



RESEARCH ARTICLE

# Funding patterns and financial viability of agricultural startups under the RKVY-RAFTAAR scheme in the states of Andhra Pradesh and Telangana, India

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## Abstract

The emergence of agri-startups in India has reshaped agricultural entrepreneurship by addressing inefficiencies in supply chains, input distribution and technology adoption. However, their financial viability remained uncertain, particularly at early stages. To strengthen this ecosystem, the Rashtriya Krishi Vikas Yojana – Remunerative Approaches for Agriculture and Allied Sector Rejuvenation (RKVY-RAFTAAR) scheme launched in the year 2017 provided structured funding, incubation and mentoring support through Business Incubation Centres. This study empirically analysed funding patterns, resource allocation and financial viability of 80 agri-startups incubated in Andhra Pradesh and Telangana across 8 sectors: Agri-Tech, Food Processing, Organic Farming, Agri-Input Supply, Agri-Marketing, Agri-FinTech, Agri-Biotechnology and Agri-Drones & Automation. A cross-sectional design was adopted using sector-wise data on funding composition, resource allocation and financial indicators, viz., Return on Investment (ROI), Operating Profit Margin (OPM) and Debt-to-Equity Ratio (D/E). A composite financial viability score (FVS) was constructed, complemented by data envelopment analysis (DEA) with slack analysis to assess efficiency and performance gaps. The findings revealed that private investment dominates funding in technology-driven sectors such as Agri-Tech and Agri-FinTech, while Organic Farming and Agri-Input Supply rely heavily on public grants. Sectoral differences were evident in resource allocation: Agri-Tech and Agri-FinTech prioritised innovation and R & D, whereas Food Processing and Organic Farming emphasised infrastructure. Financial viability was excellent in Agri-FinTech and Agri-Tech (FVS >19), while Organic Farming and Agri-Input Supply exhibited weak to moderate viability due to low ROI and higher debt exposure. DEA results confirmed higher efficiency in innovation-led sectors and inefficiencies in sustainability-oriented ones, with slack values indicating untapped potential across traditional sectors. The study highlights the need for differentiated policy interventions, where private funding helps grow scalable models, while targeted public support should conserve ecologically critical and financially vulnerable sectors, eventually promoting inclusive and resilient agri-entrepreneurship.

**Keywords:** agri-startups; data envelopment analysis; financial viability; funding patterns; RKVY-RAFTAAR

## Introduction

The emergence of Indian agri-startups played a transformative role in reshaping the rural economy, offering market-based solutions to chronic issues such as supply chains fragmentation, inefficient inputs and farmer's limited access to credit and technology. Currently around 30000 agri-startups are active, supported by progressing public-private ecosystems and policy initiatives (1). The long-term financial viability of these firms remains uncertain, especially during early growth stages characterised by high capital requirements and revenue flows inconsistency (2).

In this context, the Rashtriya Krishi Vikas Yojana – Remunerative Approaches for Agriculture and Allied Sector Rejuvenation (RKVY-RAFTAAR) scheme was introduced by the Government of India in 2017. It aims to support agri-entrepreneurship through structured funding, incubation and mentoring support, providing up to ₹25 lakhs in seed-stage capital

for eligible startups, alongside networking and capacity-building opportunities via Agricultural Business Incubation Centres (3).

Regardless of its rapid outreach, there is a major literature gap in evaluating distribution of sectoral funding and computing its effect on startup-level financial viability, especially in the Indian context and at the State level. Previous studies have explored financing, technology adoption and market access; however, empirical evidence on sector-specific performance remains limited. No prior study has notably combined composite viability scoring methods with DEA (data envelopment analysis), slack analysis for agri-startups, leaving questions about efficient capital utilisation, sustainability and optimum fiscal design unanswered.

This study addresses these gaps by conducting a sector-wise analysis of funding sources and financial viability of 80 agri-startups incubated under RKVY-RAFTAAR scheme in Andhra Pradesh and Telangana states. By employing composite financial viability metrics including return on investment (ROI), operating profit margin (OPM) and debt-to-equity ratio (D/E), alongside DEA,

slack analysis, the research offers novel, actionable insights for improving fiscal design and sustainability in India's agri-innovation ecosystem.

The findings of this study offer new empirical insights into how capital structure, innovation orientation and public-private collaboration shape the financial viability and efficiency of agri-startup. Consistent with entrepreneurial finance theory sectors with diversified capital structures and higher private equity participation exhibit superior ROI and resilience (4). The observed patterns of technology adoption and financial outperformance in Agri-Tech and Agri-FinTech lend support to innovation adoption theory (5). The differentiated impact of grant-based versus private funding models underscores the continued relevance of Public-Private Partnership economics in fostering sector-specific growth and risk mitigation (6).

The paper investigates the funding patterns and financial viability of startups supported under RKVY-RAFTAAR scheme in the Indian States of Andhra Pradesh and Telangana.

## Materials and Methods

### Research design

The study employed a cross-sectional design to assess the funding patterns and financial viability of agri-startups incubated under RKVY-RAFTAAR scheme at:

1. Nutrihub, ICAR-Indian Institute of Millets Research (IIMR), Hyderabad
2. Centre for Innovation and Excellence (CIA), National Institute of Agricultural Extension Management (MANAGE), Hyderabad
3. Rashtriya Agri-Business Incubator, Acharya N.G. Ranga Agricultural University (R-ABI ANGRAU) Poshan, Tirupati.

The focus was on seed and early-growth stage startups, with a sector-wise comparative assessment. The financial viability was evaluated using three indicators, viz., ROI, OPM and DER. Data envelopment analysis (DEA) is generally applied at the individual decision-making unit (DMU) level. In the present study, DEA was applied at the sector level, with each agri-startup sector treated as a composite DMU. Firm-level financial and resource allocation data were first compiled and then aggregated using sector-wise mean values for all input and output variables prior to DEA estimation.

