था। डेटा अर्ध-संरचित और संरचित साक्षात्कार अनुसूची के माध्यम से एकत्र किया गया था। डिजिटल कृषि प्रौद्योगिकियों के मामले में, कृषि किसानों के बहुमत (55.00%) ने लेजर लैंड लेवलर का उपयोग किया। जब कि स्वचालित मशीनरी और आर्द्रता सेंसर उत्तरदाताओं के केवल 10.00 प्रतिशत द्वारा अपनाए गए थे। डेयरी किसानों के मामले में, शत प्रतिशत उत्तरदाताओं के पास अपने जानवरों के लिए पीले क्यूआर कोड टैग थे। इसके बाद 30.00 प्रतिशत उत्तरदाताओं द्वारा बल्क मिल्क कूलर को अपनाया गया है। डिजिटल सेवा प्रौद्योगिकियों में से अधिकांश (99.17%) किसान फसल डेयरी खेती से संबंधित अपडेट प्राप्त करने के लिए ऑनलाइन संसाधनों का उपयोग करना थे। उत्तरदाताओं ने दृढ़ता से सहमति व्यक्त की कि डिजिटल कृषि प्रौद्योगिकियां 4.08 के औसत मूल्य के साथ किसान की निर्णय लेने की क्षमता में सुधार करती हैं। उत्तरदाताओं में 45.00 प्रतिशत ने सहमति व्यक्त की कि डिजिटल प्रौद्योगिकी पीएच, तापमान और मौसम की जानकारी को तुरंत जानने में मदद करती है। जबकि 28.33 प्रतिशत उत्तरदाताओं ने दृढ़ता से असहमति व्यक्त की कि कृषि क्षेत्र में डिजिटलीकरण बिना मिलावट वाले उत्पादों को सुनिश्चित कर रहे हो। उत्तरदाताओं के बहुमत (53.33%) में मध्य मस्तर की धारणा थी। मुझे पता चला था कि किसानों को डिजिटल कृषि और पशु कृषि प्रौद्योगिकियों पर कम जागरूकता थी। यह भी देखा गया कि अधिकांश किसान डिजिटल प्रौद्योगिकियों का उपयोग करने के लिए कम आश्वस्त थे। हालांकि, वे नए कौशल सीखने और खुद को अपग्रेड करने के लिए तैयार हैं। इसलिए, किसानों को प्रशिक्षित करने और डिजिटल कृषि प्रौद्योगिकियों को अपनाने को मजबूत करने के लिए आवश्यक हस्तक्षेप किए जाने चाहिए।

## CONTENTS

Chapter No.	TITLE		Page No.
<b>1.</b>	<b>INTRODUCTION</b>		<b>1-12</b>
	<b>1.1</b>	Digital agriculture	2
	<b>1.2</b>	Components of digital farming technology	2-4
	<b>1.3</b>	Benefits of digital agriculture	4-5
	<b>1.4</b>	Drawbacks of digital agriculture	5
	<b>1.5</b>	Digitalization in Indian agricultural sector	5-7
	<b>1.6</b>	Status of digital agriculture in the world	7-9
	<b>1.7</b>	Need for digital agriculture	9
	<b>1.8</b>	Importance of digital dairy farming	9
	<b>1.9</b>	Genesis – cum – statement of problem	10
	<b>1.10</b>	Justification of study	10-11
	<b>1.11</b>	Objective of the study	11
	<b>1.12</b>	Scope of the study	11
	<b>1.13</b>	Limitations of the study	11-12
	<b>1.14</b>	Presentation of the dissertation	12
<b>2.</b>	<b>REVIEW OF LITERATURE</b>		<b>13-24</b>
	<b>2.1</b>	Status of digitalisation in agricultural sector	13-18
	<b>2.2</b>	Perception towards digital agro-animal farming technology	18-21
	<b>2.3</b>	Farmers awareness about digital agro-animal farming technologies	21-24
	<b>2.4</b>	Feedback about digital agro-animal farming technology	24-29
<b>3.</b>	<b>RESEARCH METHODOLOGY</b>		<b>30-55</b>
	<b>3.1</b>	Locale of the study	30-33
	<b>3.2</b>	Research design	33-34
	<b>3.3</b>	Sampling Procedure	34-35
	<b>3.4</b>	Operationalization of variable and their measurement	36-51

	<b>3.5</b>	Data collection	51-52
	<b>3.6</b>	Statistical Tools for Data Analysis	52-55
<b>4.</b>	<b>RESULTS AND DISCUSSION</b>		<b>56-109</b>
	<b>4.1</b>	General profile of the respondents	56-73
	<b>4.2</b>	Status of digital farming technologies in the study area	74-81
	<b>4.3</b>	Perception of farmers towards digital agro-animal farming technology	82-86
	<b>4.4</b>	Awareness of farmers on digital agro-animal farming technology	86-98
	<b>4.5</b>	Feedback of farmers about digital agro-animal farming technology	98-109
<b>5.</b>	<b>SUMMARY AND CONCLUSIONS</b>		<b>110-117</b>
	<b>5.1</b>	Introduction	110-111
	<b>5.2</b>	Research Methodology	111-112
	<b>5.3</b>	Salient findings of the research	112-115
	<b>5.4</b>	Conclusion and implications from the research study	115-116
	<b>5.5</b>	Suggestions for future research	116-117
<b>6.</b>	<b>BIBLIOGRAPHY</b>		<b>i-xii</b>
<b>7.</b>	<b>APPENDICES</b>		<b>I-XV</b>

## LIST OF TABLES

Table No.	TITLE	Page No.
3.1	List of INDO-ISRAEL CoE in the Haryana state	31
3.2	Karnal district profile at a glance	32
3.3	Sonipat district profile at a glance	33
3.4	Variable and their measurement	36
3.5	List of selected statements of perception for final scale construction with their respective 't' values	50-51
4.1	Distribution of respondents based on Age	57
4.2	Distribution of respondents based on Gender	58
4.3	Distribution of respondents based on Family Type	58
4.4	Distribution of respondents based on Family Size	59
4.5	Distribution of respondents based on Education	60
4.6	Distribution of respondents based on Land holding	61
4.7	Distribution of respondents based on Herd Size	62
4.8	Distribution of respondents based on Herd Composition	62
4.9	Distribution of respondents based on Annual Income (Rs. In lakhs)	63
4.10	Distribution of respondents based on Annual expenditure (Rs. In lakhs)	64
4.11	Distribution of respondents based on Extension contact	65
4.12	Distribution of digital technologies based on their accessibility by respondents	66
4.13	Distribution of respondents based on Training received in Digital technology	67
4.14	Distribution of respondents according to their influencing factors to use Digital technology	68
4.15	Distribution of respondents based on their social media usage	69
4.16	Distribution of respondents based on source of information	71
4.17	Distribution of respondents based on their perceived benefits from Digital technology application	73

4.18	Distribution of agriculture farmers based on their adoption of digital agriculture technologies	74
4.19	Distribution of agriculture farmers based on digitalisation in agriculture sector	75
4.20	Distribution of respondents based on their average years of adoption of digital agriculture technologies	76
4.21	Distribution of respondents based on digital animal technology composition	77
4.22	Distribution of dairy farmers based on digitalisation in dairy farming	77
4.23	Distribution of respondents based on their average years of adoption of digital technologies in animal farming	78
4.24	Distribution of respondents based on digital service technology composition	79
4.25	Distribution of respondents based on digitalisation in service sector	80
4.26	Distribution of respondents based on their average years of adoption of digital service technologies	81
4.27	Distribution of respondents based on perception scale values	84-85
4.28	Distribution of respondents based on their overall perception level	86
4.29	Distribution of respondents on the basis of awareness on agronomical aspects of digital agriculture technology	88
4.30	Distribution of respondents on the basis of awareness on crop protection aspects of digital agriculture technology	89
4.31	Distribution of respondents on the basis of awareness on sowing & post harvest aspects of digital agriculture technology	89-90
4.32	Distribution of respondents on the basis of awareness on general aspects of digital agriculture technology	90
4.33	Distribution of respondents based on their overall awareness on digital agriculture technology	91
4.34	Distribution of respondents on the basis of awareness on	92

	animal health & comfort aspects of digital technology in Animal farming	
4.35	Distribution of respondents on the basis of awareness on physiological aspects of digital technology in Animal farming	93
4.36	Distribution of respondents on the basis of awareness on milking & its processing aspects of digital technology in animal farming	94
4.37	Distribution of respondents based on their overall awareness on digital technology in Animal farming	95
4.38	Distribution of respondents on the basis of awareness on digital service technology	96-97
4.39	Distribution of respondents based on their overall awareness on digital service technology	98
4.40	Distribution of respondents based on factors considered for future adoption of digital technology	99
4.41	Distribution of respondents based on the attributes of technology as perceived by farmers for adoption of digital technology	100

## **LIST OF FIGURES, MAPS AND DIAGRAMS**

<b>Figure No.</b>	<b>Title of the figure</b>	<b>Page No.</b>
1.1	Global map indicating active digital agriculture services	8
1.2	Number of active digital agriculture services used from 2009-19	8
3.1	Haryana state Map which was highlighted for selected districts	34
3.2	Sampling plan	35
4.1	Distribution of respondents based on feedback on contribution of digital technology to sustainability	101
4.2	Distribution of respondents based on feedback on the skill set of farmers to use digital technology	101
4.3	Distribution of respondents based on feedback on resources for using digital farming technology	102
4.4	Distribution of respondents based on feedback on information related to digital farming technology	103
4.5	Distribution of respondents based on feedback on comparison of digital farming and traditional farming	103
4.6	Distribution of respondents based on feedback on role of digital farming technology for agricultural sector development	104
4.7	Distribution of respondents based on feedback on role of digital farming technology on farmer work comfort	104
4.8	Distribution of respondents based on feedback on proof of economic benefits from digital farming technology	105
4.9	Distribution of respondents based on feedback on information related to purchase, rental facilities of digital farming technology	105
4.10	Distribution of respondents based on feedback on credit facility for purchase of digital farming technology	106
4.11	Distribution of respondents based on feedback on data security issues of digital farming technology	106

4.12	Distribution of respondents based on feedback on constraints of digital farming technology	107
4.13	Distribution of respondents based on their interest to learn skills related to digital farming technology	108
4.14	Distribution of respondents based on feedback on suitability of digital technology in existing pattern of farming	108
4.15	Distribution of respondents based on their confidence to use digital farming technology	109

## **LIST OF ABBREVIATION**

<b>Sl. No.</b>	<b>Abbreviation</b>	<b>Explanation</b>
1.	<b>PLFS</b>	Periodic Labour Force Survey
2.	<b>VDSA</b>	Village Dynamics Studies in South Asia
3.	<b>ICRISAT</b>	International Crops Research Institute for the Semi-Arid Tropics
4.	<b>GDP</b>	Gross Domestic Product
5.	<b>MMS</b>	Multimedia Messaging service
6.	<b>IBM</b>	International Business Machines
7.	<b>AI</b>	Artificial Intelligence
8.	<b>IoT</b>	Internet of Things
9.	<b>ISPA</b>	The Indian Space Association
10.	<b>PMGDisha</b>	Pradhan Mantri Gramin Digital Saksharta Abhiyan
11.	<b>DFI</b>	Doubling Farmers Income
12.	<b>IDEA</b>	India Digital Ecosystem for Agriculture
13.	<b>GIS</b>	Geographic Information System
14.	<b>e-NAM</b>	Electronic-National Agricultural Market
15.	<b>ICTs</b>	Information and Communication Technology
16.	<b>MoUs</b>	Memorandum of Understanding
17.	<b>NCDEX</b>	National Commodity & Derivates Exchange Limited
18.	<b>GSMA</b>	Group Special Mobile Association
19.	<b>IAMAI</b>	Internet & Mobile Association of India
20.	<b>CAGR</b>	Compound Annual Growth Rate
21.	<b>UAVs</b>	Unmanned Aerial Vehicle
22.	<b>AMS</b>	Automatic Milking Systems
23.	<b>NITI Aayog</b>	National Institution for Transforming India
24.	<b>SMS</b>	Short message service
25.	<b>GPS</b>	Global Positioning System
26.	<b>EU</b>	European Union
27.	<b>IRS</b>	Indian Remote Sensing
28.	<b>WEF</b>	World Economic Forum
29.	<b>AIC</b>	Agriculture Insurance Company
30.	<b>IMARC</b>	International Market Analysis Research and Consulting Group

31.	<b>PA</b>	Precision Agriculture
32.	<b>CoE</b>	Centres of Excellence
33.	<b>MIDH</b>	Mission for Integrated Development of Horticulture
34.	<b>KVK</b>	Krishi Vigyan Kendra
35.	<b>VEO</b>	Village Extension Officer
36.	<b>AO/VO</b>	Agricultural officer/ Veterinary officer
37.	<b>ATMA</b>	Agricultural Technology Management Agency
38.	<b>ICAR</b>	Indian Council of Agricultural Research
39.	<b>SAU</b>	State Agricultural University
40.	<b>NDRI</b>	National Dairy Research Institute
41.	<b>DFT</b>	Digital Farming Technology
42.	<b>CSRF</b>	Cumulative Square Root Frequency
43.	<b>QR code</b>	Quick Response Code
44.	<b>CIMMYT</b>	International Maize and Wheat Improvement Center
45.	<b>NDVI</b>	Normalized Difference Vegetation Index
46.	<b>CPI</b>	Critical Point of Irrigation
47.	<b>BC ratio</b>	Benefit Cost ratio
48.	<b>ROI</b>	Return on Investment

# CHAPTER -1

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## Introduction

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## INTRODUCTION

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*“If agriculture is to continue to feed the world, it needs to become more like manufacturing”- Geoffrey Carr, The Economist.*

Farming is the major occupation of India from several generations. It was revealed from 2011 census of India’s population that 70 percent is the rural population and agriculture is the main source of livelihood for 50 percent of the population. However, according to the PLFS survey of 2018-19, it was observed that there was a dramatic decrease in the prime-working age (20 – 59 years) group of Indians involved in agriculture from 40 percent in 2004-05 to 23.3 percent in 2018-19. In addition to this, the share of young adults (i.e., 20-29 years) in the agricultural workforce also drastically declined from 34 percent in 2004 – 05 to 14.4 percent in 2018 – 19. This sharp decrease in the share of the workforce in the agricultural sector resulted in a scarcity of labour which in turn resulted in rising of wages in the sector. Even, it was reported that there was less than 20 percent of the prime-age working group in rural areas of the states with largest agricultural economies like Punjab and Haryana in 2018-19. However, these states have overcome the situation and attained higher farm productivity and income by replacing the role of farm laborers with machinery in major agricultural operations.

One of the VDSA (Village Dynamics Studies in South Asia) research studies at ICRISAT (2015) revealed that Indian farmers are struggling to pay higher wages to the agricultural laborers who are still working in the sector. These challenges of the declining workforce in the agricultural sector can be overcome by following technology-oriented farming which will reduce the requirement for laborers. Hi-tech farming also attracts and retains the younger generation in the agricultural sector.

In addition to the decreasing workforce share over the years, Indian agriculture is also witnessing a decline in the contribution of the agricultural sector towards the national GDP from 34 percent in 1983-84 to 16 percent in 2018-19. The decline in GDP contribution of the sector may be due to factors like bad weather, efficiency gaps, pest and disease infestation, market price fluctuations, productivity losses over agriculture value chains, and other operational challenges etc. Digital technology could be a game changer by providing solution to these issues by ensuring efficient use of resources, rapid decision-making, MMS based weather alerts that would enhance productivity and

sustainability in the agricultural sector. The efficiency gaps were due to lack of accurate and instant information on weather, market facilities, existing prices, improved crop production and protection practices etc. Digital service technologies like online resources, mobile apps etc. can assist in overcoming these hurdles. It was observed that over use of chemicals was increasing cultivation costs and also imposes negative impact on environment which could be overcome by precision farming technology or drones.

### **1.1. DIGITAL AGRICULTURE**

Digital agriculture refers to use of tools that collect, store, analyze, and share electronic data and/or information along the agricultural value chain digitally. According to the United Nations project breakthrough, Digital agriculture is the use of advanced technologies which are integrated into one system, to enable farmers and other stakeholders within the agriculture value chain to improve food production. The College of Agriculture, Purdue University defined it as the use of digital devices to gather, process, and analyze spatial (object) or temporal (time) data which can guide targeted actions to boost efficiency and sustainability in agriculture.

Digital farming is the complex accumulation of systems, drivers, and associations of the evolving digital technologies in agriculture. This assemblage includes the use of computers, sensors, satellite positioning, and imaging software package for farm management, robots, and machine learning to substitute manpower and smartphones for information access, grouping, and analysis of data.

Digital Agro-animal Farming Technology is an umbrella of several technologies that use digital devices for gathering, processing, analyzing & transmitting information which aids in improved decision-making and efficient farm management.

### **1.2. COMPONENTS OF DIGITAL FARMING TECHNOLOGY**

#### **Cloud computing/big data analysis tools**

Big-data analytics is a type of advanced analytics with complex applications that use predictive models and statistical algorithms. Rainfall patterns, fertilizer requirements etc. can be assessed using big data technology. Whereas cloud computing is the technology which delivers faster and flexible computing services from servers, databases, software, storage and analytic systems over internet. Here, the term “cloud” represents internet. This technology can be used for obtaining collective information from sensors, satellites and weather stations etc.

## **Machine learning and Artificial intelligence**

According to IBM, “Machine learning is a branch of artificial intelligence and computer science which focuses on using data, statistical models and algorithms for learning and adapting the way humans interpret from patterns in data”. Artificial intelligence is the assemblage of different technologies that work simultaneously to enable machines to mimic humans in terms of sensing, understanding, and discovering things. Machine learning and natural language processing are all part of the AI backdrop. These technologies can be installed in sensor systems for automated decision making. Driverless tractors, AI-based irrigation systems are some of the applications in agricultural sector.

## **Internet of Things**

Internet of Things (IoT) can be described as the network of physical objects/things that are fixed with sensors, software, and other technologies with the intention of connecting and exchanging data among various devices over the internet. IoT aids in tracking animal health, soil moisture, water level in a dam using sensors remotely.

## **Digital communication technologies**

These are digital tools that allow two or more people to communicate with one another. This communication can be verbal, visual, written, or audible type. These tools provide updates on market prices, weather alerts, improved production practices and price forecasts etc.

## **Precision agriculture technologies**

According to *ISPA* “Precision Agriculture is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for resource use efficiency, productivity, quality, profitability and sustainability of agricultural production.”

## **Sensor systems**

These help in providing data to farmers that help in monitoring crops as well as adapting to changing environmental factors. The different sensors applicable in agriculture are soil moisture sensor, pH sensor, humidity sensor, soil Ec sensor and crop

## *Introduction*

sensor etc. Whereas in animal farming heartbeat sensor, biosensor, heat detection sensors are available.

### **Satellite and drone imagery techniques**

Aerial and satellite images are 2 types of images that are taken from a certain point above the ground, but satellite images normally cover a much wider area and therefore have larger scientific purposes. Whereas aerial images are taken at lower altitudes and thus cover a small amount of area. Aerial images in agricultural sector are usually taken using drones. The drones can monitor crop and animal health. Besides monitoring, drones can be used for chemical application on agricultural crops.

### **Automated machinery and agricultural robots**

Agricultural robots are specialized items of technology that can assist farmers with a wide range of operations. They can analyze, contemplate, and carry out a multitude of functions, and they can be programmed to grow and evolve to match the needs of various tasks. Whereas automated machinery operates based on certain commands and simplifies human tasks. Laser land levellor, automated processing machines, automated sprayers etc. can simplify agricultural operations and also reduces labour requirement in agricultural sector.

### **Blockchain technologies**

Blockchain is a mutual, unchangeable ledger that enables the process of recording transactions and tracking assets in a business network. An *asset* can be tangible (like a house, land, cash, etc) or intangible (like intellectual property, copyrights, patents, etc). Almost everything of value can be tracked and traded on a blockchain set-up. Risk mitigation, transparency over agri value-chain are the added advantages from the use of blockchain technology.

Digital farming technologies can be the future of farming as it has several benefits which was mentioned below

### **1.3. BENEFITS OF DIGITAL AGRICULTURE**

Digital agriculture technology can aid in better farm management and decision making. It also ensures precise application of chemicals, water etc. Thereby it promotes productivity and efficiency in agriculture. The components of digital farming technology like sensors, IoT devices enable real time monitoring of the farm. The sensors related to

dairy farming detects animal physiological changes, animal under heat and thus it enables the dairy farmer in planning Artificial insemination etc. Marketing facilities, price alerts, updates on government services etc. can be obtained from online resources like agri portals, apps etc. The digital technologies like cloud computing, big data technology aids in storing of large volumes of data and drawing inferences from them for decision making. Some of the digital farming technologies like automated machinery, IoT devices etc. improves farmers work comfort, saves time and reduces regulatory burden. Artificial intelligence-based MMS services can provide weather alerts to farmers. The digital technology ensures risk mitigation, efficiency in farm operations by giving rapid and precise information.

In spite of several applications of digital farming technology, the global adoption of these technologies was still at growing stage only because of following challenges faced by farmers.

#### **1.4. DRAWBACKS OF DIGITAL AGRICULTURE**

The challenges for digitalizing agricultural sector are requirement of high initial investment and technical knowledge. High fuel and power costs may also prohibit the adoption of digital farming technology. In addition to this, requirement of proficiency to handle those machineries may hinder the adoption. Fragmented land holdings and e-illiteracy among farmers were major constraints for digitalizing agricultural sector in India. Apart from these, lack of institutional support, poor repair and technical assistance from companies, poor internet facility and low credit availability to purchase the equipment could be considered as the roadblocks for digitalisation in agricultural sector. In addition to these, low awareness on these technologies could be considered as one of the major factors hindering the wide spread adoption of these technologies.

#### **1.5. DIGITALIZATION IN INDIAN AGRICULTURAL SECTOR**

To address the above-mentioned drawbacks as well as to promote e-literacy, the Prime Minister of India, Shri. Narendra Modi launched the DIGITAL INDIA program in July 2015. The strategy of this program is to link rural areas with high-speed internet facilities and to increase e-literacy. It also ensures accessibility of Government services to the citizens through improved internet facilities. It has three core components: the

## *Introduction*

development of secure and stable digital infrastructure, digital delivery of government services, and making citizens digitally literate.

The government of India has undertaken an initiative named **PMGDisha** (Pradhan Mantri Gramin Digital Saksharta Abhiyan) under the Digital India scheme. The main aim of this initiative is to make 6 crore people across rural India, digitally literate.

### **Digital India program and Agricultural sector**

The Digital India scheme is making an impact on Indian agriculture by ensuring better market prices by creating a network among farmers, traders, and consumers which would help in reducing intermediate costs and increasing profits. Farmers can avail location-specific updates, or real time information on prevailing market prices, rainfall variability, price fluctuations and weather alerts via internet. The increased connectivity also enables farmers in getting customized advices on crop production, protection and animal health etc. It will simplify the financial transactions by enabling direct cash transfer. Digital India program has provided the privilege of online payments by the improved digital infrastructure. This would aid in increased agricultural efficiency and decreased farmers' debt load. Apart from this, the farmers are obtaining information or training on several aspects via social media platforms. Thus, it has simplified the procedure for obtaining the knowledge on crop production and dairy farming aspects.

Over the years, the Government of India has taken significant steps to support the agriculture sector with proven farming technologies and helpful policies. The current progress of digital technology in farming will further hasten agricultural growth by ensuring higher production and enhancing sustainability by reducing water consumption and the use of agrochemicals. Indian Agritech sector is currently valued at US\$ 370 billion (Bain & Company). Thus, the sector is expected to witness radical transformation shortly because of supportive government strategies and technological developments.

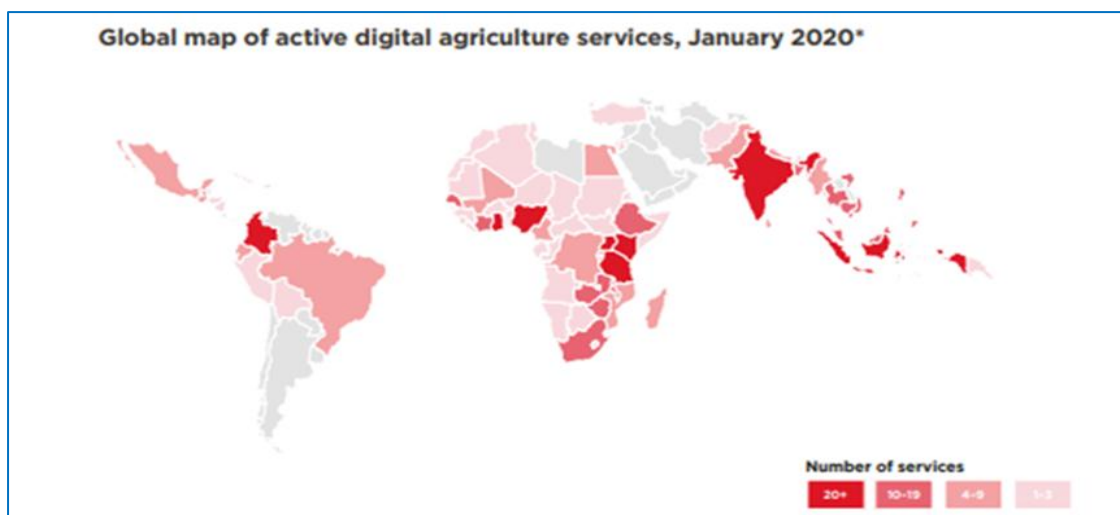
Information Technology Division of the Department of Agriculture & Farmers Welfare is reoriented to Digital Agriculture Division with recommendations from the Doubling Farmers Income (DFI) Committee. This Division is engaged in developing "Agristack", a combined database by assembling information of the farmers from various databases available with the Government and further linking them with land

records. It also creates a Farmer Identification number, to uniquely identify them. The division is also trying to create “The India Digital Ecosystem for Agriculture” (IDEA). This ecosystem intends to promote free digital technologies by placing farmers at the center of agro-ecology. It also enables the Government to effectively plan for Farmer’s income. In September 2021, the Union Minister of Agriculture & Farmers Welfare, GoI, Mr. Narendra Singh Tomar, has announced initiation of the Digital Agriculture Mission 2021–2025. The Digital Agriculture Mission 2021–2025 aims to support and accelerate the adoption of new technologies like AI, blockchain, remote sensing, GIS, drones, and robots in farming. The government has also taken initiatives like creation of online trading platform for agricultural commodities like e-NAM, operation of National Optical Fibre Network (BharatNet), increasing internet connectivity among rural areas by Bharat Nirman scheme, promotion of ICTs, mobile applications for transfer of agricultural technology and several e-governance efforts etc.

In addition to these government is focusing on digitalizing agricultural sector by highlighting the use of Drones for the assessment of crops, digitalization of land records, chemical spray, etc. The Government has planned to provide subsidies to farmers for promoting the use of Drones and it is also signing MoUs with various leading technology service providers like Esri India, Agribazaar, Patanjali organic research institute, Jio Digital life, ITC Limited, NCDEX, CISCO, Amazon, Microsoft, Ninjacart for promoting the digitalization in the agricultural sector. These companies provide services to farmers on direct marketing via online platforms, creation of agricultural field maps as well as soil analysis that aid in variable rate fertilizer application, yield estimation etc.

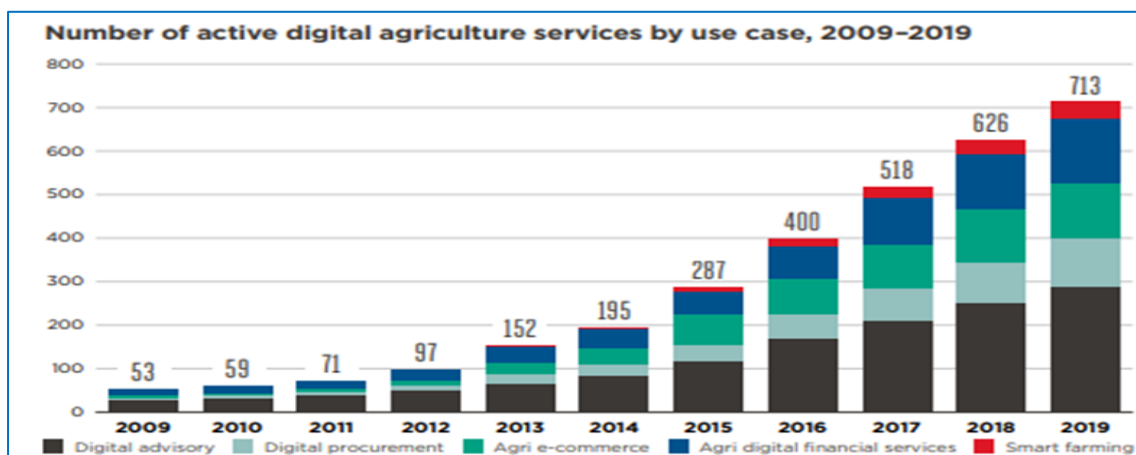
## **1.6. STATUS OF DIGITAL AGRICULTURE IN THE WORLD**

The Asia-pacific region is the highest digital agriculture market in the world. The use of digital technologies in agriculture and allied sectors is increasing steeply since 2018 as internet access is increasing even in rural areas. The global map below illustrates the number of digital agricultural services country-wise whose range of technologies is depicted with various shades of red. Darker shades depict the countries which use more than 20 digital technology services. India is one of the countries which uses more than 68 services.



**Figure 1.1: Global map indicating active digital agriculture services**  
 (Source: GSMA digital agriculture maps,2020-21)

Globally, the number of digital agriculture services is on an increasing trend since 2009. Among all digital agriculture services, digital advisory services take first place in terms of usage whereas digital financial services take second place. However, smart farming alone stands last.



**Figure 1.2: Number of active digital agriculture services used from 2009-19**  
 (Source: GSMA digital agriculture maps,2020-21)

The 2020 report of the Internet and Mobile Association of India - IAMAI Kantar I-cube revealed that there were 622 million internet users in 2020 which is expected to rise to 900 million active users of the Internet by 2025, recording a growth of about 45 percent in the following five years. The urban internet users grew by 4 percent (reaching 323 million users, i.e.,67 percent of the urban population) in 2020, whereas it increased

by 13 percent in rural India reaching 299 million internet users (31 percent of the rural population) compared to 2019.

