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Research Article

From Convenience to Trust: Determinants of Consumer Adoption of Drone Delivery Services in India

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Abstract: As a fast-paced tech-powered service for getting products delivered directly to homes, drone delivery has been gaining popularity as an alternative option to traditional delivery services for the final stretch of the supply chain. Apart from saving time and providing a great user experience the technology can also help the environment through lower emissions and reduce carbon footprint of traditional delivery services. Rapid delivery is another factor of last-minute logistics that can be quite a bit improved by drone delivery. This makes it a promising and attractive option for customers who are looking for their goods and services right at home or nearby quickly. Still, despite the benefits, the use of such technology by consumers is limited. The present review is an exploration of the factors that influence the consumer adoption of drone delivery which in particular, focuses transition stage from convenience to consumer trust and considers the Indian perspective of a broader international picture. The study of literature has revealed that perceived usefulness, ease of use, delivery speed, service performance safety privacy, perceived risk, environmental value, social influence and consumer innovativeness, are the key variables that determine the acceptance of delivery by drone. Indian case presents us an example with its importance: family safety and security proved to be the highest predictor of adoption intention and even outmatched delivery speed and green image. Besides, different research evidence reveals that consumers' opinions are also not uniform and change based on whether one is from the city or the countryside and what one's culture is. Given this, the review suggests an integrative model that combines the influence perceived convenience has in generating curiosity, the role risk assessment plays in the formation of hesitation and trust as the mechanism that triggers the adoption decision and continued usage. The main finding is that the success of drone delivery in India will not depend on technology and infrastructure alone. In addition, it will have to rely on transparent company practices, high safety standards, privacy protection measures, consumer education initiatives and supportive government regulations.

Keywords: Drone Delivery, Consumer Adoption, Consumer Trust, Perceived Risk, Last-Mile Logistics

INTRODUCTION

Evolution of Drone Delivery in Modern Logistics

The fast evolution of UAV (unmanned aerial vehicle) tech has broadened the use of drones to be more than for military and surveillance activities; they are now involved in commercial healthcare agriculture and logistics activities. A prime example among is unmanned aerial vehicles (UAV) delivery, which has developed as a kind of technology-driven innovation for solving the ongoing delivery problems at the last mile-the distribution stage where goods are brought from a local warehouse or fulfillment center to the customer's doorstep. The problem with conventional last-mile delivery has become more evident due to large numbers of online orders, traffic jam, delivery delays, human force requirements and of course, consumers' demands which require very rapid and flexible fulfillment methods. That is why drone-based logistics have caught the attention of many researchers and businesses because mostly it would mean faster and a shorter route of moving things without having to rely solely on the road network [1-6]. Almost uniformly,

the sources for this literature review have consistently listed quicker delivery, higher operational efficiency, better service flexibility and accessibility, as well as the potential impact of drones as an environmentally-friendlier distribution tool as significant benefits of drone-assisted logistics.

The technology-based idea of drone delivery has become very pertinent, given that online customers have changing expectations. Drones can fly through the air and are not limited by the streets and traffic which for one thing, may minimize the effect of traffic congestion and but, may make delivery times more predictable. Earlier research singled out delivery speed as a top, if not the main, perceived benefit of drone delivery while other works in turn have associated it with customer value and convenience [3,4,7,8]. What makes the Indian consumer study by Singh, Yadav and Kumar so interesting is that the authors found a positive and statistically significant relationship between the speed of delivery and customer's intention to adopt with a standardized regression coefficient of $\beta = 0.224$ ($p < 0.001$). Same here, from the wider study, Dabi, et al, have highlighted the main drone-delivery perks as decreased delivery time, improved delivery efficiency and a better customer experience [5].

The significance of drone delivery, of course, goes far beyond just saving time. It's also about contactless and location-adjacent deliveries, which has become more evident recently with the spread of the virus. Really a drone-delivery system calls for no physical interaction between people and helps in the supply of vital commodities was one of the main reasons why it was looked into [6,9]. At the same time, there are indications from the body of literature that under suitable conditions drones operate and produce lower carbon emission, thereby contributing towards environmental sustainability. For instance, a study by Singh et al revealed a positive link between the green image of a drone and its adoption with an estimate of $\beta = 0.181 (p<0.001)$. This factor, in fact, was the key reason why people regarded drones as delivery option that cares more about the environment [10]. Recently, the consumer acceptance models have also been updated to include environmental aspects. One of such studies is an urban-rural study done by Wu *et al.* 2025 that identified environmental cognition as an important positive determinant of the product acceptance [11].

On the flip side, Really the development of technology does not immediately lead to widespread consumer embrace. Drone deliver is a radical departure from the regular one because consumers are being asked to accept the operation of a partly or entirely autonomous system which is set to perform tasks in their intimate space in fact, the focus of the literature seems to gradually shift from questions of how well drones can deliver, questions which can be solved by technological means, to the question of the willingness of the consumer to be delivered by a drone. Dabi *et al.* through a study of 1,108 Portuguese consumers showed that consumer' perception of the ease of operation of the device and the usefulness of it were both good predictors of attitudes and intention to adopt an innovation (i.e. to be delivered by a drone) while concerns about privacy but resulted in decreased consumer' perception of a drone being a good solution for their needs more recent research from China supports the idea that perceived usefulness and perceived ease of use still remain crucial factors in shaping consumer acceptance, while perceived risk negatively affects the customer willingness to adopt the technology [11,5].

Because of this, a drone-enabled delivery system does not simply replace a human-based delivery with tech. Drone delivery is rather a complete socio-technical redefining of what delivery is and who delivers it, where the technology not only needs to perform but also to be accepted as safe private trustworthy by the consumers as a service. This change opens up a channel to investigate how a service becomes trustworthy, rather than only a convenience, which is the focus of this present review, as shown in Figure 1. Current literature has documented that perceived usefulness, ease of use, time-saver or environmental benefits of a delivery service are the key elements for the consumers, but a new generation of consumer research is emerging that tells these advantages should fade whenever consumers get the perception of safety privacy technology, or reliability issues [4,5,8,11].

Indian Context of Drone Delivery

India is considered a suitable setting for the study of customer behavior on drone delivery as it combines a rapidly rising digital-consumer culture with significant geographical and infrastructural disparities as well as demographic varieties. Consumer requirements with delivery speed, service responsiveness and service quality have much changed with the introduction of e-commerce and digital-consumption modes. In this context, unmanned aerial vehicle delivery can be the option for overcoming some road-based constraints while also enabling fast delivery, mainly for time-sensitive or hard-to-reach locations [1,3,6]. Besides conventional e-commerce product deliveries, it is claimed in literature that delivery drones might be a solution for, for example, delivering food items, pharmaceutical products, medicines and other emergency logistics goods.

The Indian evidence base, though still relatively limited, offers significant insights into consumer perceptions. Singh, Yadav and Kumar conducted a consumer study involving 157 residents of India through a structured questionnaire and

a seven-point Likert scale. Participants came from Bihar, Uttar Pradesh, Himachal Pradesh and Jharkhand with 60.5% of them were from urban areas and 39.5% from rural areas. Importantly, 78.3% said that they have some understanding of drone services and 73.9% believed drones can be the preferred way of getting service delivery. These numbers suggest an encouraging start for drone delivery systems among the consumer group surveyed, but they also show that knowledge and acceptance do not automatically lead to the use of such technologies.

Like that, this piece of research is really helpful in highlighting the Indian consumers' motivations which besides, the technological innovation also encompasses other factors. The exploratory factor analysis of the data came up with four factors - family safety and security, delivery speed, desire to use and an appeal for environmental concern and these jointly accounted for the variation as high as 76.599%. Family safety and security alone, accounted for the 45.554% of initial variability followed by the delivery speed (12.248%), desire (9.990%) and the green image (8.807%) [10]. The regression analysis that followed revealed that safety and security aspect at home or in family was the strongest predictor of the adoption intention by the customers ($\beta = 0.436$, $p < 0.001$), then came the delivery speed ($\beta = 0.224$, $p < 0.001$) followed by the green image ($\beta = 0.181$, $p < 0.001$). The whole model explained only 45.2% of the variance in a customer's intention to adopt. A finding like this is very useful for the present review as it is an indicator that in India at least, consumer acceptance of a product could be due to reasons other than convenience alone.