This aggregation was undertaken to facilitate sectoral comparison of efficiency under the RKVY-RAFTAAR scheme and to minimise volatility arising from heterogeneous incubation stages and scale differences among seed and early-stage startups. The approach enables identification of structural efficiency variations across sectors associated with differences in capital intensity, technology orientation and regulatory exposure.

Accordingly, DEA results are interpreted as sectoral efficiency benchmarks of RKVY-RAFTAAR supported agri-startups and not as firm-level efficiency measures.

Data were collected for 12 to 24 months post-incubation period, ensuring meaningful observation of financial stabilisation, market response and operational maturity. This time-frame aligns with Government evaluation cycles for startup viability (3).

### Sampling framework

A stratified purposive sampling method was used to ensure representation across agri-startup sectors under RKVY-RAFTAAR scheme in Andhra Pradesh and Telangana. While appropriate for programme specific and sector-wise analysis, this design limits external validity, as the sample includes only incubated startups with structured access to finance, mentoring and infrastructure, which may differ systematically from non-incubated agri-enterprises. In addition, purposive selection may introduce selection bias by excluding startups with incomplete financial records or early-stage failures. Accordingly, the findings should be interpreted as context-specific to RKVY-RAFTAAR-supported startups and generalisation beyond the programme should be undertaken with caution. Andhra Pradesh and Telangana were selected for the study due to their high concentration of RKVY-RAFTAAR supported agricultural business incubators, consistent implementation of the scheme and availability of verified startup-level financial data. The two states host nationally recognised incubators, including Nutrihub (ICAR-IIMR), MANAGE-CIA and R-ABI ANGRAU Poshan, which together represent diverse agri-startup domains and incubation models. In addition, these states exhibit a balanced mix of technology-driven and traditional agri-enterprises, making them suitable for examining sectoral variations in funding patterns and financial viability. While the states are not claimed to be fully representative of national agri-startup dynamics, they provide a policy-relevant and analytically robust setting to assess the functioning and outcomes of the RKVY-RAFTAAR programme under well-established incubation ecosystems. The sampling frame was built using official cohort lists (2020–2023) from R-ABI ANGRAU Poshan incubator, Tirupati from Andhra Pradesh; and Centre for Innovation and Agripreneurship, MANAGE, Hyderabad and Nutrihub, ICAR-IIMR, Hyderabad from Telangana.

### Sample size

80 startups meeting the following criteria:

1. Active incubation (2020–2023)
2.  $\geq 1$  financial year completed by March 2024
3. Verified financial data on ROI, OPM and D/E ratio

### Stratification

Eight agro based sectors such as Agri-Tech, Food Processing, Organic Farming, Agri-Input Supply, Agri-Marketing & Supply Chain, Agri-FinTech, Agri-Biotechnology, Agri-Drones & Automation were categorised.

This method highlighted diversity of startup sectors and concentrated on seed and early-stage startups, aligning with the scheme's objective of supporting startups during their scale-up phase while capturing early signals of financial sustainability and distress.

### Analytical approach

The study followed a multi-phased methodology: Descriptive financial analysis used to interpret the financial performance of a startup, DEA for efficiency and comparing the performances and slack value analysis for evaluating the slack value for improvement and collaboration in a startup to achieve goals, more effectively.

### Descriptive & percentage analysis

A sector-wise analysis was conducted to study:

1. Composition of funding across sectors (RKVY-RAFTAAR grants, private investments, bank loans) highlighting each startup's financial dependence.
2. Allocation of resources across 6 functional areas viz., Product Development & Technology, Infrastructure & Equipment, Marketing & Expansion, R & D, Training & Capacity building and Regulatory Compliance, to capture sector-specific strategic priorities.

This part provided insights into funding and resource allocation patterns across the 8 agri-startup sectors.

### Financial viability analysis

Three key financial performance indicators were used:

#### Return on Investment (ROI)

$$ROI = \left( \frac{\text{Net Profit}}{\text{Total Investment}} \right) \times 100 \quad (i)$$

#### Operating profit margin (OPM)

$$OPM = \left( \frac{\text{Operating Profit}}{\text{Net Sales}} \right) \times 100 \quad (ii)$$

#### Debt-to-Equity Ratio (D/E)

$$\frac{D}{E} = \frac{\text{Total Liabilities}}{\text{Shareholder Equity}} \quad (iii)$$

These were normalised and are used to derive a composite Financial viability score (FVS).

### Construction of financial viability score (FVS)

#### Conceptual framework

The FVS is a composite index measuring profitability, operational efficiency and financial leverage of RKVY-RAFTAAR startups. It integrates 3 indicators, viz., ROI, OPM and DER, following the standard guidelines for composite metrics (7). The FVS was included as an output in the DEA model to represent overall financial sustainability by integrating profitability, operational efficiency and financial leverage. While ROI and OPM capture specific performance dimensions, FVS reflects a broader viability outcome relevant for policy analysis. A robustness checks excluding FVS yielded largely unchanged sector-wise efficiency rankings, confirming that results are not driven by double counting; accordingly, FVS is reported in the tables as a composite descriptive indicator for summarising and classifying sector-wise financial viability.

**Data normalisation:** Indicators were standardised using Min–Max normalisation:

$$X_{ij}^* = \frac{X_{ij} - \min(x_j)}{\text{Max}(X_j) - \min(x_j)}$$

where,  $x_{ij}$  is the raw value of indicator  $j$  for startup  $i$ .

Outliers ( $> 1.5 \times$  Inter quartile range) were winsorised.

A Spearman test ( $\Delta p < 0.01$ ) confirmed rank stability post-normalisation.

#### Indicator weighting

Weights for the FVS were derived using a triangulation approach involving principal component analysis (PCA), logistic regression and Monte Carlo simulation to ensure robustness. PCA was first applied to the standardised indicators (ROI, OPM and D/E), where the first principal component explained the majority of variance and indicated higher loading for ROI, followed by OPM and D/E. Logistic

regression was then employed with startup viability status as the dependent variable and the relative magnitudes of standardised coefficients supported the same ordering of importance. Finally, Monte Carlo simulations were conducted by repeatedly perturbing indicator weights within feasible bounds; ranking stability was maximized when weights approximated 40:35:25 for ROI, OPM and D/E, respectively. The convergence of these methods justified the final weighting scheme.

