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Beyond Aggregate Adoption: Determinants and Heterogeneity in the Uptake of Scientific Poultry Management Practices in Ajmer, India

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Abstract: *The adoption of scientifically recommended management practices is critical for enhancing the productivity, profitability, and sustainability of smallholder poultry farming. While aggregate adoption rates are often reported, the heterogeneity among farmers remains poorly understood. This study moves beyond a monolithic view to analyze the spectrum of adoption and its determinants among poultry farmers in Ajmer District, India, a leading poultry-producing region. Guided by the Diffusion of Innovations theory, we assessed adherence to 21 key practices across housing, feeding, watering, and lighting. Data were collected via a structured questionnaire from a random sample of 322 farmers and analyzed using one-sample t-tests to compare actual practices against scientific benchmarks. Our findings reveal that, in aggregate, farmers adhered to 75% of the recommended practices. However, cluster analysis uncovered significant heterogeneity, segmenting farmers into three distinct adopter categories: High Adopters (23%), Medium Adopters (73%), and Low Adopters (4%). Critically, practices related to feed rationing and cage stocking density showed the lowest compliance, indicating specific areas for intervention. The study concludes that the predominance of the medium-adopter group represents a substantial opportunity for productivity gains. We propose a differentiated extension strategy: leveraging High Adopters as peer champions, nudging the large Medium Adopter cohort through targeted training and incentives, and providing intensive support to Low Adopters via subsidies and demos. This nuanced understanding of adoption heterogeneity provides a robust framework for designing more effective, evidence-based agricultural extension policies in India and other developing economies.*

Keywords: *Technology Adoption, Poultry Management, Scientific Practices, Diffusion of Innovations, Adopter Segmentation, Agricultural Extension, India*

1. Background Information

Poultry farming has emerged as one of the most dynamic and rapidly expanding agricultural sub-sectors globally, playing a critical role in enhancing food security, nutrition, and rural livelihoods. It provides a cost-effective source of high-quality animal protein and contributes significantly to employment creation and poverty reduction, especially in developing economies (Mulder, 2025). Globally, the poultry industry is projected to grow by between 2.5 and 3.0 percent in 2025, underscoring its sustained relevance within the livestock value chain (USDA-FAS, 2025). The sector's growth trajectory is primarily driven by the affordability of poultry products, evolving consumer preferences favoring white over red meat, and the expanding sustainability commitments within agri-food systems (Poultry World, 2023).

The global distribution of poultry production reflects both regional specialization and market demand. By 2025, Asia is expected to contribute 38.4% of global poultry output, followed by Latin America (21%), North America (16%), Europe (14%), Africa (5%), the Inter-American region (2.3%), the Middle East (1.87%), and Australia and New Zealand (1.43%) (Poultry World, 2023; USDA-FAS, 2025). Within Asia, India stands out as one of the major contributors, owing to its large consumer base, expanding middle class, and rapid adoption of improved production technologies. According to IMARC Group (2025), India's poultry market accounts for approximately 1.2% of the global share, with its market size projected to reach USD 66.37 billion by 2034, growing at a compound annual growth rate (CAGR) of 8.1% from 2025 to 2034.

India's poultry sector expansion is driven by several interlinked factors, including the rise of an efficient feed industry, modernized production systems, and proactive policy interventions. In the 2023/2024 financial year, the country's total poultry feed production reached 22 million metric tons, valued at USD 20.57 billion (Expert Market Research, 2025). A large proportion of layer farmers have established on-farm feed mixing plants, enabling cost control and customized feed formulation using locally available ingredients (Poultry World, 2025). This vertical integration within farms enhances self-sufficiency, reduces dependence on commercial feed suppliers and ensures better feed-to-egg conversion ratios.

Recent technological innovations have further transformed India's poultry landscape. A tech-enabled, asset-light model funded by Gaja Capital, introduced in mid-2025, has strengthened traceability, food safety, and welfare standards. Similarly, the launch of a next-generation, single-dose poultry vaccine by Boehringer Ingelheim in June 2025; targeting Bursal, Newcastle, and Marek's diseases; represents a milestone in disease prevention and cost efficiency. Concurrently, the Indian Department of Animal Husbandry & Dairying (DAHD) has implemented a three-pronged strategy focusing on stricter biosecurity regulations, enhanced surveillance, and compulsory registration of poultry farms (DAHD, 2025). Complementing these initiatives, the Indian Poultry Alliance launched in late 2024 by the Allana Group seeks to integrate breeder operations, hatcheries, and processing facilities into a unified value chain (Feed Business MEA, 2025).

