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Enterprise type as a unit of analysis in rural entrepreneurial ecosystems based on multivariate assessment of twelve agricultural enterprise models

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Research Article

Keywords: agripreneurship, rural entrepreneurship, entrepreneurial ecosystem, enterprise heterogeneity, rural development, multivariate analysis of variance

Posted Date: November 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11537470/v1

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Additional Declarations: No competing interests reported.

Abstract

Rural development policy and extension programmes usually promote agripreneurship as a single pathway, yet little is known about whether different agri-enterprise types occupy distinct behavioural and ecosystem positions. This study tests whether twelve agri-enterprise models differ, jointly and individually, on six agripreneurial dimensions (socio-personal, socio-economic, communicational, digital behaviour, entrepreneurial behaviour and an overall Agripreneurial Ecosystem Score, AES) and on seven ecosystem constructs. Survey data from 230 agripreneurs in twelve enterprise types, including integrated farming systems (IFS), were analysed using one-way multivariate analysis of variance (MANOVA), univariate ANOVA with Welch and Kruskal–Wallis robustness checks, Tukey–Kramer post hoc tests, Holm adjustment and rank-based force-field profiling. Enterprise type had a significant multivariate effect (Wilks' $\Lambda = 0.403$, $p < 0.001$), and all six dimensions differed ($\eta^2 = 0.09–0.20$), most strongly socio-economic status. Of 396 pairwise comparisons, 16 were significant; 11 concerned socio-economic status and all favoured IFS. Market, finance, culture, network and infrastructure differed across enterprises, whereas government policy and human capital did not. Finance was the weakest construct overall. Enterprise type is therefore a meaningful unit of analysis for rural entrepreneurship research, and support schemes should be differentiated by enterprise rather than offered as one uniform pathway, targeting finance for fishery, infrastructure for vegetables, and culture and networks for floriculture and fruit crops.

1. Introduction

Agripreneurship, the pursuit of entrepreneurial opportunity in agriculture and allied activities, is increasingly treated as a strategy for raising farm incomes, creating rural employment and diversifying risk. Rural development policy and extension programmes commonly promote it as a single, undifferentiated pathway, on the implicit assumption that rural entrepreneurs face a common support environment. In practice, however, the enterprises that farmers actually run, such as dairy, poultry, fishery, mushroom, floriculture or integrated farming, differ sharply in capital intensity, production cycle, perishability, technical demand, market structure and reliance on institutional support. These differences make it unlikely that all agripreneurs share the same behavioural profile or experience the same supporting ecosystem.

The entrepreneurial ecosystem literature explains entrepreneurial outcomes through the combined presence of markets, finance, culture, networks, policy, human capital and infrastructure (Isenberg, 2010; Mason & Brown, 2014; Stam, 2015; Spigel, 2017). Most of this work, however, takes the region or city as its unit of analysis. Far less is known about how ecosystem support varies between enterprise types operating within the same agrarian setting, and whether the farmer's own socio-personal, socio-economic, communicational and digital characteristics co-vary with that support. Enterprise type is the point at which technology, market and institutional conditions meet the individual agripreneur, and it is therefore a practical level at which support can be designed and targeted. From a rural development

perspective, the question is whether a place-based support offer reaches enterprises equally, or whether support is experienced differently according to the kind of enterprise a farmer runs.

Two analytic gaps follow. First, enterprise comparisons are typically made one variable at a time, ignoring the correlated, multidimensional nature of agripreneurial behaviour and risking inflated Type I error. Second, group-level significance tests rarely identify which enterprise is advantaged or constrained on which dimension, which is the information that extension planners need. This study addresses both gaps by combining omnibus multivariate testing with univariate, post hoc and enterprise-wise analysis.

The study had four objectives: (i) to test whether twelve agri-enterprise models differ jointly on six agripreneurial dimensions; (ii) to identify which dimensions, and which pairs of enterprises, differ; (iii) to test whether the seven ecosystem constructs differ across enterprises; and (iv) to build an enterprise-wise model of each enterprise showing the dimensions on which it is favoured, moderate or not favoured. The following hypotheses were tested.

H1. The twelve enterprise types differ significantly on the combined set of six dimensions (multivariate analysis of variance, MANOVA).

H2. Enterprise types differ significantly on each of the six dimensions individually (analysis of variance, ANOVA).

H3. Enterprise types differ significantly on each of the seven ecosystem constructs (ANOVA).

H4. Diversified enterprises (integrated farming systems, IFS) occupy a higher position than single-commodity enterprises, as shown by Tukey–Kramer post hoc contrasts.

The remainder of the paper sets out the conceptual framework, the methods, the results at the multivariate, univariate, post hoc and enterprise-wise levels, and a discussion of implications, limitations and future research.