Rather, the latest studies have reinforced the view that India's situation should be interpreted by drawing references from elsewhere and comparing it with them. For instance, Mathew *et al.* looked into the factors influencing drone food-delivery adoption in India, which were identified as innovativeness, perceived risk and green image [12], while Kumar *et al.* focused on the variables influencing users' acceptance of drone deliveries of food [13]. The literature review in the paper given in PLOS One identifies social influence as a predictor variable of attitudes and behavioral intentions toward drone food delivery in India, that is, it means that one might accept a technology if one's family, friends, or peers recommend it and speak highly of its benefits.

India' s diversity also renders a single national consumer profile problematic. Comparative evidence from China highlights that urban and rural consumers may not share the same perception or evaluation of drone delivery. Analyzing 498 respondents, Wu *et al.* found that urban consumers were mainly affected by perceived usefulness, perceived ease of use, environmental cognition and social norms, whereas perceived risk had a negative impact on their intentions to adopt the service. When it comes to rural consumers, perceived usefulness, perceived ease of use, environmental cognition and service performance were the main factors driving adoption intention, while the effects of social norms and policy support were not statistically different from zero Wu *et al.* [11]. These result is relevant to India as it indicates that urban, semi-urban and rural populations may experience different levels of infrastructural availability, technological familiarity and perceived usefulness in similar ways.

So, one should not interpret the Indian drone delivery scenario merely as a question of customers perceiving the technology as innovative or easy to use. Rather, factors like adoption should be viewed related to service performance, safety and privacy and even social influence, environmental perceptions, technological familiarity and trust. While the available data from the Indian context is encouraging, it still is just a minor piece in comparison with the wide spectrum of consumer-technology research. In fact, the 2022 Indian study itself pointed out a scarcity of research on the behavioural aspects surrounding the decision of Indian consumers to adopt drone delivery [10]. A study focusing in particular on moving from convenience to trust seems to be highly warranted in this area as the gap highlights a real need.

Rationale, Objectives and Scope of the Review

As much as drone delivery gives operational efficiency and convenience for consumers, it is consumer acceptance that becomes one of the critical factors in successfully introducing this innovation. In fact, the limited body of research that has come up with this topic indicates that there always exists an imbalance between the positive side and the negative side, that is, one the hand, how good/beneficial a thing can be (i.e. how good/beneficial drone technology is) and then again, how bad/risky a thing can be (i.e. what are the problems linked to/what are the drawbacks from autonomous aerial systems). Consumers are in general likely to love very quick, versatile and probably even eco-friendly deliveries, but at the same time they may be doubtful that these autonomous systems can, for instance, avoid causing accidents, keep a person's information away from third parties, make sure that a delivery reaches the correct location on time and handle situations adequately if things go wrong [4,5,8,14]. Dabi *et al.* showed that perceived usability and product utility positively influence consumer views and behaviors, while perceived privacy risk has an adverse effect on consumer's views [5].

This debate becomes mostly crucial when trust plays a role. A good example is how convenience may be sufficient to spark consumer interest since they are exposed to an advantage that saves or accelerates time. On the flip side, trust

is related to whether the consumer feels that the technology as well, as the service provider, can be trusted to perform consistently and safely. It's actually a quite important point, as consumers are not in a situation where they can control the delivery by their own, as it's the case in a personal handover delivery. This means that privacy, package safety, system errors and safety in case of system failure are all major issues about turning a positive attitude of the consumers into a real usage or adoption of the delivery technology [4] [8,14]. Recently Almuraqab *et al.* did a survey among 410 people in UAE to test an acceptance model that includes perceived benefits, perceived risks, costs and social influence. In their report these researchers found out how positive a role perceived benefits and social influence have towards attitude formation and the opposite way for risk perception in predicting acceptance [4,8,14].

Risk assessment is not a context-free issue based only upon risk levels, as shown by the empirical findings. In Portugal, the risk of privacy was barely a factor influencing consumers' attitudes to a negative direction. On the contrary, the Chinese urban, rural research found that risk perception was the only important negative factor that affected, mostly city dwellers' choices [5,11]. Truth is there are differences between these two countries implies that consumers' behavior cannot be predicted solely by one sequence of factors. In different consumer segments, cultural setting, residential factors, technical know-how, level of infrastructure and exposure to autonomous technologies will lead to different interpretations of the risks and benefits offered.

The findings of a study about Indian consumers confirm this. As per the study by Singh *et al.* the most significant factor influencing the Indian consumers' adoption intention was family safety and security that outstripped both speed and green image in their relevance [10]. Meanwhile, the studies of Indian consumers reveal that social influence and risk perception are the two components that determine drone-delivery acceptance [12,13]. The social influence from social network, peer recommendations and social media has also been a topic of discussion in other works, suggesting that this might have the power to transmit trust from one consumer to the next.

Essentially, this review stems from the realization that, despite in reality these different aspects may appear to be independent, they should rather be brought together in a well-reasoned explanation of how a consumer adopts a product or service. Most authors that have addressed these variables have tended to treat usefulness, ease of use, perceived risk etc. separately and sometimes have even combined several of these with other factors in technology-acceptance studies [1,5-6,12]. The recent findings though suggest that adopting is a multi-stage process where convenience grabs the spotlight, perceived risk causes pause, whereas trust is a factor that may or may not cause consumers to make the decisive step of a purchase and then continue to use the product or service. Dabi *et al.* explicitly mention trust, perceived safety, perceived innovation and word-of-mouth as crucial areas for further research beyond their three-variable TAM. It is a very good move to be thinking along these lines.

Objectives of the Review

Accordingly, this review aims to:

- Synthesize the major determinants of consumer adoption of drone delivery services, with particular attention to convenience, usefulness, service performance, safety, privacy, perceived risk and social influence
- Examine the transition from perceived convenience to consumer trust, identifying how reliability, safety, transparency and risk perceptions influence the conversion of adoption intention into actual and continued use
- Develop an India-oriented conceptual understanding of drone-delivery adoption, highlighting contextual differences, existing empirical evidence, research gaps and implications for logistics providers, technology developers and policymakers

The review therefore moves beyond the conventional question of "Do consumers perceive drone delivery as useful?" toward the more consequential question of "Do consumers trust the technology and service sufficiently to adopt it?" This distinction provides the conceptual foundation for the subsequent sections of the article. The empirical studies summarized in Table 1 demonstrate that consumer adoption is influenced by a combination of functional benefits, psychological perceptions, social factors and perceived risks rather than by technological capability alone.

The sample sizes and statistical results shown in the table were taken either directly from the papers provided or were synthesized where they were not included explicitly in the papers. For example, the Indian study describes 157 respondents, four extracted factors that explain a 76.599% of the variance and a regression R that is 45.2%. Dabi *et al.* article presents 1,108 respondents and PLS (Partial Least Squares) analysis but Wu *et al.* have done 498 respondents plus tested in an independent 102-questionnaire set Table 1.

