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Modelling the Barriers to the Implementation of Drone Technology in Indian Agriculture

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ABSTRACT

Background: One of the developments in the adoption of ICT, information and communications technology, that has been brought swiftly into the agriculture sector with its operation is the drone technology as a result of the rise of food demand all around the globe. This study presents the challenges in the use of done technology in Indian agriculture system.

Methods: Major barriers are identified through literature review and then Failure Mode and Effect Analysis is done to rank the barriers. They are further subjected to interrelationships for identifying the driving variables to the occurrence of major challenges using Interpretive Structural Modelling technique.

Result: The study concludes that Social anxiety concerning automation in agriculture is a dependent challenge. This results from concerns about job loss, resistance to change, skill gaps, ethical misgivings and regulatory uncertainty. Moreover, the conservatism of traditional techniques could well strengthen their aversion to technological change and the environmental toll, along with power concentration in some agricultural sectors, may deter farming activity.

Key words: Agriculture, Drone technology, Failure mode and effect analysis (FMEA), Interpretive structural modelling (ISM).

INTRODUCTION

In view of the influence of disruptive technologies in Agriculture 4.0, with technologies like IoT, AI, Robotics and Big Data Analytics, face farming in the world changes (Narmilan and Puvanitha 2020; Umme *et al*., 2020; Konstantina *et al*., 2021; Spanaki *et al*., 2022). Said technologies drive smart farming, increasing productivity and lowering costs while being more sustainable because of data-driven decision-making and techniques for precision agriculture. Application of disruptive technologies in agriculture addresses challenges like climate change, population growth and resource scarcity, all the applications ensure efficient manpower use and resources by better crop yield and quality. IoT for monitoring (Balaji and Santhosh, 2021; Dayananda *et al*., 2024), AI for predicting and robotics for automating-these types of disruptions shall change the agricultural sector toward resilience, productivity and sustainability with productivity and sustainability as part of the new paradigms that they can assure for generations to come (Aggarwal and Sharma, 2022). Since its entrance into the environmental and agricultural sector, drone technology has been on the list of very disruptive technologies in farming (Bryceson, 2019).

Drones are increasingly being used in agriculture due to their potential benefits in modern farming practices. These technologies include fruit picking, field analysis, disease detection and pest management (Bharambe *et al*., 2020; Kailashkumar *et al*., 2023; Rus *et al*., 2023; Metagar and Walikar, 2024). They are being developed with foldable features, enhancing efficiency and productivity. The integration of drones in agriculture has revolutionized traditional farming, improving sustainability and productivity. This technological revolution is transforming the agricultural sector globally. Similarly, such technologies are also being accepted and embraced in developing economies like India. In India, the use of drones in agriculture is hampered with several issues despite its potential benefit. The first issue lies in the adverse effects that are caused on the farmers due to health risks of manual pesticide spraying (Michael *et al*., 2022). Similarly, overreliance on a traditional farming system to satisfy the demand for increasing population with limited land component suitable for agriculture further presses the dire need for the improvement of farming methods, where drones certainly hold a possible great solution. Automatic spray via drones for pesticides and fertilizers could replace manual spray technology, lessen the impact on human health and attain efficiency with large coverage of land in agriculture.

Overcoming challenges such as assembly errors, sizing issues and weight balancing problems during drone development is crucial to realizing the full potential of drone

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technology in Indian agriculture. This motivated the authors to undertake this study with following research objectives:

Research question 1

What are the barriers to the adoption of drone technology by farmers in Indian agriculture?

Research question 2

Are there interrelationships among the barriers? If yes, what are the interrelationships among the barriers?

Review of literature

A detailed literature study is undertaken to determine the barriers impeding the wider application of drones. Table 1 shows the gaps founded in the past literature with respect to the use of technological advancement s like Arial technology-drones in agricultural purposes.

Further, a comprehensive set of challenges as identified through review of literature are represented in Fig 1.