### **1.7. NEED FOR DIGITAL AGRICULTURE**

The global population is estimated to be 9.6 billion by 2050. This would lead to a substantial increase in food demand, but arable land and freshwater resources are diminishing swiftly. Therefore, it becomes important to upscale, update, and modify the agriculture sector. Digital technology could be the solution to this problem. With Industry 4.0, the Internet of Things (IoT), Artificial Intelligence (AI), and Nano Technology are gaining importance. Digital technology not only helps in farming operations but also facilitates post-harvest processes that include pricing, storage, transportation, logistics, and marketing by increasing transparency in agri value chain and by providing timely information. It also ensures the efficient and sustainable use of resources by sensing nutrient content in various locations of field. While attempts to digitalize Indian agriculture have commenced, the acceptance of digital technology remains in a budding phase as of now.

### **1.8. IMPORTANCE OF DIGITAL DAIRY FARMING**

According to the “World Dairy Situation report, 2019” milk productivity in the USA is the highest in the world i.e., 10,500 kg per cow as against 1,715 kg per cow in India which is the second-lowest in the world. Improving productivity is one of the major responsibilities for increasing the income of dairy farmers. Besides the poor productivity, dairy farmers are facing many difficulties in herd management, and less supply of farm labour. With these constraints and challenges, digital dairy farming technology serves as a game-changer through which a dairy farmer can increase productivity and efficiency by using smart monitoring of the herd for preventing diseases, detection of health issues, smart milk production, etc. Cattle management is one of the crucial areas where digitalization can have a meaningful influence. By using the Internet of Things and sensors, farmers can monitor cattle’s health and track their feeding patterns. This will increase productivity and yields. The digitalization of dairy farms has a wide range of applications like cattle health monitoring, milk procurement, quality assessment, supply chain management, etc. In addition to these, digital technology provides solution to the negative impacts of climate change on dairy farming via web platforms, mobile apps etc.

## **1.9. GENESIS – CUM – STATEMENT OF PROBLEM**

With the increasing population, the demand for food and dairy products is increasing. On the other side, resources such as land, water, and resources are diminishing. So, in this context to feed the growing population, the farming and scientific community have to change the way of doing cultivation and animal rearing. Some parts of the world have already been using innovative technologies like precision agriculture, sensors, ICTs, drones, etc, and are reaping benefits. These technologies help in saving time, labour efforts, efficient use of resources, monitoring, quality assessment, food safety, etc. The global Digital Agriculture Market size is assessed to be 5131.9 million USD in 2020 and projected to reach 10587.6 million USD by 2027 with a CAGR of 10.9% over the estimated period (Brandessence Market Research). Labour shortages, increased farm mechanization, and the development of digital agriculture infrastructure are expected to increase the adoption of digital technologies in the agricultural sector. Suppose Indian farmers can be inspired and empowered to apply advanced tools, and offer them need-based critical support. In that case, India can renovate itself from a traditional farming system to a hi-tech farming system despite all the challenges in the Indian agricultural sector. In such a situation, the profitability of the Indian agricultural sector will shoot up. With digitalization, the farming practices too will become effective and efficient and can meet the growing quality preferences of consumers towards Agriculture and dairy products. Despite the above-mentioned utilities of digital agro and dairy farming, Indian farming condition is at the nascent stage of digitalization. This study is going to focus on the following aspects.

- a) What are the digital farming technologies being used in the study area?
- b) What is the perception of farmers towards digital agro-animal farming technologies?
- c) What is the level of awareness of farmers regarding digital agro-animal farming technologies?
- d) What is the response of farmers towards digital agro-animal farming technologies?

## **1.10. JUSTIFICATION OF STUDY**

- 1) The demand for agriculture and dairy products is on an increasing trend.

- 2) Global and India's population is estimated to rise. So, to feed them production should be increased.
- 3) Available resources are on a diminishing trend. Thus, they should be used efficiently.
- 4) Recent pandemic situation has strengthened the importance of digitalization.
- 5) The contemporary knowledge and infrastructure available favour digitalization.
- 6) Digital connectivity is also on an increasing trend for over a decade.
- 7) Start-up environment is also on-trend in the country. Thus, this favours the accessibility of infrastructure and services.

#### **1.11. OBJECTIVE OF THE STUDY**

1. To document the digital farming technologies in the study area.
2. To measure the perception of farmers towards digital agro-animal farming technology.
3. To assess awareness of farmers on digital agro-animal farming technology.
4. To obtain the feedback of farmers about digital agro-animal farming technology.

#### **1.12. SCOPE OF THE STUDY**

As the focus on the implementation of technology in agriculture and dairy farming is growing, this study helps policymakers, researchers, companies, and other stakeholders of agriculture and allied sectors in understanding the status of digital technology in the agricultural sector and also gives insights into farmers perceptions and knowledge towards digital agro-animal technologies. This study will also be exploring the challenges and opportunities of digital farming in India.

#### **1.13. LIMITATIONS OF THE STUDY**

1. Universality and generalization cannot be claimed since the study was conducted in a particular area due to the limitations of time and other resources.
2. As the data collected mostly depend on the memory of the respondents, the accuracy of the same cannot be ensured. However, the researcher made a possible effort to ensure that the data collected were to the best of the knowledge of the respondents, bearing minimal distortion.

3. Like other social science/extension research, the findings are based on the ability and honesty of respondents to recall and express their opinions. Hence, complete freedom from individual biases and prejudices cannot be called for.
4. Although care had been taken to include all the relevant variables for the study, still the possibility of missing some important variables cannot be ruled out. However, it is hoped that this study would provide a better insight to understand the different digital farming technologies adopted by farmers.
5. Utmost effort had been taken to develop/build rapport with the respondents; still, full support cannot be claimed. Even then, proper care and considerate thought had been exercised in making the study, empirically as systematically as possible.

#### **1.14. PRESENTATION OF THE DISSERTATION**

This thesis has been presented in five chapters. The first one is, “**INTRODUCTION**” providing background information, genesis-cum-statement of the research problem along with the scope and limitations of the investigation. Chapter two encompasses “**REVIEW OF LITERATURE**” which provides an overall outlook of the similar types of research carried out in the past. The third is “**RESEARCH METHODOLOGY**” which describes the sampling procedure, research design, variables used, and their measuring techniques along with statistical tools used for analysis. In the fourth chapter “**RESULT AND DISCUSSION**”, the findings of the study along with thorough explanations have been presented. The last chapter “**SUMMARY AND CONCLUSION**” depicts the interpretation and inferences drawn from the study. In the end, “**BIBLIOGRAPHY**” and “**ANNEXURE**” has been given.

# **CHAPTER -2**

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## **Review of Literature**

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## REVIEW OF LITERATURE

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A comprehensive understanding of the area being researched is prerequisite for a researcher and channelize one's efforts in achieving the defined objectives. Literature review helps the researcher to frame the initial focus of the study, analysis of study, generate thematic area and provide deeper understanding of the theme, says Marsick and Watkins (1997).

Keeping in view of the objectives, the review of literature has been presented under following sub heads:

- 2.1 Status of digitalisation in agricultural sector
- 2.2 Perception towards digital agro-animal farming technology
- 2.3 Farmers awareness about digital agro-animal farming technologies
- 2.4 Feedback about digital agro-animal farming technology

### **2.1 DIGITALISATION IN AGRICULTURAL SECTOR**

Digital farming is related to the use of technology not only in cultivation but also in whole value-chain till the produce reaches customers. Due to changing consumer preferences, growing population, depleting resources and so on, digitalization of agriculture is considered as the obvious solution. There is also a growing interest in the topic of digital agriculture within the policy circles, including the socio-economic elements of digitalization, and this has also resulted in several policymaker and practitioner-oriented publications.

Shamshiri, et al (2019) conducted a study on "Use cases of Digital Agriculture" in Dubai and reported that technologies and uses of Digital Agriculture technologies such as Sensor-based field mapping, Wireless crop monitoring, Climate monitoring and forecasting, Wireless equipment monitoring, Predictive analytics for crop and livestock, Livestock tracking and Geo-referencing, Smart logistic and warehousing were used by the respondents. Ampatzidis et al., (2020) conducted a study in USA on new technologies applicable in Agriculture and stated that Digital agriculture involves cloud computing, big data, blockchain, deep learning, Internet of Things (IoT), mobile

## *Review of Literature*

applications and artificial intelligence. It is also found that Cloud computing aids in the adoption of UAVs by simplifying the data processing and visualization procedures.

Cavallo et al., (2014) in a study conducted in Italy on role of farm size on adoption of technological innovations and found that digital innovations were mostly confined to large farms even though they increase comfort and safety. Fuller et al., (2020) in a study related to Digital twin in United Kingdom stated that there were over 1,600 digital farming start-ups globally and these start-ups deals with a diversity of products for agronomic data collection, farm management, financial operations, and other applications. Bronson and Knezevic (2019) conducted a study on digital divide issues in Canada and concluded that the market for smart farming technologies is bifurcated between large, commodity farms whose managers are adopting these tools, and smaller-scale, unconventional growers who are not adopting at an equal rate.

Steenefeld and Hogeveen (2015) conducted a study on Dutch dairy farms using sensor systems for cow management. They observed that among 512 dairy farms surveyed, 202 farms indicated that they had sensor systems and 310 farms indicated that they did not have sensor systems. A wide variety of sensor systems was used on Dutch dairy farms; those for mastitis detection and oestrus detection were the most-used sensor systems. The sensor systems were used based on the type of milking system (conventional or automatic) in farm. Van der Tol and van der Kamp (2010) in *Proceedings of the first North American conference precision dairy management* stated that in Netherlands and other northwest European countries, the demand for sensors was increasing due to raise in use of automatic milking systems (AMS). As a milker is not present during the automatic milking process to judge the udder and milk for abnormalities, AMS include sensors for the detection of mastitis.

NITI Aayog (2021) in its report on Artificial intelligence revealed that to achieve 4 percent or higher growth rate of agriculture, digitization is critically important which includes use of technology like sensor-assisted soil assessment, automated monitoring of free-ranging animals on pastures and the targeted control of agricultural machinery and modern farming methods which enable the management of spatial and temporal variability within plots of land.

Crookston (2006) on a paper titled “A top 10 list of developments and issues impacting crop management and ecology during the past 50 years” unveiled that

precision farming is one of the advanced innovations in agriculture. Timmermann et al., (2003) conducted a study on site-specific weed control and revealed that sensor-based management of herbicides and other pesticides is another promising implementation of Precision agriculture and it was also found that use of sensors will increase savings. Bramley and Ouzman (2019) on a study related to Australian farmers usage of sensors and automation unveiled that farm size had no significant impact on whether a consultant was used for obtaining crop advice and analysis of sensor information. 84 percent of respondents were from larger farms (> 2500 ha) and 74 percent were from smaller farms (< 2500 ha) use a consultant. Thus, there is no significant difference between large and small farms for use of consultant service.

Bronson and Knezevic (2016) in a study on “Big Data in food and agriculture” in Canada found that smart farming and big data are becoming buzz words in agribusiness and Big Data is assured to duplicate long-standing relationships between food system players like between farmers and corporations, or between organic and conventional farmers.

Baumüller (2018) conducted a study in Germany on utility of digital agro-advisory services to small-holder farmers and revealed that new digital agro-advisory services consist of SMS-based market information services, call centres for specific farm advice, enabling of farmer-to-farmer knowledge sharing via participatory video, or decision support systems executed as smartphone apps. Microsoft (2017) in a study conducted in collaboration with ICRISAT in Andhra Pradesh, India reported that Farmers are using AI (Artificial Intelligence) based advisories for obtaining timely information and it was observed that average crop yield of Andhra Pradesh farmers was increased by 30 percent due to timely advice.

In 2018, Karnataka government had implanted GPS-enabled digital chips in the ears of 56 lakh animals across the state to track their health, early diagnosis of medical condition and prevent them from slaughter. (India times, November 15,2018)

In a study on Dairy automation conducted by Meena, et al., (2020) revealed the data on automation/ mechanization in dairy animal milking and it was observed that majority (48.66%) of the commercial farm uses Bucket milking machine and 35.33 percent have milking parlour.

## *Review of Literature*

Lee and Choudhury (2017) in a study on IoT impact on farming found that IoT can help to get real-time information and it was also specified that Collar units and ear tags provide insights into animal behavior, herd location, walking time, grazing time, resting time and water consumption and it was also found that in recent years there has been an increasing interest in autonomous UAVs usage and their applications including recognition and surveillance, geolocalization, search and rescue, forest fire detection etc. Meola (2016) in a study related to technologies which are future of agriculture has found that there are several IoT applications in farming like collecting data on temperature, rainfall, humidity, wind speed, pest infestation, and soil content which can be used to automate farming techniques, taking informed decisions to improve quality and quantity, minimizing risk and waste, and reducing the effort and it was revealed that the installation of IoT devices is rising at a compounded annual growth rate of 20 per cent worldwide.

Corsini et al. (2015) in a survey on expected crop farming scenario by 2030, identified that 60 percent of farmers from EU countries (France, Germany, Poland, and the UK) were in favour of adopting precision farming. Chatterjee (2020) in a study related to IoT in India revealed that in India there were, 40 start-ups which were dealing with agricultural IoT which makes the accessibility of tools and infrastructure to farmers.

Sharma and Panigrahy (2007, September) in *Proceedings of Remote Sensing and Photogrammetry Annual Conference* revealed that Apple orchards of Shimla district of Himachal Pradesh were mapped using high resolution remote sensing data from most advance Indian Remote Sensing (IRS) satellite P6 to develop a systematic management plan for orchards. They stated that Geospatial technology determines horticultural crop yield, quantifies and schedules precise and proper fertilizer, irrigation needs, estimate number of fruits on individual trees, fruit quality, leaf area index or crown cover and application of pesticides for pest and disease management as well. Thus, these mapped images aid in gathering and updating information to user.

Ahirwar et al. (2019) studied application of drone technology in agriculture and unveiled that in the next few years, nearly 80 percent of the agricultural market will comprise of drones. Sharma (2018) reported in a news article in Business standard that Maharashtra state government signed a partnership with the World Economic Forum (WEF) Centre for the Fourth Industrial Revolution for exploring the use of drones to improve irrigation systems in agricultural field by estimating soil conditions, crop yield

prediction, crop disease, pest management, unpredictable seasonal variations etc. Sally (2015) stated in Economic Times that Agriculture Insurance Company (AIC), India along with Skynet has carried out few pilot investigations in Gujarat and Rajasthan to evaluate UAV viability for farm survey and crop monitoring. It was found that Remote sensing through unmanned aerial vehicles allows non-destructive sampling to observe agronomic indicators every square metre. Thus, research is being done in various parts of India on applicability of digital technology in Indian conditions.

Mulla and Khosla (2016) conducted a study on evolution and recent advances in precision farming, North America and revealed that digital farming technologies originated in 1980's with rise in precision farming and there was accelerated adoption of it, due to factors like accessibility of loans, entrepreneurship etc., till early 2000's and later the adoption was slowed down. Balafoutis et. al., (2017) on Precision agriculture technologies contribution and economies in USA and Canada stated that in the past decade, adoption of digital farming technologies grew alongside the advances of robotics, the decreasing costs of sensor technology, and the computing capabilities for collecting and analyzing massive volumes of data and therefore, influence of digital technologies and big data in the food system continues to rise.

IMARC Group in an analysis in 2020 on global precision agriculture market revealed that it reached a value of US\$ 6.7 Billion, and it was expected that the market will reach a value of US\$11.9 Billion by 2026. Borghi., et al (2016) conducted a study related to adoption of precision farming in Brazil and concluded that huge percentage of farmers in Brazil are willing to implement more composite and innovative technologies, such as sensor systems, to extend provision in planting and fertilizer application at different rates (67%), analysis, and compilation of different databases in agriculture (78%) and it was also found that 22 percent of the farmers at the time of study had been using Precision farming technologies for more than 8 years.

Reichardt et al., (2009) in a study related to dissemination of precision farming in Germany identified that about 11 percent of the interviewed farmers used Precision Farming. Majority of them used data collection techniques such as GPS-based area measurement and soil sampling rather than variable rate application techniques such as site-specific sowing and fertilising and it was revealed that most of the farmers interviewed believe that the dissemination of Precision Farming in Germany would increase in the future. The main reasons mentioned by farmers were the increasing

economic pressure on farmers as well as more environmental constraints and increased requirements for complete documentation. Due to this, they also thought that the demand for technologies like Precision Farming would increase in the future.

## **2.2 PERCEPTION TOWARDS DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY**

Perception is the method by which we try to understand the world around us. It is the process by which individuals coordinate and infer their sensory impressions to give meaning to their environment.

Carolan (2017) on a study on perception of producers & consumers on digital farming technologies in USA used case study approach and concluded that increase or decrease of farmers' dependency on smart/digital farming technology could depend on how and what are the perceived barriers to adoption of producers and consumers towards smart/digital Farming Technology.

Verbeke et al., (2007) reported consumers behaviour on food safety and risk information in Belgium found that public perceptions of both risks and benefits connected with technological innovation processes are vital for the future approval of a technology or product. Takács and Baranyai (2010) in a study related to cooperation of farmers for mechanization in Hungaria revealed that the attitude of farmers towards community mechanization is unfavourable and most of the Hungarian farmers want to possess their own machinery and if they do not have the required capital for investing, they are in the intention to give up the idea of using or adopting the technology. Thus, ownership of machinery was perceived as an important attribute for the adoption.

Barnes et al., (2019) studied on influential factors related to precision farming technologies on farmers growing wheat, potato, and cotton in five European countries and revealed that Farmers indicate that costs of Agriculture 4.0 technologies can be prohibitive to adopt technologies and it was found that 29 percent of farmers are in favour of using technology if cost was reduced.

Bramley and Ouzman (2019) on attitude of Australian farmers towards sensors and automation revealed that Eighty seven percent of growers who have been farming for less than 10 years intend to use sensors as a part of their farm practice compared to 65 percent of growers who have been farming for more than 20 years; those who have farmed for between 10 and 20 years were intermediate between the other groups in their

intention to use sensors. It was assumed that those who have been taking farming as an occupation for less than 10 years are the youngest group of respondents. Thus, younger farmers are perceiving sensor technology as useful and they are also expecting that noteworthy changes in agricultural systems can be brought because of the merging of new digital technologies, including, for example, actual monitoring through sensors, big data, the Internet of Things, machine learning and cloud computing.

Lee and Choudhury (2017) in a study related to IoT in agriculture in United States stated that majority of the small holder farmers perceive new technologies to be favourable/ beneficial only if they receive grants and it was also found that if they were not aware of grants, they were not ready to uptake new technology. The results shown a positive relationship between trust and perceived value and a negative relationship between trust and perceived risk. Perceived value and perceived risk had positive and negative impact on IoT adoption respectively.

Fraune et al, (2019) in a conference on human-robot interaction stated that humans tend to be afraid of those technologies, as they are perceived to cause competition between humans and robots, computers for employment and other essential resources.

Lioutas et al., (2019) in a study related to big data in farming in Greece found that farmers have less capacity to deal with complex data and thus they do not perceive the need of accurate data.

Chaudhary (2019) studied on Perception of farmers on Precision farming technologies in India and revealed that majority of the user farmers had high to moderate perceptual level towards precision farming technologies. Whereas planners and non-users were having moderate to high and low to moderate perceptual level, respectively. Keskin et al., (2016) conducted a study related to precision farming technologies in Turkey and found that small farmers are unable to devote in innovative technologies due to income factor and when a training brochure was handed out to each participant and the PA technologies were explained, 97.6 percent of the participants expressed that these technologies would be somehow beneficial for agriculture in Turkey and 88.4% of the participants wanted to get more detailed training on these technologies.

Kudari (2014) in a study on Perception of North Karnataka farmers on precision farming found that relative advantage was perceived as important by 80.26 percent of the

## *Review of Literature*

farmers, increase in yield as an important aspect was perceived by 68.42 percent of the farmers. The findings with respect to relative advantage indicated that majority of the farmers strongly agree that precision farming practices suits for all types of soils (77.63%). With respect to complexity attribute, majority of the farmers strongly agree that precision farming practices are difficult to adopt (75%). Regarding trialability attribute, majority of farmers strongly agree that precision farming practices can be tried on all types of soils (76.32%). In case of observability attribute, majority of the farmers strongly agree with saving or optimum utilization of chemical fertilizers (68.42%) and grid wise increase in yield can be observed (64.47%).

Lubell et al (2011) in a study related to perceived benefits and costs of sustainable agricultural practices, found that consumers are willing to accept innovative Precision Farming technologies when the perceived personal benefits outweigh the perceived risks. Adrian et al., (2005) conducted a study related to perceptions and attitudes of producers in USA towards precision farming technologies and revealed that perception of net benefit, farmer educational levels, confidence towards technology usage and farm size influenced the intention to adopt precision agriculture technologies in a positive manner.

Napier et al., (2000) in a study on adoption of precision farming in mid-west watersheds in Ohio, Minnesota and Iowa exposed that farmers perception towards returns on conservation investments was important and farmers who perceive precision farming technologies contribute significantly to these aspects were likely to adopt it. Tey and Brindal, (2012) on a study on factors influencing farmers adoption of precision farming technology in Australia found that the cost of precision farming is one of the most prevalent perceived barriers to adoption. Reichardt et al., (2009) in a study related to dissemination of precision farming in Germany stated that lack of training and technical support was perceived as constraints to uptake precision agricultural technologies. Fleming et al., (2018) in a study related to “Perception of Australian farmers on big data” stated that the experiences and perceptions of farmers are essential to understanding the digital agricultural revolution and its implications.

Meena, et al, (2020) in a study related to Dairy automation in India found that majority of the farmers consider benefit cost ratio as the most important factor prior to the purchase of dairy automation/ mechanisation / equipment followed by total investment cost, and it was concluded that about half of the respondents (54.44%) were

having a high perceptual level followed by moderate perceptual level (35.56%) towards dairy automation/ mechanisation.

Bewley et al., (2015) stated that high cost-to-benefit ratio limits the use of innovative technology by 42%, while 7% of surveyed farmers considered compatibility with other technologies as a problem.

Skevas and Kalaitzandonakes (2020) studied on Farmer perceptions and adoption of unmanned aerial vehicles (UAV's) at Missouri, USA and unveiled that 83 percent of the respondents did not perceive that the use of UAVs can reduce farm input costs while 65 percent of them did not perceive UAVs can reduce the environmental footprint of farming. A large majority of respondents were uncertain about the initial costs of acquiring UAVs, the knowledge required to operate them, the assistance needed to process and interpret the data collected through UAVs, and the ease of turning them into agronomic solutions for their farm. The perception of farmers on high cost and limited efficiency of drones inhibits the tendency to adopt UAVs. About 40 percent of the farmers stated they were worried about potential privacy concerns their neighbours' might harbour over the use of UAVs on their farm.

### **2.3 FARMERS AWARENESS ABOUT DIGITAL AGRO-ANIMAL FARMING TECHNOLOGIES**

Awareness about digital agro-animal farming technology is the state of being conscious of existence and other aspects related to digitalisation in agricultural sector.

Wilson (2014) on a review related to community resilience stated that developing an awareness of the digital trends and their consequences can help agricultural stakeholders and policymakers to foresee, and therefore turn toward or away from, transition pathways that are desirable. Sorensen et al., (2010) conducted a study on future farm management information system in Europe and reported that farmers who are using digital technologies should have to obtain, assess, and examine a mass of information from many unrelated sources to make economic decisions.

Knierim et al, (2017) conducted a study related to agricultural service providers in Europe and stated that digitalization demands service providers to have awareness on diversified and specialized services. Viatte (2001) in a workshop on adopting technologies for sustainable farming systems unveiled that crop, fruits and vegetable

## *Review of Literature*

grower farmers were more aware of these modern technologies as compared to dairy farmers.

Vecchio et al, (2020) on a study related to adoption of Precision Farming tools by Italian farmers revealed that information requirements, interaction processes etc., differ from farmer to farmer and it also varies between different stakeholders. Thus, resulting in heterogeneous information needs. Barnes et al., (2019) studied on enabling factors for adoption of precision farming by farmers found that farmers' interactions with, and access to, digital agriculture differs significantly depending on multiple farm, farmer, and wider enabling factors. Therefore, it can be concluded that need of awareness towards digital technologies varies from individual to individual.

Griffin and Yeager (2019) on research conducted at Kansas state, USA on “how speed farmers adopt technologies?” revealed that the awareness and capacities needed to operate different digital farming technology influences the farmers adoption rates. Farmers adopt technologies that need less technical skills on their part.

Ashby (2016) on study related to smarter farmers in London stated that farmers who were using smart agricultural technology must be aware of skills like technology usage, digital literacy, agricultural standard, marketing skill, and smart agriculture practice.

In a study conducted by Skevas and Kalaitzandonakes (2020) on Farmers awareness on unmanned aerial vehicles (UAVs) at Missouri, USA revealed that more than 75 percent of the respondents were aware that UAVs can be used to evaluate plant health and monitor disease or insect outbreaks. 56 percent and 62 percent respondents respectively were aware that UAVs can be used to apply agrochemicals or monitor plant hydration and nutrient uptake. Almost half of the participants were aware of all four UAV agricultural applications included in the survey, while 18 percent had never heard of any of these UAV applications.

Reichardt et al., (2009) in a study related to dissemination of Precision farming in Germany observed that Roughly 50 percent of the interviewed farmers were aware about Precision Farming. The results indicated that many farmers did not even know what Precision Farming meant and to promote awareness of Precision Farming among farmers, information and teaching materials which can be adapted to the relevant educational levels of farmers were developed and tried out at training events. Keskin et

al., (2016) in a study related to Precision farming technologies in Turkey found that 51.8 percent of all participants indicated that they did not hear the term 'Precision Agriculture' before. Only 29.3 percent of the participants who heard the term 'Precision Agriculture' knew its concept. Whereas Internet was considered as one of the important sources to obtain information on new technologies. Most three well-known technologies by all participants were satellite positioning (GPS) (81.7%), geographical information systems (GIS) (69.5%) and remote sensing (61.0%) and the least known two ones were variable rate application (33.5%) and soil sampling and mapping (34.8%).

Bramley and Ouzman (2019) on a study related to Australian farmers awareness towards sensors and automation identified that 57 percent respondents believe that they need to develop significant new skills and knowledge to use new Sensors or Precision Agriculture technologies. On the other hand, 43 percent did not see the need of such skills/knowledge.

Duncan and Fraser (2018) reviewed on smart farming and precision agriculture in Canada and revealed that the integration of digital technology into existing farm machinery requires flexibility, familiarity with computers and newer technology and it was found that there was a growing demand for education and capacity building support for farmers. Eastwood et. al, (2019) on a study on socio-ethical implications of smart farming in New Zealand specified that individual agricultural knowledge providers must be aware of and need new skills for using technology and for linking data which aids in better decision making on farm. Whereas it was observed that data analysis skills, digital literacy, were fundamental for agricultural knowledge providers to educate on digital agro-advisory services. Chaudhary and Meena, (2019) studied on Perception of farmers on Precision farming technologies in India and found that majority of the user farmers had high to medium level of awareness about precision farming technologies whereas, planner and non-user farmers were having medium to high and low to medium level of awareness, respectively.

Bewley et al., (2015) on Precision Dairy Monitoring opportunities reported that use of innovative technology will be affected by lack of familiarity with the available technologies affects the 55% of the adoption of those technologies.

Khateeb and Ahmed Abdulteef (2017) on a study related to ICT literacy and digital competence in Saudi Arabia found that service providers must be aware of and have knowledge on digital literacy.

## **2.4 FEEDBACK ABOUT DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY**

Feedback about digital agro-animal farming technology is the response obtained regarding the technology.

Berckmans (2014) in a study conducted on “Precision Livestock Farming” in Belgium revealed that Digital Agro-animal technologies offer significant opportunities for achieving a more universal, evidence-based study in supervising the health and welfare of farm animals and thereby enhances the productivity of livestock. Kamilaris et al., (2017) on a study related to “Big Data analysis” in Spain found that opportunities from digital agriculture includes expansion of digital platforms to estimate the demand and supply of high-quality products and processes, providing suitable advice to farmers, developing tools for yield, demand forecasts and it was concluded that taking up digital agriculture requires large amounts of data, which demands agricultural data science.

Chatterjee, (2020) on a study related to IoT in smart cities of India revealed that the main challenges in India are the lack of awareness about IoT technology among the farmers and the lack of usage of a high-level technology-based machinery. Chaudhary (2019) on a study on Precision farming technologies in India disclosed that the high yield obtained with precision farming technologies and non-availability of skilled labour was the major pull and push factor for adoption of precision farming technologies respectively. Bronson and Knezevic (2019) studied on Digital divide issues in Canada and stated that Challenges of digital technology include lack of policy interferences, unregulated technological change and the power imbalances that could hinder the integration of societal issues.

Zhang et al., (2020) in a study related to IoT in Australia revealed that farmers are insecure physical requirements for equipment, about data safety and they are very skeptical in sharing their data. Anderson, (2020) in a study related to Agricultural extension policy in USA unveiled that the use of digital equipment by agricultural extension agencies and farmers to interact easily represents a advance in service delivery. Robertson et al., (2018) on a study related to Digital agriculture identified that the use of

smart farming approaches enables efficient learning which will eventually improve knowledge about an individual enterprise and results in sharing data from multiple enterprises. Weersink et al., (2018) on opportunities and challenges for Big data in agriculture stated that the digital agricultural revolution is being driven by the less cost in collecting data on soil conditions, animal health and crop development along with easy accessibility of weather station data and data collected by drones and satellites. The Big data technologies enables production of more food, on less land, with fewer inputs and a smaller environmental impact. However, barriers include lack of ability to aggregate, interpret data and the need to train farmers in how to use new tools. It is also understood that the difficulty in constructing, maintaining, analyzing, and sharing the data limits the opportunity to derive effective decision rules with high information value to producers. Rose and Chilvers, (2018) in a study conducted in UK related to Smart farming stated that digital farming could improve the condition of the agri-food sector by alleviating the labour burden, replacing jobs that cannot be filled.

Pivoto et al., (2018) conducted a study on Smart farming applications in Brazil and found that digital farming reduces environmental impacts, and it could also support the viability of farming despite the effects of climate change. Ferris and Rahman, (2016) on a study related to “Responsible data in Agriculture” in USA observed that open data may harm particularly vulnerable populations such as indigenous people or migrant farmers as they don’t have any land rights, thereby collection of their data may harm their existence. Driessen and Heutinck, (2015) in a study related to Milking robots and the co-evolution of ethics and technology on Dutch dairy farms reported that due to the robots there was reorientation in the daily work of dairy farmers and thus there was radical change that makes some farmers feel like an ‘intern’ at their own farm.