Table 1: Selected Empirical Evidence On Consumer Adoption of Drone Delivery

Study	Country/Context	Sample / Method	Major variables examined	Key empirical findings	Relevance to present review
Yoo, Yu and Jung [1]	General public / drone delivery	Consumer/public acceptance study	Attitude, perceived benefits, risks, intention	Identified multiple factors affecting public attitude and intention toward drone delivery	Establishes early consumer-adoption foundation
Mathew *et al.* [12]	India; drone food delivery	Empirical consumer study	Innovativeness, perceived risk, green image	Examined the relationship of innovativeness, perceived risk and green image with attitudes toward drone food delivery	Provides direct Indian evidence linking benefits and risk
Singh, Yadav and Kumar [10]	India; product delivery	157 espondents; factor analysis + multiple regression	Family safety/security, speed, green image, desire	Family safety/security was strongest (β = 0.436); speed (β = 0.224) and green image (β = 0.181) were significant; model R^2 = 45.2%	Particularly important for India's consumer-adoption context
Valencia-Arias *et al.* [6]	Colombia	121 respondents; DOI + TAM	Performance risk, compatibility, innovativeness, relative advantage	Performance risk, compatibility, personal innovativeness and environmental advantage were among the strongest factors influencing intention	Shows importance of combining TAM with innovation and risk perspectives
Waris *et al.* [9]	Drone food delivery	Extended TAM	Usefulness, ease of use, attitude, adoption	Extended TAM demonstrated the importance of technology-acceptance variables in drone food-delivery adoption	Supports theoretical foundation of adoption research
Kumar *et al.* [13]	India; drone food delivery	Empirical study	Determinants of user acceptance	Investigated consumer acceptance of drone-based food delivery in the Indian context	Strengthens the India-specific evidence base
Dabić *et al.* [5]	Portugal; parcel delivery	1,108 respondents; PLS	Ease of use, usefulness, privacy risk, attitude	Ease of use and usefulness positively affected adoption-related attitudes; privacy risk negatively affected attitudes	Strong evidence for the convenience–risk tension
Wu *et al.* [11]	China; urban vs rural	498 respondents + 102 independent test cases; ridge regression	Usefulness, ease of use, risk, environmental cognition, service performance, social norm	Significant differences emerged between urban and rural consumers; perceived risk was particularly important in urban areas	Demonstrates the importance of contextual consumer segmentation
Almuraqab *et al.* [14]	UAE; AI-enabled drone delivery	410 respondents; PLS-SEM	Benefits, risks, costs, social influence, security	Perceived benefits and social influence positively affected attitudes; perceived risk negatively affected acceptance	Provides direct evidence connecting risk, social influence and trustworthy AI
Kellermann, Biehle and Fischer [8]	Germany	TAM-based acceptance study	Usefulness, acceptance, technology perceptions	Demonstrates applicability of TAM to drone-delivery acceptance	Supports theoretical integration
Kellermann, Biehle and Mostofi [15]	Germany	Public-attitude study	Public attitudes and drone delivery	Examined public attitudes toward drone delivery and broader acceptance issues	Highlights social/public dimensions of adoption

Drone Delivery Services: Opportunities and Challenges

Drone delivery represents a shift from conventional ground-based last-mile logistics toward faster, more flexible and technology-driven distribution. However, its benefits are accompanied by technological, infrastructural, regulatory and social barriers. The literature therefore suggests that successful implementation depends not only on drone performance but also on consumer confidence and the surrounding delivery ecosystem.

Operational and Consumer Benefits

The main benefit of using drones for delivery is the high speed with which they can carry goods from one place to another. Drones being a type of aviation technology, they are enabled to fly directly and not restricted by roads, congestion and other hindrances. This might help in minimizing delivery time at the last-mile [16-17]. This is very important for things like delivery of medicines, food, or any such products which are time-sensitive. Besides, in India speed also proved to be the decisive factor in delivery: Singh *et al.* found a considerable and statistically significant positive correlation between delivery speed and the level of adoption ($\beta = 0.224$, $p < 0.001$) [10].

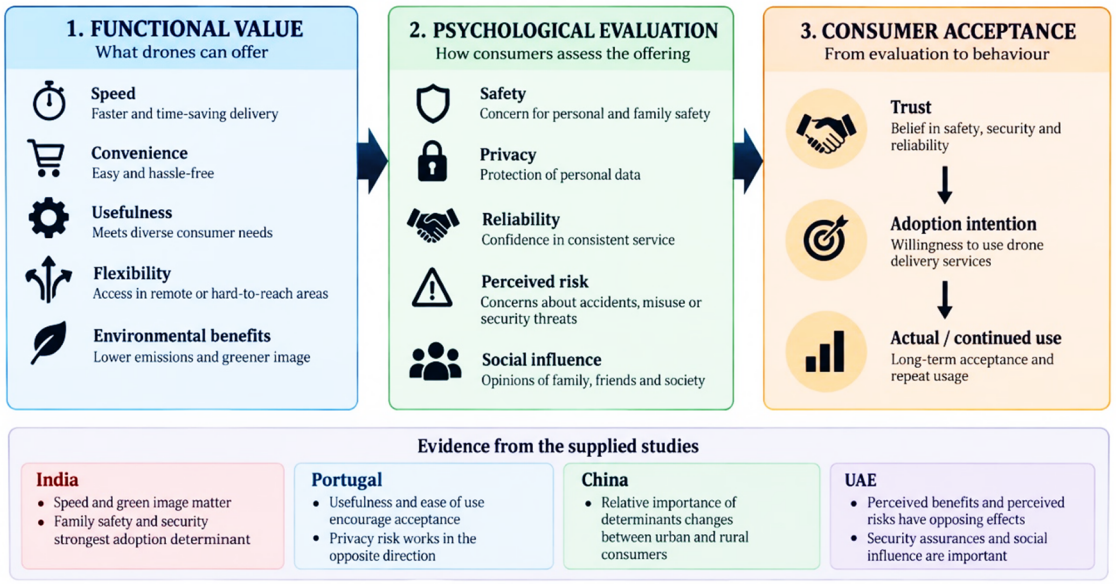

Figure 1: Analytical Interpretation of the Introductory Evidence

Table 2: Major Opportunities Associated with Drone Delivery

Opportunity	Mechanism	Potential consumer value	Supporting evidence
Faster delivery	Direct aerial routes and avoidance of road congestion	Reduced waiting time	[16,17]
Greater accessibility	Ability to reach difficult or remote locations	Improved service availability	[18,21]
Operational flexibility	Flexible routing and integration with other delivery modes	More convenient delivery	[17,20]
Cost efficiency	Lower operating requirements for suitable short-distance routes	Potentially lower delivery cost	[19,21]
Environmental benefits	Possible substitution of conventional vehicles	Perception of greener delivery	[10,19]
Time-sensitive delivery	Rapid transport of food, medicines and essential goods	Greater usefulness	[16,21]
Reduced dependence on road infrastructure	Aerial movement avoids traffic-related constraints	More predictable delivery	[17,22]

Besides speeding up a delivery, drone shipping will offer the opportunity of making it even more efficient with delivery accessibility and operational flexibility. A drone can deliver goods to places which would be hard, expensive or even impossible to get to by conventional transport [18-19]. But, its practical range is affected mainly by such factors as payload weight, battery performance and authorized locations. A system combining drones with trucks can be an interesting development as it brings together the strength of ground transport (i.e. large loading capacity) and aerial transport features (i.e. rapid and agile delivery) leading to a more efficient combined delivery [17,20].

Reduction of environmental footprint would also be another plus point of drone delivery. In case of proper delivery routes, electric drones could reduce the reliance on the regular road vehicles so making use of road vehicles only as a delivery mode of choice. Still, the total environmental impact largely depends on how the electricity is generated, the production of a drone, the usage of its batteries and even the conditions under which it operates [19,21]. Also, the survey of consumers also revealed that the views of the environment of a person influence its perception of a product and so might affect the likelihood of its adoption. One of the studies in this field, conducted in India by Singh *et al.* showed that people having a "green image" of a product A lot and consistently predicted their adoption intention of the product ($\beta = 0.181$, $p < 0.001$) [10] Figure 1.

To put it another way, drone delivery presents various advantages such as faster pace, wider coverage, higher capacity, greater efficiency in cost and environment, but all these benefits can gain consumers' trust only if the service is regarded as trustworthy and safe.

The literature therefore supports the view that functional value forms the first layer of consumer attraction**,** while psychological evaluation determines whether consumers are ultimately willing to use the service Table 2.

Technological and Infrastructural Challenges

Even though these are advantages of drone delivery, replacing traditional delivery cars completely with drones remains far-fetched at least. Drone battery life and capacity are a major limiting factor when it comes to drone operations. Drones are usually limited to a short range and can't carry lots of weight, so not every type of goods and place of delivery

are viable for them [18,21]. These are the kinds of issues that one might have to address by setting up more warehouses, installing charging points and arranging for the delivery by the regular cars.

Unreliability can result from the environment/weather factors. Wind, rain and other elements that are a source of the bad weather can make drones fly worse or even stop the flight operation. This is one of the aspects where the desire of a consumer for an uninterrupted delivery might go hand in hand with Truth is the drone cannot fly anytime it wants. The biggest issue but seems to lie in drone communication and navigation. Communication channels, navigation systems, monitoring technologies, charging points and safe touchdown or delivery spots are the ones that the operators of a drone should count on as far as a safe drone operation is concerned.