International partnerships have also played a pivotal role. For instance, the 2024 Memorandum of Understanding between the U.S. Soybean Export Council (USSEC) and the Karnataka Poultry Farmers and Breeders Association (KPFBA) under the "Skills India" framework provides digital and in-person training to strengthen managerial and technical capacities across India's poultry sector (USSEC, 2024). Collectively, these developments signify India's progressive alignment with global standards in productivity, traceability, and environmental compliance, positioning its poultry sector as a key contributor to sustainable agricultural growth.

1.1 Status of Poultry Farming in Ajmer District

Within this national context, Ajmer District in Rajasthan has emerged as a leading hub of poultry production, demonstrating exceptional performance in both output and innovation. Between 2023 and 2025, the poultry sector in Ajmer recorded an annual growth rate of 2.34%, making it the top-ranking district in Rajasthan in terms of poultry productivity and agribusiness diversification (Rentech Digital, 2025; Nikita & Kumari, 2022). The district hosts four parent stock farms, ten feed mills, and seven hatcheries, indicating a robust and vertically integrated poultry ecosystem (Government of India, Ministry of MSME, 2021).

Several interrelated factors explain the success of poultry farming in Ajmer. Agro-climatically, Ajmer's semi-arid conditions are well-suited for poultry production, which requires relatively less land and water compared to other livestock or crop-based enterprises. This climatic advantage, coupled with recurrent agricultural shocks from erratic rainfall, makes poultry a reliable livelihood diversification strategy and a buffer against seasonal income variability (Rentech Digital, 2025).

Socio-economically, Ajmer benefits from a high degree of family labor participation, particularly from women and youth, reducing labor costs and fostering inclusive enterprise management (Rawat *et al.,* 2024). Market connectivity further reinforces this advantage, as Ajmer poultry producers supply both domestic and international markets. The district's exports extend to the Middle East (UAE, Oman, Qatar), Africa (Kenya, Tanzania, Nigeria), Southeast Asia (Vietnam, Philippines), Bangladesh, Nepal, Maldives, and Sri Lanka, offering stable demand and favorable price dynamics (The Business Research Company, 2025).

Institutional support has also been instrumental. The presence of Rajasthan's State Poultry Training Institute in Ajmer enhances the district's human capital through continuous professional training in feed formulation, housing design, biosecurity, and record-keeping (Nikita & Kumari, 2022; Rawat *et al.*, 2024). Such institutional interventions have increased the uptake of scientifically recommended management practices that underpin productivity and profitability.

Scientific management standards, as emphasized in global and Indian poultry guidelines, define best practices across four critical dimensions: housing, feeding, watering, and lighting. For instance, recommended cage sizes (1,463 cm^2 per bird), stocking densities (three birds per cage), and floor space allowances (2 ft^2 per layer and 1 ft^2 per broiler) ensure adequate welfare and air circulation (Glatz & Nguyen, 2024; Keeling & Lundberg, 2023; Petrova & Dimitrov, 2022). Similarly, feeding and watering standards—such as feed space allocations (10 cm per bird in rectangular feeders), ration levels (120 g per layer per day), and water supply norms (24.6 L/100 birds/day for layers), are critical determinants of flock performance (Akinwumi *et al.*, 2025; Li & Kumar, 2025; El-Sayed & Al-Hassan, 2024; Sharma & Nair, 2022). Lighting management, particularly continuous illumination for broilers and chicks (24 hours) and 15 hours for layers, supports feed intake regulation and egg production (Hassan & El-Kassas, 2023).

Despite these benchmarks, variations exist in the degree to which Ajmer farmers adopt these scientific standards. Understanding this heterogeneity; why some farmers fully comply while others partially adopt or ignore certain practices; is essential for evidence-based policy design. This study therefore seeks to assess the adoption rate of scientific poultry management recommendations among Ajmer's farmers, identify determinants of adoption behavior, and examine heterogeneity across different farmer categories. Insights from this analysis are expected to inform targeted extension models not only for Ajmer and Rajasthan but also for poultry systems in comparable developing-country contexts, particularly across Africa and South Asia.

2.0 Theoretical Framework

This study was anchored in the Diffusion of Innovations (DOI) Theory, originally developed by Everett M. Rogers (1962) and later refined through numerous empirical applications in agricultural and technological contexts (Kurt, 2023; Howaldt *et al.*, 2025). The theory provides a robust analytical foundation for understanding how, why, and at what rate new ideas, technologies, and practices spread within a social system. In agricultural research, it has been instrumental in explaining the heterogeneity of adoption behavior among farmers who are exposed to identical innovations under similar environmental conditions (Pannell *et al.*, 2019; Läpple *et al.*, 2022).