MATERIALS AND METHODS

This research was conducted by the authors at Symbiosis Institute of Business Management, Nagpur, Symbiosis International (Deemed University) Pune in 2024. A questionnaire-based study was conducted to identify major barriers in the use of drones in agriculture in India. Experts from farming business owners were involved. The study ranked these challenges on a 1-10 scale and used a Failure Mode and Effect Analysis approach. The study also identified interrelationships between the barriers using Interpretive Structural modelling. The data was collected in two phases.

Failure mode and effect analysis

Barriers prioritization

The system or process is identified by recognizing its barriers, assessing the severity of each risk using a scale of 1 to 10, determining the frequency of risk occurrence (O) and the rating of detection (D). The severity of each risk is then rated, ranging from 1 to 10, ensuring a comprehensive risk assessment.

Risk Priority Number (RPN)=S*O*D.

Table 2 shows the detailed FMEA constructed thorough the inputs from the farm owner experts.

Analysis of FMEA

Based on the RPN of all the challenges identified, top 15 challenges with highest RPN are considered for further analysis, given below.

1. High initial costs.
2. Economy and employment.
3. Intentional hacking, cyberattacks and terrorism.
4. Social anxiety about automation.
5. Liability for drone owners.
6. Congested airspace for manned aircraft.
7. Adverse weather conditions.
8. Violations of rights.

Table 1: Literature review for research gap identification.

Author	Objectives	Gaps identified
Kahlid *et al.* (2022)	Develop blockchain-based framework for secure sensor-drone communication in smart farming.	Addressed: Data integrity, availability.
Muthukumar *et al.* (2023)	Explore drones' role in precision agriculture, specifically in minimizing chemical wastage.	Assembly mistakes, sizing issues, weight balancing challenges.
Michael *et al.* (2022)	Review recent developments in agricultural drone technology and highlight challenges.	Various challenges identified; directions for future research outlined.
Borikar *et al.* (2022)	Review types of drones and components used, with a focus on crop spraying applications.	Need to minimize drone weight, maximize flight time, improve autonomous control.
Husain *et al.* (2022)	Assess drones for monitoring agriculture, addressing crop quality and field damage concerns.	Labour shortage, challenges related to weather, fertilizer and diseases identified.
Rathod and Shinde (2023).	Assess state-of-the-art agricultural drones and their applications in precision agriculture.	Issues with SLAM technology and short flight times expected to be resolved.
Yadav *et al.* (2023)	Present advancements in agricultural drone technologies, emphasizing crop health and farm management.	Insufficiency of traditional methods to meet food demands; need for drone adoption by more farmers.
Katekar and Cheruku (2023)	Discuss advantages and challenges of drone technology adoption in Indian agriculture.	Addressing challenges crucial for sector transformation and farmer livelihood improvement in India.