2. Conceptual Framework

2.1 Agripreneurial dimensions

The study treats the agripreneur as an actor whose enterprise performance is shaped by five personal and behavioural dimensions and by the ecosystem around the enterprise. Socio-personal characteristics (age, education, farming experience) capture human resources and accumulated knowledge. Socio-economic characteristics (annual income, land holding) capture the material resource base. Communicational behaviour captures exposure to information sources, which supports opportunity recognition and the adoption of innovations (Rogers, 2003). Digital behaviour (utilisation of information and communication technology, ICT, and digital inclusion) captures access to market, price and technical information. Entrepreneurial behaviour captures the composite of entrepreneurial constructs, in the tradition of entrepreneurial orientation research (Lumpkin & Dess, 1996). The socio-personal, socio-

economic, communicational and digital dimensions are treated here as profile characteristics of the agripreneur that may differ by enterprise, not as outcomes of enterprise choice; they are analysed jointly with entrepreneurial behaviour and the ecosystem score because targeting support requires the whole profile.

2.2 Agripreneurial ecosystem

The ecosystem is represented by seven constructs: Market, Finance, Culture, Network, Government Policy, Human Capital and Infrastructure. These correspond closely to the domains proposed by Isenberg (2010) and are aggregated into an overall Agripreneurial Ecosystem Score (AES), the mean of the seven constructs.

2.3 Enterprise-wise force-field models

To translate statistical results into an interpretable picture of each enterprise, an enterprise-wise force-field model was constructed, drawing on Lewin's (1951) idea that a situation reflects the balance of driving and restraining forces. Each enterprise is placed at the centre of a diagram. Dimensions on which it ranks among the top four of twelve act as supporting forces (arrows in), those ranking in the bottom four act as restraining forces (arrows out), and the remainder are moderate. The framework is descriptive: it summarises relative standing and does not assert causation. The rank thresholds (top four, middle four, bottom four) are a descriptive convention; classifications should be read together with the effect sizes and post hoc results, because adjacent ranks are often not statistically distinguishable.

3. Materials and Methods

3.1 Study design and sample

The study used a cross-sectional survey design. Data were collected from 230 agripreneurs distributed across twelve enterprise types: poultry (n = 26), vegetable (24), mushroom (22), fishery (22), IFS (20), fruit crops (20), honeybee (18), goatery (18), dairy (17), nursery (17), floriculture (14) and millet (12). Respondents were selected through a combination of institutionally recognised agripreneurs and snowball sampling (Goodman, 1961). Institutionally recognised agripreneurs were identified in consultation with officials of the line departments and with established agri-entrepreneurs, and further respondents were reached through referrals. This combination was used to represent both formal networks, such as scheme beneficiaries and members of promoted groups, and informal networks of entrepreneurs who operate outside programme channels. The dataset contained no missing values on any analysed variable. Summary rows of the data sheet (overall mean and standard deviation) were excluded before analysis.

3.2 Variables and composite construction

Six dependent variables (DVs) were constructed (Table 1). Because the socio-personal, socio-economic, communicational and digital components are measured on different scales (years, rupees, hectares and

rating scores), each component was z-standardised before averaging, so that these four composites are in standard-score units (0 = grand mean). Entrepreneurial behaviour and the AES were computed as simple means of 1–5 scale constructs and retain the original metric. The AES equalled the mean of the seven ecosystem constructs exactly.

Table 1
Dependent variables and their construction

Dimension	Components	Computation	Metric
Socio-personal (SP)	Age, education, farming experience	Mean of z-scores	SD units
Socio-economic (SE)	Annual income, total land	Mean of z-scores	SD units
Communicational (COM)	PCS, PLS and miscellaneous information sources	Mean of z-scores	SD units
Digital behaviour (DB)	ICT utilisation, digital inclusion	Mean of z-scores	SD units
Entrepreneurial behaviour (EB)	Eight entrepreneurial constructs	Mean of constructs	1–5
Agripreneurial ecosystem (AES)	Market, Finance, Culture, Network, Government Policy, Human Capital, Infrastructure	Mean of seven constructs	1–5

3.3 Statistical analysis

A one-way multivariate analysis of variance (MANOVA) with enterprise type (12 levels) as the factor and the six DVs was used to test H1. Wilks' lambda (Wilks, 1932), Pillai's trace (Pillai, 1955), the Hotelling–Lawley trace and Roy's greatest root were reported. Pillai's trace is the most robust of these to violations of homogeneity of covariance matrices (Olson, 1974) and was treated as the primary statistic where the four disagreed in emphasis. The multivariate effect size was computed as $1 - \Lambda^{(1/s)}$, with $s = 6$.

