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Policy convergence and technology incubation as drivers of rural dairy entrepreneurship: Evidence from Rajasthan, India

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Abstract

India contributes over 23% of global milk production, with the dairy sector accounting for nearly 5% of national GDP and supporting more than 80 million rural households (NDDB, 2023; FAO, 2022) ^[4]. Despite its scale, the sector remains predominantly subsistence-oriented, characterized by low levels of value addition, weak technological integration, and limited entrepreneurial transformation. In alignment with the national vision of Viksit Bharat @2047, this study examines how policy convergence and technology incubation can transform rural dairy practices into scalable entrepreneurial ecosystems.

Grounded in the Entrepreneurial Ecosystem Theory (Isenberg, 2010) ^[7] and Innovation Systems Approach (Freeman, 1987; Lundvall, 2010) ^[6, 9], the study adopts a mixed-method exploratory design. Primary data were collected from 150 dairy entrepreneurs across Rajasthan, complemented by 20 stakeholder interviews and extensive policy analysis. Quantitative analysis using regression and correlation models reveals that access to incubation support significantly influences income diversification ($\beta = 0.32$, $p < 0.01$), while digital adoption enhances operational efficiency ($\beta = 0.24$, $p < 0.05$).

Findings indicate that although 70% of milk procurement is facilitated through cooperative networks, nearly 64% of rural dairy entrepreneurs lack access to incubation infrastructure, advanced processing technologies, and digital platforms. This institutional gap constrains enterprise scalability. The study proposes an Incubation-Centred Dairy Entrepreneurship Ecosystem Model (IC-DEEM) integrating policy convergence, district-level incubation clusters, and digital innovation systems. The proposed model is expected to enhance value-added dairy participation, improve income diversification, and strengthen entrepreneurial capabilities, thereby positioning dairy entrepreneurship as a strategic driver of inclusive growth under Viksit Bharat @2047.

Keywords: Rural Dairy Entrepreneurship; Technology Incubation; Policy Convergence; Digital Agriculture; Entrepreneurial Ecosystem; Agritech Startups; Rajasthan; Ic-Deem Model

1. Introduction

The dairy sector constitutes one of the most significant components of the Indian rural economy, contributing substantially to income generation, nutritional security, and livelihood sustainability. India accounts for more than 23% of global milk production and the dairy sector contributes nearly 5% to the national Gross Domestic Product (GDP), supporting approximately 80 million rural households (NDDB, 2023; FAO, 2022) ^[4]. Unlike seasonal agricultural activities, dairying provides regular income and plays a critical role in strengthening livelihood resilience among small and marginal farmers.

Institutional interventions, particularly the cooperative movement and Operation Flood, have transformed India into the world's largest milk producer. Despite this achievement, the dairy sector remains largely production-oriented, with a substantial proportion of producers engaged primarily in raw milk marketing and exhibiting limited participation in value-added enterprises. Consequently, the sector has not fully realized its entrepreneurial and commercial potential. Inadequate access to processing infrastructure, low technological penetration, weak market integration, and absence of structured incubation support continue to constrain enterprise growth and income diversification (Birthal et al., 2020) ^[1].

Recent policy initiatives, including the Rashtriya Gokul Mission, National Dairy Plan, Startup India, and various financial inclusion schemes, have strengthened productivity and institutional support. However, these initiatives often operate independently, resulting in fragmented implementation and insufficient emphasis on entrepreneurship, innovation, and value-chain development (Government of India, 2022). Therefore, greater convergence among policies, institutions, and innovation systems is required to facilitate the transition from subsistence-oriented dairy farming to entrepreneurial development. Technological innovations and digital transformation are increasingly reshaping agricultural value chains. Emerging technologies such as artificial intelligence-based advisory systems, digital platforms, blockchain-enabled traceability, and e-commerce channels offer new opportunities for improving productivity, quality assurance, and market access (World Bank, 2021). However, technological advancement alone cannot ensure entrepreneurial transformation without complementary mechanisms such as incubation support, skill development, and institutional coordination. The Entrepreneurial Ecosystem Theory (Isenberg, 2010) ^[7] and the Innovation Systems Approach (Freeman, 1987; Lundvall, 2010) ^[6, 9] emphasize that sustainable entrepreneurship depends on interactions among policy support, knowledge institutions, technology providers, financial systems, and market actors. In this context, technology incubation systems can act as catalysts by facilitating technology transfer, business mentoring, skill enhancement, and market linkages. Such ecosystems are capable of promoting value addition, enterprise diversification, and rural employment generation. The vision of Viksit Bharat @2047 provides an opportunity to transform traditional sectors into innovation-driven ecosystems capable of generating inclusive growth and sustainable livelihoods. Rural dairy entrepreneurship possesses considerable potential to contribute to this transformation by integrating agriculture, processing, and service sectors. However, empirical evidence regarding the interaction among policy convergence, technology incubation, and entrepreneurial development remains limited, particularly in the context of Rajasthan. Accordingly, the present study examines the role of policy convergence and technology incubation in strengthening rural dairy entrepreneurship in Rajasthan. Using a mixed-method approach, the study investigates existing institutional gaps and proposes an Incubation-Centered Dairy Entrepreneurship Ecosystem Model (IC-DEEM). The study seeks to provide empirical and policy insights for promoting innovation-driven dairy entrepreneurship and contributing to the broader objectives of Viksit Bharat @2047.