Maru et al., (2018) in a study related to “Digital and data driven agriculture” and its impact on small farmers found that there was no certainty that poor will be benefitted from commercially developed applications, those recommendations done based on data were not always well-suited to the needs of small farms, indeed there was a significant risk that they will be further marginalized and disadvantaged as the last in line to benefit from the data revolution. Therefore, it was suggested that the data should be viewed in a collective manner to support the needs of the community.

Wolfert et al., (2017) on review of big data in Netherlands found that big data is supposed to cause major shifts in roles and power relations among traditional and non-

## *Review of Literature*

traditional players. It was also stated that digital agriculture improved decision-making capabilities of farmers that were causing radical changes in farm management. Aker et al., (2016) on a study related to promise and pitfalls of ICT for agriculture initiatives revealed that even though ICT's have potential to provide timely and low-cost information to the farmers and traders, the service providers should focus on issues like high quality information provision, digital divide, making information better understandable. ICT pitfalls were also stated as the farmers were frequently suffered from a lack of feedback mechanisms and mismatches with farmers' information needs, their technological capabilities and habits, timing of information delivery, or insufficient trust in information sources.

Trendov et al., (2019) in a study on Digital technologies in agriculture and rural areas stated that Digital agriculture could lead to greater food security, profitability, and sustainability. Carolan, (2020) in a study related to Automated Agri food futures in USA concluded that, digital farming will reinforce rigorous, industrial modes of production and farm consolidation, wearing down farmer autonomy. Jakku et al., (2019) in a study related to Australian farmers issues on data security stated that trust and transparency are key concerns for farmers which increases uncertainty in adoption. Eastwood et al., (2019) conducted a study on socio-ethical implications of Smart farming in New Zealand and reported that Digital farming will change the skills and capacities needed to farm, which may also change labour requirements of agriculture sector and concluded that it will increase the dependency on agricultural companies. Rose et al., (2021) in a study related to Applicability of Agriculture 4.0 in UK stated that digital technologies will increase sustainability of farming and it also changes the labour role.

Mark et al. (2016) in a study related to role of wireless band connectivity on agricultural industry in USA and Australia identified that internet connectivity was a major constraint for digitalisation. Miller et al. (2017), on a study on adoption path of precision farming technologies in Kansas (USA), found that farms which had either adopted no, or several PA technologies were "steadfast" in their view of technology adoption, whereas intermediate adopters were more flexible. Baumüller (2018) on a study in Germany related to utility of Digital agro-advisory services to small-holder farmers revealed that Mobile technologies could help to advance service delivery to smallholder farmers and found that farmers would be benefited through improvements in information provision regarding production planning, management of weather-related

risks, and greater ease in receiving money. Eastwood et al., (2012) on a study related to Precision dairy farms in Australia stated that digitalization may change the culture of farming from 'hands-on' and experience driven management to a data-driven approach.

Budaev et al., (2019) on a study related to Smart farming systems revealed that Smart systems have the capability to execute autonomous actions which will in turn reduce the labour and time burden. Shepherd et al., (2020) in a study related to hurdles of digital agriculture unveiled that there was a perceived risk of increasing reliance on technical experts and the technology which results in a loss of tacit knowledge if the cognitive processing of information is delegated to machines or algorithms. Fountas et al., (2020) in a study related to digital agriculture stated that farm management and information systems require a user-centric approach for better adoption and usage. Rotz et al., (2019) on politics of digital agriculture unveiled that digital technologies reduces need for human labour and affect rural employment and rural-urban migration. Liakos et al., (2018) on a review on machine learning in agriculture stated that digital agriculture is the use of hi-tech computer systems to compute various parameters such as weed recognition, yield prediction, assessment of crop quality and several machine learning techniques.

Ruder (2019) in a study related to Perception of Ontario Grain farmers towards Digital agriculture and noted the narration of both proponents and critics of digital farming as follows: Proponents argue that digital farming will improve efficiency, productivity, and profits for farmers and addresses food system challenges, including food security for a swiftly growing world population. Critics are worried about the allocation of risks and benefits, especially between farmers and corporations, as well as the possible unfavourable effects for justice, quality of life, and the environment. Balafoutis et al., (2017) on a study related to Precision farming technologies revealed that Proponents of digital farming make claims that new technologies and big data will help farmers and solve food system challenges, including food insecurity. Carbonell (2016) in a study related to ethics of Big data in agriculture reported that Critics raise concerns for impacts of digital farming on business power, data access, agricultural labour, and sustainability.

Wolfert et al., (2017) in a study related to Big data in farming reported that the development of big data and digital technologies give rise to a new model of agriculture i.e., digital farming, establishing more precise and data-driven agriculture as a probable

## *Review of Literature*

solution to complex problems in the agri-food system and digitalization of farms is considered as a promising technological ‘fix’ for a wide range of societal problems, such as the provision of food for the growing world population, environmental protection and ensuring safe food products due to increased traceability and transparency. Bronson and Knezevic (2016) on a study related to Big data in agriculture revealed that beyond technological change, digital farming is a continuing social, cultural, political, and ecological transformation, perhaps even driving a “digital agricultural revolution” like previous revolutions in agriculture. Garnett (2013) on a study related to food sustainability stated that Proponent’s frame digital farming as a solution to food system challenges. According to the United Nations Food and Agriculture Organization, Digital innovation in agriculture is considered as a great opportunity to eradicate poverty and hunger and lessen the effects of climate change. Jasanoff (2016) on ethics of invention stated that as the profits of technological innovation for quality of life and productivity are undeniable, so too are the effects, risks, and adjustments.

Prager et al., (2016) on impact of commercialisation on Farm advisory services stated that various digital technologies will remain to improve the ability of existing agricultural advisory services to provide value to clients in even more accurate and efficient ways. Dawkins (2016) on a review related to animal welfare and efficient farming stated that digitalization in agriculture is expected to provide technical optimization of agricultural production systems, value chains and food systems. Besides, it has been claimed that it may help address societal worries around farming, including traceability of food animal welfare in livestock industries. Bronson (2018) on smart farming stated that Agriculture 4.0 is considered to benefit large scale, technology intensive and specialized farms following a conventional agricultural and food system. Guerra, (2017) on IoT in Agriculture revealed that digital agriculture allows farmers to lessen human errors in spraying insecticides, reduce overlaps and skips in managing crop rows and reduce machinery costs also. Lencsés et al., (2013) on investment possibilities of Precision farming technologies in Hungary stated that Advantages of the smart farming technology are the following: augmented yields, improved quality of produce, increased income, decreased use of chemicals and thereby reduced impact on environment. Whereas the disadvantages of the smart farming technology are the increase of operational costs.

Kamphuis et al., (2012) in a study related to Field evaluation of collar-mounted activity meters for detecting cows in oestrus found that there is an expected improvement in disease and oestrus detection which can be a reason to invest in sensor systems. Studies indicated that sensor systems detect approximately 80 to 85 percent of the cows in oestrus whereas the average farmer detects approximately 55 percent of the cows in oestrus.

Yang, et al., (2016) on a study related to mechanization and precision farming found that the next generation of farmers should satisfy requirements for the use of smart agricultural development because trained farmers are the foundation of Smart Agricultural development. Takács-György (2012) on economic aspects of Precision farming technologies stated that for the producer, the technology-driven farming can be a tool for reducing the production risk. According to Klerkx et al., (2019) digitalization can transform market contributions, business procedures, or models using digital technologies. It may also lead to changes in subject-matter delivered and expected of agricultural experts and might cause intra-organisational changes. Rotz et al., (2019) on politics of digital farming reported that the effect of digitalization on farmers self-sufficiency, include concerns about farmers becoming data labourers. Leone (2017) on food architecture unveiled that the traceability and transparency of the production process in Digitalized farms, not only allows to enhance and guarantee food safety, but it also enables to give personalized and context-sensitive dietary recommendations. Trendov et al., (2019) in a status report on digital agriculture stated that implementing these smart technology changes will require governments to increasingly strengthen rural infrastructure and promote the development of rural communities.

# CHAPTER –3

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## Research Methodology

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## RESEARCH METHODOLOGY

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Research Methodology is the systematic investigation, theoretical analysis of the methods applied to a field of study. It deals with scientific techniques, systematic research procedures and operationalization of different concepts and variables according to the objectives of the research study. Research methodology not only talk of the research methods but also consider the logic behind the methods we use in the context of our research study and explain why we ae using a particular method or technique and why we are not using others so that research results are capable of being evaluated either by the researcher himself or by others. It further helps in interpretation of the research findings. In this chapter, the details of various aspects of research methodology are presented under the following sub-heads:

- 3.1. Locale of the study
  - 3.1.1. Description of the study area (Haryana)
  - 3.1.2. Brief description of the Karnal district
  - 3.1.3. Brief description of the Sonipat district
- 3.2. Research design
- 3.3. Sampling procedure
  - 3.3.1. Selection of districts
  - 3.3.2. Selection of blocks
  - 3.3.3. Selection of respondents
- 3.4. Operationalization of variable and their measurement
- 3.5. Data collection
- 3.6. Statistical tools for data analysis

### **3.1. LOCALE OF THE STUDY**

Agricultural sector is the backbone of Indian economy and among all the states, Punjab, Haryana, and Western Uttar Pradesh play a vital role in the production and productivity of Agricultural commodities. The present study was conducted in the Haryana state which was selected purposively due to the following reasons:

1. Haryana is one of the states on which government is focussing by promoting digital agriculture by collaborating with tech companies.

2. Government also established INDO-ISRAEL CoE for promoting advanced agriculture technologies.
3. One of the largest Agriculture economies which had higher agricultural mechanization and lower work force. This might cause tendency to adopt digital agricultural technology.

### **3.1.1. BRIEF DESCRIPTION OF HARYANA STATE**

Haryana is one of the top agricultural producers in India. It is between 27°39' to 30°35' N latitude and between 74°28' to 77°36' E longitude. The total geographical area of the state is 4.42 m ha, which is 1.4 percent of the geographical area of the country. The altitude of Haryana varies between 700 and 3600 ft above sea level. It came into existence on 1<sup>st</sup> November 1996 as a newly carved out of Punjab state based on language. Haryana has 6 administrative divisions, 22 districts, 72 sub-divisions, 140 community development blocks, 154 cities and towns, 7,356 villages, and 6,222 villages panchayats. As per the Aadhar Statistics the Haryana population in 2021-2022 is 27,388,008 (27.39 million) as compared to 25,353,081 inhabitants during last census in 2011. Chandigarh is the capital city of the state. Haryana has emerged as a forefront progressive state in India and set a glaring example of planned economic development. It is the second largest contributor to the national food grain pool of wheat, rice, coarse cereals, and pulses. There are two agro-climatic zones in Haryana. During winter, temperature gets as cool as 4-5 Degree Celsius. Haryana is also blessed with some of the best breeds of cattle and buffaloes in the country. The state is well known for the native tract of world famous “Black Gold” (Murrah buffalo) and “Hariana” (Cattle) for their excellence in milk production and dual character respectively. According to 20<sup>th</sup> livestock census, total livestock population of Haryana is 7.04 million. Haryana alone have 4 out of 29 Centre of Excellence institutes in India. The mandate of CoE is transfer of advanced technologies in their respective area.

**Table 3.1: List of INDO-ISRAEL CoE in the Haryana state**

State	CoE
Haryana (4)	Vegetables, Karnal
	Fruits, Mangiana
	Mango, Ladwa
	Beekeeping Ram Nagar

*(Source: Indo-Israel MIDH)*

### 3.1.2. BRIEF DESCRIPTION OF KARNAL DISTRICT

Karnal is one of the historical districts of Haryana state. It is one of the oldest districts in Haryana state, existing since the inception of 1<sup>st</sup> November 1966. The district is located between 29°09'50" to 29°50' north latitudes and between 76°31'15" and 77°12'45" east longitudes. The district's headquarters is the Karnal city. Divided into two sub-divisions, the district has an area of 2,520 square kilometres and a population of 1,505,324 (2011 census). The district is divided into 4 sub-divisions i.e., Karnal, Indri, Assandh, and Gharaunda. The above 4 sub-divisions are divided into 5 revenue tehsils namely, Karnal, Indri, Nilokheri, Gharaunda & Assandh and 3 sub-tehsils namely Nigdhu, Nissing and Ballah.

**Table 3.2: Karnal district profile at a glance (Haryana)**

Particulars	No./Unit/ %
Total population	1,505,324
Male	797,712
Female	707,612
Area sq.km.	2520
Density/km <sup>2</sup>	600
Sex Ratio (Per 100)	887
Average Literacy (%)	74.73
Total cultivators	101,588
Total agricultural labour	82,915
No.of. blocks	8

(Source: Directorate of Census Operations, 2011 Haryana)

### 3.1.2. BRIEF DESCRIPTION OF SONIPAT DISTRICT

The district is named after its administrative headquarters, Sonipat. Sonipat was earlier known as *Sonprastha*, which later became *Swarnprastha* (Golden City), which is derived from two Sanskrit words, *Svarna* (Gold) and *Prastha* (Place). This district was carved out of the erstwhile Rohtak district on 22 December 1972. The district comprises three sub-divisions: Ganaur, Sonipat, and Gohana. They are further divided into four

tehsils: Ganaur, Sonipat, Kharkhoda and Gohana. The tehsils of Kharkhoda and Sonipat fall under jurisdiction of Sonipat subdivision, while tehsils of Ganaur and Gohana fall under the jurisdiction of their respective sub-divisions. These are further divided into seven blocks: Ganaur, Sonipat, Rai, Kharkhoda, Gohana, Kathura and Mundlana. The district comprises 343 villages, out of which 15 are uninhabited. Over most of the district, the soil is fine loam of rich colour. However, some areas have sandy soil and others Kallor. A much smaller part of the district is covered with soil consisting of sand or sandy loam. Parts of this region have high pH values leading to Kallor land.

**Table 3.3: Sonipat district profile at a glance (Haryana)**

Particulars	No./Unit/ %
Total population	1,450,001
Male	781,299
Female	668,702
Area sq.km.	2,260
Density/km <sup>2</sup>	640
Sex Ratio (Per 100)	937
Average Literacy (%)	73.71
Total cultivators	110,262
Total agricultural labour	54,040
No.of. blocks	8

*(Source: Directorate of Census Operations, 2011 Haryana)*

### **3.2. RESEARCH DESIGN**

According to Gay and Airasian (2000) a design is general strategy for conducting a research study and it involve nature of the hypothesis, the variables used and the constraints of the “real world” as factors for selection of research design. The research design refers to the overall strategy that you choose to integrate different components of the study in a coherent and logical way, thereby, ensuring you will effectively address the research problem; it constitutes the blueprint for the collection, measurement and analysis of data. The Exploratory research design was used in the

present study. The major purpose of exploratory studies is identification of problems, discovery of ideas and gain insights into the situation. This type of research design is flexible in nature. Due to its flexible nature, non-probability sampling methods can be used.



Figure No: 3.1: Haryana state Map which was highlighted for selected districts

### 3.3. SAMPLING PROCEDURE

#### 3.3.1. SELECTION OF DISTRICTS

Haryana state consists of 22 districts. Out of the 22 districts, two districts namely Karnal and Sonipat were randomly selected for the study.

### 3.3.2. SELECTION OF BLOCKS

From each district, three blocks were randomly selected. The three blocks that were selected from Karnal district were Karnal, Gharaunda and Nilokheri. While Sonipat, Kharkhoda and Mundlana blocks were selected from Sonipat district.

### 3.3.3. SELECTION OF RESPONDENTS

For the study, two types of respondents were selected i.e., crop growers and dairy animal rearers. The respondents for the current study were also selected randomly. The criteria for selection of respondents are that the dairy farmers should have at least 10 dairy animals and agriculture farmers should have at least 2 acres of land. The respondents who were selected as particular category i.e., dairy and agriculture farmers should be using at least 2 digital technologies at the time of investigation. Sampling frame includes list of farmers from the selected blocks who were adopting at least 2 digital technologies. This list was obtained from State agriculture and veterinary department, KVK etc. From this sampling frame, the 10 dairy farmers and 10 agriculture farmers were randomly selected. Thus, from each block, 20 respondents were selected, and total sample size was 120.

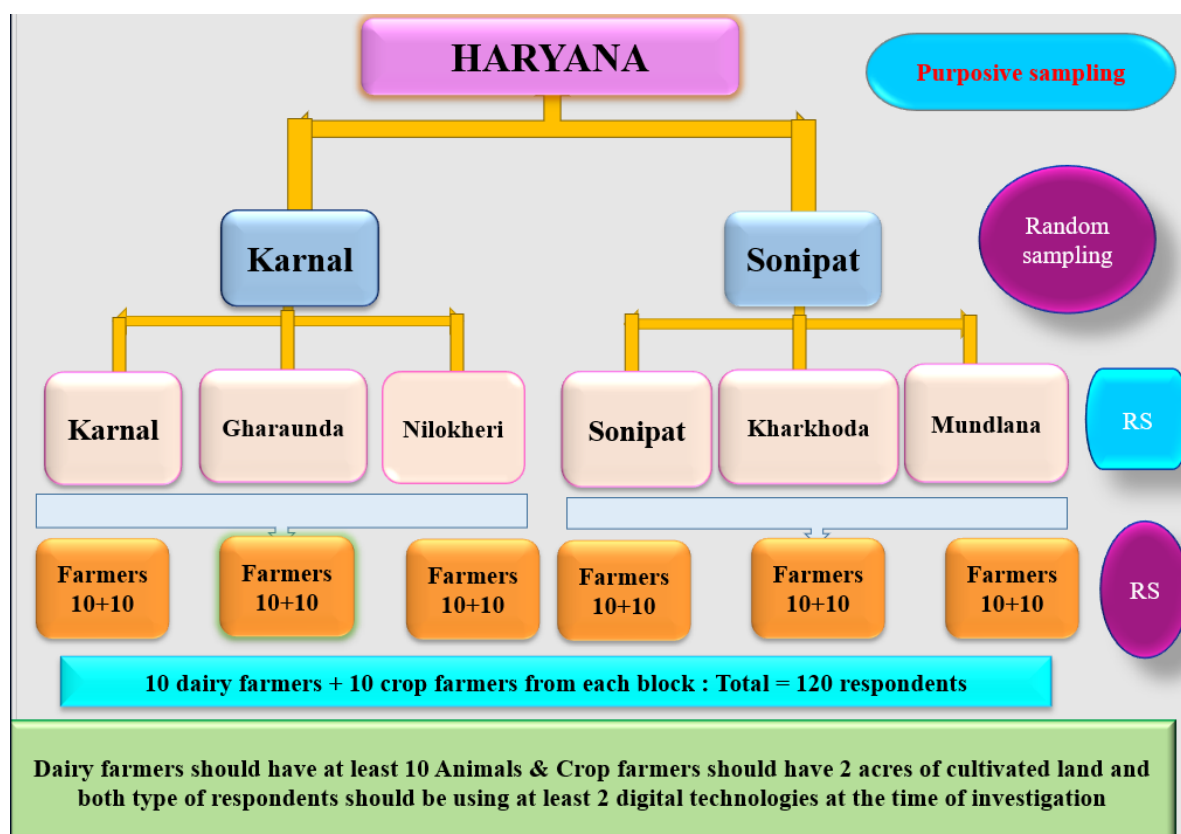


Figure 3.2: Sampling plan

### **3.4. VARIABLES, THEIR OPERATIONALIZATION AND MEASUREMENTS**

For any study undertaken in social science research, it is customary to precisely mention the variables used for the study with their working concepts and measurement procedures. After extensive review of literature and consultation with the experts, relevant variables were included which had been found significant for the study. Table 3.4., depicts the variables and their respective measurement at a glance. The selected variables and their operational definitions and measurement procedures have been dealt in detail as follows:

**Table 3.4: Variable and their measurement**

<b>S. No</b>	<b>Variables</b>	<b>Measurement</b>
<b>I</b>	<b>Independent Variables</b>	
1.	Age	Direct questioning
2.	Gender	Observation
3.	Family type	Direct questioning
4.	Family size	Direct questioning
5.	Education	Direct questioning
6.	Land holding	Schedule was developed
7.	Herd size	Schedule was developed
8.	Herd composition	Schedule was developed
9.	Annual income	Schedule was developed
10.	Annual expenditure	Schedule was developed
11.	Extension contact	Schedule was developed
12.	Accessibility of digital technology	Schedule was developed
13.	Training received on digital technology	Schedule was developed
14.	Influencing factors to use digital technology	Schedule was developed

15.	Social media usage	Schedule was developed
16.	Source of information	Schedule was developed
17.	Perceived benefits on digital technology	Schedule was developed
18.	Experience in using digital technology	Schedule was developed
<b>II</b>	<b>Dependent Variables</b>	
1.	No. of digital technologies available and used	Schedule was developed
2.	Perception of farmers towards digital farming technology	Scale was developed
3.	Awareness of farmers on digital farming technology	Schedule was developed
4.	Feedback from farmers	Semi-structured schedule was developed

### **3.4.1. OPERATIONAL DEFINITION OF INDEPENDENT VARIABLES**

Operationalization is the process of defining a concept so as to make the concept clearly distinguishable or measurable and to understand it in terms of empirical observations. The operational definitions of the variables studied under the study were given below:

#### **1. AGE**

It was operationalized as number of completed years of the respondents at the time of data collection and it was determined by direct questioning. The respondents were classified on the three categories such as young, middle, and old age groups according to the procedure followed in population census report, 2011 (GoI).

<b>S.No.</b>	<b>Category</b>	<b>Age (in years)</b>
1.	Young	Up to 35
2.	Adult	36 to 50
3.	Old	Above 50

## 2. GENDER

It was operationalised as the societal meaning assigned to respondents as male or female. It was determined by direct observation. As this is a categorical variable, the respondents were assigned as following:

S. No	Category	Score
1.	Male	1
2.	Female	2

## 3. FAMILY TYPE

It is the family pattern of the respondent expressed in terms of joint & nuclear family. It was measured by direct questioning and scores as following for each category of family type.

S. No	Category	Score
1.	Nuclear	1
2.	Joint	2

## 4. FAMILY SIZE

It was operationally defined as the total number of persons living together in one household and sharing a common kitchen. It was determined by direct questioning and responses given by the respondents. Cumulative square root frequency method was used to classify the respondents into small, medium, and large family size.

## 5. EDUCATION

It was operationalized as the academic qualification of responses acquired through formal schooling and collegiate education. It was measured by direct questioning. Frequency and percentage of each category was calculated and presented accordingly. The respondents were assigned score as:

<b>S. No</b>	<b>Category</b>	<b>Score</b>
1.	Illiterate	1
2.	Primary	2
3.	Middle	3
4.	Secondary	4
5.	Higher secondary	5
6.	Graduate and above	6

## **6. LAND HOLDING**

It was operationalized as the extent of land an individual possessed and cultivated at the time of investigation. It was determined by a schedule developed for the same. The respondents were classified into landless, marginal, small, semi-medium, medium, and large categories as follows (Suggested by GoI., 2001):

<b>S. No</b>	<b>Category</b>	<b>Land holding</b>
1.	Landless	0 ha
2.	Marginal	Less than 1 ha
3.	Small	1-2 ha
4.	Semi-medium	2-4 ha
5.	Medium	4-10 ha
6.	Large	More than 10 ha

## **7. HERD SIZE**

Herd size was operationalized as the total number of cattle and buffaloes owned by the respondent at the time of investigation. Herd size was determined by a schedule developed and responses given by the respondents. Cumulative square root frequency methods were used to classify the respondents into small, medium, and large herd size.

## **8. HERD COMPOSITION**

It was operationalized as breed and species wise dairy animals possessed by the respondent at the time of investigation i.e., buffalo, indigenous cow, crossbred cow and were expressed in frequency and percentage accordingly.

## **9. ANNUAL INCOME**

It was operationally defined as the income generated from various sources in one year by the respondent at the time of investigation. It was generally expressed in Rs/annum. Respondents were categorized as low, medium, and high categories of annual income based on cumulative square root frequency method.

## **10. ANNUAL EXPENDITURE**

It was operationalized as the amount spent by the respondent on various operations and machines by the respondent at the time of investigation. It was generally expressed in Rs/annum. Respondents were categorized as low, medium, and high categories of annual expenditure based on cumulative square root frequency method.

## **11. EXTENSION CONTACT**

It was considered as both acquaintance and frequency of respondent's contact with Krishi Vigyan Kendra, Village Extension Officer, Agricultural Officer/Veterinary Officer, Block Development Officer, scientists, educational institutes, private agency etc. Extension contact was determined by schedule and responses were given by the respondents in a three-point continuum as never (1), occasionally (2) and regularly (3). Then, Cumulative square root frequency methods were used to classify the respondents into low, medium, and high level of extension contact. The sum of scores were used for classification of extension contact.

Sl.No.	Extension personnel	Frequency of contact		
		Regularly (3)	Occasionally (2)	Never (1)
1.	VEO			
2.	AO/VO			
3.	Scientists			

4.	KVK			
5.	Other research institutes/ education institutes			
6.	Private agency			
7.	Any other			

## 12. ACCESSIBILITY OF DIGITAL TECHNOLOGY

It was operationally defined as the level of nearness of availability of various digital technologies adopted by the respondents. This was determined by schedule and responses were given by the respondents and the accessibility of a specific technology at particular level was denoted by a symbol.

Sl.No.	Technology used	Block	District	Outside the district/state	Online
1.					
2.					
3.					
4.					
5.					

(✓ - yes, × - no)

## 13. TRAINING RECEIVED ON DIGITAL TECHNOLOGY

Training received on digital technology was operationally defined as the duration, source of the guidance on the expertise of digital technology by the respondents.

S. No	Training received	Score
1.	Yes	1
2.	No	0

#### **14. INFLUENCING FACTORS TO USE DIGITAL TECHNOLOGY**

It was operationalized as the aspect which is considered before the adoption of digital farming technologies. The influencing factors for digital farming technologies were presented through schedule to farmers and their responses were taken as yes or no. Then frequency and percentage of each factor was calculated.

<b>Sl.No.</b>	<b>Particulars</b>	<b>Response (Yes = 1; No = 0)</b>
1.	Availability of loan/ subsidy	
2.	Accessibility of infrastructure	
3.	On farm efficiency	
4.	Marketing aspects	
5.	Profits	
6.	Benefit to cost ratio	
7.	Relative advantage, compatibility,	
8.	Other's success	
9.	Other factors	

#### **15. SOCIAL MEDIA USAGE**

It was operationally defined as the extent of utilization of different social media platforms by the respondents. The various social media platforms were presented through schedule to farmers and their responses were taken as yes or no. Then frequency and percentage of each factor was calculated.

<b>Sl.No.</b>	<b>Media</b>	<b>Response (Yes=1; No=0)</b>
1	WhatsApp	
2	Facebook	
3	Twitter	
4	YouTube	

5	Instagram	
6	Telegram	
7	ResearchGate	
8	LinkedIn	

## 16. SOURCE OF INFORMATION

It was operationalized as the exposure of respondents to different sources for obtaining information about digital farming technologies. To measure this variable, a schedule was developed, and responses were expressed in frequency and percentage.

Sl. No.	Category	Response (Yes=1; No=0)
	<b>Public sources</b>	
1.	KVK/ ATMA/ other Govt. agencies and on webpage	
2.	ICAR, SAU, SVS, NDRI personal and on webpage	
3.	State department of Agriculture, Dairy, Animal Husbandry personal and on webpage	
4.	Govt. organizations published Magazine/ bulletins/ folder etc.	
5.	INDO-ISRAEL CoE	
	<b>Private sources</b>	
1.	Pvt. Practitioners/ Para vets	
2.	Input dealers	
3.	Output buyers	
4.	Rural retail hubs	
5.	Mobile Apps, Media, ICT	
6.	Companies in collaboration with Department of agriculture	

**17. PERCEIVED BENEFITS**

It was operationally defined as the benefits or applications of digital farming technologies that are felt by the respondents. Perceived benefits were presented through a schedule and measured on three-point continuum as Disagree, slightly agree, and agree. For the responses as agree, 3 marks were allocated. Whereas 2 and 1 mark were assigned for slightly agree and agree respectively.

Sl. No.	Statements	Response		
		Disagree (1)	Slightly agree (2)	Agree (3)
1.	Increase in yield			
2.	Efficiency in inputs usage			
3.	Saving time			
4.	Less labour requirement			
5.	Improved quality of produce			
6.	Timely and accurate information			
7.	Early detection of pests and diseases			
8.	Efficiency in irrigation			
9.	Efficiency in chemical application			
10.	Efficiency in sowing & harvesting operations			
11.	Aids in knowing pH, temperature, weather conditions etc.			
12.	Aids in identifying animal physiological processes			
13.	Aids in getting market information			
14.	Aids in financial aspects			
15.	Increased sustainability			
16.	Improved record-keeping			
17.	Increased profits			
18.	Reduced risk and regulatory burden			
19.	Reduced environmental pollution			

### **3.4.2. OPERATIONALIZATION AND ANALYTICAL FRAMEWORK OF DEPENDENT VARIABLES**

#### **3.4.2.1. Documentation of digital farming technologies in the study area**

Under this objective, the information on various digital technologies being adopted by farmers, source of technology was obtained. The respondents were categorized into three categories based on their extent of adoption of digital technologies. The frequency of respondents under average years of adoption was also classified.

The status of digital farming technologies was operationalized as the number of digital technologies, source and average years of adoption of all the digital technologies by each respondent. The digital farming technologies were classified as three categories i.e., Agriculture technologies, animal technologies and service technologies.

In case of technologies, frequency and percentage were calculated for each digital technology. Whereas, average years of adoption of each technology was calculated for each respondent and further respondents were categorized based on certain range of average years of adoption. While, as the source of digital technology was descriptive, all the sources of technology was enlisted.

Sl.No.	Digital Agro-animal farming technology	Response		Years of adoption	Source
		Yes	No		

#### **3.4.2.2. PERCEPTION OF FARMERS TOWARDS DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY**

Perception refers to an opinion or a subjective measurement on a certain object. It is a process by which an individual organizes and interpret their sensor impressions to give meaning to their environment. It is the process by which an individual selects,

organizes, and evaluates stimuli from the external environment to provide meaningful expression for oneself.