As the last-mile drone logistics study, infrastructure is one of the most essential requirements in the field of drone delivery since urban environments were mainly designed for ground transportation without giving much thought to flights at low altitudes [21-22]. Definitely, safety is among the biggest concerns that come with what I just said technical shortcomings. A drone's battery going dead, the lack of communication lines, navigational errors, bad weather and any other obstruction that can bring a flight accident may increase the level of hazards of the operations.

Actually, the enhancement of these key features - autonomous navigation, route planning, automatic collision detection and airspace-management systems - should go hand in hand to guarantee a dependable drone service at the level of consumer mass adoption this way, the academic publications show that development along these two dimensions - capability of the technology and the development of infrastructure - should run parallel to each other [21-22] The most cutting-edge drone will also not be able to carry out the functions of a customer-friendly delivery if facilities and systems for charging the drone connectivity landing, or the management of flight areas are lacking.

Regulatory and Social Challenges in India

Regulatory uncertainty has been and remains to be one of the most significant hurdles to the proliferation of drone-delivery. In a drone-made delivery system, there are a number of regulations relative to airspace, flight authorizations, air safety control, operator accountability, as well as liability and privacy issues. Uncertainty or frequent alterations in regulation can mean doubts among users and providers [23,24].

Similar pilot research in the field of logistics points out to legislation, city and suburban infrastructure and user acceptance as related prerequisites to efficient drone delivery. This is mainly relevant to India, where delivery is to be implemented across densely populated cities, semi-urban and rural areas which differ in infrastructure and acceptance conditions. Indian consumer research showed that family safety and security was the most powerful predictor for adoption intention ($\beta = 0.436$, $p<0.001$), much stronger than speed or green image [10]. This shows that the operational benefits of faster delivery doe's not necessarily outweigh safety concerns. The other social concern is privacy. Delivery drones could be equipped with cameras, sensors and GPS to deliver and locate the delivery destination.

Consumers may so have concerns for surveillance, data collection and potential misuse of captured data [24-25]. Dabi *et al.* found in their study on 1,108 Portuguese that perceived privacy risk negatively impacted attitudes towards the use of delivery drones; still the impact was only marginal [5]. And, the level of social acceptance depends on geographic and demographic context. Similar to the nominal distinction between urban and rural consumer groups as presented in the U.S. in China, the analysis identified that there was a difference between urban and rural consumers in how drone delivery was perceived. Whereas perceived usefulness and ease of use were considered important within urban environments, service performance appeared to be more influential within rural contexts.

Overall, the literature reveals a clear benefit–risk trade-off. Drones offer speed, convenience, accessibility and potential environmental advantages, but consumers simultaneously evaluate safety, privacy, reliability, infrastructure and regulation. Recent systematic research similarly identifies safety, privacy, infrastructure, policies and public acceptance as interconnected barriers rather than isolated problems Table 3.

Table 3: Major Challenges Affecting Drone-Delivery Adoption

Challenge	Main issue	Consumer implication	Relevance to India
Safety	Crashes, navigation failure, battery problems	Reduces trust	High
Payload limitations	Restricted parcel size/weight	Limits service applicability	High
Battery endurance	Limited flight range and charging requirements	May reduce reliability	High
Weather	Rain, wind and extreme conditions	Possible delivery delays	High
Infrastructure	Charging, landing and communication systems	Affects service availability	High
Privacy	Cameras, GPS and data collection	Creates perceived privacy risk	High
Noise	Low-altitude flight and repeated operations	May create community resistance	Moderate–High
Regulation	Airspace, liability and operating requirements	Creates uncertainty	High
Social acceptance	Public attitudes toward drones	Determines market expansion	High
Cost	Infrastructure and system investment	May affect delivery fees	High

Theoretical Foundations of Consumer Adoption

Consumer adoption of drone delivery cannot be explained through convenience alone. Existing studies generally combine technology-acceptance variables with perceived risk, innovation characteristics, attitudes and social influences. This section therefore considers three complementary perspectives:

- Technology Acceptance Model (TAM), Innovation and Risk Perspectives and Trust-Based Adoption

Technology Acceptance Perspective

The Technology Acceptance Model (TAM) can explain some of the key aspects of drone delivery acceptance, it is a well-respected theory for that, Davis argued that perceived usefulness (PU) and perceived ease of use (PEU) of a technology are the main factors which lead to its acceptance [2]. With drone delivery PU is the degree to which customers think that the delivery service is enhanced by the drones. In particular, how fast, flexible and convenient, whereas PEU is the how easy the customer thinks they will be able to use/interact with the service.

Repeating itself drone-delivery studies applied TAM in logistics [5,9,31]. Based on their findings, Waris et al. pointed out that the perceived usefulness of drones is a factor that increases customers' liking of drone-delivered food [9]. Also, parcel delivery was the subject of the research of Dabi et al. and TAM was the main theory they tested with the help of PLS methods on 1,108 Portuguese sample responses, exploring the PEU, PU and perceived privacy risk dimensions [5]. The results indicate that the PEU and usefulness, have positive effects, but the risk of privacy leads to a negative effect on attitude.

The present overview is based to some extent on TAM because the model gives a theoretical background for the convenience-related side of using drone delivery. Before adopting, a customer will mainly look and evaluate if drone delivery is helpful to them, quick and easy. Besides, TAM alone can't account for the issues that a customer might encounter related to safety privacy reliability and uncertainty.

Innovation and Risk Perspectives

Drone delivery changes the whole expectations of a consumer as products delivered from the air. Through the characteristics like relative advantage compatibility complexity and other perceptions linked to an innovation the adoption of innova- tion is explained by the theory of Diffusion of InnovationsDOI) these characteristics are in particular important for drones because consumers have to compare a brand-new aerial delivery method with traditional ground-based delivery [26].

And, the literature has shown that risk perception may counteract risk perception. Safety privacy performance and reliability concerns can turn people off even when they understand the main advantage of quick delivery [27-28]. For example, Dr. Zhu studied public risk beliefs for drone delivery, showing the significance of recognizing different forms of perceived threat unlike treating risk as a single dimension [29]. O. M. Osakwe et al. looked into the variables determining the attitude of consumers towards the use of last-mile delivery drones [30].

Research on drone food orders shows how the level of innovation in a buyer can affect both the buyer and his behavior intention, that is, a customer who is highly might be more open to a new way of delivering goods [31]. The innovation and risk aspects because of this uncover an essential puzzle: the same piece of technology can offer a powerful advantage while causing doubt at the same time. This puzzle of high convenience leading to adoption has mostly to do with this.

Trust-Based Adoption Perspective

Trust represents why connecting the advantages of technology to a user's actual willingness to adopt. Since consumers are not able to directly see the inner workings of the autonomous drone, they have to trust the technology and the service provider to deliver the parcel safely, accurately and on time. As a result, perceived reliability safety privacy protection and institutional measures might play a role in whether perceived usefulness is transformed into adoption intention.

Factual support from drone-delivery research backs up the trust-based explanation. Dabi et al. state that fears about the safe and trusted operation of a drone may undermine consumer confidence in the service, although it delivers the goods much faster and less laboriously. Their elaborated TAM model because of this factors in private risk as a determining element of consumer perception.

Besides showing that trust plays such a vital role in Indian consumer behavior, a study by Singh et al. highlights family safety and security as the most significant variables to predicting adoption behavior ($\beta = 0.436$, $p < 0.001$) [10].

Table 4: Theoretical Perspectives Explaining Drone-Delivery Adoption

Theoretical Perspective	Core constructs	Application to drone delivery	Main contribution to the review
Technology Acceptance Model (TAM)	PU, PEU, attitude, intention	Explains usefulness, convenience and ease of interaction	Explains initial attraction
Diffusion of Innovations	Relative advantage, compatibility, complexity, innovation characteristics	Explains consumer response to a new delivery technology	Explains innovation acceptance
Perceived Risk Perspective	Safety, privacy, performance and delivery risk	Explains barriers despite perceived benefits	Explains consumer hesitation
Innovation/Consumer Innovativeness	Innovativeness and openness to new technology	Explains differences among consumers	Explains heterogeneous adoption
Trust Perspective	Reliability, safety, privacy, confidence	Explains willingness to depend on autonomous delivery	Explains conversion from interest to adoption
Social Influence Perspective	Family, peers, social norms	Social approval can strengthen adoption attitudes	Explains social acceptance
Integrated perspective	Benefits + risks + trust + social factors	Combines functional and psychological determinants	Provides the basis for the review framework

The evidence from UAE further supports this as it shows that perceived benefits and influence of society have a positive effect on attitudes, while perceived threat is a negative predictor (β = -0.146) [14].