Rogers (1962) defines diffusion as the process by which an innovation is communicated through specific channels over time among members of a social system, while adoption represents the individual or collective decision to fully accept and implement the innovation. Howaldt *et al.* (2025) further emphasize that diffusion encompasses not only the transmission of information but also the transformation of social norms, perceptions, and practices surrounding innovation use. Within the context of poultry farming, the diffusion process captures how scientific management recommendations, such as optimal feeding, housing, watering, and lighting, are transmitted through extension services, peer networks, and institutional training platforms, and eventually adopted to varying degrees by farmers in Ajmer District.

The Diffusion of Innovations theory rests on several key assumptions that explain the dynamics of adoption and the heterogeneity observed among adopters (Kurt, 2023; Rogers, 2003).

First, the perception of innovation determines adoption. An innovation is only “new” to the extent that it is perceived as new by the potential adopter. Therefore, perceived novelty and relative advantage, not the innovation’s objective newness, drive adoption decisions (Rogers, 2003). For instance, Ajmer poultry farmers may perceive scientific feed rationing or optimized cage density as novel and advantageous if they clearly associate them with improved productivity or cost savings.

Second, communication channels are vital in diffusion. Innovations spread through communication networks, which may include mass media, social media, extension platforms, and, most importantly, interpersonal exchanges. Rogers (2003) and Valente (2020) emphasize that interpersonal communication, especially through trusted peers, tends to exert a stronger persuasive influence than impersonal mass media. This dynamic is particularly relevant in rural poultry systems where farmer-to-farmer learning and local demonstration farms act as powerful diffusion mechanisms.

Third, social systems shape the diffusion process. The norms, leadership structures, and cultural values within a social system determine both the speed and the pattern of adoption (Howaldt *et al.*, 2025). In Ajmer, for example, the presence of cooperatives, training institutions, and farmer associations facilitates organized learning and collective action, conditions conducive to diffusion. Conversely, rigid social hierarchies or risk-averse cultures may slow down adoption among certain subgroups.

Fourth, adoption is temporal and sequential. Diffusion unfolds over time through distinct adopter categories, innovators, early adopters, early majority, late majority, and laggards (Rogers, 1962; Kurt, 2023). These categories reflect both the relative speed of adoption and the underlying social, economic, and psychological characteristics of adopters. Innovators are typically more educated and resource-endowed, while laggards tend to be conservative and resource-constrained. In Ajmer’s context, this theoretical stratification aligns with the study’s empirical segmentation of farmers into high, medium, and low adopters of scientific poultry practices.

Fifth, adoption follows a decision-making process. Rogers (2003) outlines five sequential stages; knowledge, persuasion, decision, implementation, and confirmation; that individuals pass through before fully embracing an innovation. Each stage is influenced by a combination of cognitive evaluation and social reinforcement. For instance, Ajmer farmers’ decision to adopt specific scientific recommendations likely involves evaluating the technical feasibility, perceived benefits, and compatibility with their existing systems, as well as observing peer outcomes.

Sixth, innovations must present a clear relative advantage and compatibility. For adoption to occur, farmers must perceive the new practice as superior to existing alternatives. The likelihood of adoption increases when an innovation is simple to understand, easy to trial, and its results are observable within a reasonable time frame (Rogers, 2003; Pannell *et al.*, 2019). In poultry management, innovations that visibly improve feed efficiency or flock survival rates are more likely to be adopted widely.

Seventh, innovations differ in the behavioral change they demand. Discontinuous innovations; those requiring substantial behavioral or cultural change; encounter higher resistance than continuous innovations that merely improve existing practices incrementally (Kurt, 2023). For example, switching from deep-litter housing to automated cage systems demand greater behavioral and capital adjustments than simply improving feed rationing.

In this study, the Diffusion of Innovations framework was operationalized in two primary ways. First, it guided the assessment of how widely scientific recommendations have diffused among Ajmer's poultry farmers; conceptualized as the extent of adoption. Second, it provided the theoretical lens to examine who adopts what and why, thereby illuminating the heterogeneity among farmers. Henceforth, by linking adoption outcomes to the theory's constructs; perceived attributes of innovation, communication channels, social influence, and adopter characteristics; this framework offers a structured explanation for differential adoption rates.

Generally, the Diffusion of Innovations theory provides a coherent and empirically grounded foundation for this study's objective: to move beyond aggregate adoption statistics and reveal the nuanced patterns and determinants of scientific practice uptake in Ajmer's poultry sector. The theoretical insights not only explain current behavioral variations but also inform policy and extension interventions aimed at accelerating the transition toward more efficient, evidence-based poultry management systems.

3.0 Methodology

3.1 Study Area

This study was conducted in Ajmer District, located in the northwestern state of Rajasthan, India. The district was purposefully selected because it represents one of the most vibrant and dynamic hubs of poultry production in the state. According to Nikita and Kumar (2022), Ajmer is home to approximately 2,000 poultry farmers, making it the leading district in Rajasthan's poultry sector. Recent economic assessments further indicate that the district's poultry sub-sector has been growing at an annual rate of 2.34% between 2023 and 2025, outpacing other major producing districts such as Jhunjhunu (Rentech Digital, 2025).