Perception towards digital farming technology is operationally defined as meaningful sensation of farmers about digital farming needs in meeting their needs. For this, Perception scale like that of Likert's on a 5-point scale continuum ranging from "strongly agree, mostly agree, agree, mostly disagree, strongly disagree" was developed.

The method of summated rating technique suggested by Likert (1932) and Edward (1957) was followed in the development of the scale. The following steps were considered for developing the perception scale.

**3.4.2.2.1. Collection of Statements:** The first step in the construction of perception scale was to collect statements related to the perception towards digital farming technology. A care was taken to include positive and negative (60:40) statements in the list. A tentative list of 76 statements was prepared from available literature, consultation with experts in the field of digital farming technology and progressive farmers.

**3.4.2.2.2. Editing of Statements:** The statements were edited as per 14 informal criteria suggested by Edwards (1957) as outcome 13 statements were eliminated. Finally, 63 statements were retained after editing and considered for judge's response.

**3.4.2.2.3. Response to Raw Statements:** The Performa containing 63 raw statements on three-point continuums i.e., Most relevant, relevant, and least relevant was through e-mail, via Google forms and also handed over personally to the total 70 judges. These judges were experts in the field of extension education. The judges were requested to indicate their response by tick mark in suitable continuum in front of each statement. Also, the judges were requested to make necessary modifications and additions or deletions if they desired so. Out of 70 judges, 52 judges had returned the same set of statements after duly recording their judgements in a stipulated span of 2 months. Out of 52 responses, 4 responses were found unsuitable for item analysis and eliminated after careful examination of responses. The remaining 48 responses were considered for the item analysis.

**3.4.2.2.4. Item Analysis:** Item analysis is an important step while constructing valid and reliable scale. The judges were asked to indicate their degree of agreement or disagreement on each statement with five-point continuums that is Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree with scoring 5, 4, 3, 2, and 1,

respectively for positive statements and vice-versa for negative statements. The total individual score of judges was calculated by summing up the response score of each statement given by individual judge.

**3.4.2.2.5. Calculation of 't' values:** Based upon the total individual scores, the judges were arranged in descending order. The top 25 per cent of judges with their total individual scores were considered as high group and the bottom 25 per cent as the low group so that these two groups would be criterion groups in terms of which the individual statements were evaluated. Thus, out of 48 judges to whom the statements were administered for the item analysis, 12 judges with highest and 12 judges with lowest scores were considered as criterion groups. The critical ratio, that is between the high and low groups of the respondents for each statement was calculated by using the formula given by Edwards (1957).

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\sum(X_H - \bar{X}_H)^2 + \sum(X_L - \bar{X}_L)^2}{n(n-1)}}$$

Where;

$$\sum(X_H - \bar{X}_H)^2 = \sum X_H^2 - \frac{(\sum X_H)^2}{n}$$

$$\sum(X_L - \bar{X}_L)^2 = \sum X_L^2 - \frac{(\sum X_L)^2}{n}$$

$\bar{X}_H$  = The mean score on a given statement for the high group

$\bar{X}_L$  = The mean score on a given statement for the low group

$\sum X_H^2$  = Sum of squares of the individual score on a given statement for high group

- $\sum X_L^2$  = Sum of squares of the individual score on a given statement for low group
- $\sum X_H$  = Summation of scores on given statement for high group
- $\sum X_L$  = Summation of scores on given statement for low group
- $n$  = Number of judges in low and high groups
- $t$  = The extent to which a given statement differentiate between the high and low groups
- $\Sigma$  = Summation

The 't' value is a measure of the extent to which a given statement differentiates between the high and low groups. As a crude and approximate rule of thumb, we may regard any 't' value equal to or greater than 2.06 as indicating that the average response of high and low groups to a statement differs significantly. Thus, 20 (17 positive and 3 negative) statements for measuring the perception towards digital farming technology with significant 't' values were retained in the final scale (Table 3.5).

**3.4.2.2.6. Standardisation of the Scale:** The validity and reliability were determined for standardisation of the scale. The reliability and validity were measured by split half method and content validity, respectively.

**i) Reliability of the Scale:** A scale is reliable when it gives consistently the same results when applied to the same sample. The final set of the 20 statements which represent the farmers perception towards digital farming technology, was administered on five-point continuums to a fresh group of 12 respondents (10% of actual sample size for the study) from non-sample area and which was not included in the actual sample size of study. The designed perception scale for the study was pre-tested for its reliability by using the split half method in which a scale is divided into two halves. One half (one set) contains the odd numbered statements (1, 3,...,7) and the other half (other set) contains the even numbered statements (2, 4,...,8). The total individual score of each farmer was calculated by summing up the responses given by farmers who were adopting digital technology on two halves of the statements. The correlation coefficient (r<sub>hh</sub>) between scores of two halves of statements was 0.73. The positive and significant correlation between the two sets of scores indicated that the scale was reliable. The

reliability coefficient of whole scale was calculated by the formula given by Spearman (1910) and Brown (1910) as follows;

$$r_{SB} = \frac{2 * r_{hh}}{1 + r_{hh}}$$

Where;

$r_{SB}$ = Reliability coefficient of the whole scale

$r_{hh}$ = Reliability coefficient of the half-scale, found experimentally

i.e., 0.73

$$r_{SB} = \frac{2*r_{hh}}{1+r_{hh}} = \frac{2*0.73}{1+0.73} = \frac{1.46}{1.73} = 0.84$$

The reliability coefficient of whole scale was 0.84, which indicates that the whole scale was significant and reliable.

**ii) Validity of the Scale:** It is the property that ensures the obtained test score as valid, only if it measures what it is intended to measure. A scale is said to be valid if it stands for one's reasoning. The content validity of the scale was tested by expert's judgement. It is the representative or sampling adequacy of the content, the substance, the matter, and the topics of a measuring instrument. This method was used in the present scale to determine the content validity of the scale. The content of the perception scale was thoroughly covered through literature scan and expert opinions. The statements which had at least 80% judges' agreement were retained. This indicated validity of the scale content. As the scale value difference for almost all the statements included had discriminating values, it seemed reasonable to accept the scale as valid measure of the desired dimension.

**3.4.2.2.7. Administration of the Scale:** The final scale consisting of 20 (Table 3.5) statements can be administered to the farmers towards perception of digital farming technology on a five-point continuum viz., Strongly Agree (SA), Mostly Agree (MA), Agree (A), Mostly Disagree (MDA) and Strongly Disagree (SDA) with a score of 5,4,3,2 and 1, respectively for positive statements and reverse scoring system for negative statements. The overall possible maximum and minimum score ranges between 100 to 20. Scores were summed up to get the total score for perception of each respondent.

Then the respondents were categorized into low, medium, and high categories by cumulative square root of frequency method.

**Table: - 3.5. A list of selected statements of perception for final scale construction with their respective ‘t’ values:**

<b>Perception statements</b>		
<b>Sl.No.</b>	<b>Statement</b>	<b>t-value</b>
1.	Application of digital agro-animal farming technologies are feasible for all types of farming system	3.10
2. *	Digital farming technologies can be more beneficial for large farmers	2.47
3.	Do you think that application of Digital technologies will increase the efficient use of farm resources?	2.86
4.	Do you think that there is need to identify socio-economic issues for enhancing adoption of digital farming technology?	2.94
5.	Digital India and other government schemes were creating awareness on digitalisation in agricultural sector	3.01
6.	Digital agro-animal technologies will encourage sustainability in farming	2.69
7.	Digital technologies reduce labour requirement in farming operations	2.90
8.	Do you think digital technologies may influence youth to take farming up as a new occupation?	2.51
9.	Do you think that digital technologies can mitigate the effects of climate change?	2.77
10. *	Do you think Digital agricultural technologies requires high-cost machines, equipment, and software	2.90
11.	Digital technologies aids in easier marketing of farm produce	2.73
12.	Digital innovation in farming ensures chemical free/unadulterated farm produce	2.96
13. *	I don't want digital technology in my farm because I believe that farming should be more traditional and natural	3.19
14.	Do you think that digital agricultural technologies promote agricultural sector development?	3.09

15.	Do you feel that smart farming reduces the amount of chemical applied on crops?	2.09
16.	The adoption of digital farming technology highly depends on the age of farmer	2.84
17.	I believe that digital farming technology and services will reduce the cost of cultivation	3.23
18.	I would invest more in digital technologies if financial support from government was higher (subsidies, lower taxes)	2.81
19.	Digital farming technologies improve the decision-making capability	2.21
20.	Digital farming technologies would allow more time for social participation	2.68

(\* = Negative Statement)

### **3.4.2.3. AWARENESS OF FARMERS ON DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY**

The degree/status of familiarity of respondents on smart farming technologies, their traits, applications, and advantages etc., is referred as the awareness of farmers on digital farming technologies. This was measured by interview schedule. Frequency and percentage of farmers belonging to three-point continuum such as moderately aware, slightly aware, and not at all aware was calculated and summation of each individual responses was done, and the respondents were categorized by cumulative square root frequency method.

### **3.4.2.4. FEEDBACK OF FARMERS ABOUT DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY**

It is operationally defined as a response obtained from farmers on strengths, barriers, macro-level benefits, attractive and repulsive factors of digital technology. Semi-structured interview schedule was developed to obtain feedback on DFT. Frequency and percentage for each category was calculated and ranked accordingly.

## **3.5. TOOLS OF DATA COLLECTION**

For the purpose of data collection, an interview schedule was constructed covering all the objectives and was pretested among respondents from non-sample area. Personal interview, coupled with observation method was employed to collect data from

the respondents. Secondary data was also collected from the authentic sources like statistical handbooks, economic survey reports, and published annual reports etc.

### **3.6. STATISTICAL TOOLS FOR DATA ANALYSIS**

The collected data was properly scored, compiled, tabulated, and subjected to various appropriate statistical tools to draw meaningful results and logical conclusion. Some of the statistical tools used were Frequency, Percentage, Arithmetic mean, weighted mean percentage, Cumulative Square Root Frequency (CSRF), 2 sample t-Test and correlation.

#### **3.6.1. FREQUENCY**

It was calculated to find out the number of respondents in a particular category.

#### **3.6.2. PERCENTAGE**

Percentage values were calculated to make simple comparisons. These were calculated by dividing the frequency of a particular category by total number of respondents and multiplying by 100.

$$P = (n/N) * 100$$

Where,

- n = Frequency of a particular cell
- N = Total number of respondents
- P = Percentage

#### **3.6.3. ARITHMETIC MEAN**

Mean score for each category were worked out separately by the formula.

$$\bar{X} = \frac{\sum X_{ij}}{N}$$

Where;

- $X_{ij}$  = Sum of each of the individual comparisons
- I = 1,2,3,...N
- N = Number of observations
- $\bar{X}$  = Mean

#### **3.6.4. WEIGHTED MEAN SCORE**

Weighted mean score was computed by the following formula

$$a_w = \sum mW / W$$

**Where,**

- $a_w$  = Weighted mean score  
 $mW$  = Product of weight and measurement  
 $W$  = Total number of observations

#### **3.6.5. TWO SAMPLE t- TEST**

In the present study, t-test was done in the process of scale construction. This type of t-test is used to determine when one variable is defined by two groups. Here, as there were two groups such as higher and lower, two sample test can be used. It can be assumed that two sample t-test which assumes equal variances.

Steps for calculating 2 sample t-test:

1. Determine the two groups i.e., higher and lower groups for scale development.
2. Calculate the means for two groups i.e., higher and lower groups
3. Calculate the difference of means for two groups
4. Calculate sum of squares of individual score, summation of scores for a given statement for each group.
5. Then, calculate the t-statistic, this statistic follows a t-distribution with n-1 degrees of freedom.
6. Use tables of t-distribution to compare t-table value and t-calculated value.
7. Then, eliminate the statements whose t- calculated value is lower than t-table value.

#### **3.6.6. CUMULATIVE SQUARE ROOT FREQUENCY (CSRFB) METHOD**

Of the various methods available to determine stratum boundaries, cumulative square root frequency (CSRFB) method allows greater efficiency for setting stratum boundaries. CSRFB methodology breaks down the population into intervals, which can be of equal or unequal width. The steps involved in its calculation are given below:

1. Evaluate the data and determine the units that can be reviewed on actual basis.

2. Stratify the remaining data into ranges or classes. No of classes and class interval are determined using the formulas given as below:

$$\text{No. of. classes} = 2.5 \times (\text{number of samples})^{\frac{1}{4}}$$

$$\text{Class interval} = \frac{(\text{Largest figure} - \text{smallest figure})}{\text{No.of.classes}}$$

3. Determine the frequency for each range. This is the number of units within the range.
4. Calculate the square root of the frequency for the first range. Then calculate the square root of the next range. Continue this process for each of the ranges.
5. Sum of the square root of the first and second range gives cumulative square root of the second range; sum of first, second and third gives the third range and so on for all the ranges.
6. The cumulative square root frequency value of the last class is divided by the number of sample strata desired (can vary 3-9) to get the cumulative square root value for each item.
7. Suppose we desire to have 3 strata, then the upper limit of the first strata is determined using the formula as given below:

$$L_i = \frac{Y_{i-1} + (Y_i - Y_{i-1}) \left\{ \left( \frac{S_k}{L} \right) - S_{i-1} \right\} \dots \dots \dots \text{Value 1}}{i\sqrt{f}}$$

Where;

- $L_i$  = Upper limit of the  $i^{\text{th}}$  strata (In this case first strata)
- $L$  = Number of strata
- $Y_i$  = Upper limit of the class in which  $L_i$  lies
- $Y_{i-1}$  = Lower limit of the class in which  $L_i$  lies
- $S_k$  = Cumulative square root frequency value
- $i\sqrt{f}$  = Square root of the frequency of the  $i^{\text{th}}$  class in which  $L_i \left( \frac{S_k}{L} \right)$  lies
- $S_{i-1}$  = Cumulative square root frequency of the preceding class in which  $L_i \left( \frac{S_k}{L} \right)$  lies
- $Y_i - Y_{i-1} =$  Width of the class in which  $L_i \left( \frac{S_k}{L} \right)$  lies

For the upper limit of second strata, the formula is:

$$L_i = \frac{Y_{i-1} + (Y_i - Y_{i-1}) \left\{ \left( \frac{S_k}{L} \right) \times 2 - S_{i-1} \right\} \dots \dots \text{Value 2}}{\sqrt{f}}$$

For the upper limit of third strata, the formula is:

$$L_i = \frac{Y_{i-1} + (Y_i - Y_{i-1}) \left\{ \left( \frac{S_k}{L} \right) \times 3 - S_{i-1} \right\} \dots \dots \text{Value 3}}{\sqrt{f}}$$

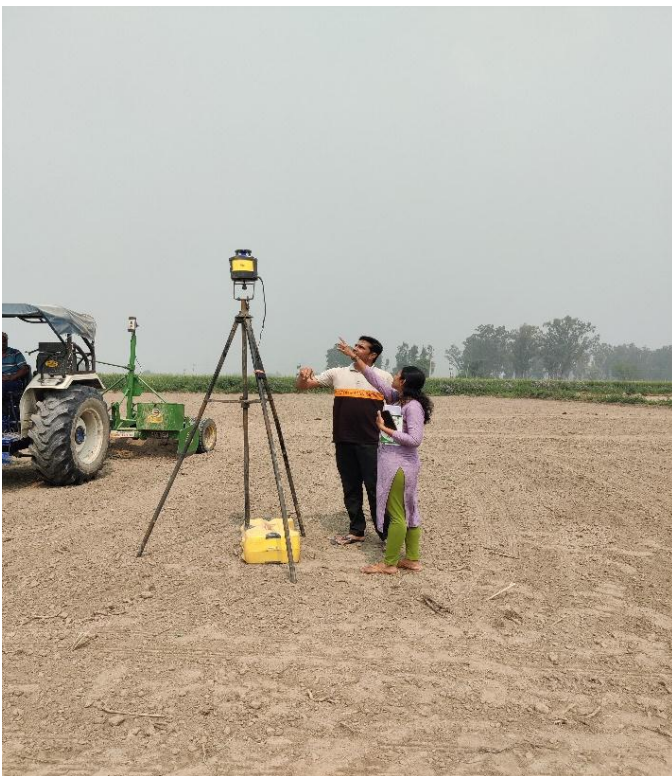
In this way, three strata are formed i.e., below value 1; between value 1 and value 2; above value 2 up to value 3.



**Boom Irrigation System**



**Cane Sett Treatment Machine**



**Laser Leveler**



**Automatic tray sowing machine**



**Agri Processing Machines**



**pH Meter**



**Crop Sensor**



**Soil Moisture Sensor**

# CHAPTER -4

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## Results and Discussion

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## RESULTS AND DISCUSSION

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Based on the objectives taken up for the study, the collected data was analysed by using suitable statistical tools and techniques as described in the earlier chapter i.e., research methodology. The results and their interpretations are presented as following:

- 4.1 General profile of the respondents
- 4.2 Status of digital farming technologies in the study area
- 4.3 Perception of farmers towards digital agro-animal farming technology
- 4.4 Awareness of farmers on digital agro-animal farming technology
- 4.5 Feedback of farmers about digital agro-animal farming technology

### **4.1 GENERAL PROFILE OF THE RESPONDENTS**

Profile characteristics of the respondents gives a clear-cut picture about the respondent's family, living condition, surroundings and possessions which sequentially will help in drawing apt interpretations based on the results. Thus, profiling of the respondents from two districts of Haryana state was done to get a clear view of the respondents and their perspective on digital farming technologies.

In the present study, 18 independent and 4 dependent variables were taken into consideration. The relevant data were collected, and the analysed findings are presented below.

#### **4.1.1. AGE**

The age of respondents was selected as an independent variable as it influences the farmer in his/her choice and adoption of innovative technology. It plays a significant role as it indicates the mental maturity and decision-making capability of the person.

An appraisal of the Table 4.1 revealed that majority (66.67%) of the crop farmers belonged to middle age group i.e., (36-50 years) followed by young age group (up to 35) and old age group (>50 years) which accounts for 18.33 percent and 15.00 percent respectively, whereas in case of dairy farmers, 43.33 percent belong to middle age group followed by 36.67 percent young and 20.00 percent old age group.

## Results and Discussion

In pooled data, majority i.e., 55.00 percent fall into middle age group category followed by young and old categories with 27.50 and 17.50 percent respectively. These results were in agreement with Chaudhary (2019) and Kudari (2014), who reported that most of the precision farmers were middle-aged. As precision farming technology is a component of digital farming technologies, the results of precision farming technology study can be linked with digital farming technology.

This could be because digital farming technology being a hi-tech approach, logically farmers who are above 50 years age may not be leaning to adopt the technology, whereas most of the young age farmers, who recently entered the farming career need to do some research and cannot take up high investments. Thus, middle aged farmers have more tendency to adopt digital farming technologies.

**Table 4.1: Distribution of respondents based on Age**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Young (up to 35 years)	11	18.33	22	36.67	33	27.50
Middle (36 to 50 years)	40	66.67	26	43.33	66	55.00
Old (more than 50 years)	9	15.00	12	20.00	21	17.50
Mean	42.25		41.18		42.30	

### 4.1.2. GENDER

Gender of the respondents is taken as one of the independent variables as it will give picture of composition of farmers who are adopting these technologies and it can reveal whether there are any female respondents who are taking up the above technologies.

A glance at the Table 4.2 revealed that majority of the crop farmers are male (96.67%) and only 3.33 percent were female. Whereas, in case of dairy farmers, 93.33 percent are male.

When we pooled the data, and it was found that only 5.00 percent respondents were female. In the study area, head of the family were male and women are not coming to discussion with outsiders, this may be the reason for few numbers of female respondents.

These results agreed with Chuang et al., (2020), who reported that majority of the smart farming technology user farmers are males.

**Table 4.2: Distribution of respondents based on Gender**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Male	58	96.67	56	93.33	114	95.00
Female	2	3.33	4	6.67	6	5.00

#### 4.1.3. Family Type

Family type of the respondents was taken as an independent variable to know whether majority of the respondents belong to Nuclear or Joint family type. It is clearly evident from the Table 4.3 that majority of the crop respondents (i.e.,63.33%) belong to nuclear family type. Whereas the findings of dairy farmers contrasted this as majority (i.e., 60.00%) of them belong to Joint family type. However, the pooled responses revealed that majority i.e., 51.66 percent of farmers belong to nuclear family type.

**Table 4.3: Distribution of respondents based on Family Type**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Nuclear	38	63.33	24	40.00	62	51.66
Joint	22	36.67	36	60.00	58	48.34

#### 4.1.4. Family size

From the results given in Table 4.4 it was found that majority i.e., 51.67 percent of the crop farmers had small family size followed by medium and large family sizes with 45.00 and 3.33 percent respectively. However, in case of dairy farmers, medium family size was the major category with 55 percent of the respondents which was followed by small (38.33%) and Large (6.67%). Whereas, in case of pooled responses, 50.00 percent of the respondents belong to medium family size category. This was followed by small and large family sizes i.e., 45.00 and 5.00 percent respectively.

**Table 4.4: Distribution of respondents based on Family Size**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Small (up to 5 Members)	31	51.67	23	38.33	54	45.00
Medium (5-8 Members)	27	45.00	33	55.00	60	50.00
Large (More than 8 Members)	2	3.33	4	6.67	6	5.00
Mean	5.79		5.84		5.98	

#### 4.1.5. EDUCATION

Education level shapes the farmer's behaviour on adoption of advanced technology, since education increases open-mindedness which will further drive farmers to adopt new technologies and earn profits. It was clear from Table 4.5 that about 36.67 percent of the crop farmers had senior secondary education followed by graduate and above (28.33%). The third major category is secondary education level with 21.67 percent of farmers followed by primary and middle education level with 6.67 percent of respondents each. However, 33.33 percent of the dairy farmers belong to secondary level of education followed by senior secondary, graduate and above, primary, and middle level of education categories with 31.67, 21.67, 8.33, 5.00 percent of respondents respectively.

In case of pooled responses, it was observed that 34.17 percent had senior secondary level of education followed by secondary education level with 27.50 percent of farmers. The third category of responses were under-graduate and above category with 25.00 percent of responses. This was followed by primary (7.50%) and middle (5.83%) categories. Illiterates are not observed in the current study. The findings of the study are in line with the study of Pfeiffer (2021) who unveiled that majority of the farmers who are accepting digital farming technologies belong to higher secondary level of education.

**Table 4.5: Distribution of respondents based on Education**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Primary	4	6.67	5	8.33	9	7.50
Middle	4	6.67	3	5.00	7	5.83
Secondary	13	21.67	20	33.33	33	27.50
Senior secondary	22	36.67	19	31.67	41	34.17
Graduate and above	17	28.33	13	21.67	30	25.00

#### **4.1.6. LAND HOLDING**

From the results presented in Table 4.6 it was revealed that majority (53.33%) of crop farmers belong to medium land holding category followed by semi-medium, large, small, and marginal landholding with 21.67, 16.67, 6.67, 1.67 percent of farmers respectively. Whereas, in case of dairy farmers 31.67 percent of the respondents belonged to small land holding category. Among dairy farmers, the small land holding category is followed by semi-medium, medium, marginal, large, and landless with 30.00, 23.33, 8.33, 5.00, 1.67 percent of farmers respectively.

**Table 4.6: Distribution of respondents based on Land holding**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Landless	0	0.00	1	1.67	1	0.83
Marginal (<1 ha)	1	1.67	5	8.33	6	5.00
Small (1-2 ha)	4	6.67	19	31.67	23	19.17
Semi-medium (2-4 ha)	13	21.67	18	30.00	31	25.83
Medium (4-10 ha)	32	53.33	14	23.33	46	38.33
Large (>10 ha)	10	16.67	3	5.00	13	10.83
Mean	5.27		4.77		5.19	

In pooled data, among all categories medium landholding is first with 38.33 percent of responses which was followed by semi-medium, small, large, marginal, and landless land-holding categories with 25.83, 19.17, 10.83, 5.00 and 0.83 respectively. The above discussed findings are in consistent with Chaudhary (2019) study, in which it was unveiled that majority of the precision farmers were having medium land holding.

#### **4.1.7. HERD SIZE**

The findings presented in Table 4.7 revealed that majority (81.67%) of crop farmers were maintaining small herd size (<12 animals) followed by medium and large herd size with 18.33 and 1.67 percent of crop farmers. Among dairy farmers, about 46.67 percent of them preferred to maintain 12-24 animals (medium category) which was followed by small and large herd size with 35 and 18.33 percent. These findings are similar to that of Meena et al., (2020) in which it was stated that majority of automated dairy farms had medium herd size.

In pooled data, majority of respondents (58.33%) maintain small herd size which was followed by medium (32.50%) and large (9.17%) herd size.

**Table 4.7: Distribution of respondents based on Herd Size**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Small (<12 animals)	49	81.67	21	35.00	70	58.33
Medium (12-24 animals)	11	18.33	28	46.67	39	32.50
Large (> 24 animals)	0	0.00	11	18.33	11	9.17
Mean	12.61		15.78		14.19	

**4.1.8. HERD COMPOSITION**

The data collected on dairy animal number was analysed further to know the category wise distribution of dairy animals in the study area. The findings from Table 4.8 revealed that agriculture farmers had 43.86, 37.54 and 18.60 percent of crossbred cows, buffalo, and indigenous cow respectively. Dairy farmers had higher preference to maintain crossbred which was the major category among all types with 56.92 percent. This was followed by buffaloes and indigenous cows with 22.14 and 20.93 percent respectively. The findings of this study are similar to the study on dairy automation in north India by Meena et al., (2020) who stated that majority of dairy farms maintained crossbred cows.

**Table 4.8: Distribution of respondents based on Herd Composition**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Buffalo	226	37.54	219	22.14	445	27.96
Crossbred Cow	264	43.86	563	56.92	827	51.97
Indigenous Cow	112	18.60	207	20.93	319	20.05
Total	602		989		1591	

## Results and Discussion

In pooled data, majority i.e., 51.97 percent were maintaining crossbred cows as the most preferred dairy animal which was followed by buffalo (27.96%) and indigenous cow (20.05%). It was also observed from the study area that farmers were rearing indigenous cow for milk and milk products for their home consumption.

### 4.1.9. ANNUAL INCOME

The results presented in Table 4.9 revealed that about 46.67 percent of agriculture farmers had annual income up to 13 lakhs (low category) which was followed by medium (13 – 20) and high (> 20 lakhs per annum) income categories with 33.33 and 20.00 percent farmers respectively. Among dairy farmers, about 46.67 percent belonged to medium income category. This was followed by low (45.00%) and high (8.33%) income categories.

The pooled data unveiled that 45.83 percent of farmers belonged to low-income category which was followed by medium and high-income farmers with 40.00 and 14.17 percent respectively. The findings of the study opposed that by Padma (2013) who stated that majority of precision farmers belong to medium income category which is 5 to 8 lakhs per annum according to her study.

**Table 4.9: Distribution of respondents based on Annual Income (Rs. In lakhs)**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Low (up to 12.88)	28	46.67	27	45.00	55	45.83
Medium (12.89-20.11)	20	33.33	28	46.67	48	40.00
High (more than 20.11)	12	20.00	5	8.33	17	14.17
Mean	15.36		14.95		15.29	

### 4.1.10. ANNUAL EXPENDITURE

A glance at Table 4.10 indicated that about 46.67 percent of agriculture farmers had medium expenditure i.e., 7.5 – 12 lakhs per annum which was followed by low (up

to 7.5 lakhs per annum) and high (>12 lakhs per annum) with 38.33 and 15.00 percent respectively. Among dairy farmers, majority (88.33%) of them had low annual expenditure. This was followed by medium (6.67%) and high (5.00%) annual expenditure.

The pooled data revealed that majority of farmers belong to low level of annual expenditure with 63.34 percent farmers. Then, 26.66 percent of farmers were having medium level of annual expenditure which was followed by high annual expenditure (10.00%).

**Table 4.10: Distribution of respondents based on Annual expenditure (Rs. In lakhs)**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Low (upto 7.5)	23	38.33	53	88.33	76	63.34
Medium (7.5-12)	28	46.67	4	6.67	32	26.66
High (more than 12)	9	15.00	3	5.00	12	10.00
Mean	6.96		3.32		5.32	

#### **4.1.11. EXTENSION CONTACT**

From the findings of Table 4.11 it was revealed that 43.33 percent of Agriculture farmers had high extension contact. The subsequent categories include medium (33.33%) and low (23.33%) extension contact respectively. Among dairy farmers, the farmers with high extension contact were major with 65.00 percent which was followed by medium and low extension contact with 25.00 and 10.00 percent.

The findings from pooled data revealed that majority (54.17%) of farmers had high extension contact. This was followed by medium (29.17%) and low (16.67%) level of extension contact. The results showed high extension contact play a key role in educating and suggesting farmers on advanced agricultural technologies. The findings are similar to that by Amfo et al., (2021) who stated that innovative farmers tend to have higher extension contact.

**Table 4.11: Distribution of respondents based on Extension contact**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Low (<11)	14	23.33	6	10.00	20	16.67
Medium (11-13)	20	33.33	15	25.00	35	29.17
High (>13)	26	43.33	39	65.00	65	54.17
Mean	13.45		13.32		13.46	

#### **4.1.12. ACCESSIBILITY OF DIGITAL TECHNOLOGY**

The data was collected on accessibility of digital technology i.e., within block, district, outside district/state and online availability of various technologies adopted by farmers. Table 4.12 indicated that technology like sensors for agronomy purpose were available within district, outside district or state and online. Whereas, sensor-based foggers were available within district and online.

However, the digital technology like automated machinery for agriculture purpose were accessible at other states or online only. Whereas the automated machinery for dairying can be accessed within the district, other districts/state and online. In case of Drones, farmers accessed it within district or other district/state. Whereas the digital land preparation equipment was accessible within the block, district or online. In case of digital services like mobile applications, software, online resources, the accessibility is at online only. However, the yellow QR code tags are accessible within the block itself.