Univariate one-way ANOVAs (H2, H3) were then run for each DV and for each ecosystem construct, with eta-squared (η^2) as the effect size. Following Cohen (1988), η^2 values of about 0.01, 0.06 and 0.14 were read as small, medium and large effects (see also Lakens, 2013). Because group sizes were small and unequal, three robustness checks were applied: the median-centred Levene (Brown–Forsythe) test for equality of variances (Levene, 1960; Brown & Forsythe, 1974), Welch's ANOVA, which does not assume equal variances (Welch, 1951), and the Kruskal–Wallis test (Kruskal & Wallis, 1952). Where several ecosystem constructs were tested, Holm-adjusted p-values were also reported (Holm, 1979). Evidence was treated as robust when ANOVA, Welch and Kruskal–Wallis agreed (see also Lix et al., 1996).

Where an ANOVA was significant, Tukey's honestly significant difference test (Tukey, 1949), in its Tukey–Kramer form for unequal group sizes (Kramer, 1956), identified which of the 66 possible enterprise pairs differed, at $\alpha = 0.05$. This procedure controls the familywise error rate within each dimension.

Enterprises were ranked 1–12 on each dimension by group mean (1 = highest). For the enterprise-wise force-field models, ranks 1–4 was classed as *Favoured* (supporting, arrow in), ranks 5–8 as *Moderate* and ranks 9–12 as *Not favoured* (restraining, arrow out). In the ecosystem analysis, enterprises were additionally ranked on each of the seven constructs, and the constructs were ranked 1–7 within each enterprise from strongest to weakest. All tests were two-tailed.

4. Results

4.1 Multivariate effect of enterprise type (H1)

Enterprise type had a highly significant multivariate effect on the six dimensions on all four test statistics (Table 2). Wilks' lambda was 0.403, $F(66, 1145) = 3.21$, $p < 0.001$, giving a multivariate effect size of $1 - \Lambda^{(1/6)} \approx 0.14$, which corresponds to a large effect by Cohen's benchmark. Pillai's trace, the most robust statistic, was also significant ($V = 0.817$, $F(66, 1308) = 3.12$, $p < 0.001$). H1 was therefore supported: enterprise types differ jointly on the six agripreneurial dimensions.

Table 2
One-way MANOVA of enterprise type on six dimensions (N = 230)

Statistic	Value	F	Num. df	Den. df	p
Wilks' lambda	0.403	3.21	66	1145	< 0.001
Pillai's trace	0.817	3.12	66	1308	< 0.001
Hotelling–Lawley trace	1.015	3.25	66	783	< 0.001
Roy's greatest root	0.366	7.26	11	218	< 0.001

4.2 Univariate ANOVA across the six dimensions (H2)

All six dimensions differed significantly across enterprises (Table 3), supporting H2. Socio-economic status showed by far the largest effect ($F(11, 218) = 4.98$, $p < 0.001$, $\eta^2 = 0.20$, a large effect). Entrepreneurial behaviour and the AES each had $\eta^2 = 0.12$ ($F = 2.58$, $p = 0.004$), communicational behaviour and socio-personal characteristics each had $\eta^2 = 0.10$ ($p = 0.016$ and $p = 0.022$), and digital behaviour had the weakest effect ($\eta^2 = 0.09$, $p = 0.038$).

Levene's test indicated unequal variances for three dimensions: socio-economic ($p = 0.002$), digital behaviour ($p = 0.029$) and the AES ($p = 0.001$). Welch's ANOVA, which tolerates unequal variances, was significant for all six dimensions (all $p \leq 0.023$), so the significance conclusions are robust to this violation. Post hoc results for the three heteroscedastic dimensions should nevertheless be read with caution.

Table 3
Univariate ANOVA and robustness checks by dimension

Dimension	F (11, 218)	p	η²	Levene p	Welch F	Welch p
Socio-personal	2.09	0.022	0.10	0.063	2.19	0.023
Socio-economic	4.98	< 0.001	0.20	0.002	2.55	0.008
Communicational	2.19	0.016	0.10	0.241	2.87	0.003
Digital behaviour	1.92	0.038	0.09	0.029	3.43	< 0.001
Entrepreneurial behaviour	2.58	0.004	0.12	0.142	2.66	0.006
Agripreneurial ecosystem (AES)	2.58	0.004	0.12	0.001	2.87	0.003

4.3 Enterprise means and ranks

Table 4 gives the group mean and rank of each enterprise on each dimension. The spread between the highest and lowest enterprise differed markedly by dimension, which mirrors the effect sizes. On socio-economic status the range was 1.38 standard-score units (IFS, 1.08; honeybee and goatery, − 0.30), far wider than for digital behaviour (0.95; fishery 0.47 to millet − 0.48), socio-personal characteristics (0.87; dairy 0.36 to millet − 0.51) or communicational behaviour (0.77; fishery 0.43 to mushroom − 0.34). On the 1–5 scale, entrepreneurial behaviour ranged from 3.73 (IFS) to 3.09 (floriculture) and the AES from 3.88 (IFS) to 3.16 (floriculture).