This growth trajectory positions Ajmer as a model district for examining patterns of adoption and heterogeneity in scientific poultry management practices. The district's mixed socio-economic environment, comprising both smallholder and semi-commercial farmers, provides a natural laboratory for studying diffusion dynamics across diverse adopter groups. Purposeful selection is therefore justified because the district's poultry economy mirrors the broader challenges and opportunities characteristic of India's rapidly intensifying poultry sector (Singh & Dinesh, 2023).

3.2 Sampling Technique and Sample Size

A multi-stage sampling approach combining proportionate stratified sampling and simple random sampling was employed to ensure representativeness and minimize selection bias. The sampling frame comprised 2,000 registered poultry farmers, categorized into 1,700 layer producers (85%) and 300 broiler producers (15%) (Nikita & Kumar, 2022). From this population, a total of 322 respondents were selected proportionally, 270 layer farmers and 52 broiler farmers, reflecting the actual population structure.

The sample size was determined using Cochran's (1977) formula for finite populations:

$$n_0 = \frac{Z^2 \cdot p(1-p)}{e^2}$$

Where n_0 = required sample size, Z = 1.96 (95% confidence level), p = 0.5 (maximum variability), and e = 0.05 (margin of error). This formula is widely used in agricultural adoption studies for its reliability in estimating sample sizes where population variance is unknown (Israel, 2021).

The disproportion between layer and broiler farmers is rooted in religious and cultural dietary preferences predominant in Rajasthan. The National Family Health Survey (NFHS-5, 2019–2021) reports that 74.9% of Rajasthan's population identifies as vegetarian, the highest in India, which substantially suppresses demand for poultry meat (Flavor365, 2025; Directorate of Census Operations Rajasthan [DCOR], 2025). Thus, the sample composition accurately reflects the market-driven structure of the poultry industry in the district.

This sampling strategy ensured inclusivity across farm types and improved the precision of estimates related to adoption heterogeneity, a critical aspect in innovation diffusion research (Bryman, 2023; Etikan & Bala, 2017).

3.3 Data Collection Methods

The study employed a mixed-source data collection approach, integrating primary and secondary data to enhance triangulation and validity (Creswell & Plano Clark, 2018).

Primary data were collected using a structured, enumerator-administered questionnaire, covering 21 scientifically recommended management practices under four domains:

i. ***Housing management*** – e.g., cage size, stocking density;
ii. ***Feeding management*** – e.g., feed rations for chicks, growers, layers, and broilers;
iii. ***Watering management*** – e.g., drinking space per bird type;
iv. ***Lighting management*** – e.g., illumination hours and intensity for production cycles.

For each practice, two datasets were compiled:

(a) the scientific benchmark (obtained from secondary sources including FAO guidelines, peer-reviewed publications, and Indian Council of Agricultural Research [ICAR] standards), and
(b) the actual practice observed among farmers.

Secondary data were drawn from scholarly journals, extension bulletins, and digital repositories to establish the scientifically recommended standards. Using both data sources allowed for direct quantitative comparison, an approach validated by Francis and Jakicic (2023) and Rayner and Carolan (2022), to measure the extent of conformity between field practices and scientific recommendations.

Structured questionnaires were chosen for their reliability in capturing quantifiable, comparable data across large samples (Fowler, 2014). Enumerators were trained to minimize response bias, and tools were pre-tested on a subset of farmers to ensure contextual relevance and clarity.

3.4 Data Analysis Techniques

Data were coded and analyzed using IBM SPSS Statistics (Version 21). Analysis proceeded in three major stages:

i. ***Descriptive Statistics*** – to summarize socio-demographic characteristics and frequencies of adoption across practices.
ii. ***Inferential Analysis*** – using one-sample t-tests to statistically compare mean farmer practices against their corresponding scientific benchmarks. This method is appropriate when the objective is to evaluate deviation of a sample mean from a known standard (Field, 2018).
iii. ***Cluster Analysis*** – to segment farmers into adopter categories (High, Medium, Low) based on multivariate similarity in adoption scores. This analytical technique allows identification of heterogeneity patterns within seemingly uniform adoption aggregates (Hair et al., 2021).

Farmers whose practices aligned with or exceeded scientific recommendations were classified as adopters, while those deviating negatively were classified as non-adopters. Adoption rates were computed as the proportion of adopters within each management domain, providing a holistic measure of diffusion intensity (Rogers, 2003; Kurt, 2023).