**Table 4.12: Distribution of digital technologies based on their accessibility by respondents**

Technology	Accessibility at			
	Block	District	Outside the district/ state	Online
Sensors for agronomy purpose (pH, Temperature, Humidity, Soil Moisture, Ec, nutrient etc.)	X	✓	✓	✓
Drones	X	✓	✓	X
Digital equipment for land preparation (Laser Land leveller, etc)	✓	✓	X	✓
Automated sprayer/Automated irrigation system	X	X	✓	✓
Automated Machine/automated processors/Automated Weather Station	X	✓	✓	X
Automated Seed sowing and seed treatment machine	X	X	✓	X
Mobile enabled Apps	X	X	X	✓
Software	X	X	X	✓
Digital resources for agro-animal farming	X	X	X	✓
Yellow QR code Tags	✓	X	X	X
Sensor-based foggers	X	✓	X	✓
Automated Machine for dairying (Milk Parlour/Milk packaging/ Milk processing/Milk packaging etc.)	X	✓	✓	✓

( ✓ - Yes; X - No)

#### 4.1.13. TRAINING ON DIGITAL TECHNOLOGY

From the Table 4.13 it can be observed that only 3.33 percent of agriculture farmers obtained training on digital technology. None of the dairy farmers had obtained training. In pooled data, only 1.67 percent of respondents had training on digital technology. The 2 persons who were trained in digital agriculture technology received it from abroad.

**Table 4.13: Distribution of respondents based on Training received in Digital technology**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Yes	2	3.33	0	0.00	2	1.67
No	58	96.66	0	0.00	118	98.33

#### **4.1.14. INFLUENCING FACTORS TO PURCHASE DIGITAL TECHNOLOGY**

A cursory look at Table 4.14 revealed the factors responsible for motivation to use Digital technology. Accessibility of infrastructure with was ranked as first major motivating factor for farmers to use Digital technology. Then farmers consider Benefit to cost ratio to use digital technology. Availability of loan/ subsidy was considered as 3<sup>rd</sup> major motivating factor to farmers to use digital technology. Later, farmers consider relative advantage and compatibility of the technology. This was followed by consideration of on farm efficiency by use of certain product which was ranked as five among given factors. Marketing aspects and fellow farmers success were ranked as seventh and eight respectively as drivers for farmers to use digital technology. The least considered drivers for adoption of digital technology were fondness of technology, innovativeness etc.

The findings are similar to studies conducted by Barnes et al., (2019), Shang et al., (2020) and Bewley (2010). Barnes et al., (2019) reported that cost reduction and on-farm efficiency are major influencing factors for adoption of Precision agricultural technologies. It was also revealed that financial support or subsidies play a major role among incentives for encouraging uptake of precision farming technology. Whereas Shang et al., (2020) unveiled that relative advantage of the technology is the major influencing factor for adoption of digital farming technology by farmers. Bewley (2010) stated that benefit-cost ratio is the major pre-purchase consideration factor for adoption of precision technologies.

**Table 4.14: Distribution of respondents according to their influencing factors to purchase Digital technology**

Statements	Respondents Category						RANK
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)		
	Freq.	%	Freq.	%	Freq.	%	
Availability of loan/subsidy	5	8.19	35	59.30	40	33.33	III
Accessibility of infrastructure	24	39.34	36	61.00	60	50.00	I
On farm efficiency	19	31.15	17	28.80	36	30.00	V
Marketing aspects	28	45.90	6	10.20	34	28.33	VI
Profits	12	19.67	12	20.30	24	20.00	VIII
Benefit to cost ratio	25	40.98	21	35.60	46	38.33	II
Relative advantage, compatibility	17	27.87	22	37.30	39	32.50	IV
Other's success	9	14.75	22	37.30	31	25.83	VII
Other factors	5	8.20	1	1.70	6	5.00	IX

#### 4.1.15. SOCIAL MEDIA USAGE

A glance at Table 4.15 disclosed that majority of Agriculture farmers use WhatsApp and YouTube with 98.33 percent of respondents each. This was followed by Facebook, Instagram, Twitter, Telegram, LinkedIn and ResearchGate with 55.00, 38.33, 23.33, 18.33, 3.33 and 1.67 percent of users respectively. In case of dairy farmers, the order was WhatsApp, YouTube, Facebook, Instagram, Twitter, Telegram, LinkedIn and ResearchGate with 100.00, 100.00, 56.67, 38.33, 16.67, 10.00, 3.33 and 0.00 percent of users respectively.

The pooled data too have a same order with WhatsApp and YouTube having 99.17 percent of users each. Facebook, Instagram, and Twitter reported to have 55.83, 38.33 and 20.00 percent of respondents respectively. From the table, Telegram is reported to have 14.17 percent users. This was followed by LinkedIn with 3.33 percent users. Research Gate (0.83%) is the least used platform by the respondents.

The findings are in line with that of Das et al., (2019) who stated that the adopters of smart farming technologies have been using more social media compared to non-adopters.

**Table 4.15: Distribution of respondents based on their social media usage**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
WhatsApp	59	98.33	60	100.00	119	99.17
Facebook	33	55.00	34	56.67	67	55.83
Twitter	14	23.33	10	16.67	24	20.00
YouTube	59	98.33	60	100.00	119	99.17
Instagram	23	38.33	23	38.33	46	38.33
Telegram	11	18.33	6	10.00	17	14.17
ResearchGate	1	1.67	0	0.00	1	0.83
LinkedIn	2	3.33	2	3.33	4	3.33

#### **4.1.16. SOURCE OF INFORMATION**

A detailed outlook at Table 4.16 unveiled the major source of information for agriculture farmers is contributed equally by state department of Agriculture, Dairy & Animal Husbandry, and mobile applications/ICT's etc. This was followed by institutes like ICAR, SAU, SVS, NDRI etc. personnel and webpages. The subsequent sources of information include Input dealers, government agencies like KVK/ATMA etc with rank 3 and 4 respectively. Then, Private practitioners and output buyers equally contribute as source of information. These were followed by equal contribution of publications of government organizations and INDO-ISRAEL COE. Then, rural retail hubs and companies having collaboration with agriculture department were considered at the last contributors for information with 7<sup>th</sup> and 8<sup>th</sup> rank respectively. In case of dairy farmers, the order changes slightly with mobile applications/ICT's being at 1<sup>st</sup> position followed by State department, various educational institutes, Government agencies like KVK/ATMA etc, and Input dealers with 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> positions respectively. This was followed by contribution of private practitioners and publications in 6<sup>th</sup> and 7<sup>th</sup> position. The least contribution for dairy farmers was by INDO-ISRAEL COE, private companies which have collaborations, rural retail hubs and output buyers equally with 8<sup>th</sup> position.

The pooled data revealed that mobile applications/ ICTs occupied the 1<sup>st</sup> rank. This was followed by contribution by state departments, educational institutes, government agencies, input dealers, private practitioners, and output buyers in all the positions from 2<sup>nd</sup> to 7<sup>th</sup> positions respectively. The 8<sup>th</sup> position in case of source of information was being occupied by various publications which was followed by INDO-ISRAEL COE being at 9<sup>th</sup> place. Rural retail hubs and companies with which agricultural department has signed MoU were ranked in 10<sup>th</sup> and 11<sup>th</sup> position respectively. The companies in collaboration with department has least contribution was the least information contributor among all the sources. The majority of farmers (54.59%) considered public source of information as major information contributor related to digital technology rather than private sources with 45.40 percent contribution. The findings are in line with that of the studies done by Meena et al., (2019) who stated that public sources as major contributor.

**Table 4.16: Distribution of respondents based on source of information**

Statements	Respondents Category								RANK
	Agriculture farmers (n=60)		RANK	Dairy farmers (n=60)		RANK	Pooled (n=120)		
	Freq.	%		Freq.	%		Freq.	%	
<b>Public sources</b>									
KVK/ ATMA/ other Govt. agencies and on webpage	41	13.27	<b>IV</b>	40	17.02	<b>IV</b>	81	14.89	<b>IV</b>
ICAR, SAU, SVS, NDRI personal and on webpage	44	14.24	<b>II</b>	42	17.87	<b>III</b>	86	15.81	<b>III</b>
State department of Agriculture, Dairy, Animal Husbandry personal and on webpage	59	19.09	<b>I</b>	44	18.72	<b>II</b>	103	18.93	<b>II</b>
Govt. organizations published Magazine/ bulletins/ folder etc.	12	3.88	<b>VI</b>	3	1.28	<b>VII</b>	15	2.76	<b>VIII</b>
INDO-ISRAEL CoE	12	3.88	<b>VI</b>	0	0.00	<b>VIII</b>	12	2.21	<b>IX</b>
<b>Private sources</b>									
Pvt. Practitioners/ Para vets	18	5.83	<b>V</b>	24	10.21	<b>VI</b>	42	7.72	<b>VI</b>
Input dealers	43	13.92	<b>III</b>	25	10.64	<b>V</b>	68	12.50	<b>V</b>
Output buyers	18	5.83	<b>V</b>	0	0.00	<b>VIII</b>	18	3.31	<b>VII</b>
Rural retail hubs	2	0.65	<b>VII</b>	0	0.00	<b>VIII</b>	2	0.37	<b>X</b>
Mobile Apps, Media, ICT	59	19.09	<b>I</b>	57	24.26	<b>I</b>	116	21.32	<b>I</b>
Companies in collaboration with Department of agriculture	1	0.32	<b>VIII</b>	0	0.00	<b>VIII</b>	1	0.18	<b>XI</b>
<b>Total Public sources</b>	168	54.37		129	54.89		297	54.59	
<b>Total Private sources</b>	141	45.63		106	45.11		247	45.40	
<b>Total Public &amp; Private</b>	309			235			544		

**4.1.17. PERCEIVED BENEFITS**

Table 4.17 presents data on the farmer's responses on perceived benefits from digital technology. Later the weighted mean percentage was calculated for each statement. The findings from the table revealed that about 45.00 percent of the respondents agreed that digital technology aids in knowing pH, temperature, and weather information instantly with weighted mean percentage of 2.17. About 46.67 percent of the respondents agreed that digital technologies improve efficiency of irrigation with weighted mean value of 2.14. Whereas about 38.33 percent of respondents agreed that digital technologies reduce risk and regulatory burden with weighted mean score of 2.10. This was followed by 35.83 percent of respondents agreeing that digital technologies reduce labour requirement with weighted mean score of 2.05. While only, 29.17 percent respondents reported that it provides timely and accurate information with 2.05 weighted mean value.

On the other hand, 49.17 respondents disagreed with statement that digital technology help in early detection of pests and diseases and very closely 48.33 percent of the respondents also disagreed with statement that digital technology increases efficiency in Chemical application. About 47.50 percent of respondents disagreed that the smart agriculture ensures efficiency in sowing and harvesting. The responses might be in this way because, farmers were not aware of all benefits of every digital technology. Other benefits perceived by the respondents were saving of time, identification of animal physiological processes, financial & market information, promotes sustainability, reduces pollution, increased yield, quality of produce, increased efficiency of input usage, increased profits and improved record keeping.

The findings from the Table 4.17 were in consistent with that of Lencsés et al., (2014) and Knierim et al., (2019).

**Table 4.17: Distribution of respondents based on their perceived benefits from Digital technology application**

S. No	Statements	Disagree		Slightly agree		Agree		Weighted Mean Score	RANK
		Freq.	%	Freq.	%	Freq.	%		
1	Increase in yield	44	36.67	38	31.67	38	31.67	1.95	<b>VI</b>
2	Efficiency in inputs usage	48	40.00	37	30.83	35	29.17	1.89	<b>VII</b>
3	Saving time	38	31.67	50	41.67	32	26.67	1.95	<b>VI</b>
4	Less labour requirement	36	30.00	41	34.17	43	35.83	2.05	<b>IV</b>
5	Improved quality of produce	54	45.00	44	36.67	22	18.33	1.73	<b>XIII</b>
6	Timely and accurate information	29	24.17	56	46.67	35	29.17	2.05	<b>IV</b>
7	Early detection of pests and diseases	59	49.17	28	23.33	33	27.50	1.78	<b>XI</b>
8	Efficiency in irrigation	39	32.50	25	20.83	56	46.67	2.14	<b>II</b>
9	Efficiency in chemical application	58	48.33	30	25.00	32	26.67	1.78	<b>XI</b>
10	Efficiency in sowing & harvesting operations	57	47.50	37	30.83	26	21.67	1.74	<b>XII</b>
11	Aids in knowing pH, temperature, weather conditions etc.	33	27.50	33	27.50	54	45.00	2.17	<b>I</b>
12	Aids in identifying animal physiological processes	46	38.33	34	28.33	40	33.33	1.95	<b>VI</b>
13	Aids in getting market information	41	34.17	36	30.00	43	35.83	2.01	<b>V</b>
14	Aids in financial aspects	48	40.00	39	32.50	33	27.50	1.87	<b>IX</b>
15	Increased sustainability	52	43.33	30	25.00	38	31.67	1.88	<b>VIII</b>
16	Improved record-keeping	48	40.00	40	33.33	32	26.67	1.87	<b>IX</b>
17	Increased profits	52	43.33	36	30.00	32	26.67	1.83	<b>X</b>
18	Reduced risk and regulatory burden	34	28.33	40	33.33	46	38.33	2.10	<b>III</b>
19	Reduced environmental pollution	53	44.17	40	33.33	27	22.50	1.78	<b>XI</b>

## 4.2. STATUS OF DIGITAL FARMING TECHNOLOGIES IN THE STUDY AREA

### 4.2.1.1. VARIOUS DIGITAL AGRICULTURE TECHNOLOGIES ADOPTED BY AGRICULTURE FARMERS

**Table 4.18: Distribution of agriculture farmers based on their adoption of digital agriculture technologies**

Sl. No	Technology	Adoption (n=60)	
		Freq.	%
1.	pH sensor	24	40.00
2.	Temperature sensor	18	30.00
3.	Humidity sensor	6	10.00
4.	Soil moisture sensor	20	33.33
5.	Soil Electrical conductivity sensor	18	30.00
6.	Handheld crop sensors like GreenSeeker	9	15.00
7.	Drones for chemical application on crops	7	11.67
8.	Digital Laser Land leveller	33	55.00
9.	Automated sprayer/Automated Boom irrigation system	14	23.33
10.	Automated seed sowing machine	8	13.33
11.	Automated Vegetable processing system/ Automated grader, sorter machine, Automated pipeline system for cooling	6	10.00
12.	Sugarcane Setts treatment machine	9	15.00
13.	Global Positioning System	15	25.00

A brief look at Table 4.18 revealed that majority i.e., 55.00 percent of agriculture farmers adopted digital laser land leveller. This was followed by use of pH sensor (40.00%), soil moisture sensor (33.33%), temperature sensor (30.00%), soil Electrical conductivity sensor (30.00%). The subsequent major technologies were GPS, automated sprayer/automated boom irrigation system, handheld crop sensors, sugarcane sett machine, automated sowing machine, drones for chemical application, humidity sensor and automated processing machine with 25.00, 23.33, 15.00, 15.00, 13.33, 11.67,

10.00 and 10.00 percent respectively. The technologies which were adopted more might be either accessible (hired like laser landlevellor or purchase) or affordable (like sensors). Whereas automated processing machines might be too costly for an individual to adopt. These technologies were obtained from government or private sources like INDO-ISRAEL Centres of excellence, CIMMYT, Mass media, private companies etc.

The findings from the Table 4.18 were similar to the study conducted by Ruder (2019) which stated that majority of digital agriculture technologies adopted by farmers include GPS technology, sensors, and Drones.

However, automated machinery is adopted by only some of the respondents. These findings were contrast to the study conducted by Chuang et al., (2020) who stated that automated machineries were the highest adopted digital technology in the study area. The reason for these dissimilarities may be due to the differences in socio-economic profile of respondents in India and Taiwan.

#### **4.2.1.2. CATEGORICAL DISTRIBUTION OF RESPONDENTS ACCORDING TO THEIR OVERALL ADOPTION OF DIGITAL AGRICULTURE TECHNOLOGIES**

From the findings of Table 4.19 it can be reported that majority (56.67%) of agriculture farmers belong to medium level of adoption. This was followed by low and high adoption category with 35.00 and 8.33 percent of farmers respectively.

**Table 4.19: Distribution of agriculture farmers based on digitalisation in agriculture sector**

Category	Agriculture farmers (n=60)	
	Freq.	%
Low (<2)	21	35.00
Medium (2-4)	34	56.67
High (>4)	5	8.33

#### **4.2.1.3. CATEGORICAL DISTRIBUTION OF RESPONDENTS BASED ON THEIR AVERAGE YEARS OF ADOPTION OF DIGITAL AGRICULTURE TECHNOLOGIES**

A glance at Table 4.20 revealed that majority of respondents i.e., about 41.67 percent had been adopting the technologies for 2-3 years. This was followed by 3-4

years, 1-2 years, and 4-5 years with 28.33, 20.00 and 10.00 percent respectively. The average years of adoption of digital agriculture technology was 2.99 years.

**Table 4.20: Distribution of respondents based on their average years of adoption of digital agriculture technologies**

Average years	Agriculture farmers (n=60)	
	Freq.	%
1 – 2	12	20.00
2 – 3	25	41.67
3 – 4	17	28.33
4 – 5	6	10.00
Mean	2.99	

**4.2.2.1. VARIOUS DIGITAL TECHNOLOGIES AMONG ANIMAL FARMING ADOPTED BY DAIRY FARMERS**

A cursory look at Table 4.21 unveiled that cent percent of dairy farmers had yellow QR code tags for their animals. This was followed by adoption of Bulk milk coolers, lactometers, and pedometer with 30.00, 18.33, and 13.33 respectively. The subsequent technologies include sensor-based fogger systems and milk parlour which were adopted equally (11.67%) by respondents. These were followed by adoption of automatic milk analyzer with 10.00 percent. The least adopted technology was milk processing and packaging machines with 8.33 percent.

Cent percent of dairy farmers were adopting yellow QR code tags because they were accessible and cheap. The findings were similar to the study conducted by Das et al., (2019) who reported some of the dairy farmers uses activity meters like pedometers. However, the adoption of milk processing & packaging machines is too low i.e., about 8.33 percent because of requirement of high investment and larger herd size. The other digital animal technologies were less adopted due to low awareness of certain technologies like sensor-based fogging systems, automatic milk analyzer etc. whereas the adoption of Bulk milk coolers was about 30.00 percent due to their accessibility and

## Results and Discussion

affordability. The sources of these technologies were government or private organisations like SAUs, state department, input suppliers and output dealers.

### 4.21: Distribution of respondents based on digital Animal technology composition

Sl. No	Technology	Adoption	
		Freq.	%
1.	Yellow QR code tags/ Mobile enabled tags	60	100.00
2.	Sensor-based fogger systems	7	11.67
3.	Pedometer	8	13.33
4.	Lactometer	11	18.33
5.	Milk parlour	7	11.67
6.	Milk processing & packaging machines	5	8.33
7.	Automatic milk analyzer	6	10.00
8.	Bulk milk coolers	18	30.00

### 4.2.2.2. CATEGORICAL DISTRIBUTION OF RESPONDENTS ACCORDING TO THEIR OVERALL ADOPTION OF DIGITAL TECHNOLOGIES AMONG ANIMAL FARMING

The findings from Table 4.22 unveiled that majority (56.67%) of dairy farmers belong to medium level of adoption. This was followed by low and high adoption category with 31.67 and 11.67 percent of farmers respectively.

**Table 4.22: Distribution of dairy farmers based on digitalisation in dairy farming**

Category	Dairy farmers (n=60)	
	Freq.	%
Low (<1)	19	31.67
Medium (1-3)	34	56.67
High (>3)	7	11.67

**4.2.2.3. CATEGORICAL DISTRIBUTION OF RESPONDENTS BASED ON THEIR AVERAGE YEARS OF ADOPTION OF DIGITAL TECHNOLOGIES AMONG ANIMAL FARMING**

A glimpse at Table 4.23 shown that majority of respondents i.e., about 38.33 percent had been adopting the technologies from less than 1 year. This was followed by 1-2 years, 2-3 years, and 3-4 years with 35.00, 25.00 and 1.67 percent respectively. The average year of adoption of digital animal technology was 1.45 years.

**Table 4.23: Distribution of respondents based on their average years of adoption of digital technologies among animal farming**

Average years	Dairy farmers (n=60)	
	Freq.	%
0 – 1	23	38.33
1 – 2	21	35.00
2 – 3	15	25.00
3 – 4	1	1.67
Mean	1.45	

**4.2.3.1. VARIOUS DIGITAL SERVICE TECHNOLOGIES ADOPTED BY THE RESPONDENTS**

A cursory look at Table 4.24 reported that majority (98.33%) of agriculture farmers use online resources. This was followed by marketing apps, production apps, financial apps, weather apps, and software with 65.00, 63.33, 43.33, 38.33, and 38.33 percent respectively. The least used digital service includes AI-based advisory services with 21.67 percent. However, cent percent of dairy farmers were using online resources. This was followed by weather apps, production apps, marketing apps, and financial apps with 33.33, 28.33, 26.67, and 11.67 percent respectively. None of the dairy farmers were using AI-based advisory services and software.

**Table 4.24: Distribution of respondents based on digital service technology composition**

S. No	Technology	Respondents Category					
		Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
		Freq.	%	Freq.	%	Freq.	%
1.	Financial apps	26	43.33	7	11.67	33	27.50
2.	Marketing apps	39	65.00	16	26.67	55	45.83
3.	Weather apps	23	38.33	2	33.33	25	20.83
4.	Production apps	38	63.33	17	28.33	55	45.83
5.	Online resources	59	98.33	60	100.00	119	99.17
6.	AI advisory services	13	21.67	0	0.00	13	10.83
7.	Software (NDVI, Nutrient expert etc.)	23	38.33	0	0.00	23	19.17

The pooled data showed that majority (99.17%) of farmers were using online resources which was followed by use of production apps, marketing apps, financial apps, weather apps, software, and AI-advisory services with 45.83, 45.83, 27.50, 20.83, 19.17, and 10.83 respectively.

Online resources were highly adopted as most of the farmers were now having smart phones and internet facility. AI advisory services were least adopted as the respondents were having low awareness about existence of such services.

**4.2.3.2. CATEGORICAL DISTRIBUTION OF RESPONDENTS ACCORDING TO THEIR OVERALL ADOPTION OF DIGITAL SERVICE TECHNOLOGIES**

A cursory look at Table 4.25 unveiled that about 46.67 percent of agriculture farmers belong to medium level of adoption category. This was followed by high and low adoption categories with 28.33 and 25.00 percent of respondents respectively. However, majority i.e., 81.67 percent of dairy farmers belong to low level of adoption category which was followed by 18.33 percent of them under medium category.

The pooled data revealed that majority (53.33%) of farmers were under low level of digital service adoption. This was followed by 32.50 percent of farmers under medium category. The least percent of farmers belong to high level of service sector digitalisation (14.17%). The findings of the study are in consistent with that of the study conducted by Singh et al., (2018).

**Table 4.25: Distribution of respondents based on digitalisation in service sector**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Low (<2)	15	25.00	49	81.67	64	53.33
Medium (2-4)	28	46.67	11	18.33	39	32.50
High (>4)	17	28.33	0	0.00	17	14.17

#### 4.2.3.3. CATEGORICAL DISTRIBUTION OF RESPONDENTS BASED ON THEIR AVERAGE YEARS OF ADOPTION OF DIGITAL SERVICE TECHNOLOGIES

A look at Table 4.26 revealed that about 31.67 percent were using digital service technologies for 3-4 years which was followed by 30.00 percent of users for 4-5 years. This was followed by 2-3 years, 5-6 years, 1-2 years, 6-7 years, and 7-8 years with 19.17, 10.00, 5.00, 3.33, and 0.83 percent respectively.

The findings from the above tables on extent of digitalisation in agricultural sector were like those revealed by Ruder (2019). It was unveiled that the major adopted digital farming technologies include digital service technology which were followed by use of GPS, sensors etc. The findings from the current study also align with the results of study conducted by Bolfe et al., (2020) who stated that major adopted digital technologies include internet, which was followed by mobile apps, software, GPS etc.

**Table 4.26: Distribution of respondents based on their average years of adoption of digital service technologies**

Average years	Total respondents (n=120)	
	Freq.	%
1 – 2	6	5.00
2 – 3	23	19.17
3 – 4	38	31.67
4 – 5	36	30.00
5 – 6	12	10.00
6 – 7	4	3.33
7 – 8	1	0.83
Mean	4.34	

### **4.3. PERCEPTION OF FARMERS TOWARDS DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY**

#### **4.3.1. DISTRIBUTION OF RESPONDENTS BASED ON THEIR PERCEPTION SCALE VALUES**

It is apparent from Table 4.27 identified that majority of the respondents had positive perception towards “Digital agro-animal farming technology”. The respondents strongly agreed that digital farming technologies improves the decision-making capability of the farmer with mean value of 4.08. This could be due to availability of real-time information from digital services, sensors etc. Majority i.e., about 50.00 percent of the farmers mostly agree that they would invest more in digital technologies if financial support from government was higher with mean value of 4.05. As farmers feel that digital technologies are costly but beneficial, they were ready to adopt various digital technologies if they had financial support. About 37.50 percent of respondents strongly perceived that digital farming technologies can be more beneficial for large farmers having mean value of 4.00. This could be because of their view that most of the farm operations of marginal and small acreage or small herd size can be maintained with manual labour itself.

About 41.67 percent of the farmers mostly agree that application of digital farming technologies would increase the efficiency of resources with the mean value of 3.95. Labour requirement was reduced by digital farming technologies was perceived by 35.83 percent of farmers with mean value of 3.91, whereas about 41.67 percent of respondents mostly agree that digital farming technology adoption depends on the age of farmer with 3.88 mean value. 36.67 percent of farmers mostly perceive that digital agricultural technology adoption would increase free time with mean score of 3.87. This might be due to reduce in the time taken for farm operations by automation etc. The need for identification of socio-economic issues before introducing advanced and hi-tech technologies was perceived by about 36.67 percent of farmers as essential with mean value of 3.85. It was perceived by about 37.50 percent of respondents that digital agricultural technologies were costly with mean score of 3.76. About 36.67 percent of farmers were in agreement of traditional or conventional farming with the mean value of 3.72. This might be because they feel those farmers may feel digital farming as costly or complex.

## *Results and Discussion*

The view that digital farming technologies would increase sustainability was mostly agreed by 40.83 percent of respondents with 3.61 mean value. Whereas 47.50 percent of farmers mostly agreed that digital agro-animal farming technologies are feasible for all farming systems with mean score of 3.56. It was mostly perceived (34.17%) that digital farming technologies and their services would reduce the cost of cultivation with 3.27 as mean value. Whereas 35.00 percent of farmers mostly agreed that climate change can be mitigated by digitalization in agricultural sector with mean score of 3.23.

About 30.83 percent of farmers were neutral i.e., agreed that digital technologies attract youth to take farming as an occupation with 3.12 as mean value. Whereas about 35.83 percent of farmers were neutral that digital technology aids in easier marketing of produce with mean score of 3.00. The statement that Digital India and other government programs creates awareness on digital agriculture was mostly disagreed by 32.50 percent of respondents with mean of 2.68. It was strongly disagreed by 30.00 percent of farmers that digital technology promotes development of agricultural sector with 2.54 as mean value. About 30.83 percent of farmers strongly disagreed that digital technology reduces the chemical usage on agriculture with mean score of 2.40. Whereas 28.33 percent of respondents strongly disagreed that digitalization in agricultural sector ensures unadulterated products with mean value of 2.24.

The above discussed results are in line with some of the findings of Kernecker et al., (2020) who unveiled that majority of farmers agreed that smart farming technologies improve decision-making, increases efficiency of resources, enhances productivity, and improves workload.

Majority of farmers agreed that digital farming technologies were costly in the current study which were in consistent with the findings of Das et al., (2019). Regarding financial support, the results are in line with Taheri et al., (2020). It was also observed that the findings that digital farming technologies are favorable to large farmers were in contrast with the outcomes of the study of Ruder (2019) and Adrian et al., (2005).

Table 4.27: Distribution of respondents based on perception scale values

Sl. No	Statements	SA	MA	A	MDA	SDA	Mean
1	Application of digital agro-animal farming technologies are feasible for all types of farming system	17 (14.17)	57 (47.50)	27 (22.50)	14 (11.67)	5 (4.17)	3.56
2 (-)	Digital farming technologies can be beneficial for large farmers	45 (37.50)	44 (36.67)	18 (15.00)	12 (10.00)	1 (0.83)	4.00
3	Do you think that application of digital technologies will increase the efficient use of farm resources?	37 (30.83)	50 (41.67)	23 (19.17)	10 (8.33)	0 (0.00)	3.95
4	Do you think that there is need to identify socio-economic issues for enhancing adoption of digital farming technology?	34 (28.33)	44 (36.67)	33 (27.50)	9 (7.50)	0 (0.00)	3.85
5	Digital India and other government schemes were creating awareness on digitalisation in agricultural sector	8 (6.67)	25 (20.83)	28 (23.33)	39 (32.50)	20 (16.67)	2.68
6	Digital agro-animal technologies will encourage sustainability in farming	18 (15.00)	49 (40.83)	43 (35.83)	9 (7.50)	1 (0.83)	3.61
7	Digital technologies reduce labour requirement in farming operations	35 (29.17)	43 (35.83)	39 (32.50)	3 (2.50)	0 (0.00)	3.91
8	Do you think digital technologies may influence youth to take farming up as a new occupation?	14 (11.67)	35 (29.17)	37 (30.83)	20 (16.67)	14 (11.67)	3.12
9	Do you think that digital technologies can mitigate the effects of climate change?	10 (8.33)	42 (35.00)	36 (30.00)	30 (25.00)	2 (1.67)	3.23
10 (-)	Do you think Digital agricultural technologies requires high-cost machines, equipment, and software	30 (25.00)	45 (37.50)	33 (27.50)	11 (9.17)	1 (0.83)	3.76

*Results and Discussion*

11	Digital technologies aids in easier marketing of farm produce	8 (6.67)	33 (27.50)	43 (35.83)	23 (19.17)	13 (10.83)	3.00
12	Digital innovation in farming ensures chemical free/unadulterated farm produce	0 (0.00)	14 (11.67)	35 (29.17)	37 (30.83)	34 (28.33)	2.24
13 (-)	I don't want digital technology in my farm because I believe that farming should be more traditional and natural	44 (36.67)	36 (30.00)	15 (12.50)	13 (10.83)	12 (10.00)	3.72
14	Do you think that digital agricultural technologies promote agricultural sector development?	7 (5.83)	28 (23.33)	24 (20.00)	25 (20.83)	36 (30.00)	2.54
15	Do you feel that smart farming reduces the amount of chemical applied on crops?	1 (0.83)	24 (20.00)	35 (29.17)	23 (19.17)	37 (30.83)	2.40
16	The adoption of digital farming technology highly depends on the age of farmer	32 (26.67)	50 (41.67)	31 (25.83)	6 (5.00)	1 (0.83)	3.88
17	I believe that digital farming technology and services will reduce the cost of cultivation	15 (12.50)	41 (34.17)	36 (30.00)	17 (14.17)	11 (9.17)	3.27
18	I would invest more in digital technologies if financial support from government was higher (subsidies, lower taxes)	34 (28.33)	60 (50.00)	25 (20.83)	1 (0.83)	0 (0.00)	4.05
19	Digital farming technologies improve the decision-making capability	44 (36.67)	46 (38.33)	26 (21.67)	4 (3.33)	0 (0.00)	4.08
20	Digital farming technologies would allow more time for social participation	31 (25.83)	44 (36.67)	43 (35.83)	2 (1.67)	0 (0.00)	3.87

### 4.3.2 CATEGORICAL DISTRIBUTION OF RESPONDENTS ACCORDING TO THEIR OVERALL PERCEPTION TOWARDS DIGITAL FARMING TECHNOLOGY

Table 4.28 unveiled that majority of agriculture farmers (51.67 %) were having medium perceptual level, while 25.00 percent were having low perceptual level which was followed by 23.33 percent of agriculture farmers under high perceptual level. Whereas majority (55.00%) of dairy farmers were having medium level of perception with 30.00 percent under low perceptual level which was followed by 15.00 percent of farmers belonging to high level of perception.