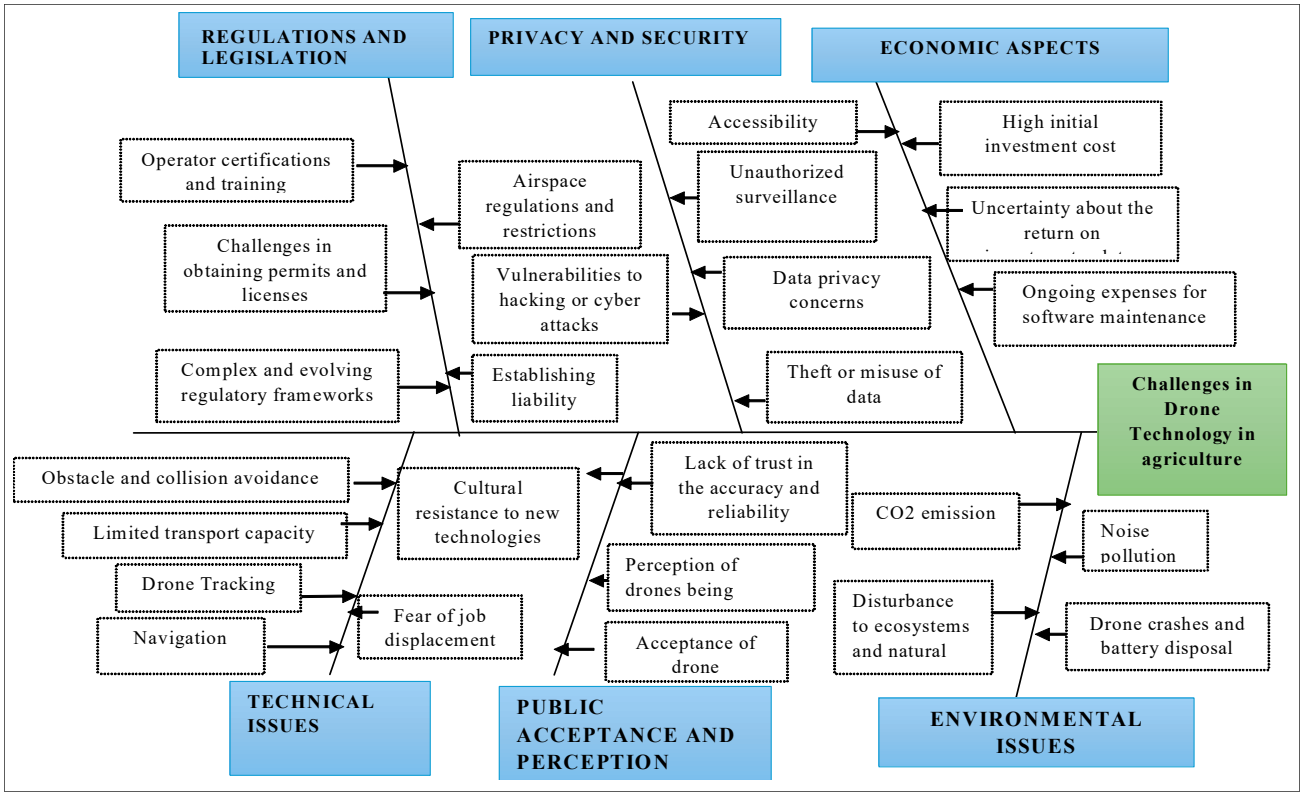


Fig 1: Cause and effect diagram for barriers to the adoption of drone technology in agriculture derived from literature.

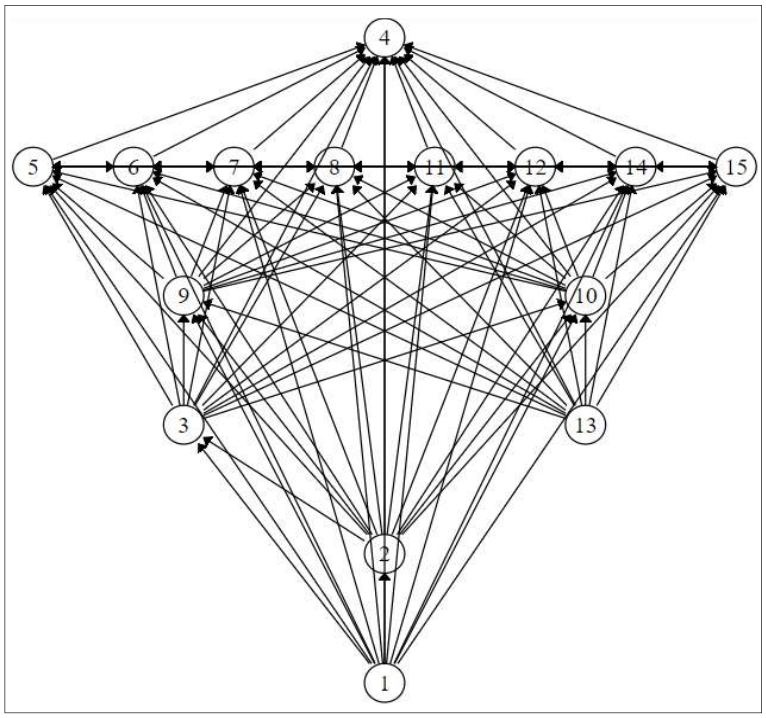


Fig 2: Diagraph.