PCA: First component explained 72.8% variance.

- Monte Carlo: Rankings robust ( $p = 0.95$ ).

$$FVS_i = 0.40 \cdot ROI_i^* + 0.35 \cdot OPM_i^* + 0.25 \cdot (1 - DER_i^*)$$

#### Composite score formulation

The  $(1 - DER_i^*)$  term inverts DER, ensuring lower leverage improves viability.

#### Viability classification

To segment startups based on financial viability, FVS values are categorised using a combination of empirical cumulative

FVS range	Classification
> 18.00	Excellent
15.00–18.00	Very good
12.00–14.99	Good
10.00–11.99	Moderate
< 10.00	Weak

distribution function (ECDF) and Youden-optimised receiver operating characteristic (ROC) cut-offs for default prediction.

#### Data envelopment analysis (DEA)

An output-oriented DEA model with variable returns to scale (VRS) was applied to examine the efficiency of agri-startups supported under RKVY-RAFTAAR. The VRS model was chosen since startups differ in scale and capital requirements, making proportional (CRS) assumptions inappropriate (8). The model evaluated how much outputs can be proportionally increased without requiring additional inputs.

#### Inputs considered

- Total investment (₹ lakhs) – grants + private investments + loans
- Per cent allocation to product development & technology adoption
- Per cent allocation to infrastructure & equipment
- Per cent allocation to R & D

#### Outputs considered

- Return on investment (ROI)
- Operating profit margin (OPM)
- Financial viability score (FVS) – composite index of ROI, OPM and DER

#### DEA model specification

Maximize  $\phi$

Subject to:

$$\sum_{j=1}^n \lambda_j x_{ij} \leq x_{io}, \quad \forall \text{ inputs}$$

$$\sum_{j=1}^n \lambda_j y_{rj} \geq \phi \cdot y_{ro}, \quad \forall \text{ outputs}$$

$$\sum_{j=1}^n \lambda_j = 1, \quad \lambda_j \geq 0$$

Where,

$\phi \geq 1$  = efficiency score

$\lambda_j$  = peer weights

$x_{ij}, y_{ij}$  = input/output levels of peer DMUs (decision making units)

**Slack analysis:** Slack identifies unutilised output potential

$$S_{ik} = y_{ik}^* - y_{ik}$$

where,  $y_{ik}^*$  = DEA-projected output and  $y_{ik}$  = observed output.

Slack values revealed performance gaps even in efficient startups, guiding sector-specific interventions.

### Result and Discussion

The study employed a cross-sectional, sectoral analysis to assess financial viability, funding structures and indicators of sustainability across startup enterprises. This framework enabled the identification of sectoral differences in startup performance.

#### Resource allocation across functional areas by sector

A comparative assessment of allocation of resources across 6 core functional areas, viz., product development and technology adoption, infrastructure and equipment, marketing and expansion, research and development (R & D), training and capacity building and regulatory compliance, in 8 agri-startup sectors is provided in Table 1. The financial resources distribution highlighted orientations in sectoral strategies and trajectories in innovation. Particularly, seed-stage startups, required higher investment in product development, infrastructure establishment, market penetration, R & D and regulatory processes, which revealed sector-specific constraints and facilitates scaling at early-stage for enduring viability.

In terms of product development and technology adoption, highest allocation was reported by Agri-Tech at 35 %, indicates sector's strong emphasis on digital and mechanised innovations. This was followed by Agri-Input Supply and Agri-FinTech, both at 30 % and Agri-Drones & Automation at 25 %, which specified these sector's reliance on continuous technological advancement. Allocations at moderate levels were observed in Agri-Marketing (25 %), food Processing (20 %) and Agri-Biotechnology (20 %), while Organic Farming sector registered the lowest share at 18 %.

In the aspect of infrastructure and equipment, Organic Farming (43 %) and Food Processing (40 %) had the largest allocations, highlighting the importance of physical assets such as

processing units, cold storage and organic input centres. Agri-Input Supply (35 %) and Agri-Drones & Automation (30 %) also demonstrated substantial allocations, followed by Agri-Tech, Agri-Marketing and Agri-Biotechnology with sharing of 25 % each. Among the sectors, Agri-FinTech, at 20 %, reflected the lowest infrastructure investment.

Marketing and expansion activities attracted significant investor attention in Food Processing (30 %) and Agri-Marketing (30 %), highlighting a focus on outreach, branding and distribution. Agri-Input Supply and Agri-FinTech had allocations of 20 % each, while Agri-Tech and Agri-Drones & Automation dedicated 15 % of their investment. Agri-Biotechnology allocated the lowest share, at just 10 %, because commercialisation is slower, dependent on regulatory approval and requires more technical validation than marketing efforts in this sector.

In the field of R & D, Agri-Biotechnology led decisively with 35 %, reflecting the innovation-driven nature of this sector. Agri-FinTech and Agri-Drones & Automation invested 20 % each, while allocation of Agri-Tech, Agri-Input Supply, Agri-Marketing and Organic Farming ranged between 10 % and 15 % each. Food Processing dedicated the lowest R & D share at 10 %, highlighting operational efficiency rather than core technological innovation in the sector.

Training and capacity building allocations remained generally modest. Agri-Marketing allotted the highest proportion (10 %), followed by Agri-Tech (7 %). Organic Farming, Agri-FinTech and Agri-Drones & Automation each committed 5 %, while Agri-Biotechnology allocated only 3 % of the investment. Food Processing and Agri-Input Supply had no allocations in this category, indicating a stronger focus on infrastructure and operational needs rather than internal training in these sectors.