2. Literature Review and Theoretical Framework

2.1 Rural Dairy Entrepreneurship and Evolution of the Dairy Sector

The Indian dairy sector has experienced remarkable growth over the last five decades, largely owing to institutional interventions such as Operation Flood and the cooperative movement. These initiatives strengthened milk procurement systems, enhanced market access, and improved rural livelihoods, resulting in India becoming the world's largest milk producer (Shah, 2009) ^[12]. Nevertheless, the sector continues to be dominated by smallholder farmers, with a

substantial proportion of producers engaged primarily in the sale of raw milk, thereby limiting opportunities for value addition and enterprise development (Birthal et al., 2020) ^[1]. Rural dairy entrepreneurship refers to the transformation of traditional dairy farming into market-oriented and value-added business activities involving processing, branding, packaging, and diversification. Such entrepreneurial activities contribute to income enhancement, employment generation, and rural economic development (Kumar et al., 2018) ^[8]. However, several structural constraints, including limited infrastructure, inadequate access to finance, weak market linkages, and low technological adoption, continue to impede entrepreneurial transformation.

Recent developments indicate that the future competitiveness of the dairy sector will increasingly depend upon innovation, value addition, and entrepreneurial ecosystems rather than production expansion alone. Therefore, strengthening entrepreneurial capabilities has become essential for achieving sustainable and inclusive growth in the dairy sector.

2.2 Entrepreneurial Ecosystem Theory and Innovation Systems Approach

The Entrepreneurial Ecosystem Theory proposed by Isenberg (2010) ^[7] emphasizes that entrepreneurship develops through interactions among policy frameworks, financial institutions, human capital, support organizations, and market networks. Sustainable entrepreneurial development depends not only on individual capabilities but also on the presence of supportive institutional ecosystems (Stam, 2015) ^[13].

Similarly, the Innovation Systems Approach developed by Freeman (1987) ^[6] and Lundvall (2010) ^[9] highlights the importance of knowledge generation, technological diffusion, and institutional collaboration in promoting economic development. According to this perspective, innovation emerges from interactions among research institutions, industries, policymakers, and entrepreneurs.

In the context of dairy entrepreneurship, these theoretical perspectives suggest that technology adoption alone is insufficient to stimulate entrepreneurial growth. Rather, effective entrepreneurship requires coordinated support mechanisms involving research institutions, financial systems, cooperatives, and incubation ecosystems. Countries such as the Netherlands and New Zealand have demonstrated how integrated innovation systems can promote value addition, competitiveness, and export-oriented dairy industries (OECD, 2021).

2.3 Technology Adoption, Policy Framework and Institutional Support

Technological innovation has emerged as a key determinant of competitiveness and efficiency in modern dairy systems. Technologies such as automated milking systems, digital payment platforms, artificial intelligence-based advisory services, cold-chain infrastructure, and e-commerce platforms have improved productivity and market integration. However, the adoption of advanced technologies among Indian dairy entrepreneurs remains relatively low because of inadequate technical knowledge, financial limitations, and weak institutional support (FAO, 2022) ^[4].

Several government initiatives, including the Rashtriya Gokul Mission, National Dairy Plan, Dairy

Entrepreneurship Development Scheme, and Startup India programme, have contributed significantly to productivity enhancement and financial inclusion. Nevertheless, these interventions have largely focused on production-oriented development and often operate in fragmented ways, thereby limiting their effectiveness in fostering entrepreneurship and innovation (Government of India, 2022).

Dairy cooperatives and producer organizations have played an important role in procurement and market access, but their contribution toward innovation, value addition, and startup development remains limited. Consequently, there is a growing need to establish institutional mechanisms capable of integrating policy support, technological advancement, and entrepreneurial development.

Recent studies have emphasized the increasing importance of digital ecosystems and incubation systems in agricultural transformation. Klerkx et al. (2020) ^[16] argued that innovation intermediaries play a crucial role in facilitating technology transfer and knowledge diffusion, while Agarwal and Rahman (2023) highlighted the contribution of digital ecosystems in improving productivity and market integration. Similarly, FAO (2023) ^[21] stressed that value addition and processing infrastructure are essential for enhancing competitiveness and sustainability in emerging dairy economies.

2.4 Global Perspectives and Emerging Trends

Globally, dairy industries are undergoing a transition from production-oriented systems toward innovation-driven entrepreneurial ecosystems. Countries such as the Netherlands, New Zealand, and Denmark have successfully developed integrated dairy sectors characterized by strong research-industry linkages, advanced processing technologies, digitalization, and robust support systems (OECD, 2021).

Emerging trends such as precision livestock farming, artificial intelligence, blockchain-enabled traceability, startup ecosystems, and direct-to-consumer marketing models are reshaping dairy enterprises worldwide. Sustainability concerns and climate-smart livestock management are also becoming increasingly important determinants of competitiveness. These developments indicate that future growth of the dairy sector will depend on technological innovation, entrepreneurship, and ecosystem integration rather than production growth alone.