Table 2: Application of FMEA to the barriers of drone technology use in Indian agriculture.

Process function	Potential failure mode	Severity score	Potential effect (s) of failure	Occurrence score	Potential cause (s) of failure	Detection score	RPN	Recommended actions to avoid the risk
Economic aspects	High initial costs	9	Barrier to entry for small farmers	7	Expensive drone technology	5	315	Develop affordable drone solutions
	Economy and employment	8	Displacement of traditional agricultural jobs	6	Automation of farming tasks	6	288	Invest in job retraining programs
	Uneven distribution of income	7	Widening income inequality	6	Concentration of drone ownership among large farms	6	252	Promote equitable access to drones
	Disruption of the transport industry	7	Competition with traditional transport	5	Integration of drones in delivery services	7	245	Regulate drone integration in transport
Environmental issues	CO_2 emission	8	Environmental pollution and climate impact	7	Use of fossil fuels for drone propulsion	6	336	Transition to eco-friendly propulsion
	Impact on animals and birds	7	Disturbance to wildlife habitats	6	Lack of wildlife impact assessments	6	252	Conduct wildlife impact assessments
	Visual and sound pollution	6	Disruption to natural landscapes	5	Noisy and visually intrusive drone designs	7	210	Develop quieter and less intrusive designs
Privacy and security	Intentional hacking, cyberattacks and terrorism	10	Data breaches and system compromise	4	Lack of cybersecurity awareness among staff	8	320	Provide cybersecurity training
	Violations of rights	9	Legal liabilities	5	Insufficient compliance monitoring	7	315	Enhance compliance monitoring
	Unauthorized usage of data and blackmail	9	Financial and reputational damage	4	Inadequate data access controls	8	288	Strengthen data access controls
	Unauthorized usage of drones	8	Misuse of drone technology	6	Lack of robust authentication methods	6	288	Implement strong authentication
	Identity theft and collection of private information	8	Loss of trust from stakeholders	5	Weak encryption protocols	7	280	Enhance data encryption protocols
	Unauthorized non -consensualphotographing and recording	7	Violation of privacy laws	6	Lack of geofencing technology	6	252	Implement geofencing technology
			7Damage to drones and equipment	6	Weak physical security measures	6	252	Improve physical security measures
	Physical attacks, obstruction and phishing	7	Violation of privacy laws	6	Lack of geofencing technology	6	252	Implement geofencing technology

Table 2: Continuee..

Table 2: Continuee..

	Complex identification of unauthorized drones	6	Increased risk of unauthorized access	7	Lack of standardized identification protocols	5	210	Develop standardized ID protocols
Public acceptance and psychological perception	Social anxiety about automation	7	Resistance to automation and technology	7	Fear of job displacement due to automation	6	294	Address concerns about job displacement
	Drones theft	8	Risk of theft or misuse of drones	6	Inadequate security measures for drone storage	6	288	Strengthen security measures
	Greater perceived risk	8	Negative public perception and resistance	7	Lack of public awareness about drone technology	5	280	Increase public awareness
	Awareness of drone technology	7	Misunderstanding and fear of technology	6	Insufficient educational initiatives	6	252	Educate the public about drone tech
	Annoyance of the public	7	Public complaints and opposition	6	Noise pollution from drone operations	6	252	Mitigate noise pollution effects
	Usage of drones in the private sector	7	Concerns about intrusion and privacy	5	Lack of regulations governing private drone use	7	245	Regulate private drone usage
	Non-transparency	6	Lack of trust and transparency	5	Limited transparency in drone operations	7	210	Improve transparency measures
Regulations and legislation	Liability for drone owners	9	Legal penalties and lawsuits	7	Unclear legal frameworks	5	315	Advocate for clearer regulations
	Congested airspace for manned aircraft	9	Airspace congestion and safety hazards	7	Lack of coordination with aviation authorities	5	315	Coordinate with aviation authorities
	Drone routes	8	Airspace violations and accidents	6	Lack of designated drone routes	6	288	Establish designated drone routes
	Operator certifications and training	8	Increased risk of accidents	6	Insufficient training programs	6	288	Enhance operator training programs
	Insurance obligations	7	Financial losses in case of accidents	5	Inadequate insurance coverage	7	245	Review and update insurance policies
	Lack of aviation regulation	7	Regulatory compliance issues	5	Absence of comprehensive regulatory framework	7	245	Advocate for comprehensive regulations
	Establishing liability	6	Legal disputes and uncertainty	6	Ambiguous liability allocation	6	216	Clarify liability allocation
Technical issues	Adverse weather conditions	8	Damage to drones and property	7	Lack of weather -resistant drones	7	392	Develop weather-resistant drones