Regulatory compliance reflected the most substantial allocations in Organic Farming (10 %) and Agri-Biotechnology (10 %), revealing their exposure to certification and biosafety requirements. Agri-FinTech and Agri-Drones & Automation allotted 5 % each, while Agri-Tech allocated just 3 %. Agri-Marketing, Food Processing and Agri-Input Supply had no dedicated expenditure for compliance, implying dependence on broader institutional frameworks.

Overall, the analysis indicates differentiated priorities of investment aligned with sector-specific operational models. Agri-Tech and Agri-FinTech concentrate innovation, technology adoption and R & D, while Organic Farming and Food Processing emphasise on infrastructure and equipment. Agri-Marketing highlights market connectivity and branding, whereas Agri-Biotechnology and Agri-Drones & Automation lead in research intensity and regulatory engagement. These patterns reflected national trends identified by early researchers, who reported

**Table 1.** Sector-wise resource allocation across key functional areas

(n = 80)

I. No.	Sector	Product development and technology adoption (%)	Infrastructure and equipment (%)	Marketing and expansion (%)	R & D (%)	Training and capacity building (%)	Regulatory compliance (%)
1.	Agri-Tech	35	25	15	15	7	3
2.	Food Processing	20	40	30	10	-	-
3.	Organic Farming	18	43	18	6	5	10
4.	Agri-Input Supply	30	35	20	15	-	-
5.	Agri-Marketing	25	25	30	10	10	-
6.	Agri-FinTech	30	20	20	20	5	5
7.	Agri-Biotechnology	20	25	10	35	3	10
8.	Agri-Drones & Automation	25	30	15	20	5	5

differentiated funding priorities across agri-startup sectors (9).

### Sector-wise funding pattern analysis of RKVY RAFTAAR incubated startups

Funding allocation patterns under RKVY-RAFTAAR scheme were examined using descriptive statistics and cluster analysis to assess variations across agricultural startup sectors as shown in Table 2. Finance is vital resource during the seed stage, where funds are required for product development, infrastructure and market entry. The scheme aids access to funding through a combination of Government grants, private investment and bank credit; and its sectoral distribution revealed both policy priorities and market dynamics.

Government grants were concentrated in Organic Farming (32.81 %) and Agri-Input Supply (32.08 %), indicating a targeted focus on sustainability and input access areas which are less attractive to private investors due to lower short-term returns. In contrast, Agri-FinTech (23.82 %) received the smallest share of grants, reflecting its lower capital intensity and stronger ability to secure private finance. This pattern underscored how public funding being directed towards higher-risk or underfunded sectors where market failures are more pronounced (10).

In overall funding, private investment dominated, particularly in Agri-Tech (52.60 %) and Agri-FinTech (52.42 %), determined by scalability, rapid adoption and strong investor confidence. Significant inflows were also observed in Agri-Biotechnology (45.82 %), Agri-Marketing (47.12 %) and Drones and Automation (47.20 %), emphasising a growing interest in technologically intensive and innovation-driven business models. These trends line up with entrepreneurial finance theory suggesting that technology orientation and favourable capital structures enhance early-stage performance (11).

A consistent role was played by bank loans, though smaller, across all sectors, accounting for about 21 to 25 % of total funding. These loans were usually utilised for working capital requirements (such as purchasing raw materials, paying wages and covering operational expenses) and fixed capital investments (including machinery, processing units and laboratory equipment). The share of bank loans was comparatively higher in capital-intensive sectors such as Agri-Drones & Automation (24.67 %) and Agri-Biotechnology (24.10 %), where firms required costly

assets and specialised infrastructure. In contrast, sectors such as Agri-Tech (21.11 %) showed lower reliance on bank finance, as their operations are more software and service-based, requiring less heavy physical infrastructure. This pattern highlighted the bridging role of institutional credit while, Government grants and private investment supported innovation and scaling, loans complement these sources by financing tangible assets and ongoing operational requirements (9).

The funding mix revealed a relatively balanced financial structure as shown in Fig. 1 with clear sectoral contrasts: Organic Farming and Agri-Input Supply remained heavily reliant on public support while, Agri-Tech, Agri-FinTech and Agri-Drones attracted substantial private capital. This reflected differences in innovation intensity, scalability and perceived risk. The findings supported the case for public-private partnership models, where grants targeted structurally underfunded sectors while private finance drove technologically oriented ventures (6).

To sum up, RKVY-RAFTAAR scheme demonstrated that while technology-driven startups benefitted from strong market traction, sustainability-oriented sectors continued to depend on strategic public funding, validating the complementary role of grants in inclusive agribusiness growth (9, 10).

### Sector-wise financial viability of RKVY RAFTAAR incubated startups

Sector-wise financial viability of startups incubated under RKVY-RAFTAAR programme is presented in Table 3. The financial performance of agri-startups played an important role in determining their sustainability, growth potential and contribution to the Indian agrarian economy. A detailed financial assessment was carried out using key financial indicators, viz., ROI, OPM and Debt-to-Equity (D/E) ratio, across major sectors. These indicators provided insights into profitability, operational efficiency and financial leverage of startups across various sectors.

Return on Investment (ROI) captured net financial returns relative to initial capital outlay, varied considerably across sectors. The highest returns were seen in Agri-FinTech (28.30 %), Agri-Tech (26.10 %) and Agri-Drones & Automation (24.50 %), indicating scalability, digital orientation and comparatively low variable costs of these technology-intensive sectors. In contrast, Organic Farming reflected the lowest ROI (13.90 %), constrained by factors