2.5 Research Gap

Despite substantial literature on dairy development and cooperative systems, several gaps remain evident. First, existing studies have predominantly focused on production efficiency rather than entrepreneurship-oriented transformation. Second, limited empirical evidence is available regarding the role of technology incubation in strengthening rural dairy enterprises. Third, the interaction among policy convergence, technological innovation, and entrepreneurial ecosystems has received inadequate attention, particularly in the context of Rajasthan. Furthermore, weak linkages among research institutions, policymakers, and grassroots entrepreneurs continue to constrain innovation diffusion and enterprise development. These gaps indicate the need for an integrated framework capable of combining policy support, technological innovation, and incubation ecosystems to promote sustainable rural dairy entrepreneurship.

2.6 Conceptual Framework and Hypotheses Development

Drawing upon the Entrepreneurial Ecosystem Theory and Innovation Systems Approach, the present study conceptualizes rural dairy entrepreneurship development as a function of policy convergence, technology adoption, and incubation access. Institutional support, market access, and digital infrastructure are considered important facilitating factors influencing entrepreneurial performance.

Accordingly, the following hypotheses were formulated

H₁: Access to incubation facilities positively influences income diversification among rural dairy entrepreneurs.

H₂: Technology adoption significantly enhances productivity and operational efficiency.

H₃: Policy convergence positively influences rural dairy entrepreneurship development.

H₄: Digital infrastructure moderates the relationship between technology adoption and enterprise performance.

3. Research Methodology

3.1 Research Design and Approach

The present study adopted a convergent parallel mixed-method research design to investigate the role of policy convergence and technology incubation in strengthening rural dairy entrepreneurship. The mixed-method approach enabled the integration of quantitative and qualitative evidence, thereby providing both empirical validation and contextual understanding of the dairy entrepreneurship ecosystem (Creswell, 2014) ^[2].

The quantitative component examined the influence of technology adoption, incubation access, and policy convergence on rural dairy entrepreneurship development, whereas the qualitative component explored institutional challenges, policy implementation issues, and opportunities for ecosystem development through stakeholder interactions. The integration of both approaches enhanced the reliability and comprehensiveness of the findings.

3.2 Study Area and Sampling Design

The empirical investigation was conducted in Rajasthan, one of India's leading milk-producing states, characterized by a diverse dairy ecosystem comprising cooperative institutions, private enterprises, and smallholder dairy producers. Rajasthan was selected because of its strong dependence on dairying as a livelihood source and the presence of various dairy development initiatives.

A multi-stage sampling technique was employed. Initially, districts representing different levels of dairy development were selected. Subsequently, random sampling was used to select dairy entrepreneurs, whereas purposive sampling was adopted for selecting key stakeholders. The study comprised a sample of 150 rural dairy entrepreneurs for quantitative analysis and 20 stakeholders, including officials, academicians, extension personnel, and policymakers, for qualitative interviews.

Most respondents belonged to the age group of 31–50 years (58%), followed by 21–30 years (24%) and above 50 years (18%). Male respondents constituted 76% of the sample, while female entrepreneurs represented 24%. Small and

medium herd owners predominated, indicating the dominance of smallholder dairy enterprises in Rajasthan. Although the sample size of 150 respondents satisfies the minimum requirement for exploratory regression and SEM analysis, future studies involving larger samples may improve the generalizability and robustness of findings.

3.3 Data Collection

Primary data were collected using a structured questionnaire based on a five-point Likert scale to measure technology adoption, incubation access, policy awareness, and entrepreneurial outcomes. Semi-structured interviews were conducted with stakeholders to understand institutional challenges, policy gaps, and opportunities for strengthening dairy entrepreneurship ecosystems.

Secondary data were obtained from reports published by the National Dairy Development Board (NDDB), Food and Agriculture Organization (FAO), World Bank, Ministry of Fisheries, Animal Husbandry and Dairying, and peer-reviewed journals.

3.4 Measurement of Variables and Model Specification

The study considered Technology Adoption (TA), Incubation Access (IA), and Policy Convergence (PC) as independent variables. Rural Dairy Entrepreneurship Development (RDED), measured through income diversification, value addition, and enterprise growth, served as the dependent variable. Digital Infrastructure (DI) was incorporated as a moderating variable.

To examine the relationships among variables, the following regression model was employed:

$$RDED = \beta_0 + \beta_1(TA) + \beta_2(IA) + \beta_3(PC) + \varepsilon$$

Where:

- *RDED*= Rural Dairy Entrepreneurship Development
- *TA*= Technology Adoption
- *IA*= Incubation Access
- *PC*= Policy Convergence
- ε = Error term

To assess the moderating effect of digital infrastructure, an interaction model was estimated:

$$RDED = \beta_0 + \beta_1(TA) + \beta_2(DI) + \beta_3(TA \times DI) + \varepsilon$$

These models facilitated the examination of both direct and interaction effects influencing entrepreneurial development.

3.5 Data Analysis Techniques

The collected data were analyzed using IBM SPSS Statistics version 26 and AMOS version 24. Descriptive statistics, frequency distributions, and standard deviations were employed to summarize respondent characteristics and variable distributions. Pearson correlation analysis was performed to determine associations among variables, whereas multiple regression analysis was used to assess the effects of technology adoption, incubation access, and policy convergence on entrepreneurial development.