IFS was the only enterprise to rank in the top four on every dimension: it ranked first on socio-economic status, entrepreneurial behaviour and the AES, and second on the other three. Several enterprises showed sharply uneven profiles. Mushroom ranked second on socio-economic status but last on communicational behaviour, and dairy ranked first on socio-personal characteristics but eleventh on digital behaviour. Millet, with the smallest sample (n = 12), ranked second on the AES but last on both socio-personal characteristics and digital behaviour.

Table 4
Enterprise means (rank of 12) on the six dimensions

Enterprise (n)	SP	SE	COM	DB	EB	AES
Mushroom (22)	0.08 (4)	0.05 (2)	−0.34 (12)	0.17 (3)	3.45 (5)	3.61 (3)
IFS (20)	0.20 (2)	1.08 (1)	0.34 (2)	0.23 (2)	3.73 (1)	3.88 (1)
Fishery (22)	0.03 (7)	−0.04 (5)	0.43 (1)	0.47 (1)	3.63 (3)	3.47 (6)
Poultry (26)	−0.08 (8)	−0.01 (3)	−0.07 (7)	−0.15 (9)	3.27 (8)	3.50 (5)
Dairy (17)	0.36 (1)	−0.02 (4)	−0.16 (9)	−0.36 (11)	3.66 (2)	3.51 (4)
Vegetable (24)	0.07 (5)	−0.07 (7)	0.00 (5)	0.13 (4)	3.29 (7)	3.45 (8)
Honeybee (18)	−0.16 (10)	−0.30 (12)	−0.04 (6)	−0.06 (7)	3.23 (11)	3.41 (10)
Floriculture (14)	0.07 (6)	−0.09 (8)	0.03 (4)	0.11 (5)	3.09 (12)	3.16 (12)
Nursery (17)	−0.27 (11)	−0.23 (10)	0.30 (3)	−0.10 (8)	3.24 (10)	3.42 (9)
Goatery (18)	−0.09 (9)	−0.30 (11)	−0.20 (10)	0.00 (6)	3.51 (4)	3.45 (7)
Fruit crops (20)	0.09 (3)	−0.06 (6)	−0.23 (11)	−0.24 (10)	3.25 (9)	3.22 (11)
Millet (12)	−0.51 (12)	−0.22 (9)	−0.08 (8)	−0.48 (12)	3.38 (6)	3.66 (2)

Note. SP, SE, COM and DB are in z-score units; EB and AES are on the 1–5 scale. Ranks: 1 = highest mean.
*

Figure 1 Mean score and rank (in parentheses) of each enterprise on the six dimensions; cell shading indicates rank from highest (1) to lowest (12). SP, SE, COM and DB are in z-score units; EB and AES are on the 1–5 scale

4.4 Post hoc comparisons across the six dimensions

Of 66 possible pairwise comparisons per dimension (396 in total), 16 were significant under Tukey–Kramer (Table 5): socio-personal 1, socio-economic 11, communicational 1, digital behaviour 0, entrepreneurial behaviour 1 and AES 2. The dominant pattern was socio-economic: IFS exceeded every one of the other eleven enterprises by 1.03 to 1.37 standard-score units (all $p < 0.001$). Elsewhere, post hoc evidence was sparse. Dairy exceeded millet on socio-personal characteristics (difference 0.87, $p = 0.011$); fishery exceeded mushroom on communicational behaviour (0.77, $p = 0.028$); and IFS exceeded floriculture on entrepreneurial behaviour (0.64, $p = 0.038$) and on the AES (0.72, $p = 0.002$), as well as exceeding fruit crops on the AES (0.66, $p = 0.002$).

Digital behaviour produced no significant pairwise contrast even though the omnibus test was significant ($p = 0.038$). This pattern is common when many groups are compared with modest, unequal sample sizes: the omnibus test pools small differences across all groups, whereas Tukey–Kramer, which

protects against 66 simultaneous comparisons, requires a larger gap between any single pair. The result should be read as a broad but diffuse enterprise gradient in digital behaviour rather than a difference attributable to specific enterprise pairs.

Table 5
Significant Tukey–Kramer contrasts across the six dimensions

Dimension	Higher enterprise	Lower enterprise	Mean difference	Tukey p
Socio-personal	Dairy	Millet	0.87	0.011
Socio-economic	IFS	Dairy	1.09	< 0.001
Socio-economic	IFS	Fishery	1.12	< 0.001
Socio-economic	IFS	Floriculture	1.16	< 0.001
Socio-economic	IFS	Fruit crops	1.13	< 0.001
Socio-economic	IFS	Goatery	1.37	< 0.001
Socio-economic	IFS	Honeybee	1.37	< 0.001
Socio-economic	IFS	Millet	1.29	< 0.001
Socio-economic	IFS	Mushroom	1.03	< 0.001
Socio-economic	IFS	Nursery	1.30	< 0.001
Socio-economic	IFS	Poultry	1.09	< 0.001
Socio-economic	IFS	Vegetable	1.14	< 0.001
Communicational	Fishery	Mushroom	0.77	0.028
Entrepreneurial behaviour	IFS	Floriculture	0.64	0.038
Agripreneurial ecosystem	IFS	Floriculture	0.72	0.002
Agripreneurial ecosystem	IFS	Fruit crops	0.66	0.002