The pooled data unveiled that majority (53.33%) of the farmers were having medium level of perception. This was followed by low and high level of perception with about 27.50 and 19.17 percent respectively. The findings contrasted with that of Chaudhary (2019) on perception of precision farming technologies. This scenario may be due to more complexity of smart farming technology than precision farming technology.

**Table 4.28: Distribution of respondents based on their overall perception level**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Low perceptual level (<65.57)	15	25.00	18	30.00	33	27.50
Medium perceptual level (65.58 -72.78)	31	51.67	33	55.00	64	53.33
High perceptual level (>72.78)	14	23.33	9	15.00	23	19.17

## 4.4. AWARENESS OF FARMERS ON DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY

### 4.4.1. DISTRIBUTION OF RESPONDENTS ON THE BASIS OF THEIR AWARENESS ON DIGITAL AGRICULTURE TECHNOLOGY

It is evident from Table 4.29 that majority i.e., 55.00 percent of the farmers were moderately aware that irrigation water efficiency can be improved by laser land

## *Results and Discussion*

levelling. About 46.67 percent of farmers were moderately aware of the application of pH sensor. Whereas about 38.33 percent of respondents were moderately aware that temperature sensor can detect changes in Greenhouse environment. While 46.67 percent of agriculture farmers were slightly aware that CPI can be identified by Soil moisture sensor.

However, majority of the agriculture farmers (56.67%) were not at all aware that boom irrigation can ensure space use efficiency. Whereas 53.33 percent of respondents had no awareness on the application of humidity sensor. This may be due to less applicability of humidity sensor and boom irrigation system in open field environment.

A glance at Table 4.30 identified that majority i.e., 70.00 percent of the respondents had slight or moderate awareness on the application of drones for pest surveillance and chemical application. This may be due to availability of drones on rental basis and more information reach on drones on social media platforms. However, about 43.33 percent of farmers were having no awareness that crop sensors can measure plant health and vigour. This may be due to lesser marketing and advertising on social media.

The critical look at Table 4.31 unveiled that majority of farmers (61.67%) had no awareness on automated processing machines. This was followed by 58.33 percent had no awareness that sugarcane setts can be treated automatically. Whereas 56.67 and 53.33 percent of respondents were not aware that field robots and automated sowing machines can be used for sowing in nursery respectively. Majority of farmers had no awareness on sowing and post-harvest digital technology as Indian farmers are economically out of reach of such technology and therefore most of them had tendency of not getting enough information on high investment technology.

The findings from the Table 4.32 revealed that majority i.e., 73.33 percent of agriculture farmers had slight or moderate awareness that labour shortage can be overcome by automated machinery. This was followed by moderate or slight awareness of GPS sensor and location tracking by 65.00 percent of the respondents. Whereas about 46.67 percent of the respondents were slightly aware that digital agriculture technology increases profitability and efficiency in farming.

**Table 4.29: Distribution of respondents on the basis of awareness on agronomical aspects of digital agriculture technology**

Sl. No	Statements	Moderately aware		Slightly aware		Not at all aware	
		Freq.	%	Freq.	%	Freq.	%
1.	Are you aware that pH of irrigation water can be identified by pH sensor?	28	46.67	17	28.33	15	25.00
2.	Are you aware that temperature changes in the Greenhouse environment can be observed from Temperature sensor?	23	38.33	19	31.67	18	30.00
3.	Are you aware that Critical Point of Irrigation (CPI) can be identified by using Soil moisture sensor?	13	21.67	28	46.67	19	31.66
4	Are you aware that moisture content in the surrounding environment can be known from Humidity sensor?	9	15.00	19	31.67	32	53.33
5	Are you aware that Boom irrigation system improves the efficiency of space use in the greenhouse?	14	23.33	12	20.00	34	56.67
6	Are you aware that irrigation water efficiency can be improved by laser land levelling?	33	55.00	17	28.33	10	16.67

**Table 4.30: Distribution of respondents on the basis of awareness on crop protection aspects of digital agriculture technology**

Sl. No	Statements	Moderately aware		Slightly aware		Not at all aware	
		Freq.	%	Freq.	%	Freq.	%
1.	Are you aware that Drones can be used for pest surveillance and chemical application in the crops?	26	43.33	16	26.67	18	30.00
2.	Are you aware that plant health and vigour can be instantly measured by crop sensors?	10	16.67	24	40.00	26	43.33

**Table 4.31: Distribution of respondents on the basis of awareness on sowing & post harvest aspects of digital agriculture technology**

Sl. No	Statements	Moderately aware		Slightly aware		Not at all aware	
		Freq.	%	Freq.	%	Freq.	%
1.	Are you aware that automated seed sowing machine can be used for sowing in the nursery trays?	7	11.67	21	35.00	32	53.33
2.	Are you aware that product quality can be improved by using automated machines like grader, sorter etc.?	6	10.00	17	28.33	37	61.67
3.	Are you aware that prior to planting sugarcane setts can be treated with chemicals automatically by using sett treatment machine?	9	15.00	16	26.67	35	58.33

4.	Are you aware that Field robots can be used in crop nurseries, primarily in moving seedlings or plants?	3	5.00	23	38.33	34	56.67
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However, majority (70.00%) of the respondents were not aware that satellite images have wide applications in digital farming. While 51.67% of the respondents had no awareness that Internet of Things, Artificial Intelligence, Sensors etc. have more scope in future. These technologies have low awareness as they are highly advanced and complex.

**Table 4.32: Distribution of respondents on the basis of awareness on general aspects of digital agriculture technology**

Sl. No	Statements	Moderately aware		Slightly aware		Not at all aware	
		Freq.	%	Freq.	%	Freq.	%
1.	Are you aware that GPS/location sensors enable in location tracking?	29	48.33	10	16.67	21	35.00
2.	Are you aware that labour shortage can be overcome by use of automated machinery?	26	43.33	18	30.00	16	26.67
3.	Are you aware that satellite images have wide applications in future farming?	5	8.33	13	21.67	42	70.00
4.	Are you aware that digital farming technologies (IoT, A.I. Sensor, robots etc) have more scope in future?	8	13.33	21	35.00	31	51.67
5.	Are you aware that Digital Farming Technology increases profitability and efficiency in farming?	9	15.00	28	46.67	23	38.33

The findings from the above tables were in contrast with the results of Chuang et al., (2020). This might be due to differences in demographic, social class, innovativeness and accessibility situations between India and Taiwan.

#### **4.4.2: CATEGORICAL DISTRIBUTION OF RESPONDENTS ACCORDING TO THEIR OVERALL AWARENESS ON DIGITAL AGRICULTURE TECHNOLOGIES**

**Table 4.33: Distribution of respondents based on their overall awareness on Digital Agriculture technology**

Category	Agriculture farmers (n=60)	
	Freq.	%
Low (<26.54)	25	41.67
Medium (26.55 – 33.30)	22	36.66
High (>33.31)	13	21.67
Mean	23.92	

It is apparent from Table 4.33 that about 41.67 percent of respondents had medium level of awareness. This was followed by 36.66 percent of farmers belonging to low awareness level. Whereas only 21.67 percent of respondents were having high level of awareness. As majority of agriculture farmers had high level of extension contact and social media exposure, they were having at least medium level of awareness of digital agriculture technology.

#### **4.4.3. DISTRIBUTION OF RESPONDENTS ON THE BASIS OF THEIR AWARENESS ON DIGITAL TECHNOLOGY RELATED TO ANIMAL FARMING**

The results presented in Table 4.34 revealed that majority (i.e., 88.33%) of the respondents were aware that heat stress in the animals can be effectively managed by sensor-based fogging system. However, 48.33 percent of the respondents were not aware that fogging can be controlled by a timer by using sensor. This might be due to less knowledge on sensor technology.

**Table 4.34: Distribution of respondents on the basis of awareness on Animal health & comfort aspects of digital technology in animal farming**

Sl. No	Statements	Moderately aware		Slightly aware		Not at all aware	
		Freq.	%	Freq.	%	Freq.	%
1.	Are you aware that robots can be used in identification of diseases as early as possible?	7	11.67	22	36.67	33	55.00
2.	Are you aware that robots can be used in cleaning cattle yard?	14	23.33	30	50.00	16	26.67
3.	Are you aware that Drones can be used in animal monitoring?	21	35.00	23	38.33	16	26.67
4.	Are you aware that IoT devices can be used for animal health monitoring?	7	11.67	16	26.67	37	61.67
5.	Are you aware that fogging can be controlled by a timer by using sensor-mounted fogging systems?	11	18.33	20	33.34	29	48.33
6.	Are you aware that yellow QR code provide vaccination and health details of animal over phone?	26	43.33	17	28.33	18	30.00
7.	Are you aware that accelerometers /pedometers help in disease tracking in animals?	17	28.33	23	38.34	20	33.33
8.	Are you aware that digital dairy technology can improve productivity of cattle?	13	21.67	16	26.67	31	51.67
9.	Are you aware that heat stress in animals can be managed effectively by using sensor-based fogging system?	29	48.33	24	40.00	7	11.67

## Results and Discussion

Whereas 73.33 percent of dairy farmers were equally aware that cattle yard cleaning robots and animal monitoring drones. 72.21 percent of respondents were aware that yellow QR code tags provide animal health and vaccination information over phone. While about 48.34 percent of respondents were either slightly or moderately aware of robots that identify diseases in dairy animals. The findings were as such due to availability of information robots, drones etc... on social media platforms.

About 38.34 percent of farmers were moderately aware that accelerometers/ pedometers can help in disease tracking in animals. However, majority i.e., 61.67 percent of respondents were not aware that IoT devices can be used for animal health monitoring. Whereas 51.67 percent of dairy farmers had no awareness that digital dairy technology improves productivity of cattle.

**Table 4.35: Distribution of respondents on the basis of awareness on physiological aspects of digital technology in animal farming**

Sl. No	Statements	Moderately aware		Slightly aware		Not at all aware	
		Freq.	%	Freq.	%	Freq.	%
1.	Are you aware that animal under heat can be identified by biosensors?	14	23.33	21	35.00	25	41.67
2.	Are you aware that Artificial Insemination/animal pregnancy can be planned by using animal heat detection sensors like “BovSmart”?	10	16.67	17	28.33	33	55.00
3.	Are you aware that animal physiological changes can be analysed by data from Biometric and Heartbeat sensors?	2	3.33	16	26.67	42	70.00
4.	Are you aware that temperature sensor when attached to animal can detect changes in body during pregnancy?	6	10.00	11	18.33	43	71.67

The findings from Table 4.35 unveiled that majority of respondents (71.67%) had no awareness that temperature sensor can detect bodily changes during pregnancy. Whereas 70.00 percent were not aware that animal physiological changes can be analysed by sensors. While about 55.00 percent of respondents were not aware that heat detection sensors can be used for scheduling Artificial insemination. About 41.67 percent had no awareness that biosensors can be used for identifying heat in animal. The findings were as such due to nascent stage of sensors usage in dairy sector in the study area.

**Table 4.36: Distribution of respondents on the basis of awareness on milking & its processing aspects of digital technology in animal farming**

Sl. No	Statements	Moderately aware		Slightly aware		Not at all aware	
		Freq.	%	Freq.	%	Freq.	%
1.	Are you aware that labour is not required for milking as it can be done by automated machines?	32	53.33	23	38.34	5	8.33
2.	Are you aware that milk quality can be assessed by using quality assessment sensors like chemical sensors, e-nose etc.?	7	11.67	14	23.33	39	65.00
3.	Are you aware that milking by machine is 3-4 times faster and safe than hand milking?	23	38.33	25	41.67	12	20.00
4.	Are you aware that protein, lactose & fat content of milk can be analysed by using automatic milk analysers?	29	48.33	26	43.34	5	8.33
5.	Are you aware that quality of processed products can be improved by using automated machines?	14	23.33	31	51.67	15	25.00
6.	Are you aware that use of milking machine will reduce the risk of injury to dairy animals during milking?	41	68.33	16	26.67	3	5.00

## *Results and Discussion*

It can be observed from Table 4.36 that majority of dairy farmers i.e., 68.33 percent were moderately aware that machine milking reduces risk of injury to dairy animal. Whereas 53.33 percent had moderate awareness that automated milk machine doesn't require labour.

While 51.67 percent of respondents were slightly aware that automated machines improve quality of processed products. About 43.34 percent had slight awareness that protein, lactose and fat content of milk can be analysed by using automatic analyzers. Whereas 41.67 percent of the dairy farmers were slightly aware that machine milking 3 times faster and safer. The findings were this way as the dairy farmers in the study area had high accessibility and adoption of milking machines and analyzers. However, 65.00 percent of the respondents had no awareness of milk quality assessment sensors. This may be due to low adoption and accessibility of such sensors.

#### **4.4.4: CATEGORICAL DISTRIBUTION OF RESPONDENTS ACCORDING TO THEIR OVERALL AWARENESS ON DIGITAL TECHNOLOGIES RELATED TO ANIMAL FARMING**

A glance at Table 4.37 revealed that about 43.33 percent of respondents had low level of awareness which might be due to less accessibility of several digital dairy technologies in their vicinity or on hired basis. This was followed by medium awareness level (40.00%). Whereas 16.67 percent of farmers had high awareness level.

**Table 4.37: Distribution of respondents based on their overall awareness on digital technology in animal farming**

Category	Dairy farmers (n=60)	
	Freq.	%
Low (<30.91)	26	43.33
Medium (30.92 – 34.83)	24	40.00
High (>34.84)	10	16.67
Mean	21.99	

#### 4.4.5. DISTRIBUTION OF RESPONDENTS ON THE BASIS OF THEIR AWARENESS ON DIGITAL SERVICE TECHNOLOGY

A cursory look at Table 4.38 unveiled that most of the respondents (99.16%) were aware that mobile apps exist for agriculture/dairy farming. Whereas 95.84 percent had awareness that prices of different agricultural products can be obtained online. About 76.67 percent were aware that digital services can also provide information from experts. 74.17 percent of farmers had awareness that marketing facilities can be obtained digitally. While 70.00 percent of the farmers were aware that direct sale can be done via digital platforms.

About 52.50 percent of the farmers were slightly aware that information related to improved crop production practices can be obtained by digital communication services. Whereas about 30.83 percent of the respondents were equally slightly aware of AI-based weather alerts and basic computer technology. This was because most of the Indian farmers have low computer skills.

**Table 4.38: Distribution of respondents on the basis of awareness on digital Service technology**

Sl. No	Statements	Moderately aware		Slightly aware		Not at all aware	
		Freq.	%	Freq.	%	Freq.	%
1.	Are you aware that mobile apps exist regarding agriculture/dairy farming?	85	70.83	34	28.33	1	0.84
2.	Are you aware that there are online resources regarding price information of different agricultural products?	68	56.67	47	39.17	5	4.16
3.	Are you aware that there are digital services on marketing facilities?	53	44.17	36	30.00	31	25.83
4.	Are you aware of basic computer technology?	26	21.67	37	30.83	57	47.50
5.	Are aware that direct sale to consumer can be done through digital services/ platforms?	25	20.83	59	49.17	36	30.00

6.	Are you aware that information from experts can be obtained using digital service technology?	39	32.50	53	44.17	28	23.33
7.	Are you aware that weather stations will provide services by sending AI-based MMS on weather alerts?	23	19.17	37	30.83	60	50.00
8.	Are you aware that Big Data technology stores vast amount of information on rainfall patterns etc.?	2	1.67	14	11.67	104	86.66
9.	Are you aware that digital communication services provide information on improved crop production practices?	24	20.00	63	52.50	33	27.50
10.	Are you aware that Block chain technology increases transparency in food supply chain?	3	2.50	21	17.50	96	80.00

However, majority i.e., 86.66 percent were unaware of big data technology. This was followed by 80.00 percent of farmers unaware of block chain technology. Most of the farmers were unaware of above two technologies as they are advanced as well as at nascent stage and government interventions to be taken for increasing awareness.

**4.4.6: CATEGORICAL DISTRIBUTION OF RESPONDENTS ACCORDING TO THEIR OVERALL AWARENESS ON DIGITAL SERVICE TECHNOLOGIES**

It is apparent from the Table 4.39 that about 40.00 percent of agriculture farmers had low awareness which was followed by medium and high level of awareness with 33.33 and 26.67 percent of farmers respectively. Whereas 48.33 percent of dairy farmers belong to low level of awareness. This was followed by 31.67 and 20.00 percent of farmers falling under medium and high level of awareness respectively. In pooled responses, about 44.17 had low level of awareness on digital service technology which

was followed by medium and high level of awareness with 32.50 and 23.33 percent of respondents.

**Table 4.39 Distribution of respondents based on their overall awareness on digital Service technology**

Category	Respondents Category					
	Agriculture farmers (n=60)		Dairy farmers (n=60)		Pooled (n=120)	
	Freq.	%	Freq.	%	Freq.	%
Low (<17.35)	24	40.00	29	48.33	53	44.17
Medium (17.36 – 20.75)	20	33.33	19	31.67	39	32.50
High (>20.75)	16	26.67	12	20.00	28	23.33
Mean	20.65		18.35		19.62	

#### **4.5. FEEDBACK OF FARMERS ABOUT DIGITAL AGRO-ANIMAL FARMING TECHNOLOGY**

##### **4.5.1. DISTRIBUTION OF RESPONDENTS BASED ON THE FACTORS CONSIDERED FOR FURTHER ADOPTION OF DIGITAL TECHNOLOGY**

Table 4.40 revealed that majority of farmers i.e., 90.83 percent of farmers will consider rental facility for future adoption of technology. This was followed by increment in profits, increment in income, and subsidy as subsequent factors being considered for further adoption of digital technology with 89.17, 76.67, and 75.83 percent of farmers respectively. Other factors include saving of time, accessibility, less operational cost, high BC ratio, easy maintenance, resource use efficiency, and less labour requirement with 72.50, 71.67, 68.03, 64.17, 57.50, 55.83, and 48.33 percent respectively. While about 46.67 percent farmers considered the facility of training for future adoption.

**Table 4.40: Distribution of respondents based on factors considered for future adoption of digital technology**

Sl.No.	Factors	Freq.	%
1	Increase in Income	92	76.67
2	Increase in Profits	107	89.17
3	Easy to maintain	69	57.50
4	Saves time	87	72.50
5	Less labour requirement	58	48.33
6	Efficiency in farm operation	39	32.50
7	Rental facility	109	90.83
8	High BC ratio	77	64.17
9	Decision making	38	31.67
10	Resource use efficiency	67	55.83
11	Accessibility	86	71.67
12	Subsidy	91	75.83
13	Internet connectivity	46	38.83
14	Less operational cost	83	68.03
15	Training on technical know-how	56	46.67

However, internet connectivity was considered by 38.83 percent of farmers only. This was followed by consideration of efficiency of farm operation and decision-making facility for further adoption of digital technology by 32.50 and 31.67 percent respectively.

The findings were in consistent with that done by Barnes et al., (2019) which unveiled that major factor's for further adoption of digital technology were cost reduction, efficiency, high ROI etc.

#### **4.5.2. DISTRIBUTION OF RESPONDENTS BASED ON THE ATTRIBUTES OF TECHNOLOGY CONSIDERED FOR ADOPTION OF DIGITAL TECHNOLOGY**

The findings presented in Table 4.41 unveiled that majority i.e., about 78.33 percent of farmers considered relative advantage of the digital technology for adoption. The subsequent major attributes considered were trialability, compatibility, and less complexity with 75.83, 73.33, and 63.33 percent respectively. These were followed by

attributes like institutional support, observability, cost-effective, and environment friendliness with 59.17, 57.50, 56.67, and 42.50 percent respectively. The least significant attribute (38.33%) was technology which has data safety and is less risky.

**Table 4.41: Distribution of respondents based on the attributes of technology as perceived by farmers for adoption of digital technology**

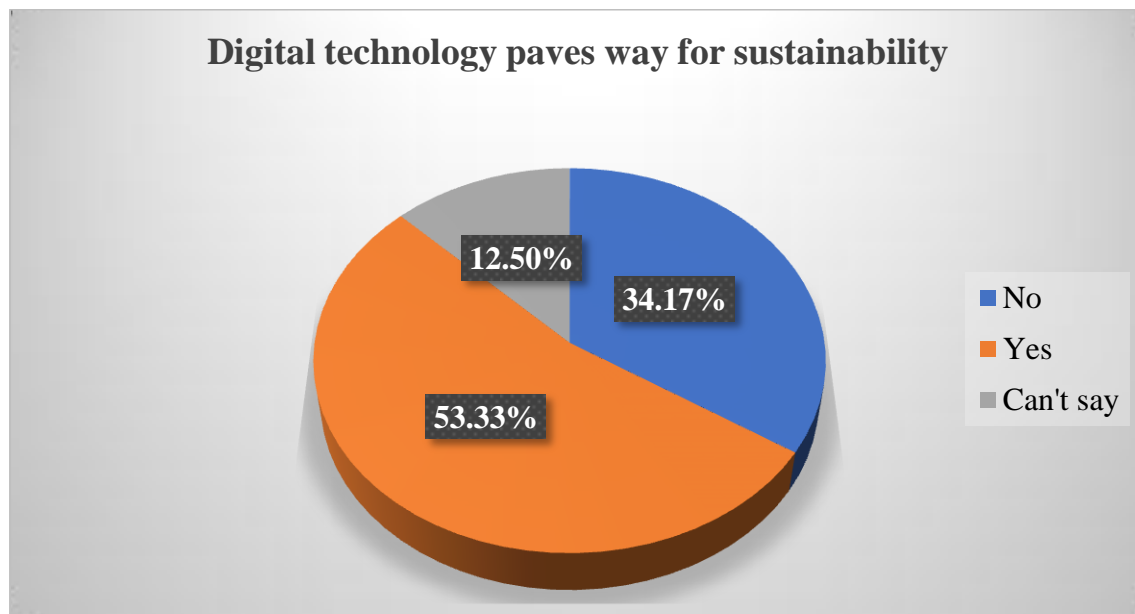
Sl.No.	Parameter	Freq.	%
1	Compatibility of technology with farm size & other resources	88	73.33
2	Less complexity of technology	76	63.33
3	Trialable before adoption	91	75.83
4	Relative advantage of technology over previously adopted technology	94	78.33
5	Perceived observability	69	57.50
6	Cost effectiveness of technology	68	56.67
7	Environment friendliness of technology	51	42.50
8	Technical support from the Institution	71	59.17
9	Technology which has Data safety	46	38.33

The current study was in consistent with findings of Shang et al., (2021) regarding attributes of digital technology who revealed that relative advantage was the major attribute considered by respondents. The observations were also in line with the view that subsidies/cost-effectiveness of the technology was one of the factors which were significant for adoption of digital technology. But the same study was in contrast regarding observability which revealed that it was not considered by the farmers for digital technology adoption. This may be due to difference of demographic conditions of the farmers which may affect their opinions.

**4.5.3. Does digital technology causes society to move toward sustainable agriculture?**

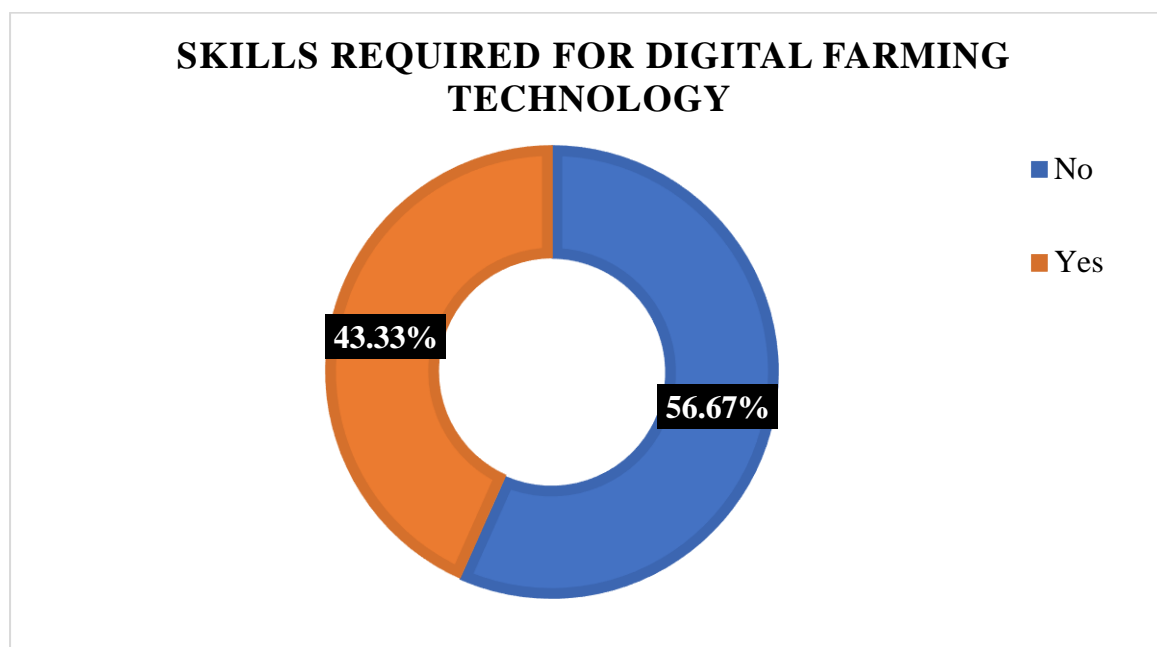
Figure 4.1 revealed that majority (53.33%) agreed that digital farming technology paves a way for achieving sustainability in agriculture. Whereas about 34.17 percent and 12.50 percent of respondents had disagreed and were unable to say respectively. The finding was similar to that conducted by Pfeiffer et al., (2021) who

reported that majority of the farmers agreed that digital farming technology enable environmentally friendly production.



*Figure 4.1 Distribution of respondents based on feedback on contribution of digital technology to sustainability*

**4.5.4. Do you need/ have enough skills to use digital farming technology?**

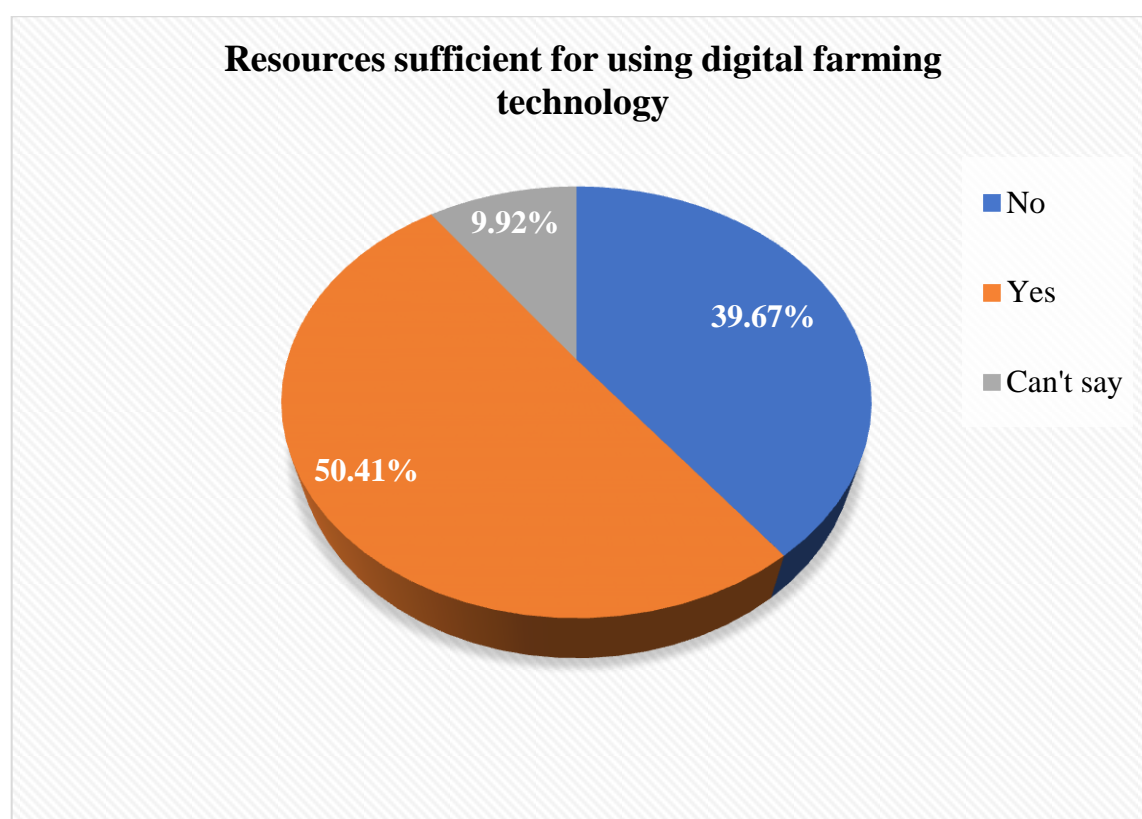


*Figure 4.2 Distribution of respondents based on feedback on the skill set of farmers to use digital technology*

Figure 4.2 unveiled that majority of farmers i.e., about 56.67 percent stated that they don't have enough skills/ need them to use digital technology. The requirement of change in skill set was one of the major barriers to adopt digital technology. The ability to cope up with technological change was considered as one of the major barriers for adoption as unveiled in the study conducted by Drewry et al., (2019).