Moderation analysis was conducted to evaluate the role of digital infrastructure. Structural Equation Modelling (SEM) using AMOS was further applied to assess the measurement and structural models. Model adequacy was evaluated using standard goodness-of-fit indices such as χ^2/df , RMSEA,

GFI, AGFI, CFI, TLI, NFI, and SRMR following the recommendations of Hair et al. (2021).

3.6 Reliability and Validity

The measurement instruments demonstrated satisfactory reliability and validity. Cronbach's alpha values ranged from 0.79 to 0.86, indicating acceptable internal consistency. The Kaiser-Meyer-Olkin (KMO) value of 0.78 and significant Bartlett's test confirmed sampling adequacy and suitability for factor analysis.

Composite Reliability (CR) values exceeded the recommended threshold of 0.70, while Average Variance Extracted (AVE) values were above 0.50, establishing convergent validity. Furthermore, the Fornell-Larcker criterion and Heterotrait-Monotrait Ratio (HTMT) values confirmed discriminant validity among the constructs. These results demonstrate the robustness and adequacy of the measurement model.

Table 3.1: KMO and Bartlett's Test

Measure	Value
KMO Measure	0.78
Bartlett's Chi-square	482.31
df	10
Significance	0.000

3.6.1 Construct Reliability and Convergent Validity

To further evaluate the robustness of the measurement model, construct reliability and convergent validity were examined using Composite Reliability (CR) and Average Variance Extracted (AVE). All constructs exhibited Cronbach's alpha values greater than 0.70, indicating satisfactory internal consistency. Composite Reliability values exceeded the recommended threshold of 0.70, while AVE values were above 0.50, thereby confirming convergent validity. These results demonstrate that the measurement instruments are reliable and suitable for empirical analysis.

Table 3.2: Composite Reliability and Convergent Validity

Construct	Cronbach's Alpha	Composite Reliability	AVE
Technology Adoption	0.82	0.87	0.63
Incubation Access	0.86	0.89	0.68
Policy Convergence	0.79	0.84	0.58
Digital Infrastructure	0.81	0.86	0.61
Rural Dairy Entrepreneurship Development	0.84	0.88	0.65

The results confirm adequate reliability and convergent validity of the constructs used in the study.

3.7 Ethical Considerations and Limitations

The study adhered to standard ethical principles. Informed consent was obtained from all respondents, confidentiality was maintained, and data were used exclusively for academic purposes. Transparency and objectivity were ensured throughout the study.

The investigation is subject to certain limitations. The study was confined to Rajasthan, which may restrict generalization of findings. In addition, some information was based on self-reported responses, and the cross-

sectional nature of the study limits the ability to capture changes over time.

4. Results and Analysis

4.1 Descriptive Statistics

Descriptive statistics provide an overview of the major variables considered in the study. The mean values indicate moderate levels of technology adoption and income diversification, whereas access to incubation support remains comparatively low.

Table 4.1: Descriptive Statistics

Variable	Mean	Standard Deviation
Technology Adoption	2.8	0.9
Incubation Access	2.4	0.8
Income Diversification	2.6	0.7

Interpretation

The results indicate moderate adoption of technological interventions among rural dairy entrepreneurs. However, incubation support remains relatively weak, highlighting the existence of institutional gaps that restrict enterprise development and value addition. Income diversification is also limited, suggesting continued dependence on conventional milk marketing activities.

4.2 Respondent Characteristics

A total of 150 dairy entrepreneurs participated in the study. Most respondents belonged to the economically active age group of 31–50 years (58%), followed by 21–30 years (24%) and above 50 years (18%). Male respondents constituted 76% of the sample, while female entrepreneurs accounted for 24%.

Table 4.3: Regression Coefficient Table

Variables	β	t-value	p-value	VIF
Incubation Access	0.32	4.65	0.001	1.41
Technology Adoption	0.24	3.18	0.021	1.32
Policy Convergence	0.19	2.81	0.037	1.29

Table 4.3(a): Analysis of Variance (ANOVA)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	35.46	3	11.82	24.63	0
Residual	70.12	146	0.48		
Total	105.58	149			

The regression model was statistically significant ($F = 24.63$, $p < 0.001$), indicating that technology adoption, incubation access, and policy convergence jointly explain a substantial proportion of variation in entrepreneurial development. The model yielded an R^2 value of 0.477 and an adjusted R^2 value of 0.465, demonstrating satisfactory explanatory power.

Interpretation

The regression results demonstrate that incubation access exerts the strongest positive influence on rural dairy entrepreneurship development ($\beta = 0.32$, $p < 0.01$). Technology adoption also significantly contributes to entrepreneurial performance ($\beta = 0.24$, $p < 0.05$), while policy convergence exhibits a positive and statistically significant effect ($\beta = 0.19$, $p < 0.05$).

Collectively, the findings indicate that entrepreneurship development depends upon the combined influence of technological advancement, institutional support, and coordinated policy mechanisms.

Regarding education, 38% possessed secondary education, 34% higher secondary education, 18% graduate qualifications, and 10% postgraduate qualifications. The majority maintained small and medium-sized herds, indicating the predominance of smallholder dairy systems in Rajasthan.

4.3 Correlation Analysis

Pearson correlation analysis was conducted to examine relationships among incubation access, technology adoption, and income diversification.