4.5 ANOVA across the seven ecosystem constructs (H3)

Because the AES is an aggregate, a second set of ANOVAs examined which ecosystem constructs drive the enterprise differences (Table 6). Five of the seven constructs differed significantly on the unadjusted test: Market, Finance, Culture, Network and Infrastructure. Government Policy ($p = 0.262$) and Human Capital ($p = 0.077$) did not. Market had the largest effect ($F(11, 218) = 3.28$, $p < 0.001$, $\eta^2 = 0.142$), followed by Culture ($\eta^2 = 0.133$), Network ($\eta^2 = 0.127$), Finance ($\eta^2 = 0.117$) and Infrastructure ($\eta^2 = 0.090$). H3 was therefore only partly supported.

After Holm adjustment for seven tests, Market (adjusted $p = 0.003$), Culture (0.005), Network (0.008) and Finance (0.015) remained significant, but Infrastructure did not (adjusted $p = 0.101$) and is best treated as suggestive. Levene's test indicated unequal variances for Network ($p = 0.006$), Human Capital ($p =$

0.048) and Infrastructure (p = 0.023), but Welch's ANOVA and the Kruskal–Wallis test returned the same verdicts as the ANOVA for every construct, with one exception: Human Capital was marginally significant on Kruskal–Wallis (p = 0.047) but not on ANOVA (p = 0.077) or Welch (p = 0.136). Human Capital is therefore best read as a weak and inconclusive difference.

Table 6
ANOVA and robustness checks for ecosystem constructs

Construct	F(11, 218)	p	η²	Holm p	Levene p	Welch p	Kruskal–Wallis p	Significant
Market	3.28	< 0.001	0.142	0.003	0.344	0.002	< 0.001	Yes
Finance	2.63	0.004	0.117	0.015	0.157	0.004	0.002	Yes
Culture	3.05	< 0.001	0.133	0.005	0.649	0.001	< 0.001	Yes
Network	2.88	0.002	0.127	0.008	0.006	0.003	0.008	Yes
Government Policy	1.24	0.262	0.059	0.262	0.466	0.155	0.280	No
Human Capital	1.69	0.077	0.079	0.154	0.048	0.136	0.047	No
Infrastructure	1.96	0.034	0.090	0.101	0.023	0.015	0.023	Yes (unadjusted)
AES (overall)	2.58	0.004	0.115	–	0.001	0.003	0.005	Yes

Figure 2 Effect sizes (η²) of enterprise type for (a) the six dimensions and (b) the seven ecosystem constructs

4.6 Enterprise means on ecosystem constructs

Table 7 gives each enterprise's mean (and rank) on the seven constructs, ordered by overall AES. Across all enterprises the construct means ordered as Market (3.60) > Network (3.57) > Human Capital (3.52) > Culture (3.47) > Government Policy (3.44) > Infrastructure (3.42) > Finance (3.34), so Finance was the weakest ecosystem construct overall. All enterprise means lay between 2.90 and 4.07 on the 5-point scale, so even the lowest-ranked enterprise did not report a poor ecosystem in absolute terms.

The highest score on a single construct was Vegetable on Market (4.07) and the lowest was Fishery on Finance (2.90). IFS ranked first on five constructs (Finance, Culture, Government Policy, Human Capital, Infrastructure) and second on the other two (Market, Network). Mushroom ranked first on Network (4.03) and second on Infrastructure (3.74). Floriculture ranked last on Culture, Network, Government Policy and Human Capital.