#### **4.5.5. Are existing resources sufficient for using digital farming technology?**

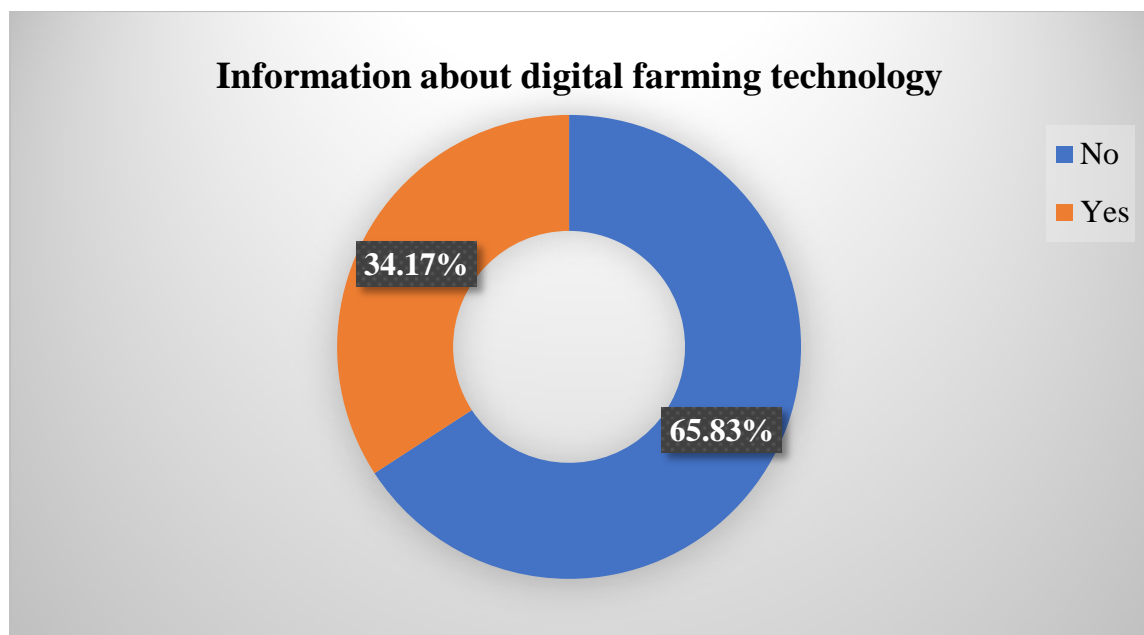
Figure 4.3 revealed that majority i.e., 50.41 percent of respondents agreed that there are sufficient resources to use digital technology. While it was disagreed by 39.67 percent of respondents. Whereas 9.92 percent of respondents had no idea about this.



**Figure 4.3 Distribution of respondents based on feedback on resources for using digital farming technology**

#### **4.5.6. Do you have enough information about digital farming technology?**

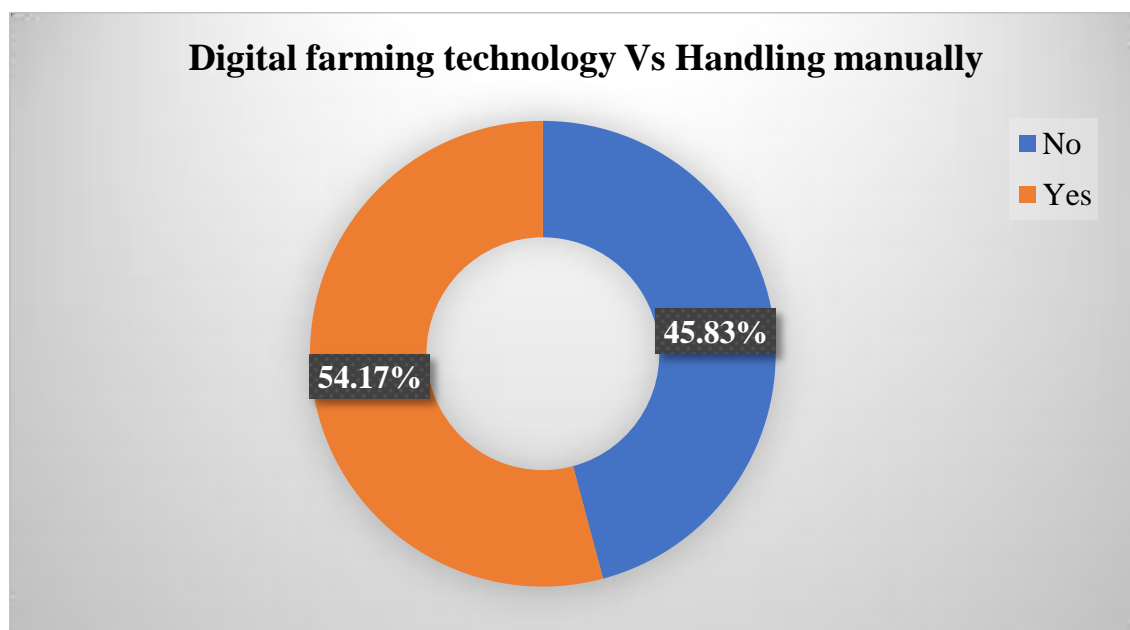
It can be observed from Figure 4.4 that majority of respondents (65.83%) disagreed that they don't have enough information about digital farming technology.



*Figure 4.4: Distribution of respondents based on feedback on information related to digital farming technology*

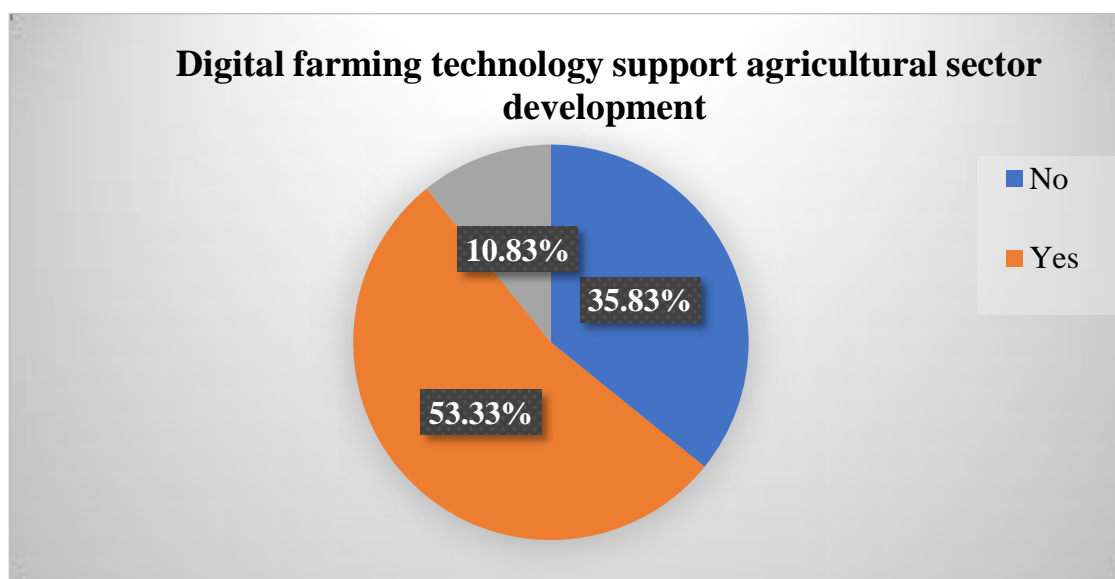
**4.5.7. Is the use of digital farming technology less stressful than handling manually?**

From the findings of figure 4.5 it can be stated that about 54.17 percent of the farmers were in favour that digital farming technology is less stressful than handling the farm manually.



*Figure 4.5 Distribution of respondents based on feedback on comparison of digital farming and traditional farming*

#### 4.5.8. Does digital farming technology support development of agricultural sector?

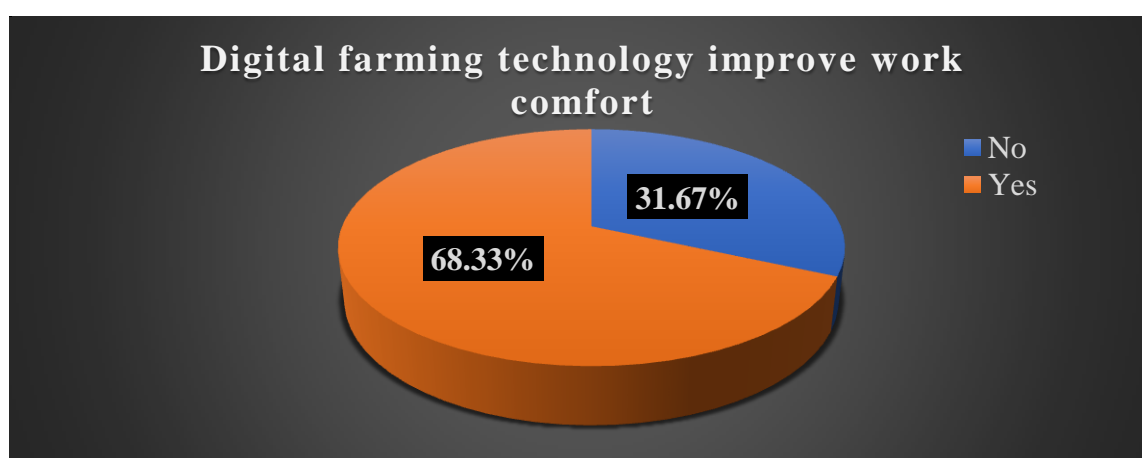


*Figure 4.6 Distribution of respondents based on feedback on role of digital farming technology for agricultural sector development*

The figure 4.6 revealed that majority (53.33%) of respondents were in favour of the aspect that digital farming technology supports the development of agricultural sector. While 35.83 percent of the farmers disagreed, and 10.83 percent of farmers have no idea on this aspect.

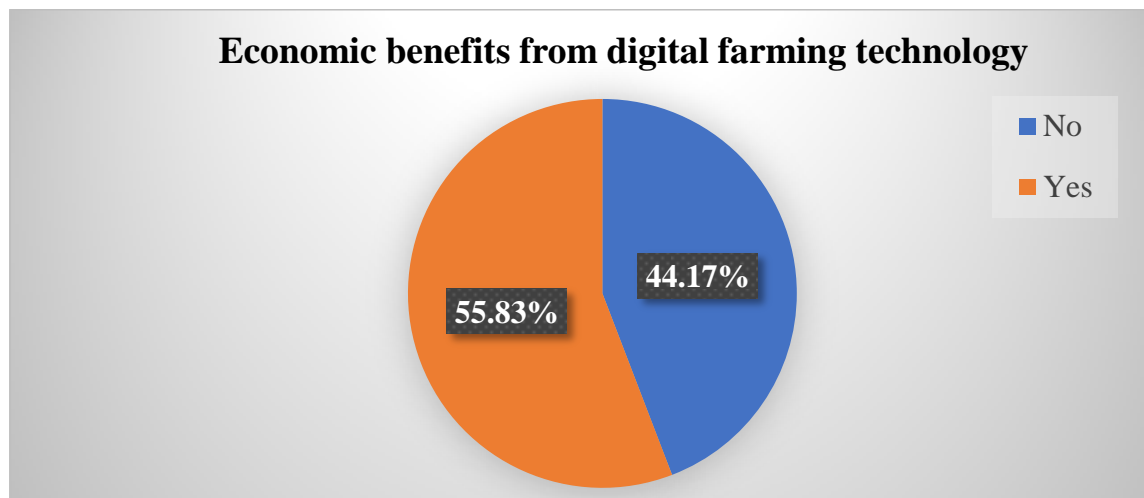
#### 4.5.9. Does digital farming technology improve farmer work comfort?

From the figure 4.7 it can be unveiled majority of respondents (68.33%) agreed that digital farming technology can improve farmer work comfort. There was similar finding from the study conducted by Pfeiffer et al., (2021) revealed that majority of the farmers agreed that digital farming technology improves quality of life.



*Figure 4.7 Distribution of respondents based on feedback on role of digital farming technology on farmer work comfort*

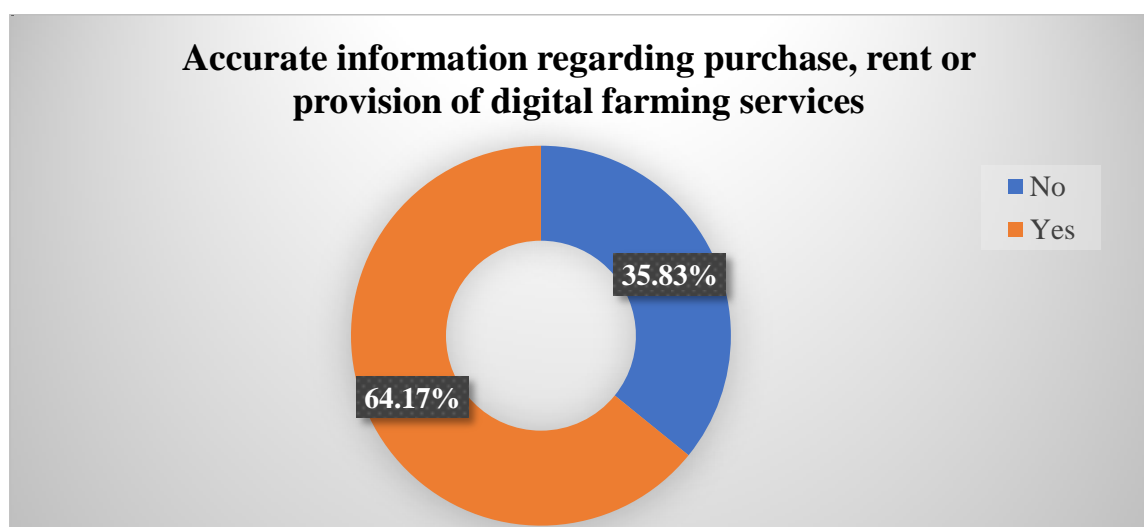
**4.5.10. Is there lack of proof regarding economic benefits from digital farming technology?**



*Figure 4.8 Distribution of respondents based on feedback on proof of economic benefits from digital farming technology*

The figure 4.8 revealed that majority i.e., about 55.83 percent of respondents agreed that there is lack of proof regarding economic benefits from the use of digital farming technology. The similar finding was revealed in the study conducted by Steeneveld et al., (2015) where majority of the people agreed that they were uncertain about the profitability of the investment in digital technology.

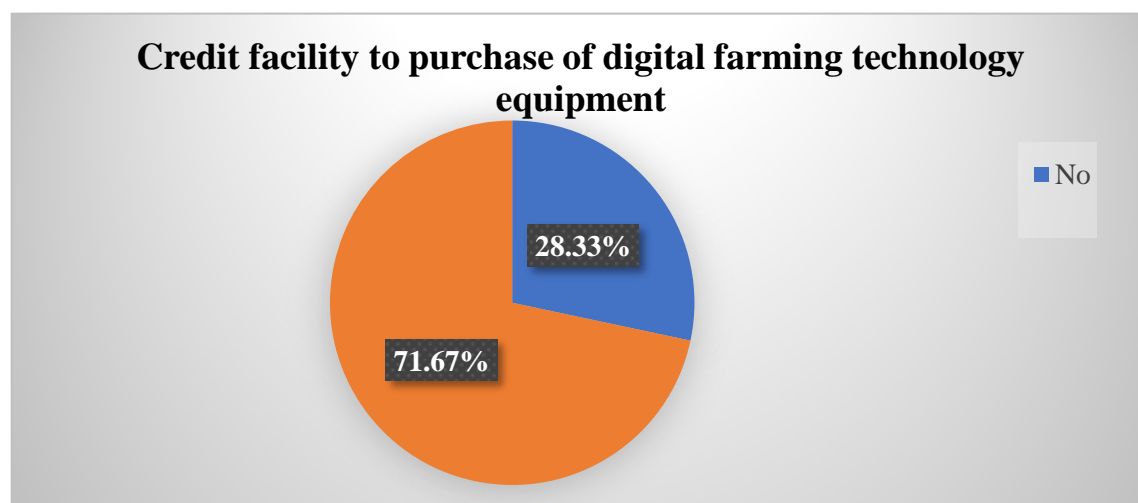
**4.5.11. Is there lack of accurate information regarding purchase, rent or provision of digital farming services?**



*Figure 4.9 Distribution of respondents based on feedback on information related to purchase, rental facilities of digital farming technology*

From the figure 4.9 it can be observed that majority i.e., about 64.17 percent of respondents agreed that there is lack of accurate information regarding purchase, rent or provision of digital technology services. The findings were reliable with the study on UAV's conducted by Skevas et al., (2020) which unveiled that majority of farmers agreed there was lack of information.

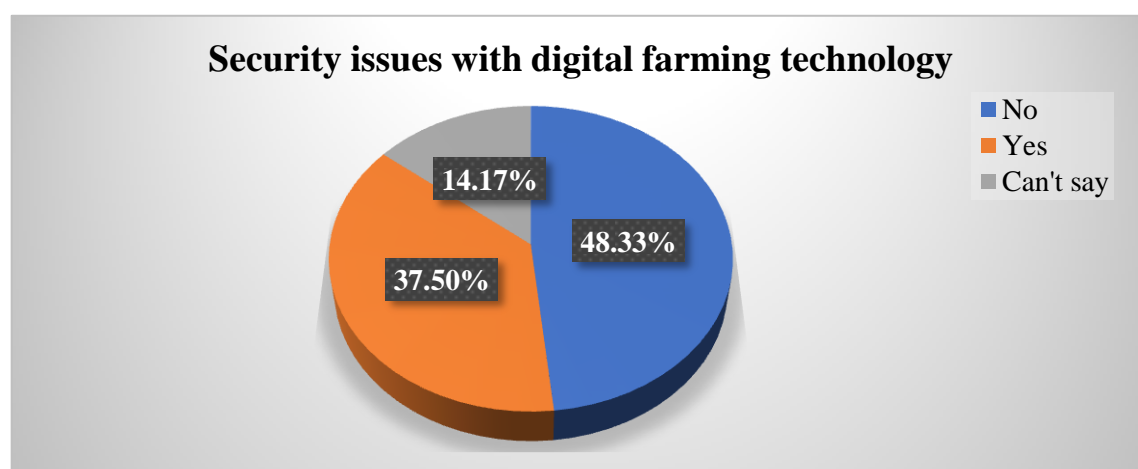
**4.5.12. Is there access to credit to purchase of digital farming technology equipment?**



*Figure 4.10 Distribution of respondents based on feedback on credit facility for purchase of digital farming technology*

The figure 4.10 unveiled that majority of respondents (71.67%) stated that there is accessibility to credit to purchase digital farming technology equipment. Whereas 28.33 percent disagreed with the availability of credit facility.

**4.5.13. Do you have security issues in using digital farming technology?**

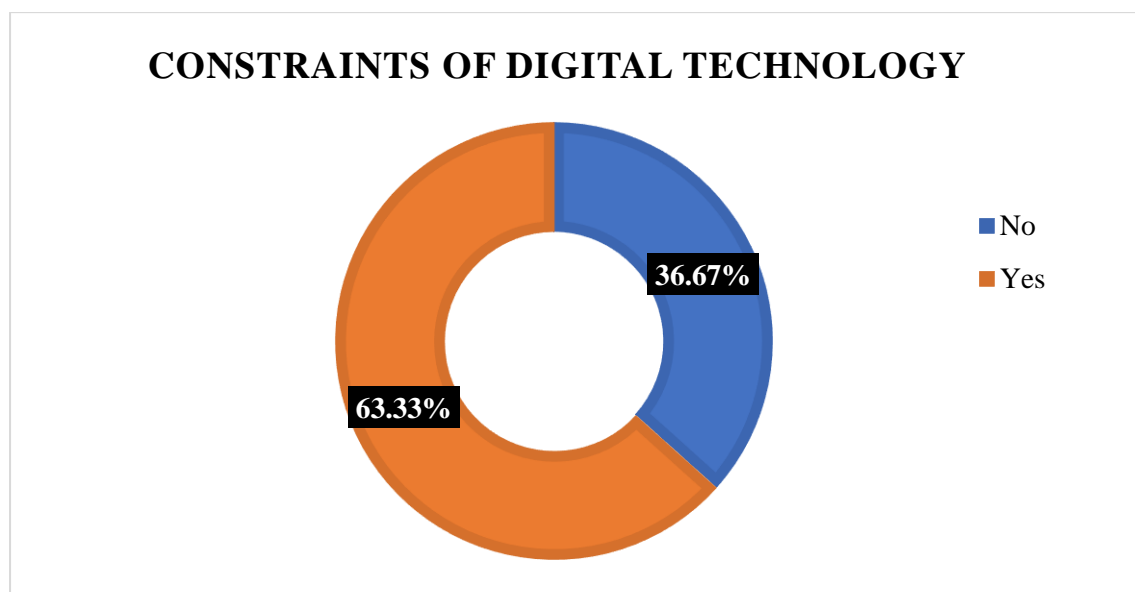


*Figure 4.11 Distribution of respondents based on feedback on data security issues of digital farming technology*

The findings from figure 4.11 revealed that about 48.33 percent of respondents agreed that they there won't be any data security issues in using digital farming technology. Whereas 37.50 percent of respondents reacted that there will be data security issues. However, 14.17 percent of respondents were unable to react as they don't have any idea. The similar finding that data sharing was an issue was identified by Das et al., (2019) in a study conducted by smart farming technology.

**4.5.14. Is familiarity with the technology and its availability major constraints in adopting technology?**

From the figure 4.12 regarding the major constraints for adoption of digital technology, majority i.e., 63.33 percent of respondents stated the familiarity and availability were the major constraints. While 36.67 percent of the respondents had opposed above response. The findings from the study conducted by Bewley et al., (2015) also revealed that about 55.00 percent of the farmers agreed that unfamiliarity with the technology reduces the rate of adoption of precision technology.



*Figure 4.12 Distribution of respondents based on feedback on constraints of digital farming technology*

**4.5.15. Do you think there is enough time for you to think and learn of digital technology?**

The figure 4.13 unveiled that most of the respondents (i.e., 80.83%) were in favour of learning digital technology. While only 19.17 percent of respondents were not favour of upgrading themselves to use digital technology due to lack of time. The

findings of the study agreed with Steeneveld et al., (2015) in which it was revealed that very few of the respondents stated that they had no time to work with the technology.

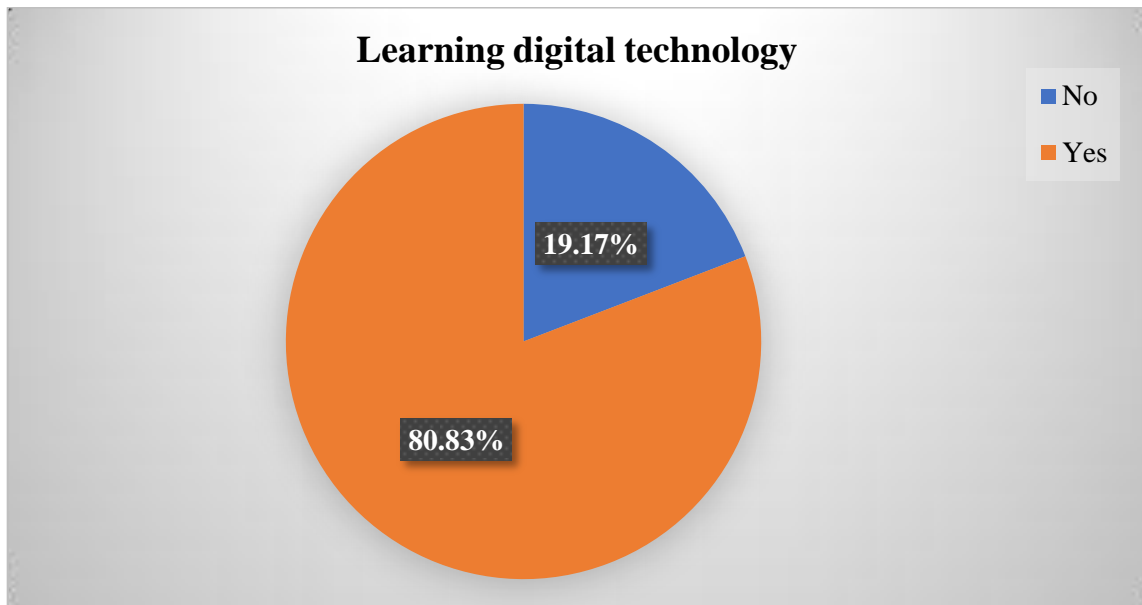


Figure 4.13 Distribution of respondents based on their interest to learn skills related to digital farming technology

#### 4.5.16. Do you think digital technology fail in fitting to existing pattern of farming?

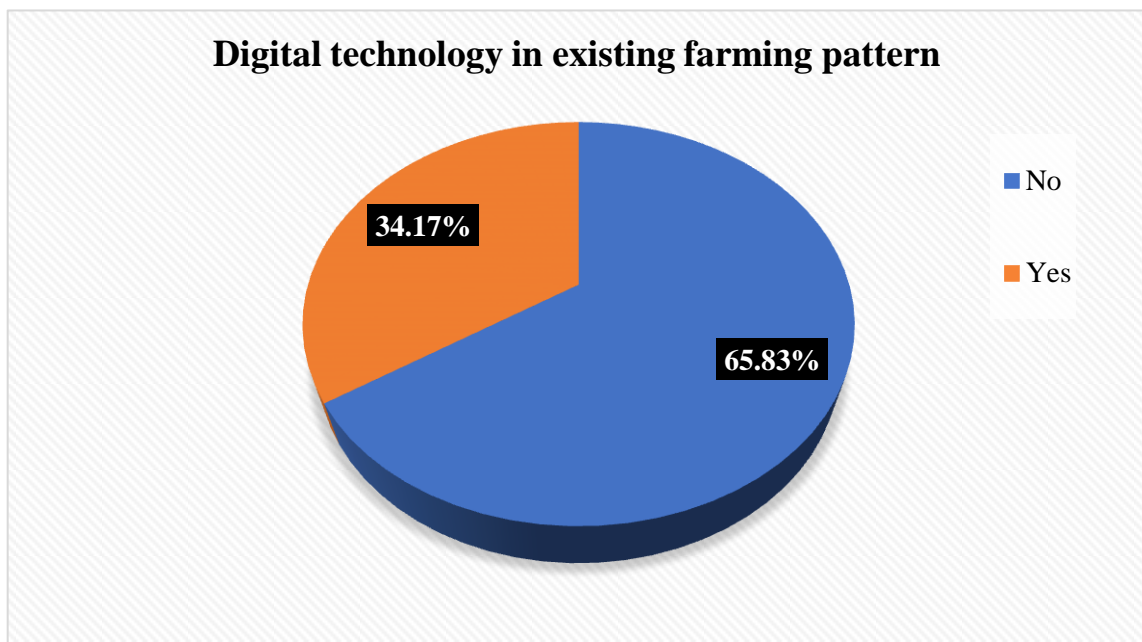
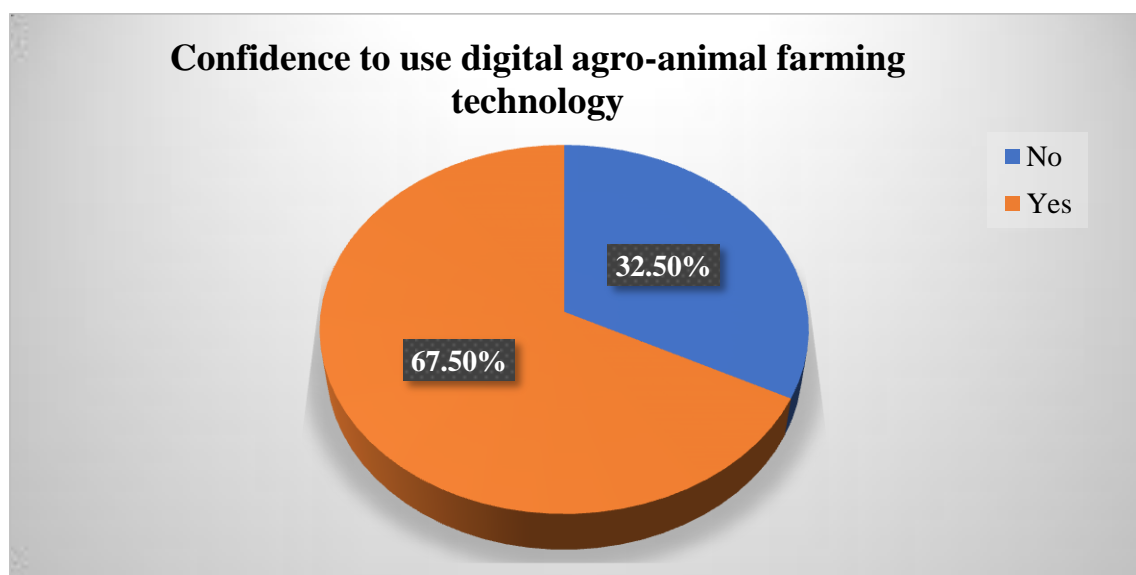


Figure 4.14 Distribution of respondents based on feedback on suitability of digital technology in existing pattern of farming

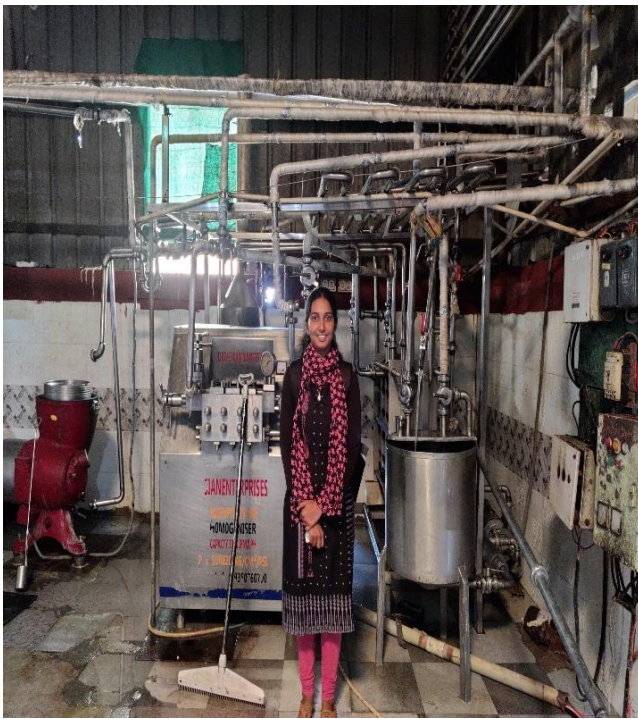
From the findings of figure 4.14 it can be stated that majority of farmers i.e., 65.83 percent disagreed that digital technology fails in fitting to existing pattern of farming. Whereas the rest (34.17%) agreed that digital technology can't be fitted in existing pattern of farming. The findings agreed with the study conducted by Steeneveld et al., (2015) who stated that only some of the farmers viewed that the sensor systems won't fit into the farming system.