Determinants of Consumer Adoption of Drone Delivery

The ways consumers embrace new technologies are usually determined by a mix of what those technologies can do, the emotional responses they provoke and the personal or contextual social conditions at play. Literature reveals consumers are more than just technically assessing drones as delivery options - they question if it's an effective solution that also satisfies aspects of comfort safety reliability and conformity with current social norms [34,39]. So, variables that determine adoption can be divided into three broad categories Table 4.

Convenience, Usefulness and Service Performance

"Drones as delivery" are very much accepted in the modern-day consumer market because of the perceived usefulness (PU) and the perceived ease of use (PEU). These two concepts are always regarded as among the key determinants of consumer acceptance of the new technology, e.g. UAVs. The consumer develops positive attitudes and the consumer gets motivated to try, if he or she believes that the technology, such as delivery by drones can result in fast fulfillment convenience flexibility, etc. [34], [35]. A research study conducted by Dabi *et al.* using 1,108 respondents concluded that PEU and the perceived use value were important determinants of the consumer's attitude and intention of adoption [5].

Service performance was another important characteristic because the customers at some point judge whether the technology can meet their expectations. A fast, yet untrustworthy drone cannot practically deliver much. A study made in the city of China showed that for rural customers, the performance of service was key, whereas perceived usefulness and ease of use were major predictors for all consumer groups.

The Indian study emphasized the factor of speed of delivery much as a crucial consideration. Speed had a statistically significant positive effect on the intention to adopt β = 0.224, p< 0.001 [10], reported Singh *et al.* Because of this, through such functional benefits like convenience, consumer interest in drone delivery first emerges.

Trust, Safety and Perceived Risk

A second key factor is the extent to which the risks linked to drone delivery are visible. Drone delivery could cause injuries and damage packages, the technology can also fail, there are privacy intrusion risks and there is an element of mystery connected to autonomously operating drones [27,28,36]. A customer having risk perceptions would be skeptical enough so as not to switch to this new option, despite appreciating the positive sides of it.

Safety is in particular central to the Indian setting. As Singh *et al.* family safety and security (β = 0.436, p< 0.001) [10] were the top indicators of customers' intention to adopt this new product. This coefficient was larger than that of speed (β = 0.224) and environment image (β = 0.181). The result shows that the safety factor may be stronger than other considerations of the product's use.

Privacy is yet another risk factor. Dobi *et al.* [5] found out that consumers' perceived privacy risk is a negative factor on their attitude towards the product, but that the impact of it is limited at best. The concern over privacy is partly due to in reality during a delivery drone may utilize a camera, some sensors, the location information and the like [37].

As an outcome, we argue that trust is the way to relieve individuals' mental distress due to autonomously delivered goods. Providing a safety assurance, performing reliably, protecting the privacy of the customer and being open about the details are elements that can be used to move people from being convinced of usefulness to actually adopting the service.

Table 5: Major Determinants of Consumer Adoption of Drone Delivery

Determinant	Expected influence	Consumer interpretation	Evidence
Perceived usefulness	Positive	Drone improves delivery experience	[5,9,34]
Ease of use	Positive	Service is simple and convenient	[5,34]
Delivery speed	Positive	Reduces waiting time	[10,35]
Service performance	Positive	Drone performs reliably	[17,35]
Safety and security	Positive when assured	Reduces fear of accidents/failure	[10,27]
Perceived risk	Negative	Increases uncertainty	[27,28,30]
Privacy risk	Negative	Concerns about personal information/surveillance	[5,37]
Environmental value	Positive	Perception of greener delivery	[10,19]
Social influence	Positive	Others' approval increases confidence	[14,33]
Consumer innovativeness	Positive	Innovative consumers are more receptive	[31]
Perceived cost	Context-dependent	Determines economic attractiveness	[14]
Technological familiarity	Generally positive	Previous exposure reduces uncertainty	[35]

Economic, Social and Individual Factors

Adoption is affected mostly by cost, the influence of society and consumer characteristics. Consumers may evaluate drone delivery for how economically worthwhile it is and in this, cost matters a lot. Still, one can not say universally that this is true in all cases. One example of that is the study in UAE which showed that perceived cost was not significant in the formation of attitude ($\beta = -0.057$, $p = 0.445$) as the case was with perceived benefits and social influence which both were significant and had a positive effect ($\beta = 0.386$) [14].

Social influence might be significant if there is not much direct experience with drones that the consumers have. Family friends peers, expert opinions and social media can offer social proof that mitigates doubt towards a new technology which is exactly why they are so important [33,38]. Yet, the degree of the effect may vary with the differences of the cultural and regional environments.

Also, characteristics of the individuals explain differences in adoption. Variables including consumer innovativeness age familiarity with technology and prior exposure to drones affect attitudes as well as behavioural intentions [31,33]. Also, data from the study in China shows that determining factors are different for city and countryside consumers which further implies adoption is a process with varying levels and stages and should not be viewed uniformly.

From Convenience to Trust: An Integrated Consumer Adoption Framework

Convenience as the Initial Adoption Driver: Consumer evaluation of drone delivery begins with a notion of convenience. For faster service, lesser dependency on road transport, adaptable delivery slots and simple interaction features can be drivers for the users' perception of the usefulness of the product (PU) and ease of use of it (PEU) [1,3,34,41]. From the case study of 1.108 Portuguese consumers, it emerged that both PEU and PU factors had a positive influence on drone delivery attitudes and further attitude was the predictor of adoption intention [5]. The research findings also highlight the major appeal of drone delivery as the possibility to enjoy a prompt and effortless delivery, but real acceptance hinges upon the consumer feeling that the service is safe and that a delivery will be reliably done.

This line of reasoning is supported by Indian findings: a significant positive relationship of the adoption intention with speed of delivery was found ($\beta = 0.224$, $p < 0.001$). So, convenience should not be seen as just an attractive feature but also a strategic lever with the help of which the company can get into the market of consumer adoption. Consumers tend to be drawn in at the first glance by what the drones are doing, but their readiness to trust the service will be based on what they can foresee going wrong from their side, the consumer's, the perspective [10,13,41].

Trust as the Conversion Mechanism

Consumers go overboard in evaluating whether safety, reliability and regularity of the claimed benefits are really possible. Their satisfaction with one product feature cannot override their discomfort and disappointment of the product in general after they've had to deal with security breaches or privacy violations or delivery failures or even accidents and system breakdowns. The literature states that worries about secure and stable use of drones can make it lose a lot of consumer confidence if the consumers were not only satisfied by the speed of its delivery but also other functions that drones can perform besides delivery Table 5.

The Indian experience offers compelling evidence for the significance of safety, Safety/Security was the first and most important factor predicting the intention to use the product based on the four factors identified by Singh *et al.* Safety&Security of Familie's was much correlated with adoption intention at $\beta = 0.436$, which is much bigger than $\beta = 0.224$ (delivery speed) or $\beta = 0.181$ (Green image). It is a sign that nowadays, consumers don't only raise "Is drone delivery convenient?" question; they often ask "Can I trust it to operate safely around my family, property and community [10]? Privacy is another element which affects trust and leads to doubt. Dabi et al showed that perceived

privacy risk had a slightly negative impact on consumer attitude, which confirms that privacy concerns should not be ignored unless their effects are statistically small and not significant [5]. Dubai's recent surveys have also shown the existence of the two contradictory forces: a positive one which is perceived benefits (beta = 0.386), the other is consumer's influence (β = 0.386), which both were found to be contributing towards consumer's attitude on the one hand.