Table 7
Enterprise means (rank of 12) on ecosystem constructs, ordered by AES

Enterprise (n)	Market	Finance	Culture	Network	Govt Policy	Human Capital	Infrastructure	AES
IFS (20)	3.88 (2)	3.88 (1)	3.99 (1)	3.94 (2)	3.81 (1)	3.82 (1)	3.85 (1)	3.88 (1)
Millet (12)	3.67 (7)	3.38 (4)	3.87 (2)	3.79 (3)	3.73 (2)	3.66 (4)	3.55 (3)	3.66 (2)
Mushroom (22)	3.53 (8)	3.20 (9)	3.72 (3)	4.03 (1)	3.38 (7)	3.68 (3)	3.74 (2)	3.61 (3)
Dairy (17)	3.68 (6)	3.60 (2)	3.55 (4)	3.58 (6)	3.25 (10)	3.48 (7)	3.44 (4)	3.51 (4)
Poultry (26)	3.71 (4)	3.37 (5)	3.42 (8)	3.51 (8)	3.52 (4)	3.61 (6)	3.38 (7)	3.50 (5)
Fishery (22)	3.78 (3)	2.90 (12)	3.49 (5)	3.36 (9)	3.55 (3)	3.76 (2)	3.44 (5)	3.47 (6)
Goatery (18)	3.68 (5)	3.19 (10)	3.22 (10)	3.61 (5)	3.49 (6)	3.62 (5)	3.37 (8)	3.45 (7)
Vegetable (24)	4.07 (1)	3.31 (8)	3.29 (9)	3.56 (7)	3.33 (9)	3.45 (8)	3.16 (12)	3.45 (8)
Nursery (17)	3.49 (9)	3.34 (6)	3.44 (7)	3.73 (4)	3.36 (8)	3.40 (10)	3.19 (11)	3.42 (9)
Honeybee (18)	3.30 (10)	3.45 (3)	3.49 (6)	3.32 (11)	3.51 (5)	3.43 (9)	3.40 (6)	3.41 (10)
Fruit crops (20)	3.18 (12)	3.11 (11)	3.11 (11)	3.32 (10)	3.21 (11)	3.29 (11)	3.31 (9)	3.22 (11)
Floriculture (14)	3.29 (11)	3.33 (7)	3.01 (12)	3.09 (12)	3.16 (12)	3.01 (12)	3.23 (10)	3.16 (12)

Figure 3 Mean ecosystem-construct scores by enterprise (scale 1–5); bold values mark the highest and lowest enterprise on each construct

4.7 Post hoc comparisons on ecosystem constructs

Tukey–Kramer tests identified 14 significant pairwise contrasts across the seven constructs: Market 4, Finance 2, Culture 4, Network 3, Infrastructure 1, and none for Government Policy or Human Capital (Table 8). IFS was the higher enterprise in nine of the 14. Its largest advantages were over floriculture and fruit crops on Culture (differences 0.98 and 0.89) and over fishery on Finance (0.98, $p < 0.001$). Vegetable was significantly higher than fruit crops (0.89, $p < 0.001$), honeybee (0.77, $p = 0.008$) and floriculture (0.79, $p = 0.018$) on Market, but was significantly lower than IFS on Infrastructure (0.69, $p = 0.036$). Mushroom exceeded floriculture (0.94, $p = 0.005$) and fruit crops (0.70, $p = 0.049$) on Network. Because

Network and Infrastructure showed unequal variances, and Infrastructure did not survive Holm correction, these two sets of contrasts, particularly the single Infrastructure contrast, should be interpreted cautiously.

Table 8
Significant Tukey–Kramer contrasts on ecosystem constructs

Construct	Higher enterprise	Lower enterprise	Mean difference	Tukey p
Market	Vegetable	Fruit crops	0.89	< 0.001
Market	Vegetable	Honeybee	0.77	0.008
Market	Vegetable	Floriculture	0.79	0.018
Market	IFS	Fruit crops	0.70	0.033
Finance	IFS	Fishery	0.98	< 0.001
Finance	IFS	Fruit crops	0.77	0.022
Culture	IFS	Floriculture	0.98	0.004
Culture	IFS	Fruit crops	0.89	0.005
Culture	IFS	Goatery	0.77	0.038
Culture	IFS	Vegetable	0.70	0.049
Network	Mushroom	Floriculture	0.94	0.005
Network	IFS	Floriculture	0.85	0.023
Network	Mushroom	Fruit crops	0.70	0.049
Infrastructure	IFS	Vegetable	0.69	0.036

4.8 Enterprise-wise ranking across ecosystem constructs

Averaging the seven construct ranks gave an overall enterprise order of IFS (mean rank 1.29) > Millet (3.57) > Mushroom (4.71) > Dairy (5.57) = Fishery (5.57) > Poultry (6.00) > Goatery (7.00) > Honeybee (7.14) > Vegetable (7.71) > Nursery (7.86) > Fruit crops (10.71) > Floriculture (10.86) (Table 9). This order tracks the overall AES rank closely, with only small swaps in the middle of the table (for example, honeybee has a better mean rank than its AES rank because of its strong Finance and Government Policy standing).

Ranking the constructs within each enterprise showed where support is strongest and weakest. Market was the strongest construct in five enterprises (dairy, poultry, fishery, goatery and vegetable), Network in three (mushroom, nursery and fruit crops), Culture in two (IFS and millet), and Finance and Government Policy in one each (floriculture and honeybee, respectively). Finance was the weakest construct in five enterprises (millet, mushroom, poultry, fishery and goatery), Government Policy in two (IFS and dairy),

Infrastructure in two (vegetable and nursery), and Market, Culture and Human Capital in one each (honeybee, fruit crops and floriculture). Finance was thus the most common weak point of the ecosystem, consistent with its lowest overall construct mean.