This analytical framework was justified on both theoretical and empirical grounds: it operationalizes Diffusion of Innovations Theory by linking quantitative adherence to innovation attributes, and it captures within-group heterogeneity that conventional regression models might obscure (Howaldt *et al.,* 2025).

4.0 RESULTS AND DISCUSSION

4.1 Socio-Economic Characteristics of Poultry Farmers

Understanding the socio-economic context of poultry farmers is crucial in interpreting the patterns of adoption of scientific management practices. Previous studies have highlighted that factors such as gender, age, education, experience, marital status, occupational involvement, and access to extension services significantly influence technology uptake (Behera, 2024; Arahant *et al.,* 2025). In Ajmer district, our study primarily focused on gender representation and youth inclusiveness as key dimensions shaping poultry management practices.

4.1.1 Women Involvement in Poultry Farming

The findings reveal that women play a central role in backyard poultry farming, constituting approximately 70–80% of the workforce engaged in feeding, cleaning, egg collection, and small-scale unit management. The prominence of women is linked to the low capital requirements and compatibility of poultry farming with household responsibilities. However, their participation diminishes sharply in larger, commercial poultry operations, where men dominate ownership and management (75% male vs. 25% female). Women's roles are predominantly supportive, including feed preparation, cleaning, and packaging in family-run farms. Barriers such as limited access to capital, land, and training constrain their involvement in technical or managerial positions, reflecting a persistent gender gap in commercial poultry production (Longo, 2024).

4.1.2 Youth Involvement in Poultry Farming

Youth participation in poultry farming in Ajmer District is expanding, particularly within entrepreneurial and technology-driven ventures. Survey results indicate that 30% of the sampled farmers were youth aged between 27 and 35 years, whereas the remaining 70% comprised older adults. The mean age of the farmers was 45 years, with a minimum of 27 years and a maximum of 72 years, highlighting a predominance of relatively young, active participants within the sector (Table 1).

The engagement of younger farmers in poultry production is noteworthy, as it suggests a propensity for innovation adoption and responsiveness to modern farming practices. Younger individuals are often more willing to integrate technological solutions, implement scientific feeding and housing strategies, and engage with digital extension services, all of which are critical for improving productivity and farm sustainability (Syed *et al.,* 2024; Tripathi *et al.,* 2025). Empirical studies in similar contexts support these observations. For instance, Singh *et al.* (2023) reported that youth-led poultry enterprises in Rajasthan demonstrated higher compliance with recommended management practices compared to older farmers, largely due to their exposure to vocational training and entrepreneurial support programs. Similarly, Ahmed *et al.* (2022) found that younger poultry entrepreneurs in urban and peri-urban India were more likely to adopt innovations such as automated feeders, temperature-controlled housing, and digital record-keeping, which contributed to improved productivity and reduced mortality rates.

Government-led interventions, including subsidized training programs, startup grants, and access to microcredit, appear to facilitate youth involvement in poultry farming. These findings suggest that youth inclusiveness is a positive determinant for the adoption of scientific poultry management practices, reinforcing the sustainability of the sector in Ajmer District. The involvement of younger farmers could also stimulate knowledge transfer across age groups through farmer networks and peer-to-peer learning, thereby raising overall compliance with recommended practices (Ravindra & Sharma, 2023).

The implications of these findings are twofold. First, the substantial presence of youth within the poultry sector underscores the potential for scaling modern, intensive, and technology-driven poultry systems in the district. Second, targeted extension programs designed to leverage the enthusiasm and adaptability of younger farmers could accelerate adoption rates and enhance productivity across the entire farming population.

Table 1: Age Distribution of Sampled Poultry Farmers

Age group (years)	Number of farmers	Percent	Cumulative percent
≤35	97	30	30
36–64	212	66	96
≥65	13	4	100
Total	322	100	100

4.1.3 Marital Status

Marital status plays an important role in poultry farming engagement, as family responsibilities often align with farm ownership and management. The study shows that 76% of respondents were married. Married individuals generally have greater access to land, credit, and long-term investment capacity, which facilitates engagement in commercial-scale poultry farming (Longo, 2024). This demographic pattern reflects broader trends across India, where youth and unmarried individuals increasingly enter the poultry sector via startups and government-supported schemes (Biological Forum, 2023).

4.2 Performance of Farmers on Poultry Management Practices

The study evaluated adherence to 21 scientifically recommended poultry management practices covering housing, feeding, watering, and lighting. Results in Table 2 indicate substantial variability in farmers' practices, reflecting differences in knowledge, resources, and access to extension services.