**Table 2.** Sector-wise funding pattern analysis of agricultural startups

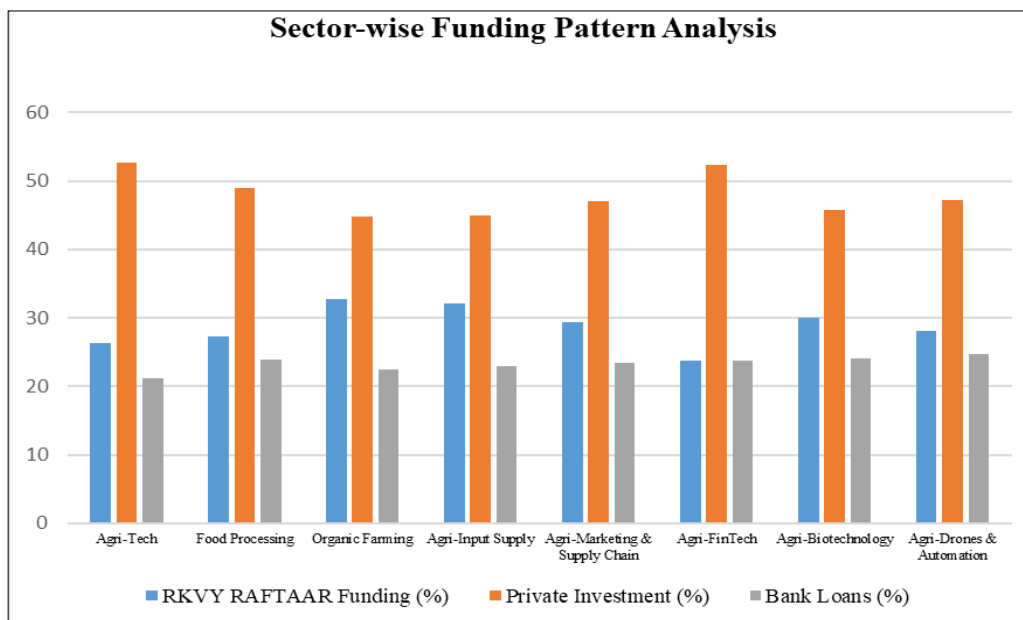
(n = 80)

Sl. No.	Sector	RKVY RAFTAAR funding (%)	Private investment (%)	Bank loans (%)	Total (%)
1.	Agri-Tech	26.29	52.60	21.11	100
2.	Food Processing	27.21	48.90	23.89	100
3.	Organic Farming	32.81	44.81	22.38	100
4.	Agri-Input Supply	32.08	44.92	23.00	100
5.	Agri-Marketing & Supply Chain	29.38	47.12	23.50	100
6.	Agri-FinTech	23.76	52.42	23.82	100
7.	Agri-Biotechnology	30.08	45.82	24.10	100
8.	Agri-Drones & Automation	28.13	47.20	24.67	100

**Table 3.** Sector-wise financial viability indicators of RKVY RAFTAAR incubated startups

(n = 80)

Sl. No.	Financial indicator	Agri-Tech	Food processing	Organic farming	Agri-input supply	Agri-marketing & supply chain	Agri-FinTech	Agri-Biotechnology	Agri-Drones & Automation
1.	Return on investment (ROI) (%)	26.10	18.80	13.90	15.70	21.50	28.30	19.20	24.50
2.	Operating profit margin (OPM) (%)	27.40	22.10	15.30	17.90	22.80	30.50	20.60	26.80
3.	Debt-to-equity ratio (D/E)	0.50	0.80	0.78	0.88	0.65	0.45	0.72	0.60
4.	Financial viability score (FVS)	19.26	14.53	10.53	11.99	15.90	21.14	14.28	18.34
5.	Classification	Excellent	Good	Moderate	Moderate	Good	Excellent	Good	Very good



**Fig. 1.** Funding pattern of agri-startups under RKVY-RAFTAAR in Andhra Pradesh and Telangana.

such as delayed market penetration, price volatility, niche demand and prolonged certification processes. These disparities highlighted the importance of sector-specific dynamics and scalability potential in determining investment attractiveness.

Operating Profit Margin (OPM), an indicator of operational efficiency, also reflected substantial variation. Agri-FinTech (30.50 %) showed the highest margin, profiting from automation, limited need of inventory and high-value digital services. Agri-Tech (27.40 %) and Agri-Drones & Automation (26.80 %) followed closely, reinforced by asset-light structures and service-based revenue models. Lower margins were detected in Organic Farming (15.30 %) and Agri-Input Supply (17.90 %), often due to high costs of logistics, limited pricing power and extreme competition from conservative market players.

Debt-to-Equity ratio (D/E), a measure of financial leverage, discovered the extent of external financing relative to internal equity. Lower D/E ratios were found in Agri-FinTech (0.45) and Agri-Tech (0.50), representing relatively stronger internal capital mechanisms and reduced financial risk. In contrast, Agri-Input Supply (0.88) and Food Processing (0.80) exhibited higher leverage, reflecting their capital-intensive nature and dependency on debt for procurement, storage and processing infrastructure. High debt levels may cause financial vulnerability, particularly for early-stage ventures.

A composite FVS was constructed to classify startups into 5 categories of viability, viz., excellent (FVS >18), very good (16–18), good (13–15.99), moderate (11–12.99) and weak (< 11). The use of composite FVS evaluated startup sustainability through multi-indicator scoring systems combining ROI, OPM and D/E ratio. The classification produced the following insights:

**Excellent viability:** Agri-FinTech (21.14) and Agri-Tech (19.26) confirmed strong financial fundamentals, characterised by high profitability, low leverage and efficient use of capital. These sectors presented promising opportunities for private investment and security prioritisation in policy support frameworks.