Table 9
Enterprise-wise ranking across ecosystem constructs

Enterprise	Mean rank across 7 constructs	AES rank	Strongest construct (within enterprise)	Weakest construct (within enterprise)
IFS	1.29	1	Culture	Government Policy
Millet	3.57	2	Culture	Finance
Mushroom	4.71	3	Network	Finance
Dairy	5.57	4	Market	Government Policy
Fishery	5.57	6	Market	Finance
Poultry	6.00	5	Market	Finance
Goatery	7.00	7	Market	Finance
Honeybee	7.14	10	Government Policy	Market
Vegetable	7.71	8	Market	Infrastructure
Nursery	7.86	9	Network	Infrastructure
Fruit crops	10.71	11	Network	Culture
Floriculture	10.86	12	Finance	Human Capital

4.9 Enterprise-wise force-field classification: summary

Combining the six-dimension ranks of Table 4, each enterprise was classified on how many dimensions were Favoured (ranks 1–4), Moderate (5–8) and Not favoured (9–12) (Table 10). A descriptive net score (Favoured minus Not favoured) summarises the balance of supporting and restraining forces. IFS was favoured on all six dimensions (net + 6). Mushroom and fishery followed (+ 3 each), then dairy (+ 2) and vegetable (+ 1), while poultry was balanced (0). Floriculture (− 1), goatery and millet (− 2 each), nursery and fruit crops (− 3 each) and honeybee (− 4) had more restraining than supporting forces. Honeybee was the only enterprise with no favoured dimension.

Table 10
Force-field classification of the twelve enterprise models

Enterprise	Favoured (arrow in)	Moderate	Not favoured (arrow out)	Net	Profile
IFS	6	0	0	+ 6	Consistently favoured
Mushroom	4	1	1	+ 3	Strong but one-sided
Fishery	3	3	0	+ 3	Broadly favourable
Dairy	4	0	2	+ 2	Polarised
Vegetable	1	5	0	+ 1	Mid-field, market-led
Poultry	1	4	1	0	Mid-field
Floriculture	1	3	2	−1	Constrained
Goatery	1	2	3	−2	Constrained, behaviour-led
Millet	1	2	3	−2	Mixed (small sample)
Nursery	1	1	4	−3	Constrained
Fruit crops	1	1	4	−3	Constrained
Honeybee	0	2	4	−4	Most constrained

Figure 4 Number of dimensions on which each enterprise is favoured, Moderate or not favoured, with the net force-field score

4.10 Enterprise-wise models

Twelve enterprise-wise models were built from the rank classifications in Table 10, the construct ranks in Tables 7 and 9 and the significant contrasts in Tables 5 and 8. Each model places the enterprise at the centre, with supporting forces for dimensions ranked 1–4, restraining forces for dimensions ranked 9–12 and moderate dimensions in between. The full models and the force-field diagrams are given in the online supplementary material (Online Resource 1, Fig. S1); the main patterns are as follows. IFS is consistently favoured: it is supported on all six dimensions and has no restraining force. Mushroom, fishery and dairy have strong but uneven profiles. Mushroom is strong on the ecosystem but last on communicational behaviour; fishery is strong on behaviour but constrained on finance (rank 12); and dairy is polarised between strong personal and behavioural standing and weak digital engagement. Vegetable and poultry are mid-field, vegetable being market-led but infrastructure-constrained. Goatery and millet are mixed, with relatively strong behaviour or perceived ecosystem set against thin resource bases (the millet model is tentative, n = 12). Honeybee, nursery and fruit crops carry the heaviest restraining forces (net − 4, −3 and − 3), and floriculture is last on both entrepreneurial behaviour and the ecosystem score.

5. Discussion

5.1 Summary of hypothesis tests

The results support enterprise type as a meaningful source of variation in agripreneurial behaviour and ecosystem support (Table 11). The multivariate effect was large, all six dimensions differed, and IFS held a distinctly higher position than the single-commodity enterprises. The ecosystem hypothesis was supported for five of seven constructs on unadjusted tests and for four after Holm correction.

Table 11
Summary of hypothesis tests

Hypothesis	Test	Key result	Decision
H1: joint difference on six dimensions	MANOVA	Wilks' $\Lambda = 0.403$, $p < 0.001$; multivariate $\eta^2 \approx 0.14$	Supported
H2: difference on each dimension	ANOVA (Welch-checked)	All six significant; $\eta^2 = 0.09–0.20$	Supported
H3: difference on each ecosystem construct	ANOVA, Holm, Welch, Kruskal–Wallis	5 of 7 significant (4 after Holm); Government Policy and Human Capital not significant	Partly supported
H4: IFS above single-commodity enterprises	Tukey–Kramer	IFS higher in 14 of 16 significant contrasts across the six dimensions and in 9 of 14 across the ecosystem constructs	Supported