**4.5.17. Are you less confident to use digital agro-animal farming technology?**

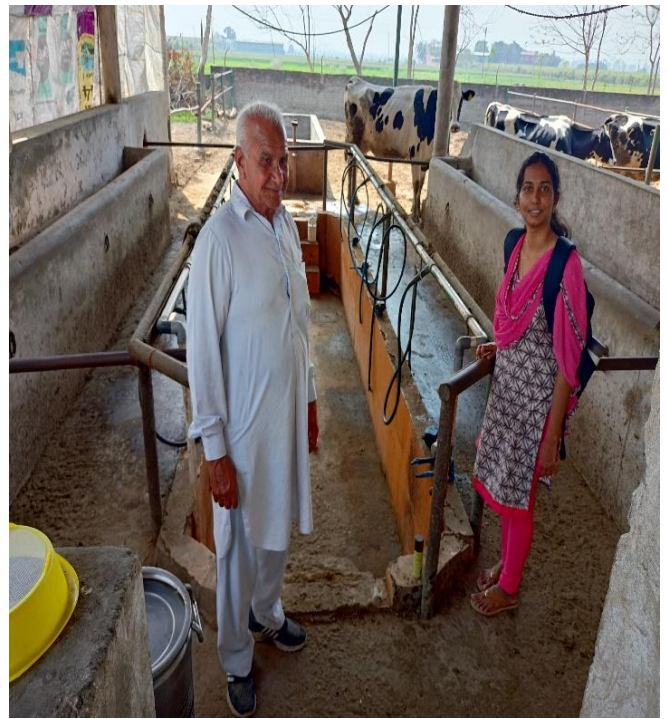
The figure 4.15 revealed that majority i.e., 67.50 percent of respondents were less confident of using digital farming technology. While 32.50 percent of farmers were confident of digital technology. The findings from the study conducted by Bewley et al., (2015) also unveiled that about 21.00 percent of the farmers were fear of the precision agriculture technology.



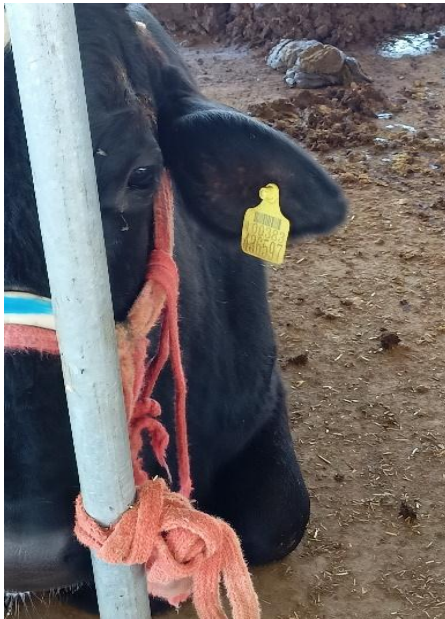
*Figure 4.15 Distribution of respondents based on their confidence to use digital farming technology*



**Milk Processing Machine**



**Milk Parlour**



**QR Code tags**



**Lactometer**



**BMC**

First time user? Working in a new location? Make sure to have the 'S' [Settings](#) /htl

- Nutrient Expert for Rice helps you to:
- evaluate current nutrient management practices
  - determine a meaningful yield goal based on attainable yield
  - estimate fertilizer NPK rates required for the selected yield goal
  - translate fertilizer NPK rates into fertilizer sources
  - develop an application strategy for fertilizers (right source, right rate, right time, right place), and
  - compare the expected or actual benefit of current and improved practices.

To start, click a button



**Software**



**Three-way meter**



**Fogger System**



**Tractor Mounted Sprayer**



**Automatic Fertilizer Mixer Tank**



**Data Collection**

# CHAPTER -5

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## Summary and Conclusions

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## SUMMARY AND CONCLUSIONS

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### 5.1 INTRODUCTION

The share of young adults (i.e., 20-29 years) in the agricultural workforce drastically declined from 34% in 2004 – 05 to 14.4% in 2018 – 19 (PLFS survey). This sharp decrease in the share of the workforce in the agricultural sector resulted in a scarcity of labour which in turn resulted in rise of wages in the sector. Even, it was reported that there was less than 20% of the prime-age work group in rural areas of states with the largest agriculture economies in India like Punjab and Haryana in 2018-19. However, these states have overcome the situation and attained higher farm productivity and income by replacing the role of farm laborers with machinery in major agricultural operations.

One of the VDSA (Village Dynamics Studies in South Asia) research studies at ICRISAT revealed that Indian farmers are struggling to pay higher wages to the agricultural laborers who are still working in the sector. These issues could be overcome by following technology-oriented farming which will reduce the requirement for laborers.

Despite the declining workforce share over the years, Indian agriculture is also witnessing a drop in the contribution of the agricultural sector towards the national GDP from 34 percent in 1983-84 to 16 percent in 2018-19. The decline in GDP contribution of the sector may be due to challenges like poor productivity, bad weather, efficiency gaps, pest and disease infestation, market price fluctuations, productivity losses over agriculture value chains, and other operational challenges, etc. The potential for overcoming these challenges is possible with digital agricultural tools. Conventional farming can be transformed through efficient utilization of resources by following Smart farming practices.

Understanding the perceptions of farmers is very important for researchers and manufacturers to address and design the products. Therefore, considering all these aspects, an attempt has been made to know the farmers perspective on digital agro-animal farming technologies through the current study titled **“Digital Agro-Animal**

**Farming Technology in Haryana: Farmers Perspective”** which was conducted by the following objectives.

1. To document the digital farming technologies in the study area
2. To measure the perception of farmers towards digital agro-animal farming technology
3. To assess awareness of farmers on digital agro- animal farming technology
4. To obtain the feedback of farmers about digital agro-animal farming technology

## **5.2 RESEARCH METHODOLOGY**

The present study was conducted in the Haryana state which was selected purposively because it has 4 out of 29 INDO-ISRAEL CoE's, state which is focussed by companies having collaboration with government. Out of the 22 districts, two districts namely Karnal and Sonipat were randomly selected for the study. From each district, three blocks were randomly selected. The three blocks that were selected from Karnal district were Karnal, Gharaunda and Nilokheri. While Sonipat, Kharkhoda and Mundlana blocks were selected from Sonipat district. For the study, two types of respondents were selected randomly i.e., crop growers and dairy animal rearers.

For the study 18 independent variables (Age, Gender, Family type, Family size, Education, Land holding, Herd size, Herd composition, Annual income, Annual expenditure, Extension contact, Accessibility of digital technology, Training received, influencing factors, social media usage, Source of information, Perceived benefits on digital technology and experience in using digital technology were considered. While four dependent variables were considered for the study namely No. of digital technologies available and used, Perception of farmers towards digital farming technology, Awareness of farmers on digital farming technology and Feedback.

For measuring the status of digital agro-animal farming technology. Schedule which comprises source of technology, years of adoption was developed. Perception scale similar to Likert's was developed to measure Perception of farmers towards digital agro-animal farming technology. Awareness of farmers on various digital agro-animal farming technologies was assessed on three-point continuum by the schedule developed. Whereas feedback was obtained from farmers by semi-structured interview schedule.

The data collected using interview schedule was analysed with the help of appropriate techniques. Statistical tools like Frequency, percentage, weighted mean, arithmetic mean, two sample t-test, cumulative square root frequency method was used and the results were interpreted and presented elaboratively under “Results and Discussion” chapter. Based on the results, the salient findings of the study were presented below.

### **5.3 SALIENT FINDINGS OF THE RESEARCH**

- ❖ Majority i.e., 55.00 percent fall into middle age group category followed by young and old categories with 27.50 and 17.50 percent respectively.
- ❖ Most of the farmers i.e., 95.00 percent were males and it was found that only 5.00 percent respondents were female.
- ❖ Majority i.e., 51.66 percent of farmers belong to nuclear family type and 48.34 percent were from joint family.
- ❖ About 50.00 percent of the respondents belong to medium family size category. This was followed by small and large family sizes i.e., 45.00 and 5.00 percent respectively.
- ❖ About 34.17 percent had higher secondary level of education followed by secondary education level with 27.50 percent of farmers. The third category of responses were under-graduate and above category with 25.00 percent of responses. This was followed by primary (7.50%) and middle (5.83%) categories. Illiterates are not observed in the current study.
- ❖ Among all categories, medium landholding is first with 38.33 percent of responses which was followed by semi-medium, small, large, marginal, and landless land-holding categories with 25.83, 19.17, 10.83, 5.00 and 0.83 respectively.
- ❖ Majority of respondents (58.33%) maintain small herd size which was followed by medium (32.50%) and large (9.17%) herd size.
- ❖ Majority of respondent i.e., 51.97 percent were maintaining crossbred cows as the most preferred dairy animal which was followed by buffalo (27.96%) and indigenous cow (20.05%).

## *Summary and Conclusions*

- ❖ About 45.83 percent of farmers belonged to low-income category which was followed by medium and high-income farmers with 40.00 and 14.17 percent respectively.
- ❖ Majority of farmers belong to low level of annual expenditure with 63.34 percent farmers. Then, 26.66 percent of farmers were having medium level of annual expenditure which was followed by high annual expenditure (10.00%).
- ❖ Majority (54.17%) of farmers had high extension contact. This was followed by medium (29.17%) and low (16.67%) level of extension contact.
- ❖ Agricultural sensors were accessible within district, outside district or state and online. Sensor-based foggers were available within district and online. Whereas automated machineries were accessible either online or at other states. Drones were accessed within the district or other district/state. While laser land levellers were accessible within block, district or online level. Yellow QR code tags were accessible within block level itself. However, digital services like mobile applications, software, online resources, were obviously accessible online only.
- ❖ Only 1.67 percent of respondents had training on digital technology. Remaining 98.33 percent had not received any training.
- ❖ About half of the respondents considered accessibility of infrastructure as the influencing factor considered for purchase of Digital technology equipment which was followed by benefit-cost ration considered by about 38.33 percent of respondents.
- ❖ WhatsApp and YouTube were used by 99.17 percent of farmers. Facebook, Instagram, and Twitter reported to have 55.83, 38.33 and 20.00 percent of users respectively. While Telegram is reported to have 14.17 percent users. This was followed by LinkedIn with 3.33 percent users. Research Gate (0.83%) is the least used platform by the respondents.
- ❖ Majority (54.59 %) of respondents were obtaining information from public sources. Whereas about 45.40 percent of respondents were obtaining information from private sources.
- ❖ About 45.00 percent of the respondents agreed that digital technology aids in knowing pH, temperature, and weather information instantly with weighted mean

score of 2.17. Whereas 18.33 percent agreed that digital technology improves quality of produce with weighted mean score of 1.73.

- ❖ Majority i.e., 55.00 percent of agriculture farmers adopted digital laser land leveller. While automated machineries and humidity sensors were adopted the least i.e., 10.00 percent. Whereas average years of adoption of digital agriculture technology was around 3 years. Majority (56.67%) of agriculture farmers belong to medium level of adoption. This was followed by low and high adoption category with 35.00 and 8.33 percent of farmers respectively.
- ❖ Cent percent of dairy farmers had yellow QR code tags for their animals. This was followed by adoption of Bulk milk coolers by 30.00 percent of respondents. However, the least adopted technology was milk processing and packaging machines with 8.33 percent. The average years of adoption of digital animal technology was around 2 years. Whereas majority (56.67%) of dairy farmers belong to medium level of adoption of digital animal technologies.
- ❖ Most (99.17%) of farmers were using online resources. The least used digital service includes was AI-based advisory services by 10.83 percent of farmers. However, majority i.e., 81.67 percent of dairy farmers belong to low level of adoption of digital service technology. It was also revealed that the farmers were using digital technology services for 5 years on average.
- ❖ The respondents strongly agreed that digital farming technologies improves the decision-making capability of the farmer with mean value of 4.08. Whereas 28.33 percent of respondents strongly disagreed that digitalization in agricultural sector ensures unadulterated products with mean value of 2.24. Majority (53.33%) of the farmers were having medium level of perception.
- ❖ Regarding awareness on agriculture technology, majority (70.00 %) of the respondents were not aware that satellite images have wide applications in digital farming. About 55.00 percent of the farmers were moderately aware that irrigation water efficiency can be improved by laser land levelling. However, about 41.67 percent of respondents had low level of awareness on digital technology.
- ❖ Majority (88.33%) of the respondents were aware that heat stress in the animals can be effectively managed by sensor-based fogging system. However, 65.00

## *Summary and Conclusions*

percent of the respondents had no awareness of milk quality assessment sensors. About 43.33 percent of respondents had low level of awareness which might be due to less accessibility of several digital dairy technologies in their vicinity or on hired basis.

- ❖ It was unveiled that most of the respondents (99.16%) were aware that mobile apps exist for agriculture/dairy farming. Whereas 95.84 percent had awareness that prices of different agricultural products can be obtained online. about 40.00 percent of agriculture farmers had low awareness.
- ❖ It was revealed that majority of respondents i.e., 90.83 percent of farmers would consider rental facility for future adoption of technology. This was followed by increment in profits, increment in income, and subsidy as subsequent factors being considered for further adoption of digital technology with 89.17, 76.67, and 75.83 percent of farmers respectively.
- ❖ Majority (78.33 %) of respondents considered relative advantage of the digital technology for adoption. About 38.33 percent of respondents considered data safe technology. However, most of the respondents (i.e., 80.83%) were in favour of learning and upgrading their skills to use digital technology.

### **5.4 CONCLUSION AND IMPLICATIONS FROM THE RESEARCH STUDY**

Based on the current research findings and conclusion made, the following implication could be recommended:

- ❖ From the findings of the study, it can be concluded that laser land leveller was the major used technology agriculture farmers due to hiring facility available via Custom Hiring Centres. The technologies which require high initial investment like automated machineries were the least used technologies by the respondents.
- ❖ Majority of the respondents were having medium and positive level of perception towards digital agro-animal farming technology. However, it was revealed that farmers were having low awareness on these technologies. This implies that farmers were in favour of digital technology and developmental agencies(public/private) should organize the awareness campaigns and training programs for the large-scale dissemination of these technologies.

- ❖ As farmers were considering attributes of technology such as compatibility, less complexity, trialability, Relative advantage, observability, cost effectiveness, environmental friendliness, Institutional support and Data safety before the adoption, the manufacturing agencies should keep those attributes in mind before designing the technology.
- ❖ It was observed that majority of the respondents were less confident of using digital technologies which was due to lack of technical knowledge. However, most of the farmers were ready to dedicate their time to learn and upgrade their skills to use digital technology. Therefore, demonstration of technologies and training programs could make farmers more confident to use these technologies.
- ❖ The study revealed that farmers were using the technologies which are less complex and affordable. Therefore, the public and private agencies could focus on promoting these types of digital technologies to kick start the process of digitalisation in agricultural sector.
- ❖ It was observed that chemical application by using drones was being discontinued due to less availability of skilled man power to operate drones. Therefore, skill upgradation could strengthen the digitalisation in agricultural sector.

## **5.5 SUGGESTIONS FOR FUTURE RESEARCH**

Based on the findings and experiences of the present study, following areas were identified where further research could be planned.

1. The similar study could be conducted in other parts of the country to know perspective of farmers on digital farming technologies.
2. The modified study with inclusion of other variables can be conducted in other countries to know the impact of digital technologies on agricultural sector, environment and farmers income. The impact study on digital technology can be conducted in India in coming years when there was wide spread adoption of digital technologies.
3. A study can be conducted to assess the knowledge level of digital technology service providers and extension agencies to train and demonstrate the technology ton farmers.

### *Summary and Conclusions*

4. The study that estimates the impact of government initiatives to digitalize the agricultural sector via Digital India or Kisan Drones scheme.
5. Detailed study on the impact of training programs and subsidies on adoption of digital farming technology by the beneficiaries can be formulated.

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# Appendix

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## **APPENDIX**

### **ICAR- National Dairy Research Institute, Karnal-132001**

Interview schedule for data collection

#### **Digital Agro-Animal Farming Technology in Haryana: Farmers Perspective**

##### **Part-A**

##### **I. General information**

- i. Name of the respondent:
- ii. Mobile no:
- iii. Name of the village:
- iv. Block:
- v. District:

##### **II. General Profile of the farmers**

1. Age (years):
2. Gender:
3. Family size:
4. Family type:
5. **Education:**

<b>Sl. No.</b>	<b>Education</b>	<b>Response</b>
1.	Illiterate	
2.	Primary	
3.	Middle	
4.	Secondary	
5.	Senior secondary	
6.	Graduate and above	

##### **6. Land Holdings:**

<b>Sl.No.</b>	<b>Category</b>	<b>Response</b>
1.	Landless	
2.	Marginal (<1 ha)	
3.	Small (1 ha to 2 ha)	

## Appendix

4.	Semi medium (2 ha to 4 ha)	
5.	Medium (4 ha to 10 ha)	
6.	Large (> 10 ha)	

### 7. Occupation and Annual income

Sl.No.	Major occupation	Response	Income from	Rs. (Year)
1.	Dairy farming		Dairy farming	
2.	Crop farming		Crop farming	

### 8. Herd size and composition

Sl.No.	Type of animal	Adult	Heifer	Calf	Bull
1.	Buffaloes				
2.	Crossbred Cows				
3.	Indigenous Cows				

### 9. Expenditure of farming/ dairying

Sl. No.	Occupation	Rs/annum
1.	<b>Agriculture farming</b>	
	Inputs	
	Equipment purchase	
	Digital technology	
	Advisory services & Consultancy	
	Repair & maintenance machinery	
	Other	
2.	<b>Dairy farming</b>	
	Equipment purchase	
	Digital technology	
	Advisory services & Consultancy	
	Feed, fodder, supplementation	
	Repair & Maintenance	
	Other	

**10. Extension-contact**

How often do you meet the following Extension officers/ Extension scientists?

Sl.No.	Extension personnel	Frequency of contact		
		Regularly	Occasionally	Never
1.	VEO			
2.	AO/VO			
3.	Scientists			
4.	KVK			
5.	Other research institutes/ education institutes			
6.	Private agency			
7.	Any other			

**11. Accessibility of digital technological infrastructure**

Sl.No.	Technology used	Within block	Within district	Outside the district/ state	Online
1.					
2.					
3.					
4.					

**12. Training received in digital technology**

Sl. No.	Training received	If training is received		
		Where (Institute)	Topic	Duration
1.	Yes			
2.	No			

**13. Perceived benefits from Digital agro-animal farming technology application**

Sl. No.	Benefits of technology	Disagree	Slightly agree	Agree
1.	Increase in yield			
2.	Efficiency in inputs usage			
3.	Saving time			
4.	Less labour requirement			
5.	Improved quality of produce			
6.	Timely and accurate information			
7.	Early detection of pests and diseases			
8.	Efficiency in irrigation			
9.	Efficiency in chemical application			
10.	Efficiency in sowing & harvesting operations			
12.	Aids in knowing pH, temperature, weather conditions etc.			
13.	Aids in identifying animal physiological processes			
14.	Aids in getting market information			
15.	Aids in financial aspects			
16.	Increased sustainability			
17.	Improved record-keeping			
18.	Increased profits			
19.	Reduced risk and regulatory burden			
20.	Reduced environmental pollution			

**14. Influencing factors to purchase digital technology**

Sl.No.	Particulars	Response
1.	Availability of loan/ subsidy	
2.	Accessibility of infrastructure	
3.	On farm efficiency	
4.	Marketing aspects	
5.	Profits	

6.	Benefit to cost ratio	
7.	Relative advantage, compatibility	
8	Other's success	
9	Other factors	

### 15. Source of information on Digital agro-animal farming technology

Sl.No.	Category	Response
	<b>Public sources</b>	
1.	KVK/ ATMA/ other Govt. agencies and on webpage	
2.	ICAR, SAU, SVS, NDRI personal and on webpage	
3.	State department of Agriculture, Dairy, Animal Husbandry personal and on webpage	
4.	Govt. organizations published Magazine/ bulletins/ folder etc.	
5.	INDO-ISRAEL CoE	
	<b>Private sources</b>	
1.	Pvt. Practitioners/ Para vets	
2.	Input dealers	
3.	Output buyers	
4.	Rural retail hubs	
5.	Mobile Apps, Media, ICT	
6.	Companies in collaboration with Department of agriculture	

### 16. Social Media used for obtaining information on advanced technologies

Sl.No.	Media	Using	Not using
1	WhatsApp		
2	Facebook		
3	Twitter		
4	YouTube		
5	Instagram		
6	Telegram		
7	ResearchGate		
8	LinkedIn		

17. No. of digital agro-animal technologies available and used

Sl.No.	Digital Agro-animal farming technology	Using		Since No. of years	Source of the technology
		Yes	No		
<b>1.</b>	<b>Agriculture technology</b>				
	pH sensor				
	Temperature sensor				
	Humidity sensor				
	Soil moisture sensor				
	Soil Electrical conductivity sensor				
	Handheld crop sensors like GreenSeeker				
	Drones for chemical application on crops				
	Digital Laser Land leveller				
	Automated sprayer/Automated Boom irrigation system				
	Automated seed sowing machine				
	Automated Vegetable processing system/ Automated grader, sorter machine, Automated pipeline system for cooling				
	Sugarcane Setts treatment machine				
	Global Positioning System				
	Other				
<b>2.</b>	<b>Animal technology</b>				
	Yellow QR code tags/ Mobile enabled tags				
	Sensor-based fogger systems				

	Pedometer				
	Lactometer				
	Milk parlour				
	Milk processing & packaging machines				
	Automatic milk analyzer				
	Bulk milk coolers				
	Others				
<b>3.</b>	<b>Service based technology</b>				
	Financial apps				
	Marketing apps				
	Weather apps				
	Production apps				
	Online resources				
	AI advisory services				
	Software (NDVI, Nutrient expert etc.)				
	Other				
<b>4.</b>	<b>Other</b>				

### 18. Perception on digital agro-animal farming technology:

Sl. No	Statements	SA	MA	A	MDA	SD A
1)	Application of digital agro-animal farming technologies are feasible for all types of farming system					
2) *	Digital farming technologies can be beneficial for large farmers					
3)	Do you think that application of digital technologies will increase the efficient use of farm resources?					

## Appendix

4)	Do you think that there is need to identify socio-economic issues for enhancing adoption of digital farming technology?					
5)	Digital India and other government schemes were creating awareness on digitalisation in agricultural sector					
6)	Digital agro-animal technologies will encourage sustainability in farming					
7)	Digital technologies reduce labour requirement in farming operations					
8)	Do you think digital technologies may influence youth to take farming up as a new occupation?					
9)	Do you think that digital technologies can mitigate the effects of climate change?					
10)*	Do you think Digital agricultural technologies requires high-cost machines, equipment, and software					
11)	Digital technologies aids in easier marketing of farm produce					
12)	Digital innovation in farming ensures chemical free/unadulterated farm produce					
13)*	I don't want digital technology in my farm because I believe that farming should be more traditional and natural					
14)	Do you think that digital agricultural technologies promote agricultural sector development?					
15)	Do you feel that smart farming reduces the amount of chemical applied on crops?					
16)	The adoption of digital farming technology highly depends on the age of farmer					

17)	I believe that digital farming technology and services will reduce the cost of cultivation					
18)	I would invest more in digital technologies if financial support from government was higher (subsidies, lower taxes)					
19)	Digital farming technologies improve the decision-making capability					
20)	Digital farming technologies would allow more time for social participation					

### 19. Awareness on digital agro-animal farming technology

Sl.No.	Statements	Aware	Moderately aware	Not aware
<b>I</b>	<b>Agriculture technology</b>			
	<i>Agronomical aspects</i>			
1.	Are you aware that pH of irrigation water can be identified by pH sensor?			
2.	Are you aware that temperature changes in the Greenhouse environment can be observed from Temperature sensor?			
3.	Are you aware that Critical Point of Irrigation (CPI) can be identified by using Soil moisture sensor?			
4.	Are you aware that moisture content in the surrounding environment can be known from Humidity sensor?			
5.	Are you aware that Boom irrigation system improves the efficiency of space use in the greenhouse?			
6.	Are you aware that irrigation water efficiency can be improved by laser land levelling?			

## Appendix

	<i>Crop protection aspects</i>		
7.	Are you aware that Drones can be used for pest surveillance and chemical application in the crops?		
8.	Are you aware that plant health and vigour can be instantly measured by crop sensors?		
	<i>Sowing &amp; post harvest aspects</i>		
9.	Are you aware that automated seed sowing machine can be used for sowing in the nursery trays?		
10.	Are you aware that product quality can be improved by using automated machines like grader, sorter etc.?		
11.	Are you aware that prior to planting sugarcane setts can be treated with chemicals automatically by using sett treatment machine?		
12.	Are you aware that Field robots can be used in crop nurseries, primarily in moving seedlings or plants?		
	<i>General aspects</i>		
13.	Are you aware that GPS/ location sensors enable in location tracking?		
14.	Are you aware that labour shortage can be overcome by use of automated machinery?		
15.	Are you aware that satellite images have wide applications in future farming?		
16.	Are you aware that digital farming technologies (IoT, A.I. Sensor, robots etc) have more scope in future?		

17.	Are you aware that Digital Farming Technology increases profitability and efficiency in farming?			
<b>II</b>	<b>Animal technology</b>			
	<i>Animal health &amp; comfort aspects</i>			
1.	Are you aware that robots can be used in identification of diseases as early as possible?			
2.	Are you aware that robots can be used in cleaning cattle yard?			
3.	Are you aware that Drones can be used in animal monitoring?			
4.	Are you aware that IoT devices can be used for animal health monitoring?			
5.	Are you aware that fogging can be controlled by a timer by using sensor-mounted fogging systems?			
6.	Are you aware that yellow QR code provide vaccination and health details of animal over phone?			
7.	Are you aware that accelerometers /pedometers help in disease tracking in animals?			
8.	Are you aware that digital dairy technology can improve productivity of cattle?			
9.	Are you aware that heat stress in animals can be managed effectively by using sensor-based fogging system?			
	<i>Physiological aspects</i>			
10.	Are you aware that animal under heat can be identified by biosensors?			

## Appendix

11.	Are you aware that Artificial Insemination/animal pregnancy can be planned by using animal heat detection sensors like “BovSmart”?			
12.	Are you aware that animal physiological changes can be analysed by data from Biometric and Heartbeat sensors?			
13.	Are you aware that temperature sensor when attached to animal can detect changes in body during pregnancy?			
<b>Milking &amp; its processing aspects</b>				
14.	Are you aware that labour is not required for milking as it can be done by automated machines?			
15.	Are you aware that milk quality can be assessed by using quality assessment sensors like chemical sensors, e-nose etc.?			
16.	Are you aware that milking by machine is 3-4 times faster and safe than hand milking?			
17.	Are you aware that protein, lactose & fat content of milk can be analysed by using automatic milk analysers?			
18.	Are you aware that quality of processed products can be improved by using automated machines?			
19.	Are you aware that use of milking machine will reduce the risk of injury to dairy animals during milking?			
<b>III Service-based technology</b>				
1.	Are you aware that mobile apps exist regarding agriculture/dairy farming?			

2.	Are you aware that there are online resources regarding price information of different agricultural products?			
3.	Are you aware that there are digital services on marketing facilities?			
4.	Are you aware of basic computer technology?			
5.	Are aware that direct sale to consumer can be done through digital services/ platforms?			
6.	Are you aware that information from experts can be obtained using digital service technology?			
7.	Are you aware that weather stations will provide services by sending AI-based MMS on weather alerts?			
8.	Are you aware that Big Data technology stores vast amount of information on rainfall patterns etc.?			
9.	Are you aware that digital communication services provide information on improved crop production practices?			
10.	Are you aware that Block chain technology increases transparency in food supply chain?			

## 20. Feedback from farmers

Sl.No.	Factors considered for future adoption of digital technology	Yes	No
1	Increase in Income		
2	Increase in Profits		
3	Easy to maintain		
4	Saves time		

## Appendix

5	Less labour requirement		
6	Efficiency in farm operation		
7	Rental facility		
8	High BC ratio		
9	Decision making		
10	Resource use efficiency		
11	Accessibility		
12	Subsidy		
13	Internet connectivity		
14	Less operational cost		
15	Training on technical know-how		

Sl.No.	Attributes of technology perceived by farmers for adoption of digital technology	Yes	No
1	Compatibility of technology with farm size & other resources		
2	Less complexity of technology		
3	Triable before adoption		
4	Relative advantage of technology over previously adopted technology		
5	Perceived observability		
6	Cost effectiveness of technology		
7	Environment friendliness of technology		
8	Technical support from the Institution		
9	Technology which has Data safety		

Sl. No	Statements	Yes	No	Can't say
1	Does digital technology causes society to move toward sustainable agriculture?			
2	Do you have enough skills to use digital farming technology?			

3	Are existing resources sufficient for using digital farming technology?			
4	Do you have enough information about digital farming technology?			
5	Is the use of digital farming technology less stressful than handling manually?			
6	Does digital farming technology support development of agricultural sector?			
7	Does digital farming technology improve farmer work comfort?			
8	Is there lack of proof regarding economic benefits from digital farming technology?			
9	Is there lack of accurate information regarding purchase, rent or provision of digital farming services?			
10	Is there access to credit to purchase of digital farming technology equipment?			
11	Do you have security issues in using digital farming technology?			
12	Are familiarity with the technology and its availability major constraints in adopting technology?			
13	Do you think there is enough time for you to think and learn of digital technology?			
14	Do you think digital technology fail in fitting to existing pattern of farming?			
15	Do you lack confidence to use digital agro-animal farming technology?			