Table 2: Continuee..

Table 2: Continuee..

Obstacle and collision avoidance	9	Damage to drones and property, injuries	8	Inadequate obstacle detection systems	4	288	Enhance obstacle detection systems
Short flight range	8	Limited coverage and efficiency	7	Inadequate battery technology	5	280	Improve battery technology
Limited transport capacity	8	Limitation in agricultural operations	7	Insufficient payload capacity	5	280	Develop drones with higher payload capacity
Navigation	7	Risk of collisions and lost drones	6	Inaccurate GPS systems	6	252	Enhance GPS accuracy and reliability
Drone tracking	7	Loss of valuable equipment	6	Limited tracking technology	6	252	Implement robust drone tracking systems

9. Unauthorized usage of data and blackmail.
10. Unauthorized usage of drones.
11. Drone routes.
12. Operator certifications and training.
13. Drones theft.
14. CO_2 emission.
15. Obstacle and collision avoidance.

Thus, these above mentioned failure modes become the high level risks in the system.

Interpretive structural modelling

Interpretative Structural Modelling is a general-purpose method for analysis and a decision-support system that discovers and structures relationships among the key concerns or problems. It provides a structured approach for attending with complex situations. Table 3 shows the first step of constructing the structural self-interaction matrix.

The contextual relationship between the risks amongst themselves is obtained consulting academic and industrial experts. Based on four symbols, on the relationship between the various factors, the SSIM matrix is prepared The terminologies used to explain any two factors 'i' and 'j' are in the following words.

V: if factor i influences on factor j.
A: if factor j influences on factor i.
X: if the both factors influence on each other.
O: if the factors are unrelated.

The initial reachability matrix is formed as shown in Table 4.

Transitivity is performed on the initial reachability matrix to identify indirect relationships among the barrier variables as shown in Table 5. Transitivity means when variable A impacts variable B, variable B impact variable C, then the relationship also exists between A and C.

Partitioning of reachability matrix into different levels or level partitioning

The reachability matrix is broken into distinct levels using an algorithm-based level partitioning procedure. This creates a multilevel interpretive structural model based on risk variables. Reachability, antecedent and intersection sets are formed for each barrier, allowing level partitioning.

Table 6 shows the result of first iteration as element 4 being the top barriers in the implementation of drones in agriculture.

Table 7 shows that iteration 2 reveals 5, 6, 7, 8, 11, 12, 14 and 15 are level 2 barriers.

Table 8 shows the result of third iteration as element 9 and being the next level barriers in the implementation of drones in agriculture.

Table 9 shows the result of third iteration as element 3 and being the next level barriers in the implementation of drones in agriculture.

Table 10 shows the result of final iteration as element 2 being next level barrier and the bottom barrier in the system is element 1.

Table 3: Development of structural self-interaction matrix (SSIM).

Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
High initial costs	V	V	O	V	V	V	V	V	O	O	O	O	V	V	X
Economy and employment	V	V	O	V	V	V	V	V	O	O	O	V	V	X	
Intentional hacking, cyberattacks and terrorism	V	V	O	V	V	V	V	O	O	O	O	V	X		
Social anxiety about automation	A	A	O	A	A	A	A	A	O	O	O	X			
Liability for drone owners	V	A	O	V	A	A	A	A	O	V	X				
Congested airspace for manned aircraft	V	A	O	A	A	O	O	O	A	X					
Adverse weather conditions	V	A	O	O	O	O	O	V	X						
Violations of rights	O	O	O	O	O	O	O	X							
Unauthorized usage of data and blackmail	O	O	A	O	O	O	X								
Unauthorized usage of drones	O	O	A	O	O	X									
Drone routes	V	O	A	A	X										
Operator certifications and training	V	O	O	X											
Drones theft	O	O	X												
CO_2 emission	X	X													
Obstacle and collision avoidance	X														

Table 4: Initial reachability matrix.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Driving power
1	1	1	1	0	0	0	0	1	1	1	1	1	0	1	1	10
2	0	1	1	1	0	0	0	1	1	1	1	1	0	1	1	10
3	0	0	1	1	0	0	0	0	1	1	1	1	0	1	1	8
4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
5	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1	4
6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	2
7	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	4
8	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	3
9	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	3
10	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	3
11	0	0	0	1	1	1	0	0	0	0	1	0	0	0	1	5
12	0	0	0	1	0	1	0	0	0	0	1	1	0	0	1	5
13	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	4
14	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	6
15	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	3
Dependence power	1	2	3	10	6	6	2	4	5	5	6	5	1	5	10	

Table 5: Final reachability matrix with transitivity applied.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Driving power
1	1	1	1	1*	1*	1*	1*	1	1	1	1	1	0	1	1	14
2	0	1	1	1	1*	1*	1*	1	1	1	1	1	0	1	1	13
3	0	0	1	1	1*	1*	1*	1*	1	1	1	1	0	1	1	12
4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
5	0	0	0	1*	1	1	1*	1*	0	0	1*	1	0	1*	1	9
6	0	0	0	1*	1*	1	1*	1*	0	0	1*	1*	0	1*	1	9
7	0	0	0	1*	1*	1	1	1	0	0	1*	1*	0	1*	1	9
8	0	0	0	1	1	1*	1*	1	0	0	1*	1*	0	1*	1*	9
9	0	0	0	1	1	1*	1*	1*	1	0	1*	1*	0	1*	1*	10
10	0	0	0	1	1	1*	1*	1*	0	1	1*	1*	0	1*	1*	10
11	0	0	0	1	1	1	1*	1*	0	0	1	1*	0	1*	1	9
12	0	0	0	1	1*	1	1*	1*	0	0	1	1	0	1*	1	9
13	0	0	0	1*	1*	1*	1*	1*	1	1	1	1*	1	1*	1*	12
14	0	0	0	1	1	1	1	1*	0	0	1*	1*	0	1	1	9
15	0	0	0	1	1*	1*	1*	1*	0	0	1*	1*	0	1	1	9
16	1	2	3	15	14	14	14	14	5	5	14	14	1	14	14	

Table 6: Iteration 1.

Elements	Reachability set	Antecedent set	Intersection set	Level
1	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15,	1,	1,	
2	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15,	1, 2,	2,	
3	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15,	1, 2, 3,	3,	
4	4,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	4,	1
5	4, 5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	
6	4, 5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	
7	4, 5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	
8	4, 5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	
9	4, 5, 6, 7, 8, 9, 11, 12, 14, 15,	1, 2, 3, 9, 13,	9,	
10	4, 5, 6, 7, 8, 10, 11, 12, 14, 15,	1, 2, 3, 10, 13,	10,	
11	4, 5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	
12	4, 5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	
13	4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	13,	13,	
14	4, 5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	
15	4, 5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	

Table 7: Iteration 2.