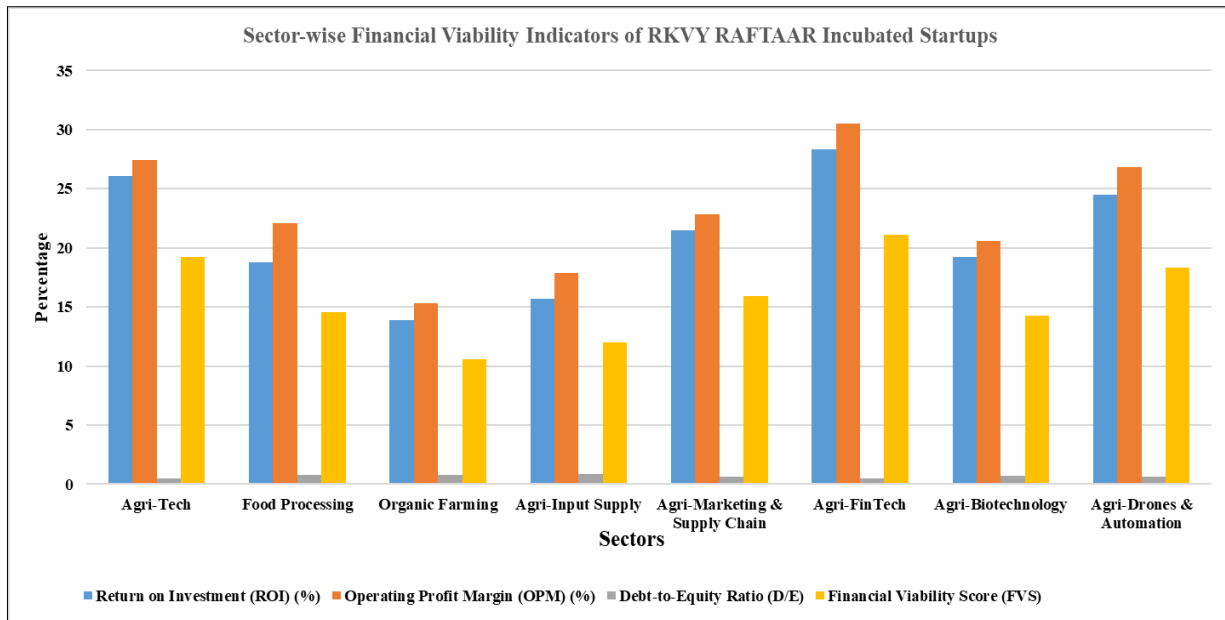
**Very good viability:** Agri-Drones & Automation (18.34) reflected robust financial indicators and balanced operational models, demonstrating their potential for sustained growth with moderate institutional support.

**Good viability:** Agri-Marketing & Supply Chain (15.90), Food Processing (14.53) and Agri-Biotechnology (14.28), though capital-intensive, indicated stable financial profiles. Enhancing access to credit and refining supply chain efficiency could enable advancement to higher viability tiers.

**Moderate viability:** Agri-Input Supply (11.99) sector faced challenges related to high debt exposure and moderate returns, suggesting the requirement for strategic interventions in procurement and pricing efficiency. Organic Farming (10.53) appeared as the least financially viable sector, due to low ROI and thin profit margins. While ecologically beneficial, the sector's financial fragility requires targeted interventions such as strategic subsidies, guaranteed marketing channels and consumer awareness initiatives.

Fig. 2. shows sector-wise financial viability indicators emphasising differences in profitability and capital structures among startups incubated under RKVY-RAFTAAR scheme. Agri-FinTech and Agri-Tech demonstrated the strongest performance, with high ROI and operating margins, reflecting strong scalability and investor confidence. Food Processing and Organic Farming showed lower returns and higher debt-to-equity ratios, reflecting greater financial vulnerability. Moderate viability was detected in Agri-Marketing, Agri-Biotechnology and Drones & Automation, with balanced ROI and OPM levels.

The financial viability of agri-startups was differentiated sectorally with technology-driven models being more likely to determine financial robustness, scalability and investor appeal, whereas traditional or ecologically-oriented sectors faced limitations that restricted their financial performance. The sectors with low viability embrace long-term potential for inclusive and sustainable development, provided they get appropriate policy, financial and institutional support. These findings are in line with sector-specific insights were previously observed that technology-driven agri-startups, such as Agri-Tech, Agri-FinTech and Agri-Drones exhibit higher ROI and operational margins due to scalable, digital-first business models while, traditional sectors such as Organic Farming and Agri-Input Supply, though progressively adopting technology, continue to face financial limitations and slower viability gains



**Fig. 2.** Sector-wise financial performance and efficiency scores of agri-startups evaluated using data envelopment analysis. due to structural and market barriers (12).

Overall, the sector-wise financial performance of agri-startups varied significantly, stressing diverse risk and growth dynamics within the agri-startup ecosystem.

#### Efficiency analysis of RKVY RAFTAAR-incubated agricultural startups

To evaluate the relative efficiency of agricultural startups supported under RKVY-RAFTAAR scheme, a structured set of input and output variables was identified. Input variables included total investment and percentage allocations towards product development and technology adoption, infrastructure and equipment and R & D. To capture financial performance and viability, output variables comprising of ROI, OPM and FVS were used.

#### Input variables used for DEA

The key input variables utilised in the DEA to evaluate the efficiency of agricultural startups incubated under RKVY-RAFTAAR programme is presented in Table 4. The input indicators reflected sector-specific resource allocations across various startup categories.

Investment ranged from ₹100 lakhs in Organic Farming to

₹150 lakhs in Food Processing, indicating varied capital requirements across sectors. Infrastructure and Equipment allocation (physical assets including machinery and facilities) ruled in Organic Farming (43 %) and Food Processing (40 %) sectors, indicating substantial capital expenditure. Product Development and Technology Adoption (digital solutions and tech integration) received highest importance in Agri-Tech (35 %), followed by Agri-FinTech and Agri-Input Supply (30 % each). R&D investment (innovation and technological advancement) were higher in Agri-Biotechnology (35 %), with significant allocations from Agri-FinTech and Agri-Drones & Automation 20 per cent each in these sectors. These inputs formed the basis for evaluating how startups transformed sector-specific investments into operational and financial outcomes efficiently.

#### Output Variables used for data envelope analysis (DEA)

The key output indicators employed in DEA to evaluate the financial performance of startups supported under RKVY-RAFTAAR scheme is presented in Table 5. The selected output metrics included ROI, OPM and FVS, each serving as a proxy for different dimensions of financial efficiency and sustainability.