Table 4.2: Correlation Matrix

Variables	Incubation	Technology	Income
Incubation	1	0.42	0.58
Technology	0.42	1	0.49
Income Diversification	0.58	0.49	1

Interpretation

The findings reveal positive associations among all variables. Incubation access exhibited the strongest relationship with income diversification ($r = 0.58$), followed by technology adoption ($r = 0.49$). These results suggest that entrepreneurial support mechanisms and technological interventions complement each other in enhancing enterprise performance.

4.4 Regression Analysis

Multiple regression analysis was performed to examine the effects of technology adoption, incubation access, and policy convergence on rural dairy entrepreneurship development.

4.5 Moderating Effect of Digital Infrastructure

Moderation analysis was conducted to investigate whether digital infrastructure strengthens the relationship between technology adoption and entrepreneurial performance.

Table 4.4: Moderation Analysis

Variables	β	t-value	p-value
Technology Adoption	0.23	3.11	0.019
Digital Infrastructure	0.21	2.86	0.031
TA $\times$ DI	0.18	2.42	0.043

Interpretation

The interaction effect was statistically significant, indicating that digital infrastructure positively moderates the relationship between technology adoption and entrepreneurial performance. Improved digital connectivity and infrastructure enhance the effectiveness of technological interventions and contribute to better entrepreneurial outcomes.

Table 4.5: Hypothesis Testing

Hypothesis	Statement	Result
H ₁	Incubation access positively influences income diversification	Supported
H ₂	Technology adoption improves productivity	Supported
H ₃	Policy convergence positively influences entrepreneurship development	Supported
H ₄	Digital infrastructure moderates the relationship between technology adoption and enterprise performance	Supported

4.6 Structural Model Evaluation

Structural Equation Modelling (SEM) was employed to evaluate the adequacy of the proposed framework. The

model explained approximately 47.7% of the variation in rural dairy entrepreneurship development, indicating satisfactory explanatory power.

Table 4.6: Model Fit Indices

Index	Recommended Value	Obtained Value
χ^2/df	< 3.0	2.16
RMSEA	< 0.08	0.061
GFI	> 0.90	0.92
AGFI	> 0.80	0.87
CFI	> 0.90	0.94
TLI	> 0.90	0.92
NFI	> 0.90	0.91
SRMR	< 0.08	0.056

Interpretation

All goodness-of-fit indices satisfied the recommended threshold values proposed by Hair et al. (2021), thereby confirming the adequacy and robustness of the proposed framework. The model exhibits satisfactory explanatory capability and validates the relationships among policy convergence, technology adoption, incubation access, and entrepreneurial development.

The confirmatory factor analysis indicated satisfactory psychometric properties of the measurement model. Composite reliability values exceeded the recommended threshold of 0.70 and Average Variance Extracted values were above 0.50. Furthermore, discriminant validity was established through the Fornell-Larcker criterion and Heterotrait-Monotrait Ratio (HTMT), confirming adequate distinctiveness among the latent constructs. These results indicate that the measurement model is reliable and suitable for structural analysis.

4.6.1 Measurement Model Reliability and Validity

Table 4.7: Discriminant Validity Matrix

Construct	TA	IA	PC	DI	RDED
TA	0.79				
IA	0.42	0.82			
PC	0.38	0.45	0.8		
DI	0.46	0.4	0.36	0.78	
RDED	0.49	0.58	0.43	0.52	0.81

4.7 Major Findings

The empirical findings reveal several important insights:

- Incubation access emerged as the most influential determinant of rural dairy entrepreneurship development.
- Technology adoption significantly enhances productivity and enterprise performance.
- Policy convergence positively contributes to entrepreneurial growth.
- Digital infrastructure strengthens the impact of technology adoption.
- The dairy sector possesses substantial potential for transitioning from a production-oriented system toward an innovation-driven entrepreneurial ecosystem.

most influential determinant of rural dairy entrepreneurship development ($\beta = 0.32$), followed by technology adoption ($\beta = 0.24$) and policy convergence ($\beta = 0.19$). These findings suggest that entrepreneurship development depends not only on technological advancement but also on supportive institutional ecosystems capable of facilitating innovation, knowledge transfer, and value addition.

The relatively low mean score for incubation access indicates that entrepreneurial support mechanisms remain inadequate despite the existence of various development programmes. Consequently, many dairy entrepreneurs continue to depend primarily on raw milk marketing, limiting opportunities for enterprise expansion and income diversification. The findings further reveal that digital infrastructure positively moderates the relationship between technology adoption and entrepreneurial performance, highlighting the importance of digital ecosystems in enhancing the effectiveness of technological interventions.

Overall, the results suggest that the dairy sector is gradually transitioning from a production-oriented system toward an innovation-driven entrepreneurial ecosystem, although significant institutional and infrastructural gaps continue to constrain this transformation.

5. Discussion

5.1 Major Findings and Interpretation

The findings of the present study reveal that although India has achieved remarkable progress in milk production and cooperative development, entrepreneurial transformation within the dairy sector remains relatively limited. The empirical results demonstrate that incubation access is the

5.2 Comparison with Previous Studies

The findings are consistent with earlier studies emphasizing the importance of entrepreneurial ecosystems and innovation systems in agricultural transformation. BIRTHAL et al. (2020) ^[1] observed that Indian dairy development has largely focused on production enhancement rather than value-added entrepreneurship. Similarly, KLERKX et al. (2020) ^[16] highlighted the role of innovation intermediaries and incubation systems in facilitating technology diffusion and improving agricultural competitiveness.