Elements	Reachability set	Antecedent set	Intersection set	Level
1	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15,	1,	1,	
2	2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15,	1, 2,	2,	
3	3, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15,	1, 2, 3,	3,	
5	5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	2
6	5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	2
7	5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	2
8	5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	2
9	5, 6, 7, 8, 9, 11, 12, 14, 15,	1, 2, 3, 9, 13,	9,	
10	5, 6, 7, 8, 10, 11, 12, 14, 15,	1, 2, 3, 10, 13,	10,	
11	5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	2
12	6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	2
13	5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	13,	13,	
14	5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	2
15	5, 6, 7, 8, 11, 12, 14, 15,	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	5, 6, 7, 8, 11, 12, 14, 15,	2

Reachability matrix expressed in conical form

Combinations of the row and column risk variables in rank order from high to low form a conical matrix. Adding up the 1s in the rows and columns turns out correspondingly; what is called the driving power and the dependent power.

Reduced conical matrix (CM)

Node digraph

Combinations of the row and column risk variables in rank order from high to low form a conical matrix as shown in Fig 2, based on the driving and the dependency powers of the barriers as shown in Table 11.

ISM model

The nodal digraph is transformed into ISM model by changing the nodes with the barriers associated with the node number as shown in Fig 3.

RESULTS AND DISCUSSION

Fig 3 highlights the economic challenges and factors in integrating drone technology into Indian agriculture, highlighting its potential for enhancing efficiency and productivity. However, it also highlights the economic difficulties inherent in integrating drones, as they offer superior gains compared to traditional methods but require a costly investment in technology (Kwon *et al.,* 2017). Drones in logistics require investments in software, sensor packages and surveillance cameras for safety and efficiency. This employment may impact labor markets,

Table 8: Iteration 3.

Elements	Reachability set	Antecedent set	Intersection set	Level
1	1, 2, 3, 9, 10,	1,	1,	
2	2, 3, 9, 10,	1, 2,	2,	
3	3, 9, 10,	1, 2, 3,	3,	
9	9,	1, 2, 3, 9, 13,	9,	3
10	10,	1, 2, 3, 10, 13,	10,	3
13	9, 10, 13,	13,	13,	

Table 9: Iteration 4.

Elements	Reachability set	Antecedent set	Intersection set	Level
1	1, 2, 3,	1,	1,	
2	2, 3,	1, 2,	2,	
3	3,	1, 2, 3,	3,	4
13	13,	13,	13,	4

Table 10: Iteration 5.

Elements	Reachability set	Antecedent set	Intersection set	Level
1	1, 2,	1,	1,	6
2	2,	1, 2,	2,	5

potentially increasing social inequality. Security challenges like drone theft, hacking, cyberattacks and terrorism pose significant risks to privacy, security and ethical integrity (Chang *et al.*, 2017 and Osakwe *et al.*, 2021). Therefore, strategies must be comprehensive in light of the above regulatory measures, technology safeguards and increasing awareness. Environmental factors, too, constitute an integral part of the smooth conduction of drone operations. Although drones were nearly always shown as environment-friendly solutions in most literature, this is not the case if the customer is at a distant location from the service depository. This is because drones may produce more C02 emissions than trucks (Goodchild and Toy, 2017). Weather, routes, CO_2 emission and obstacles are very closely knit factors that efficiently and effectively impact the success of drones. Such combined challenges can be tackled only through a holistic solution where weather issues will be addressed holistically with route reduction, CO_2 emission issues and safety aspects for safely and sustainably deploying unmanned aerial systems (Stolaroff

Table 11: Levels of the barriers.

Variables	4	5	6	7	8	11	12	14	15	9	10	3	13	2	1	Driving power	Level
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
2	1*	1	1	1*	1*	1*	1	1*	1	0	0	0	0	0	0	9	2
3	1*	1*	1	1*	1*	1*	1*	1*	1	0	0	0	0	0	0	9	2
4	1*	1*	1	1	1	1*	1*	1*	1	0	0	0	0	0	0	9	2
5	1	1	1*	1*	1	1*	1*	1*	1*	0	0	0	0	0	0	9	2
6	1	1	1	1*	1*	1	1*	1*	1	0	0	0	0	0	0	9	2
7	1	1*	1	1*	1*	1	1	1*	1	0	0	0	0	0	0	9	2
8	1	1	1	1	1*	1*	1*	1	1	0	0	0	0	0	0	9	2
9	1	1*	1*	1*	1*	1*	1*	1	1	0	0	0	0	0	0	9	2
10	0	1	1*	1*	1*	1*	1*	1*	1*	1	0	0	0	0	0	10	3
11	0	1	1*	1*	1*	1*	1*	1*	1*	0	1	0	0	0	0	10	3
12	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	12	4
13	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	12	4
14	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	13	5
15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	14	6
Dependence power	15	14	14	14	14	14	14	14	14	5	5	3	1	2	1		
Level	1	2	2	2	2	2	2	2	2	3	3	4	4	5	6		