From Adoption Intention to Continued Usage

A major limitation in the existing literature is the frequent use of intention to adopt as the primary outcome rather than actual or repeated usage. A consumer may express willingness to try drone delivery because it appears innovative, fast and convenient, yet continued usage requires satisfactory real-world experiences. Dabić *et al.* explicitly identify consumer attitude as a significant predictor of future adoption intention and recommend further examination of variables such as trust, perceived safety, word-of-mouth and perceived innovation.

Consequently, the adoption process can be conceptualized as a progression:

- Perceived convenience → perceived usefulness → trial intention → safety/reliability evaluation → trust → adoption → satisfactory experience → continued usage

This framework places trust between initial convenience and sustained adoption**,** making it central to the shift from technological curiosity to routine consumer behaviour. Social experiences can further reinforce this process because peer recommendations and positive experiences may strengthen confidence in an unfamiliar delivery technology.

As shown in Table 6**,** convenience primarily creates the initial motivation to consider drone delivery, whereas trust determines whether that motivation can be converted into meaningful and sustained adoption. This distinction is particularly important for India, where the evidence indicates that safety-related considerations can be stronger than speed-related benefits [10].

Consumer Acceptance in The Indian Context

Urban, Rural and Semi-Urban Consumer Perspectives: Consumer acceptance of drone delivery should not be considered the same across different geographical locations. Research findings reveal that the perceived value of drone delivery from the consumers' perspective depends upon several factors, such as the nature of place they live in, level of technological familiarity and service requirements perceived by them. In a study conducted in the city of Patna in the state of Bihar India Singh *et al.* questioned the opinions of 157 participants, from which 60.5% came from cities whereas 39.5% came from villages and towns. And, 78.3% of the respondents were familiar with drone services and 73.9% of them were of the opinion that drones will become the best method of delivering the service. Evidence on a global scale supports the geographical context as a significant factor. Research comparing urban and rural consumers in China found differences in the relative importance of adoption factors: usefulness and ease of use were important across settings, whereas service performance and accessibility were particularly relevant to rural consumers**,** while perceived risk exerted a stronger influence in urban contexts [45]. Such differences are important for India because rural and semi-urban communities may evaluate drones primarily through accessibility and service availability, particularly where conventional logistics are less efficient.

Table 6: Integrated Convenience-To-Trust Pathway in Drone Delivery Adoption

Adoption stage	Consumer perception	Major determinants	Likely consumer response	Supporting evidence
Awareness	"This is a new delivery option."	Technology exposure, innovation awareness, social influence	Curiosity/interest	[31,33,41]
Convenience evaluation	"It may save time and effort."	Speed, accessibility, ease of use, flexibility	Positive evaluation	[1,5,10]
Usefulness evaluation	"It can improve my delivery experience."	PU, service performance, delivery efficiency	Stronger adoption intention	[5,35,39]
Risk evaluation	"Is it safe and reliable?"	Safety, delivery risk, system failure, weather	Acceptance or hesitation	[27,28,30]
Privacy evaluation	"Will my privacy be protected?"	Image/video capture, data protection, surveillance concerns	Reduced confidence when risk is high	[5,37]
Trust formation	"I believe the service can operate safely."	Reliability, transparency, security assurances, social proof	Greater willingness to try	[10,14,15]
Initial adoption	"I am willing to use it."	Positive attitude + perceived benefits	Trial/adoption intention	[5,9,13]
Experience formation	"The service worked as promised."	Successful delivery, reliability, satisfaction	Confidence reinforcement	[32,39]
Continued usage	"I would use it again."	Trust, consistent performance, convenience, low perceived risk	Repeated adoption	[32,39,41]

Therefore, an Indian adoption strategy should not assume that a single value proposition will work across all locations. Urban consumers may emphasize speed, privacy and safety, while rural and semi-urban consumers may place greater emphasis on accessibility, reliability and whether drone delivery can reach locations inadequately served by conventional logistics [10,13,45].

Demographic and Technology-Readiness Differences

Individual characteristics also influence acceptance. The Indian sample reported by Singh *et al.* was relatively young: 73.2% of respondents were aged 20–30 years and males represented 78.3% of the sample. These characteristics should be interpreted as characteristics of the surveyed sample rather than as a demographic representation of the Indian population.

Technology readiness can influence whether consumers interpret drones as useful innovation or as an unfamiliar and risky technology. Research on consumer innovativeness indicates that consumers who are more receptive to technological innovations can develop more favourable attitudes toward drone food delivery [40], [46]. Similarly, research on Generation Z indicates that peer experiences and social demonstrations can be important in reducing uncertainty surrounding drone delivery [42].

Thus, technological familiarity can reduce the psychological barrier associated with first-time use. However, familiarity alone does not eliminate safety or privacy concerns. Even technologically receptive consumers require evidence that the service is dependable, secure and appropriately regulated. This supports the central argument of this review that technology readiness may facilitate initial acceptance, whereas trust is necessary for sustained acceptance**.**

Cultural and Social Acceptance Factors

Consumers who have limited direct experience of drone delivery tend to be in particular influenced by social means. Family, friends and others close to the consumer may be good sources of information that help with the decision making process by offering social validation and minimizing the fear of the unknown connected to new technology. The articles given present a lot of the work that is there on the importance of social influence and ofcourse social influence is also considered to be important for India and other countries. Still, social influence and technology adoption is not universal; the strength of the relationship and the context of social interaction vary given the individual and the study.

Social influences of course are also present at a young generation of consumers. Studies on Gen Z put emphasis on the role of peer opinion, direct display and moving from the stage of "seeing" to belief of the real thing, i.e. safety and usefulness [42]. This is the case of drone delivery as there are very few consumers with personal experiences in this domain of autonomous aerial delivery.

That's why for India, social acceptance works through two interacting processes: social proof and trust transfer. When the consumer sees a successful delivery on drone technology by people whom he knows or receives recommendation, the uncertainty factor reduces. But, if news of drone malfunctions, drone deliveries being missed, privacy complaints arising from drone operation or drone being misused etc. gets circulated around the society, this may quickly result in the erosion of consumer trust. As a result, the technology diffusion context is jointly influenced, besides individual views, by social network members' stories, experiences and opinions.

According to Table 6, the consumer acceptance of mobile money services by Indian people is actually a multifaceted consumer acceptance. Factors that are convenience-related like speed capture interest and the subsequent stages safety privacy reliability and social validation determine the development of trust based on interest. Mostly the very high Indian coefficient of family safety ($\beta = 0.436$) in comparison with speed ($\beta = 0.224$) is the evidence for changing the adoption talk not just on convenience-based model but also a trust-based model Table 7.

Strategies for Building Consumer Trust

Enhancing Safety, Reliability and Transparency: Building trust trust should only be built upon tangible operational safety demonstrations instead of merely the promoting. The public needs to have proof that drones can do deliveries without fail when operated under real conditions. So, safety assurances that address flight stability, collision avoidance, package protection, emergency systems and communication that works consistently [22,43,47-48].

Research has also been able to identify that safety reliability etc. are considered as barriers and because of this perceived uncertainty will be the factor to undermine people's trust despite in reality the benefits to consumers from drone delivery are quite functional. Trust will continue being a result of openness for the purposes of trust building, customers have to know the current conditions of their deliveries, when their package will arrive in principle, limitations of performance and how things work if a delivery fails. Besides being more user-friendly, an interface could even be the reason why users become satisfied with perceived ease of use after Dabi *et al.*'s proposal [5].

Table 7: Key Dimensions of Consumer Acceptance in The Indian Context

Dimension	Likely consumer concern	Evidence/indicator	Implication for adoption
Geographical location	Can the service reach my area?	Urban/rural differences reported in adoption research	Accessibility should be incorporated into service design
Age/technology readiness	Is the technology understandable and familiar?	Indian sample: 73.2% aged 20–30	Younger/technology-ready consumers may be early users, but broader inclusion is needed
Delivery speed	Will it save time?	Indian speed coefficient $\beta = 0.224$, $p < 0.001$	Strong convenience-based adoption driver
Family safety	Could the drone harm people/property?	Indian family safety coefficient $\beta = 0.436$, $p < 0.001$	Major trust-building priority
Privacy	Can drones capture personal information/images?	Privacy risk negatively influences attitude, although marginally in the Portuguese study	Privacy safeguards and transparency are required
Social influence	Are people I trust using it?	Peer/social influence identified across multiple contexts	Demonstrations and positive user experiences can support adoption
Service reliability	Will the package arrive safely and correctly?	Service performance is particularly relevant in some rural contexts	Reliability is essential for conversion from trial to continued use
Environmental perception	Is the service genuinely sustainable?	Green image significantly predicted adoption in the Indian study ($\beta = 0.181$, $p < 0.001$)	Sustainability can strengthen perceived value when supported by credible evidence

With security, for AI-based drones, assurances could also involve encrypted control channels, fail-safe mechanisms, certification and third-party auditing, [14,49]. These systems are capable of turning abstract technical claims into signs of reliability that can be observed.