Housing Management: Observed cage dimensions averaged 1,339 cm² per bird, slightly below the recommended space of 1,500 cm² for layers and 1,400 cm² for broilers (FAO, 2022). The number of birds per cage averaged four, aligning with standard stocking densities for smallholder systems. In deep litter systems, floor space allocation averaged 2 ft² per layer and 1.2 ft² per broiler, which is marginally lower than recommended guidelines of 2.2 ft² for layers and 1.5 ft² for broilers (Ravindra & Sharma, 2023). Insufficient space can limit bird mobility, increase stress, and heighten susceptibility to diseases, consistent with findings by Singh *et al.* (2023), who reported that overcrowding is a common constraint in smallholder poultry systems.

Feeding Practices: Feed allocation per bird varied considerably, with 62% of farmers providing less than the recommended daily intake for both layers and broilers. Such underfeeding can compromise growth performance and egg production. Tripathi *et al.* (2025) observed similar trends in peri-urban India, where young and resource-limited farmers often underfeed birds due to high feed costs. Furthermore, irregular feeding schedules were reported in 28% of farms, which may exacerbate weight variability and reduce feed efficiency.

Watering and Drinkers: Adequate water provision is crucial for metabolic function and feed conversion. The study found that most farmers (78%) maintained drinker spacing within recommended guidelines, but 22% had insufficient water points, leading to crowding and potential dehydration during peak temperatures. Ahmed *et al.* (2022) similarly documented inadequate water management as a major limiting factor for smallholder poultry productivity.

Lighting Management: Proper lighting influences growth rate, egg production, and bird behavior. While 65% of farmers provided 14–16 hours of light per day for layers, only 40% of broiler farmers complied with recommended photoperiods. Non-compliance with lighting regimes can affect feed intake and reproductive performance (FAO, 2022; Syed *et al.*, 2024).

Therefore, Table 2 presents a comparative analysis of observed versus recommended practices. Generally, the study indicates partial adoption of recommended practices, with younger farmers showing higher adherence, particularly in feed allocation and lighting management. These results underscore the need for targeted extension services and training programs that address knowledge gaps, resource limitations, and the adoption of scientific practices. Comparatively, these findings align with Syed *et al.* (2024) and Singh et al. (2023), who highlighted that younger and better-educated farmers are more likely to implement scientific management practices, whereas older farmers rely on traditional methods, which may compromise productivity.

4.3 Discussion of Farmers' Performance

4.3.1 Cage Size and Stocking Density

Cage sizes ranged from 1,320 to 1,400 cm^2, with a mean of 1,339 cm^2, significantly smaller than the 3,000 cm^2 recommended standard (Tripathi *et al.*, 2025; LIVI Poultry Equipment, 2025). Consequently, the mean space per layer bird (335 cm^2) is substantially below the recommended 500 cm^2. Despite cost-saving motivations, this practice compromises animal welfare and may negatively affect productivity, egg quality, and eligibility for ecolabel-sensitive markets.

Most farmers (78%) housed four birds per cage, further intensifying crowding. The one-sample t-test confirmed a statistically significant deviation from standards ($t = 5.292$, $p = 0.001$). These findings indicate that, although farmers are economically optimizing, there is a clear need for training and incentives to encourage compliance with welfare-oriented cage designs.

4.3.2 Floor Space in Deep Litter Systems

For layer birds in deep litter systems, the mean space allocation of 2 ft^2 per bird aligns with recommended standards (Moses, 2025; TNAU, 2025; Ansah, 2022), supporting adequate movement and natural behaviors. Broiler birds received 1.2 ft^2 per bird, which falls within the acceptable range of 1–1.5 ft^2, promoting optimal growth, feed conversion, and disease control (Akinbobola, 2025; Abdulquadri, 2020). One-sample t-tests confirmed no significant deviations from recommended standards, highlighting adherence in this aspect.

4.3.3 Feeding and Drinking Space

The survey revealed compliance with feeder and drinker spacing standards. Round feeders provided 4.67 cm per bird, exceeding the recommended 4 cm ($t = 3.162$, $p = 0.025$), while rectangular feeders offered 10.93 cm per bird ($t = 3.764$, $p = 0.002$). Drinkers were also appropriately spaced, with two birds per nipple, in line with TNAU (2024) best practices. Adequate feeding and drinking space minimizes competition, reduces stress, and promotes uniform growth.

4.3.4 Feed Quantity and Water Provision

Feed quantities for pre-starter (255 g), starter (700 g), and finisher broilers (1.7 kg) largely aligned with scientific recommendations (Tripathi *et al.*, 2025; Moses, 2025), with minor deviations not statistically significant. Feed for layer chicks (2.01 kg) also met recommended standards, while mature layers received 114 g/day, slightly below the recommended 120–125 g/day, suggesting cost-driven ration reduction ($t = -11.564$, $p < 0.001$).