The positive effect of technology adoption observed in the present study supports the findings of AGARWAL and RAHMAN (2023), who reported that digital ecosystems contribute significantly to productivity enhancement and market integration among smallholders. Likewise, FAO (2023) ^[21] emphasized the importance of processing infrastructure and value addition in improving the competitiveness of emerging dairy economies.

The findings therefore reinforce the proposition that technological interventions alone are insufficient and that sustainable entrepreneurial development requires the integration of institutional support, policy coordination, and innovation ecosystems.

Recent developments in digital agriculture and dairy innovation further support the findings of the present study. FAO (2023) ^[21] emphasized that value addition, processing infrastructure, and technological innovation are becoming critical determinants of competitiveness in emerging dairy economies. Likewise, recent studies on digital innovation ecosystems and agritech startups have highlighted the role of incubation systems and digital platforms in improving market integration, entrepreneurial capabilities, and sustainable rural development.

The findings are also consistent with recent evidence suggesting that artificial intelligence-based advisory systems, digital marketing channels, and startup ecosystems are transforming conventional dairy farming into innovation-oriented enterprises. These developments reinforce the importance of strengthening institutional coordination and technology incubation systems to facilitate entrepreneurial transformation.

5.3 Theoretical and Practical Implications

From a theoretical perspective, the study provides empirical support for the Entrepreneurial Ecosystem Theory (Isenberg, 2010) ^[7] and the Innovation Systems Approach (Freeman, 1987; Lundvall, 2010) ^[6, 9]. The results demonstrate that entrepreneurial development is influenced by interactions among policy frameworks, institutional support systems, technological innovations, and digital infrastructure. The study extends these theoretical perspectives by highlighting the central role of incubation ecosystems in strengthening rural dairy entrepreneurship.

From a practical perspective, the findings underline the need

for agricultural universities, research institutions, cooperatives, and private organizations to move beyond conventional extension approaches and actively promote entrepreneurship-oriented support systems. District-level incubation centres, public-private partnerships, and stronger research-industry linkages can facilitate technology transfer, startup development, and commercialization of innovations. Such interventions can accelerate value addition, improve competitiveness, and generate sustainable livelihood opportunities for rural communities.

The satisfactory reliability, validity, and model-fit indices further confirm the robustness of the proposed framework and provide empirical support for the integration of policy convergence, technology adoption, and incubation ecosystems.

5.4 Implications for Viksit Bharat @2047

The transformation of rural dairy entrepreneurship into an innovation-driven ecosystem has important implications for achieving the vision of Viksit Bharat @2047. Strengthening incubation systems, promoting digital technologies, and encouraging value addition can significantly enhance rural incomes, employment opportunities, and enterprise competitiveness.

The findings suggest that rural dairy entrepreneurship can serve as an important driver of inclusive economic growth by integrating agriculture, processing, and service sectors. In this context, the proposed Incubation-Centered Dairy Entrepreneurship Ecosystem Model (IC-DEEM) offers a practical framework for promoting entrepreneurship-driven development and strengthening India's transition towards a knowledge-based and innovation-oriented economy.

6. Proposed IC-DEEM Framework (Incubation-Centered Dairy Entrepreneurship Ecosystem Model)

6.1 Conceptual Foundation of IC-DEEM

The proposed Incubation-Centered Dairy Entrepreneurship Ecosystem Model (IC-DEEM) is grounded in the Entrepreneurial Ecosystem Theory (Isenberg, 2010) ^[7] and the Innovation Systems Approach (Freeman, 1987; Lundvall, 2010) ^[6, 9]. The model is based on the premise that sustainable rural dairy entrepreneurship cannot be achieved through production enhancement alone but requires coordinated interactions among policy institutions, technological innovations, and incubation ecosystems.

The empirical findings of the present study indicate that incubation access exerts the strongest influence on entrepreneurial development. Accordingly, the IC-DEEM framework positions incubation as the central mechanism linking policy support and technological innovation. The model aims to facilitate value addition, enterprise diversification, and sustainable livelihood generation by integrating institutional support, knowledge systems, and digital technologies.