Strengthening Privacy and Consumer Protection

Privacy is a unique issue as delivery drones work in both public and home areas. A person's worry can stem from the camera, a snapshot, a location or an unknown person's gathering or revealing of private details. The given text refers to privacy risk as a negative factor in customer attitudes, although in the Portuguese empirical study the impact of that factor was quite little [5].

So, providers should implement privacy-by-design principles: get only needed information, inform data practices in a clear manner, limit secondary use and let the consumers be able to understand or challenge data collection via the mechanisms. Protection by regulation is equally important since a person may not be able to evaluate independently if the operator is complying with privacy and safety requirements [41], [47]. The literature also points out the necessary regulatory structures besides those safety laws to protect people from their privacy as one of the most important requirements.

As a result, trust is more a matter of human interaction than it is the technology's success, for trust will depend upon people's feeling that companies and authorities will be looking after their rights in case something goes wrong.

Consumer Education and Industry–Government Collaboration

Educating consumers can be a great step in addressing their concerns, fears or other negative thoughts about a technology they may not know much about. In fact, a small drone delivery or a safety brochure or even a simple word of mouth about good service could be a strong example or support when a consumer is considering the risks of drone deliveries. These strategies are most likely to work in places where most people get only a little experience or even no experience of such services.

Taking that into account, the industry should be working in collaboration with regulatory bodies for establishing shared safety regulations, certification methods, privacy policies and consumer complaint mechanisms. The UAE's experience has shown how a strong security guarantee, combined with the endorsement of the society, can be a winning factor. At the same time, the existing literature underlines that governance, infrastructure and public awareness are three critical factors for the adoption of new technologies [14,42,49].

This method would be mostly useful to India where the population is very large whereas the market for such technology is very small. Apart from highlighting the faster deliveries, the service providers have to make a more inclusive and trustworthy proposition: safe delivery + a good delivery performance, + privacy protection+ transparency in operations. This way, providers would be addressing the Indian issue where safety concerns within the family environment rather than speed were why for adopting the technology directly, as indicated in the research.

Table 8 illustrates that the development of trust cannot be attributed to a single intervention but instead is the result of the interplay of technical organizational regulatory and societal elements. This supports the existing body of scholarship which advises the enhancement of convenience and effectiveness alongside the diminution of privacy related issues and the reinforcement of both infrastructural and technological capabilities.

Table 8: Trust-Building Strategies for Drone Delivery Adoption

Trust dimension	Consumer Concern	Recommended strategy	Expected effect
Physical safety	Could the drone injure people or damage property?	Fail-safe systems, collision avoidance, controlled operating zones	Reduced safety risk
Delivery reliability	Will my package arrive safely and correctly?	Real-time tracking, robust routing, contingency procedures	Greater confidence
Transparency	What is the drone doing and where is my package?	Notifications, tracking and clear service information	Reduced uncertainty
AI/system security	Could the system be hacked or malfunction?	Encryption, fail-safe algorithms, audits and certification	Greater technological trust
Privacy	Can the drone capture images or personal information?	Data minimization, privacy policies and restricted data use	Reduced privacy risk
Regulatory assurance	Who is responsible if something goes wrong?	Clear standards, certification and grievance mechanisms	Institutional trust
Social validation	Are other people confident using the service?	Demonstrations, testimonials and trusted-user experiences	Social proof
Consumer education	How does drone delivery actually work?	Public demonstrations and simple educational material	Greater familiarity
Service recovery	What happens after a failed delivery?	Refund/replacement and responsive customer support	Trust preservation
Continuous performance	Can the service remain reliable over time?	Monitoring, performance reporting and service improvements	Continued usage

Research Gaps and Future Directions

Gaps in Existing Consumer Adoption Literature: Even though drone research has been going on extensively, a lot of the literature still focuses on technical optimization routing endurance, scheduling and airspace management. Consumer acceptance but has received much less attention [17,21,45]. The recent study by Wu *et al.* on the city-rural divide highlights this very imbalance and says that user acceptance plays a big role in successful implementation and social integration.

Another issue is the lack of convenient and trustworthy elements within a consumer-adoption model. Most studies focus on perceived usefulness, ease of use, perceived risk, innovativeness/social influence individually [34,40,42]. Even so, literature states that consumers may appreciate convenience and speed at first and while that still go through a decision process of safety, privacy and reliability aspects. In this light, future studies should investigate how trust can be a mediator between perceived benefits and an actual adoption [5,14], [44].

There haven't been solid findings for repeat usage. Quite a number of papers rely on cross-sectional questionnaires to assess attitudes or behaviour intention rather than closely watching after the consumers had made use of drone delivery service. The difference comes in handy as we may find that consumers' desire to use a technology is different from their commitment to the technology over time [41,45].

Methodological and Contextual Gaps

From a methodologist's point of view, cross-sectional and convenience-based surveys remain most commonly used. Even though these types of research are useful to find out patterns and connections, they still give very few clues on what the real cause and effect might be, nor do they allow for understanding the evolution of consumer opinions over time. The UAE research explicitly recognizes that through its non-random, cross-sectional design, the studys findings cannot be evidence of the cause-effect relationship or be generalized.

Considering this, future works should integrate longitudinal surveys, field experiments, pilot-service observations and behavioral measurements. For instance, the experimental method might be employed to check consumer reactions to drone delivery before and after the fact to investigate whether actual hands-on experience decreases consumers perceived risk while at the same time increasing trust [42,46].

In addition, it is necessary to study how various contexts differ and that differences deserve much attention too. The situation in China shows that urban and rural consumers might assign different levels of importance to risk, service performance, usefulness and ease of access [45]. Same here, in the UAE study, it turns out that the level of significance of perceived cost does not align with that in other consumer markets; in the UAE case, perceived cost (a measure which captures the consumer's perception of cost) was not an important factor for change of consumer attitude ($\beta = -0.057$, $p = 0.445$), i.e. it did not act as a mediator between the independent variables and attitude. That means, models of consumer acceptance should in no way suppose that the factors involved function equally in different countries, at different income levels, or in different service contexts [14], [45].

Table 9: Major Research Gaps and Proposed Future Directions

Research gap	Current limitation	Recommended future approach	Expected contribution
Technical–consumer imbalance	Greater emphasis on routing, endurance and scheduling	Integrate engineering and consumer-behaviour research	More realistic adoption models
Trust underrepresentation	Trust often treated indirectly through risk	Model trust as mediator/moderator	Explains conversion from interest to adoption
Cross-sectional designs	Limited causal evidence	Longitudinal and experimental studies	Establish changes over time
Self-reported intention	Intention may not equal actual usage	Study real delivery transactions	Behavioural validation
Urban bias	Rural consumers are less represented	Balanced urban–rural sampling	Better geographic generalization
Indian evidence	Limited large-scale and diverse samples	Multi-state Indian studies	Stronger India-specific conclusions
Privacy concerns	Privacy examined inconsistently	Test privacy awareness and data-governance mechanisms	Better understanding of digital trust
AI-related risks	Emerging issue	Examine cybersecurity, explainability and fail-safe systems	Secure AI adoption framework
Social influence	Effects may vary by culture	Cross-cultural and network-based studies	Understand social diffusion
Actual service experience	Limited post-use evidence	Before–after and field studies	Identify experience-driven trust
Continued usage	Adoption intention dominates research	Examine satisfaction, loyalty and switching	Explain long-term adoption
Regulatory trust	Regulations often treated as external context	Measure confidence in certification and enforcement	Connect governance with consumer trust

Future Research Agenda

Future research ought to go further than asking "will consumers adopt drone delivery?" and move to the deeper questions: "Why do they trust it?" "What is it that makes them continue using it?" and "Under which circumstances would trust get broken?" This perspective is in particular relevant to India where the current facts are quite strong with consumer interest in drone delivery while at the same time they indicate that safety and security are two important factors that can influence one's decision to use it or not.