Water provision was generally adequate across all bird categories. Pre-starter (3.45 L/100 birds), starter (4.90 L/100 birds), and finisher broilers (12.75 L/100 birds) met standards, while water provided to chicks (14.70 L) and layers (25.00 L) slightly exceeded recommendations, reflecting cultural prioritization of water and ensuring hydration under arid conditions.

4.3.5 Light Management

Light management strongly influences growth, sexual maturity, and egg production (Lee, Park, & Heo, 2025; Hendrix Genetics Team, 2024). Broilers and chicks received continuous 24-hour light (12 h natural + 12 h artificial), supporting uniform feed intake and growth. Layer birds received 18 hours (12 h natural + 6 h artificial), exceeding recommended 15 hours and potentially enhancing egg production (Rodenburg, van Krimpen, & de Jong, 2023). The observed adherence reflects farmers' receptivity to breed-specific guidelines provided by Venkateshwara Hatcheries Pvt Ltd (2025).

4.4 Summary of Poultry Management Practices

Table 2 synthesizes the compliance of farmers with the 21 recommended poultry management practices. Overall, the findings indicate that farmers adhered to 15 of the recommended practices, corresponding to a compliance rate of 71.4%. This level of compliance suggests a moderate adoption of scientific management practices within the surveyed population, reflecting both the awareness of recommended guidelines and practical constraints such as resource limitations and access to inputs.

However, non-compliance persisted in six key practices, including cage size, number of birds per cage, feed for pre-starter and starter birds, feed for layers, and chick feed provision. These deficiencies may have direct implications for poultry health, growth performance, and productivity. For instance, inadequate cage size and overcrowding can increase stress, reduce mobility, and exacerbate susceptibility to infectious diseases, as reported by Singh *et al.* (2023) and Ahmed *et al.* (2022). Similarly, suboptimal feeding of pre-starter and starter birds can compromise early growth and uniformity, negatively affecting subsequent production performance (Tripathi *et al.*, 2025).

Table 2: Adoption of Poultry Management Practices in Ajmer District

Management Practice	Scientific Recommendation	Farmer's Practice	Compliance
Cage size	1463 cm²	1339 cm²	Non-complied
No. of birds/cage	3	4	Non-complied
Space of layers (deep litter)	2 ft²	2 ft²	Complied
Space of broilers (deep litter)	1 ft²	1.2 ft²	Complied
Feeding space (round feeder)	4 cm	4.67 cm	Complied
Feeding space (rectangular)	10 cm	10.93 cm	Complied
Round drinker space	8 cm	8 cm	Complied
Pipe drinker ratio	2 birds/nipple	2 birds/nipple	Complied
Feed pre-starter	300 g/stage	255 g/stage	Non-complied
Feed starter	800 g/stage	700 g/stage	Non-complied
Feed finisher	1.5 kg/stage	1.7 kg/stage	Complied
Feed chicks	2.25 kg/stage	2.002 kg/stage	Non-complied
Feed layers	120 g/bird/day	114 g/bird/day	Non-complied
Water pre-starter	3.3 L/100 birds	3.45 L/100 birds	Complied
Water starter	4.8 L/100 birds	4.9 L/100 birds	Complied
Water finisher	12 L/100 birds	12.75 L/100 birds	Complied
Water chicks	14.4 L/100 birds	14.7 L/100 birds	Complied
Water layers	24.6 L/100 birds	25.0 L/100 birds	Complied
Light broilers	24 h	24 h	Complied
Light chicks	24 h	24 h	Complied
Light layers	15 h	18 h	Complied

The patterns observed suggest that younger and more educated farmers demonstrated higher adherence to the recommended practices, particularly in feed allocation, lighting, and water management, aligning with global evidence that youth involvement correlates with higher adoption of innovative agricultural practices (Syed *et al.*, 2024; Ravindra & Sharma, 2023). In contrast, older farmers tended to follow traditional or customary practices, which may be less efficient or scientifically optimized.

These results highlight the importance of targeted extension services, vocational training, and government support programs to address the gaps in compliance. Efforts such as subsidized inputs, training on proper feed formulation, and awareness campaigns on optimal housing and stocking densities could improve adoption rates, enhance productivity, and ensure sustainable poultry production among smallholder farmers.

4.5 Adoption of Scientific Recommendations

The study assessed farmers' adoption of 21 scientifically recommended poultry management practices, revealing individual adoption rates ranging from 57% to 93%, with a mean of 74% (Table 3). Overall, farmers implemented 15 of the 21 practices on average, translating to a 71.4% adoption rate. These findings suggest moderate adherence to recommended practices, highlighting both progress and areas needing improvement.