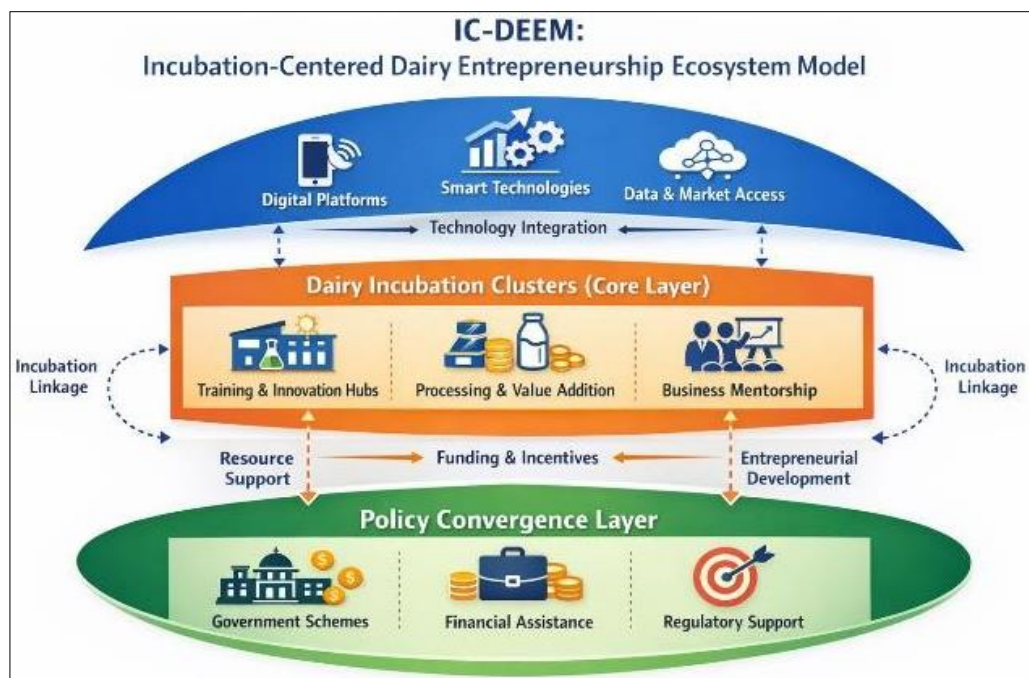


Figure 3: IC-DEEM Conceptual Model

6.2 Structural Components of IC-DEEM

The IC-DEEM framework comprises three interrelated components that collectively promote entrepreneurship-oriented transformation of the dairy sector.

(i) Policy Convergence Layer

This layer constitutes the institutional foundation of the model and focuses on integrating various government initiatives and support mechanisms. It encompasses programmes such as the Rashtriya Gokul Mission, National Dairy Plan, Startup India, and NDDDB initiatives. The objective is to enhance coordination among institutions, improve resource utilization, and provide easier access to financial and regulatory support.

Policy convergence enables effective implementation of entrepreneurship-oriented interventions and reduces duplication among various development programmes.

(ii) Dairy Incubation Cluster (Core Component)

The incubation layer represents the central component of the IC-DEEM framework. It facilitates the transition from traditional dairy farming to innovation-driven enterprises by providing technology transfer, entrepreneurship training, mentoring, and business development services.

District-level dairy incubation centres, operating through public-private partnerships and involving universities, research institutions, cooperatives, and private enterprises, can provide:

- Technology demonstration and transfer.
- Entrepreneurship development and mentoring.
- Product diversification and value addition support.
- Branding and marketing assistance.
- Startup incubation and commercialization support.

The empirical results indicating the strongest effect of incubation access on entrepreneurial development further justify the central position of this component within the framework.

(iii) Digital Innovation Layer

Digital technologies complement policy support and incubation systems by improving efficiency, transparency, and market connectivity. This layer incorporates:

- Artificial intelligence-based advisory systems.
- Digital payment and information systems.
- E-commerce platforms and direct market linkages.
- Blockchain-enabled traceability systems.
- Data analytics and demand forecasting mechanisms.

Digital infrastructure strengthens the effectiveness of technological interventions and facilitates improved decision-making and market access among rural entrepreneurs.

6.3 Expected Outcomes of IC-DEEM

Implementation of the proposed framework is expected to generate multiple economic, social, and institutional benefits.

Economic Outcomes

- Increased participation in value-added dairy enterprises.
- Improved income diversification and profitability.
- Enhanced competitiveness and market access.

Social Outcomes

- Employment generation and rural livelihood enhancement.
- Development of entrepreneurial and technical skills.
- Promotion of inclusive and sustainable growth.

Institutional Outcomes

- Improved coordination among stakeholders.
- Strengthened research-industry linkages.
- Enhanced diffusion of innovation and technology transfer.

Collectively, these outcomes support the transformation of the dairy sector from a production-oriented system to an

innovation-driven entrepreneurial ecosystem.

6.4 Contributions and Policy Relevance

The IC-DEEM framework contributes to theory and practice by integrating entrepreneurial ecosystem and innovation system perspectives within the context of rural dairy entrepreneurship. The framework emphasizes the strategic importance of incubation ecosystems and proposes a scalable mechanism for promoting entrepreneurship-oriented development.

From a policy perspective, the framework provides a roadmap for strengthening institutional coordination, promoting value addition, and accelerating digital transformation. The model offers practical implications for governments, universities, research institutions, cooperatives, and private enterprises interested in fostering rural entrepreneurship.

Furthermore, the framework aligns closely with the objectives of Viksit Bharat @2047 by promoting innovation-driven growth, enhancing rural incomes, and strengthening agro-based industries. Thus, IC-DEEM can serve as a strategic mechanism for transforming the dairy sector into a sustainable and globally competitive entrepreneurial ecosystem.

7. Policy Implications, Future Research Directions and Conclusion

7.1 Policy Implications

The findings of the present study highlight the necessity of shifting India's dairy development strategy from a production-oriented approach toward an innovation-driven entrepreneurial ecosystem. The empirical evidence demonstrates that policy convergence, technology adoption, and incubation support collectively influence entrepreneurial development, with incubation access emerging as the most significant determinant. Accordingly, the following policy implications are proposed.