ROI examined the profitability relative to capital invested, with Agri-FinTech (28.30 %), Agri-Tech (26.10 %) and Agri-Drones &

**Table 4.** Input variables used for data envelope analysis (DEA)

(n = 80)

Sl. No.	Sector	Investment (₹ Lakhs)	Product development & Technology Adoption (%)	Infrastructure & equipment (%)	R & D (%)
1.	Agri-Tech	125	35	25	15
2.	Food Processing	150	20	40	10
3.	Organic Farming	100	18	43	06
4.	Agri-Input Supply	120	30	35	15
5.	Agri-Marketing & Supply Chain	130	25	25	10
6.	Agri-FinTech	110	30	20	20
7.	Agri-Biotechnology	140	20	25	35
8.	Agri-Drones & Automation	120	25	30	20

**Table 5.** Output variables used for data envelope analysis (DEA)

(n = 80)

Sl. No.	Sector	Return on investment (%)	Operating profit margin (%)	Financial viability score (FVS)
1.	Agri-Tech	26.10	27.40	19.26
2.	Food Processing	18.80	22.10	14.53
3.	Organic Farming	13.90	15.30	10.53
4.	Agri-Input Supply	15.70	17.90	11.99
5.	Agri-Marketing & Supply Chain	21.50	22.80	15.90
6.	Agri-FinTech	28.30	30.50	21.14
7.	Agri-Biotechnology	19.20	20.60	14.28
8.	Agri-Drones & Automation	24.50	26.80	18.34

Automation (24.50 %) sectors demonstrating the highest returns due to advantages like high market demand, increased precision and high profitability. OPM indicated the operational efficiency, wherein the same 3 sectors, i.e., Agri-FinTech (30.50 %), Agri-Tech (27.40 %) and Agri-Drones & Automation (26.80 %), noted the strongest performance. The FVS, a composite index assessing overall financial health, recognised sectors, namely, Agri-FinTech, Agri-Tech and Agri-Drones & Automation as the most viable, with scores of 21.14, 19.26 and 18.34, respectively. Together, these indicators simultaneously provide insights into how effectively different agri-startup sectors converted inputs into financial outputs under the policy framework. Based on a firm-level DEA analysis of Indian food- and agro-based companies, which revealed that financial indicators such as return on assets and return on sales were strong indicators of efficiency (13). This aligned closely with the present study's usage of ROI, OPM and FVS as output variables in measuring the performance of incubated agricultural startups under RKVY-RAFTAAR scheme.

### Efficiency scores of agricultural startups by sector (DEA output-oriented model)

The DEA revealed substantial heterogeneity in technical and scale efficiency across agricultural startup sectors incubated under RKVY-RAFTAAR initiative as shown in Table 6. Technical efficiency (TE) scores captured the extent to which sectors convert inputs into outputs effectively, while scale efficiency (SE) reflects the degree to which operations are aligned with optimal firm size. The DEA was conducted using an output-oriented model under the assumption of variable returns to scale (VRS), thereby allowing for sectoral heterogeneity in input-output transformation.

Agri-FinTech appeared as the most efficient sector, recording a TE of 0.93 and SE of 0.97. Its performance was reinforced by favourable financial indicators, including a ROI of 28.3 % and 30.5 %, suggesting an effective allocation of resources and technological adaptability within lean operational frameworks. Similarly, Agri-Tech, Agri-Marketing & Supply Chain and Agri-Drones & Automation also revealed high levels of efficiency, with TE scores exceeding 0.87. These sectors showed sound infrastructure development, effective capacity-building strategies and strategically directed R & D investments.

In contrast, Food Processing, Agri-Input Supply and Agri-Biotechnology showed moderate efficiency levels, with TE scores ranging from 0.79 to 0.84. Despite achieving reasonable

financial performance, inefficiencies in resource utilisation and sub-optimal scale operation were evident. The capital-intensive nature and impact of long R & D cycles, stringent regulatory requirements and substantial capital intensity on startup performance of Food Processing and Biotechnology accounted for these deviations from scale efficiency.

Organic Farming sector noted the lowest efficiency among all sectors, with a TE of 0.68 and SE of 0.72. Though significant investments were made in training and capacity building (constituting 45 % of total expenditure) and sustainability practices, the sector had not performed well in terms of ROI and overall financial viability. The causative factors included limited market integration, poor levels of technological adoption and high certification costs and stringent regulatory compliance.

The efficiency analysis highlighted distinct sectoral patterns. Agri-FinTech, Agri-Tech and Agri-Drones & Automation appeared well-performed to scale up due to their high investor confidence, technological advancements and cost-efficient and effective business models. In contrast, sectors such as Organic Farming and Agri-Biotechnology confronted structural and market-based constraints, directing to the requirement for targeted policy interventions. These findings line up with previous studies who demonstrated that farm-level specialisation and market integration significantly impact efficiency outcomes, suggesting that the low scores in these sectors may stem from supply chain fragmentation and inadequate specialisation (14). The higher returns and efficiency scores for Agri-Tech and Agri-FinTech sectors could be explained through innovation adoption theory, as these sectors' greater investment in technology and R & D accelerates diffusion and attracts scalable private capital (5, 15).

### Slack analysis of output variables

The evaluation of the slack values of output variables across eight key agri-startup sectors was done, as shown in Table 7 providing insights into sector-wise performance. Slack values indicate the extent to which sectors could improve their performance without requiring additional inputs, thus serving as a proxy for underutilisation or untapped potential in achieving optimal output levels. Unlike overall efficiency scores, slack values highlighted sector-specific inefficiencies, enabling targeted improvements and resource optimisation.