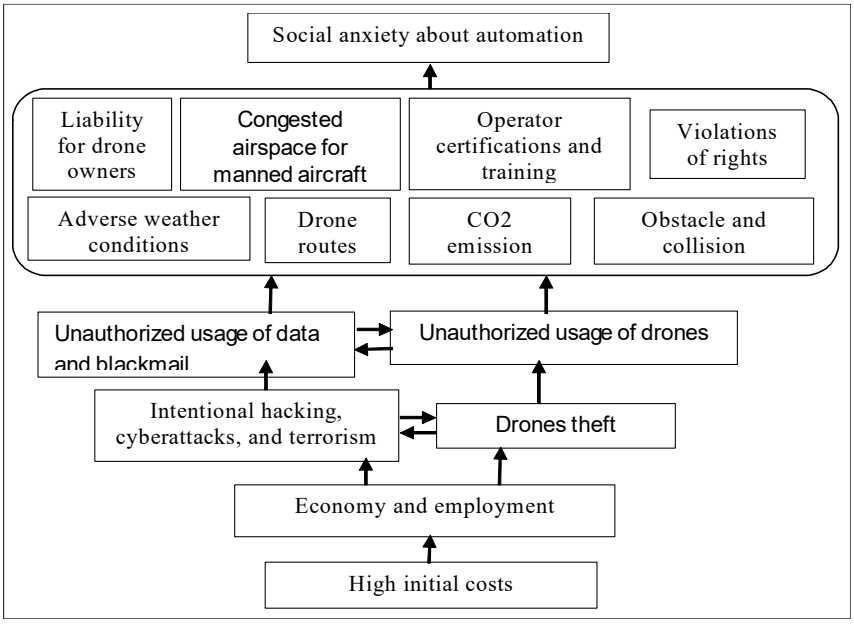


Fig 3: ISM model.

et al., 2018; Kuru, 2021; Kapoor *et al*., 2021; Toria and Clark, 2021). Responsible governance of drone operations requires balancing factors like owner liability, airspace congested, operator certificates and training. A multidimensional approach is needed to spur innovation while safeguarding safety, privacy and social wellbeing (Sah *et al*., 2020). Automation fears include job replacement, long-term business overwhelm and equal benefit sharing. An all-encompassing approach, empowering farmers and local communities to adapt and preserve their lifestyles, is crucial for sustainable development and overcoming these anxieties.

CONCLUSION

High upfront costs in acquiring and maintaining drone technology in agriculture in India are quite prohibitive for small-scale farmers to invest in modern farming practices. Automation could mean that rural employment may get displaced and hence concerns over unemployment and economic instability. Drones are prone to hacking, cyberattacks and theft, which can compromise data security and operational safety. Blackmail and unauthorized use of the drones are other results of the unauthorized misuse of data. Weak regulations and enforcement measures may also result in unsafe and troublesome operations, besides unauthorized or illegal uses. Liability issues on accidents, property damages, or charges on privacy violation haunted the owners of the drones. Congested airspaces for manned aircraft, limited operator certifications and training are other few factors that hinder wide-scale adoption of drones. Other predisposing factors to social anxiety about automation include privacy concerns or bad weather. This kind of concerns demand comprehensive strategies with elements, including clear regulatory frameworks, investment in training and technology and community engagement.

Conflict of interest

The authors declare that they have no known competing financial interests that could have appeared to influence the work reported in this paper.

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