(i) Strengthening Policy Convergence

The existence of multiple dairy-related schemes often leads to fragmented implementation and inefficient resource utilization. Therefore, a unified framework integrating programmes such as the Rashtriya Gokul Mission, National Dairy Plan, Startup India, and other entrepreneurship-oriented initiatives is required. Such integration would improve coordination among institutions and enhance accessibility of support services for dairy entrepreneurs.

(ii) Establishment of District-Level Dairy Incubation Centres

The study identifies inadequate incubation support as a major structural constraint. Establishing district-level dairy incubation centres through public-private partnerships involving universities, research institutions, cooperatives, and industries can facilitate technology transfer, skill development, mentoring, and commercialization of innovations. These centres can promote startup development and accelerate value addition in the dairy sector.

(iii) Promotion of Value Addition and Processing Enterprises

Greater emphasis should be placed on promoting value-added dairy products through financial incentives, infrastructure support, and entrepreneurship training.

Encouraging processing, branding, packaging, and product diversification can enhance profitability and improve the competitiveness of dairy enterprises.

(iv) Digital Transformation of the Dairy Ecosystem

Digital technologies should be integrated more extensively into dairy enterprises through artificial intelligence-based advisory systems, digital platforms, e-commerce channels, and blockchain-enabled traceability systems. Strengthening digital infrastructure can improve productivity, transparency, and market access while reducing transaction costs.

(v) Human Capital Development and Financial Support

Entrepreneurship development programmes should focus on enhancing managerial capabilities, digital literacy, and technical competencies among rural entrepreneurs. Incubation-linked credit mechanisms and startup financing schemes may further encourage investment and reduce financial risks associated with enterprise development.

Collectively, these policy measures can contribute to building an integrated and innovation-driven dairy entrepreneurship ecosystem.

7.1.1 Implications for Research Institutions and Universities

Agricultural universities, veterinary institutions, and research organizations can play a significant role in strengthening entrepreneurship-oriented development by establishing dairy incubation centres and facilitating technology transfer. Public-private partnerships involving universities, cooperatives, startups, and private industries can promote commercialization of innovations, product diversification, and skill development among rural entrepreneurs. Such initiatives may significantly enhance value addition and contribute to the development of sustainable dairy ecosystems.

7.2 Limitations and Future Research Directions

Although the study provides valuable insights into rural dairy entrepreneurship, certain limitations should be acknowledged. First, the empirical investigation was confined to Rajasthan, which may restrict the generalizability of findings to other regions. Second, the cross-sectional nature of the study limits the ability to capture dynamic changes in entrepreneurial development over time. Third, some variables were measured using self-reported responses, which may introduce response bias.

Future studies may employ longitudinal approaches to investigate changes in entrepreneurial ecosystems over time. Comparative studies across different states and countries can further enhance understanding of regional variations in dairy entrepreneurship. In addition, future research may explore the role of artificial intelligence, climate-smart livestock systems, digital marketing platforms, and sustainability-oriented business models in promoting dairy enterprise development. In addition, the relatively small sample size may limit the representativeness of the findings and caution should be exercised while generalizing the results beyond the study area.

7.2.1 Managerial Implications

The findings provide valuable insights for policymakers, dairy cooperatives, startup incubators, agribusiness firms,

and development agencies. Strengthening incubation ecosystems, improving digital infrastructure, and enhancing institutional coordination can facilitate commercialization, enterprise diversification, and market competitiveness. District-level incubation clusters and public-private partnerships can serve as effective mechanisms for promoting entrepreneurship-driven development and improving livelihood opportunities in rural areas.

7.3 Conclusion

The dairy sector possesses considerable potential to contribute to inclusive economic growth and rural transformation. However, despite India's leadership in milk production, entrepreneurial development within the sector remains constrained by limited value addition, inadequate incubation support, and fragmented policy implementation. The present study investigated the role of policy convergence and technology incubation in strengthening rural dairy entrepreneurship in Rajasthan using a mixed-method approach. The empirical findings revealed that incubation access exerts the strongest influence on entrepreneurial development, followed by technology adoption and policy convergence. Furthermore, digital infrastructure was found to strengthen the relationship between technology adoption and enterprise performance.

The study provides empirical support for the Entrepreneurial Ecosystem Theory and Innovation Systems Approach and proposes the Incubation-Centered Dairy Entrepreneurship Ecosystem Model (IC-DEEM) as an integrated framework for promoting innovation-driven dairy entrepreneurship. The model emphasizes the importance of policy coordination, incubation ecosystems, and digital technologies in facilitating enterprise diversification and value addition.

The findings suggest that strengthening district-level incubation systems, promoting digital transformation, and enhancing institutional coordination can significantly improve rural incomes and entrepreneurial capabilities. Consequently, the dairy sector can evolve from a production-oriented system into a sustainable and innovation-driven ecosystem capable of contributing to employment generation, rural prosperity, and the broader vision of Viksit Bharat @2047.

Therefore, strengthening incubation ecosystems and promoting policy convergence can transform India's dairy sector from a production-driven activity into a sustainable and innovation-oriented entrepreneurial ecosystem. The proposed IC-DEEM framework offers a strategic pathway for enhancing value addition, entrepreneurship, and rural prosperity, thereby contributing significantly to the realization of the Viksit Bharat @2047 vision.

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