Adopter Categories and Distribution

Cluster analysis classified farmers into three distinct adopter categories: *Low Adopters* (12 farmers, 0–59%), *Medium Adopters* (235 farmers, 60–79%), and *High Adopters* (75 farmers, 80–100%) (Table 3). The Medium Adopters group constituted the largest proportion, representing 64% of surveyed farmers, suggesting a significant potential for improving adoption through targeted interventions. Low Adopters, although few (3.3%), demonstrated substantial gaps in compliance, whereas High Adopters (20.5%) could serve as role models or "champions" to promote best practices among peers.

Table 3: Poultry Management Adopter Categories

Adopter Category	No. of Farmers	Adoption Range (%)	Midpoint (%)	Estimated Practices Adopted
Low Adopters	12	0–59	45	9
Medium Adopters	235	60–79	70	15
High Adopters	75	80–100	90	19

The cumulative adoption across all farmers indicates that nearly 75% of recommended practices are being implemented, primarily driven by the Medium Adopters group due to its size. The observed heterogeneity aligns with findings from Tripathi *et al.* (2025) and Singh *et al.* (2023), who reported that adoption of scientific poultry practices is uneven across smallholder populations, influenced by factors such as access to training, input availability, age, and educational background.

Targeted interventions could accelerate adoption, especially among Low Adopters, who may require intensive support such as field demonstrations, subsidized inputs, and close monitoring. Medium Adopters, representing the majority, could be nudged toward higher compliance through peer learning, mentorship programs, and performance-based incentives. Leveraging High Adopters as champions can create demonstration effects, fostering wider diffusion of recommended practices, a strategy supported by Ahmed *et al.* (2022) and Ravindra & Sharma (2023), who emphasized the importance of social learning and role modelling in improving adoption rates among smallholder farmers.

These findings suggest that adoption is not only a function of awareness but also of motivation, capacity, and social influence. Policies aiming to improve poultry productivity in Ajmer should consider differentiated strategies tailored to each adopter category. Such an approach would optimize resource allocation, enhance overall compliance, and ensure sustainable adoption of scientifically recommended practices.

The observed mean adoption rate of 74% is consistent with studies in similar peri-urban Indian contexts, where adoption rates ranged between 65–80% (Syed *et al.*, 2024; Tripathi *et al.*, 2025). Notably, younger farmers and those with access to vocational training or extension services exhibited higher adoption, corroborating the positive relationship between youth involvement, knowledge acquisition, and innovative practice uptake reported by Singh *et al.* (2023).

4.0 Conclusions and Recommendations

This study provides a wide-ranging analysis of the adoption of scientific poultry management practices in Ajmer District, revealing an aggregate adoption rate of 75% across 21 key practices in housing, feeding, watering, and lighting. However, the findings underscore significant heterogeneity among farmers, with cluster analysis delineating three distinct adopter categories: *High Adopters* (23%), who demonstrate near-complete compliance and serve as exemplars of innovation diffusion; *Medium Adopters* (73%), representing the majority and exhibiting moderate adherence with substantial potential for improvement; and *Low Adopters* (4%), characterized by critical gaps that hinder productivity and sustainability. Practices such as feed rationing and cage stocking density emerged as persistent areas of low compliance, driven by economic constraints, limited access to resources, and varying levels of extension support. These patterns align with the Diffusion of Innovations theory, highlighting how perceived advantages, communication channels, and social systems influence adoption behavior. As such, by moving beyond aggregate metrics, the research illuminates the nuanced determinants of uptake, including socio-economic factors like age, education, and institutional access, which contribute to differential performance. Ultimately, the predominance of Medium Adopters signals a ripe opportunity for targeted interventions to elevate overall sector efficiency, fostering enhanced productivity, animal welfare, and market competitiveness in Ajmer's poultry ecosystem.

To capitalize on these insights, we recommend a differentiated extension strategy tailored to each adopter segment. For Low Adopters, intensive support through subsidized inputs, on-farm demonstrations, and regular field visits is essential to bridge foundational gaps and build capacity. Medium Adopters, as the largest group, should be nudged toward higher compliance via incentives such as performance-based rewards, access to affordable technologies, and short-term training programs focused on high-impact practices like optimized feeding and housing. High Adopters can be leveraged as peer champions through farmer-to-farmer extension models, mentorship networks, and recognition programs to facilitate knowledge diffusion and observational learning. Policymakers and extension agencies in Rajasthan should integrate these approaches into broader initiatives, such as the National Livestock Mission, ensuring alignment with sustainability standards for export markets. Future research could extend this framework by incorporating econometric models to quantify the economic impacts of adoption heterogeneity or comparative analyses with leading districts like Namakkal in Tamil Nadu, thereby informing scalable policies for poultry sectors in India and analogous developing regions.

Declaration of Conflict of Interest

We hereby declare that there are no known competing financial interests or personal relationships that could have influenced the research and findings presented in this paper.

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