Organic Farming exhibited the highest slack across all 3 output indicators, viz., ROI (6.54 %), OPM (7.20 %) and FVS (4.96)

**Table 6.** Efficiency scores of agricultural startups by sector (data envelope analysis output-oriented model) (n = 80)

Sl. No.	Sector	Technical efficiency (TE)	Scale efficiency (SE)	Efficiency classification
1.	Agri-Tech	0.91	0.96	Very efficient
2.	Food Processing	0.84	0.90	Moderately efficient
3.	Organic Farming	0.68	0.72	Inefficient
4.	Agri-Input Supply	0.80	0.87	Moderately efficient
5.	Agri-Marketing & Supply Chain	0.89	0.93	Very efficient
6.	Agri-FinTech	0.93	0.97	Highly efficient
7.	Agri-Biotechnology	0.79	0.85	Moderately efficient
8.	Agri-Drones & Automation	0.87	0.92	Very efficient

**Table 7.** Slack values for output variables (n = 80)

Sl. No.	Sector	ROI Slack (%)	OPM Slack (%)	FVS Slack
1.	Agri-Tech	2.61	2.94	2.15
2.	Food Processing	3.61	4.42	2.63
3.	Organic Farming	6.54	7.20	4.96
4.	Agri-Input Supply	3.93	4.48	3.00
5.	Agri-Marketing & Supply Chain	2.41	2.56	1.71
6.	Agri-FinTech	1.99	2.31	1.52
7.	Agri-Biotechnology	5.10	5.48	3.79
8.	Agri-Drones & Automation	3.57	3.83	2.62

suggesting considerable inefficiencies, potentially stemming from fragmented supply chains, lower market access, or compliance challenges with organic certification norms. Agri-Biotechnology also showed elevated slack in ROI (5.10 %) and OPM (5.48 %), pointing to underperformance relative to resource investment which was likely due to the sector's high R & D risk and long gestation period for returns.

Food Processing and Agri-Input Supply recorded moderate slack levels (3–4.5 %) across indicators, implying potential to enhance financial outcomes through better operational planning, value chain integration, or improved product-market fit. Agri-Drones & Automation sector demonstrated similar inefficiencies, predominantly in FVS (2.62), representing scope for broader adoption by farmer and value realisation from high-tech interventions.

Agri-Tech, Agri-Marketing & Supply Chain and Agri-FinTech sectors revealed relatively low slack values, especially in ROI and OPM (ranging from 1.99–2.94 %), signifying that these sectors are functioning closer to the efficiency frontier. In particular, Agri-FinTech showed the lowest slack in ROI (1.99 %) and FVS (1.52), indicating robust business models with streamlined financial operations and enhanced delivery of farmer-centric value.

These differential slack levels emphasised that while innovation-led sectors such as Agri-Tech and Agri-FinTech are enhancing their output potential, traditional or infrastructure-intensive sectors such as Organic Farming and Agri-Biotechnology may need targeted support to bridge inefficiencies in their operations. The results highlighted the need for sector-specific interventions extending from technical training and market facilitation to regulatory support and research collaboration tailored to the unique efficiency gaps identified in each sector. The application of slack measures complemented traditional efficiency scores by pinpointing sector-specific performance gaps, a methodological perspective grounded in the foundational DEA work and expanded in the comprehensive treatments (16, 17). The observed slack values highlight sector-specific inefficiencies that can be strategically addressed through RKVY-RAFTAAR policy instruments. For instance, Organic Farming and Agri-Biotechnology exhibited the highest slack across ROI, OPM and FVS, suggesting untapped potential in financial and operational outcomes. Targeted grant allocation under RKVY-RAFTAAR can help these sectors overcome infrastructure deficits, certification costs and market integration challenges.

Moderate slack in Food Processing and Agri-Input Supply indicates opportunities to enhance efficiency through better market access and operational planning. The scheme's mentoring and capacity-building programmes can be leveraged to improve management practices, supply chain integration and product-market fit in these sectors.

Additionally, innovation-intensive sectors like Agri-Biotechnology can benefit from tailored R & D incentives and technical support to accelerate commercialisation of research outputs, thereby reducing slack in FVS. Linking slack-derived inefficiencies to specific policy instruments ensures that RKVY-RAFTAAR support not only provides capital but also targets operational and strategic bottlenecks, maximizing sectoral impact.

These studies emphasised that slack values provide actionable insights into how decision-making units such as

incubated startups can improve outputs without increasing inputs, thereby offering a targeted roadmap for operational enhancement.

## Conclusion

This study examined the sector-wise financial viability and efficiency of agri-startups supported under RKVY-RAFTAAR scheme in the states of Andhra Pradesh and Telangana. The results demonstrated that technology-driven sectors such as Agri-Tech, Agri-FinTech and Agri-Drones & Automation performed more efficiently and attracted higher private investments. In contrast, Organic Farming and Agri-Input Supply startups represented lower profitability and greater reliance on debt. Data envelopment analysis (DEA) emphasised these gaps sectorally, with innovative startups operating closer to the efficiency frontier. The findings underscored the need for policies that encourage both scalable innovation and provide targeted support to sustainability-oriented startup sectors. Based on DEA slack values, the study recommends that RKVY-RAFTAAR interventions be more sector-specific: Organic Farming should receive targeted grants, facilitated market linkages and consumer awareness support to improve ROI and FVS. Agri-Biotechnology requires intensified R & D mentoring, innovation support and regulatory guidance to bridge underperformance despite high resource investment. Moderate-efficiency sectors, such as Food Processing and Agri-Input Supply, can benefit from capacity-building programs, operational guidance and enhanced access to credit. These targeted policy measures, informed directly by efficiency and slack analysis, can strengthen the financial viability, operational efficiency and overall sustainability of RKVY-RAFTAAR-supported agri-startups.

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## Authors' contributions

SS conceptualized the study and carried out the complete sector-wise funding and financial viability assessment of RKVY-RAFTAAR-incubated agri-startups in Andhra Pradesh and Telangana, including the sampling design, data collection, primary survey administration, compilation of financial records, construction of the composite Financial Viability Score (FVS) and execution of the DEA efficiency and slack analyses; SS also led all statistical and econometric analyses, prepared sectoral figures and tables, interpreted the results and drafted the manuscript in full. GMR served as the doctoral supervisor and provided expert guidance throughout the research process, reviewing the research design, refining the methodology and contributing to manuscript revisions while offering critical corrections and

pedagogical mentorship to ensure academic rigor and clarity. MG provided moral and collegial support throughout the research journey. All authors read and approved the final manuscript.

### Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

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