Research should not only focus on conventional constructs like attitude (the perceived usefulness of a technology), subjective (a personal belief based on what others think about it) and behavioural (likelihood of performing an action), but it should also take into account institutional trust, regulation confidence, privacy protection, AI security, interpersonal influence and the real-life service experiences as variables to study. The paper on UAE suggests the need to do sequential as well as experimental studies on the adoption process and the measurement of the users' real actions, institutional trust, adherence to rules and cultural determinants.

Another interesting research avenue is comparing countries with each other for factors that influence adoption, in particular if the comparison is done on a cultural level and not just a general level. A joint study of the adoption drivers - convenience risk trust - by India China UAE, Europe and North America (and potentially other countries) could indicate if these factors are universal, or whether they vary based on cultural and institutional backgrounds [5,14,42,45]. For India, future research should involve sampling that is representative across the cities, villages and semi-urban areas as currently most of the Indian-based evidence is concentrated on relatively urban and young consumers.

From Table 9, the most significant research path involves linking the concept of technology adoption, the perception of danger and the building of trust with what customers actually do. The studies cited show that researchers would be better served if their samples were representative of the real-world population, the ways they use were better developed and also, they did analyses of different cultures, rather than just getting their data through intention-based surveys [5,14,45].

Managerial and Policy Implications

Implications for E-Commerce and Logistics Providers: Logistics and e-commerce companies need to know that fast delivery alone does not guarantee consumer acceptance. Fast delivery is a functional feature that satisfies the customers but an Indian study found that family safety and protection could strongly influence the decision of a buyer more than delivery time [10]. That is why, companies can market drone deliveries not only through the aspect of speed but also emphasizing safety, reliability and transparency.

Service providers can also change customer interactions in such areas as real-time tracking, delivery notifications, collection centers and flexibility of time [5]. These steps have the potential of making the service much more user-friendly so that the users feel that everything is within their control and they do not need to worry about anything during the delivery period. As a result, positive first impressions will build both word of mouth and trusting relationship which can lead consumers to repeat their transactions [41,42,44,44].

Table 10: Managerial and Policy Implications

Stakeholder	Major concern	Recommended action	Consumer outcome
E-commerce firms	Delivery reliability	Real-time tracking and service recovery	Greater confidence
Logistics providers	Safety perception	Visible safety protocols and communication	Reduced perceived risk
Service providers	Ease of use	Simple interfaces and flexible delivery options	Greater convenience
Technology developers	Flight safety	Collision avoidance and fail-safe systems	Increased trust
Technology developers	Cybersecurity	Secure communication and system monitoring	Greater security confidence
Technology developers	Privacy	Privacy-by-design and data minimization	Lower privacy concerns
Regulators	Public safety	Certification and defined operating zones	Institutional assurance
Regulators	Liability	Clearly defined responsibility for accidents/failures	Reduced uncertainty
Government	Public awareness	Demonstrations and consumer education	Greater familiarity
Industry + government	Social acceptance	Transparent information and public engagement	Stronger social trust

Implications for Drone Technology Developers

The authors suggest that technology design should focus on the aspects that consumers recognize as trustworthy, as this would result in the creation of a successful system rather than only one that works well technically. For example, the system has to be safe and robust in ways that it will be able to handle emergencies automatically, as this directly affects how safe the people using it or in the proximity will perceive the system to be [22,48,51]. That means, the collision avoidance navigation communication, package protection and safety systems are the key areas where attention should be given. These systems provide the physical safety and also a sense of trust for the product users.

Data privacy of citizens also needs to be considered at the design stage. For example, the use of cameras, sensors and location tracking devices should be done following clear rules on data collection and the users should be given the right to understand the use of their personal information [37,52]. And, with the increased application of AI in autonomous delivery drones, security measures like encrypted communication, continuous monitoring, system certification and independent audits will be very crucial [14].

Implications for Policymakers and Regulators

Policymakers have two main responsibilities: allow new technologies and services to flourish while safeguarding the public interest. Well-specified regulations governing flight paths, who is responsible if someone is hurt or their privacy is violated, safety standards, what the law takes in an emergency and how consumers can be sure they get fair treatment, etc. would give certainty to consumers and service operators that their regulations are predictable and fair [47], [50].

Regulatory clarity becomes a must when the setting is a city with high population density, as a technical malfunction in such places may cause problems not only for the people directly involved in the drone flight or delivery but also affect others who had no hand in it. In addition, studies show that the regulatory and social conditions vary from nation to nation; because of this, India ought to develop policies grounded in evidence and adapted to its own factors such as city density infrastructure landform and consumer preferences, rather than adopting international regulations blindly [45].

Successful implementation, as Table 10 illustrates, is the result of a well-coordinated effort throughout the entire ecosystem of the supply chain. Because of this, consumer acceptance should be considered as part of a shared responsibility that also includes the involvement of logistics companies, software engineers and government organizations.

On a more general level management gets a message which is not very subtle and very clear: the attraction of the customer is largely a matter of the facility of use but his loyalty will only result from confidence in the service provider. This idea is in line with the review's main theme that the shift of interest to a steady adoption process is largely a function of safety, privacy and risk concern reduction combined with a convenience factor [5,14,45].

CONCLUSION

From Convenience to Trust

According to studies cited in this article, convenience is not the only driver of consumer adoption of deliveries via drones. Perceived usefulness, ease of use, speed and accessibility are the initial motivations that trigger consumers to start thinking of drone delivery [34,41,45]. But, these benefits are weighed again with concerns about safety privacy reliability and regulatory responsibility [5,27,29].

Indian data is mainly pertinent to that kind of transition. Delivery speed had a significant positive correlation with adoption intention ($\beta = 0.224$, $p<0.001$), whereas Family Safety and Security turned out to be better predictors of adoption intentions, with ($\beta = 0.436$, $p<0.001$) correlation coefficient value, which is quite high. Also, environmental image positively predicted adoption of drone delivery ($\beta = 0.181$, $p<0.001$). So, the supporting evidence indicates that consumers' value-based acceptance of a product shifts from a focus on functional benefits to a more trust-oriented mode of acceptance, as opposite to a pure convenience-motivated way of accepting a product.

Implications for the Future of Drone Delivery in India

Drone delivery can help India solve some last-mile challenges by delivering to places where it is difficult to travel by road or where rapid delivery would result in better service [18,43,45]. Yet, for drone deliveries to gain wide popularity among consumers, it will be up to the service providers and regulators to demonstrate their operations' safety, reliability and transparency.

The study of India carried out so far, also pointed out very high awareness of and interest in, drone services: 78.3% of respondents stated that they knew something or the other about drone delivery and 73.9% of those believed that drones would one day be the preferred mode of delivery, if not the best. It looks like the level of interest differs quite a bit from the level of confidence one has so that one will be willing to make such delivery a repeating thing. Because of this, the deployment of drones in India must integrate technology with consumer education, data protection, safety clearance, fair and clear communication and mechanisms for handling complaints [14,47,50].

Final Research Perspective

In general, the evidence presented is in line with the conceptual pathway that has been drawn in this review through various stages:

- From the point of view of the researchers, one of the main implications is that future work will focus not only on measuring consumer intention to adopt or use a product but more importantly will explore how actual service experience affects consumer behavior and results in a decrease in perceived risk and increase in trust, leading them to the final stage where they become loyal users [41,45,52]
- This shows us how drone delivery in particular has to be considered beyond being just another faster logistics technology and rather treated as a socio-technical service facing consumers whose success will be mainly dependent on the interaction between the technological competence first and the social, legal and political assurance however and the public or consumer confidence towards the service
- Long-term popularity of drone delivery in India will be decided by the level and degree of consumer perception that the drone delivery service is, apart from being highly convenient, also safe secure transparent and trustworthy

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