5.2 Socio-economic status as the main separator

Socio-economic status accounted for the largest share of enterprise variance ($\eta^2 = 0.20$) and for 11 of the 16 significant post hoc contrasts, all of them IFS versus another enterprise. This result needs careful interpretation. Annual income and total land holding are the two components of the composite, and an integrated farming system combines several production activities on a single holding. Part of the IFS advantage is therefore likely structural, reflecting the scale and diversification built into the enterprise type, rather than a difference in agripreneurial capability. That said, IFS also led on entrepreneurial behaviour and on the ecosystem, and was first or second on every dimension, which is consistent with the view that diversification spreads risk and widens access to resources, markets and institutions. The cross-sectional design cannot separate whether diversified farmers build stronger ecosystems or whether those with stronger resource bases are able to diversify.

It is also notable that the remaining eleven enterprises did not differ significantly from one another on socio-economic status. Their means clustered within a narrow band (about − 0.30 to 0.05 standard-score units), so the enterprise gradient in material resources is essentially a contrast between IFS and everything else, not a ladder across the twelve types.

5.3 Uneven rather than uniformly weak ecosystems

The ecosystem analysis showed that support is not simply high or low for an enterprise but differs by construct. Vegetable growers reported the strongest market environment and the weakest infrastructure; fishery reported strong market and human capital but the weakest finance of all enterprises; mushroom reported the strongest networks; and floriculture and fruit crops were weak on culture and networks. Finance was the weakest construct overall (mean 3.34) and the most frequent weak point within enterprises, which is consistent with the broader view that access to appropriate finance is a persistent bottleneck for small-scale agripreneurs.

Government Policy and Human Capital did not differ significantly across enterprises. A cautious reading is that general policy instruments and human-capital provision are experienced in broadly similar ways whichever enterprise a farmer runs, whereas market, finance, culture, network and infrastructure conditions are enterprise-specific. Non-significance should not be read as equivalence, however: with group sizes of 12 to 26, power for modest differences is limited, and Human Capital was borderline (ANOVA $p = 0.077$; Kruskal–Wallis $p = 0.047$). Enterprise-neutral programmes may be adequate for policy awareness and training, but they are unlikely to resolve the construct-level gaps identified here.

5.4 Polarised and one-sided enterprise profiles

The force-field models reveal trade-offs that omnibus tests hide. Dairy ranks first on socio-personal characteristics and second on entrepreneurial behaviour but eleventh on digital behaviour. Mushroom ranks among the top three on socio-economic status, digital behaviour and the ecosystem but last on communicational behaviour. Goatery ranks fourth on entrepreneurial behaviour despite ranking in the bottom four on socio-economic, socio-personal and communicational dimensions, suggesting that behavioural engagement is not tightly bound to resource endowment. Millet reports the second-highest ecosystem score alongside the lowest socio-personal and digital standing, which may reflect perceptions of a supportive environment (for instance, policy and cultural attention to the crop) that are not matched by personal capacity. These profiles argue against ranking enterprises on a single composite and in favour of dimension-level diagnosis.

5.5 Omnibus significance without pairwise contrasts

Digital behaviour was significant in the omnibus ANOVA and strongly so under Welch's test ($p < 0.001$), yet no pair of enterprises differed under Tukey–Kramer. Digital engagement may vary gradually (a pattern to be tested rather than a demonstrated finding) across the twelve enterprises, with fishery, IFS, mushroom and vegetable at the top and millet, dairy and fruit crops at the bottom, without a single pair separated widely enough to survive a 66-comparison correction. Targeted digital interventions should therefore be justified from effect size and rank position, not from specific pairwise contrasts.

5.6 Theoretical and practical implications

Theoretically, the study shifts the unit of ecosystem analysis from place to enterprise. It indicates that, within a single agrarian setting, entrepreneurial ecosystems are experienced differently by enterprise type, which complements place-based ecosystem accounts (Isenberg, 2010; Stam, 2015; Spigel, 2017)

and supports treating enterprise type as a boundary condition in ecosystem theory. Methodologically, it demonstrates a multi-layer workflow (MANOVA, univariate tests with robustness checks, post hoc contrasts and rank-based force-field profiling) that moves from detecting a difference to locating it.

For rural development, the finding that support is experienced unevenly within one agrarian setting challenges the assumption behind many place-based schemes, namely that a district or block offers a common support environment to all enterprises located in it. Where support is experienced differently by enterprise type, uniform schemes are likely to reach some enterprises well and others poorly, and the enterprises that are weakest on the ecosystem and on entrepreneurial behaviour together (floriculture and fruit crops in this sample) are the ones that a uniform offer is least likely to serve well. Extension and development agencies could therefore combine place-based provision with enterprise-specific services, in particular finance products suited to biological production cycles, since finance was the weakest construct across the sample.

Practically, the models translate into differentiated priorities (Table 12). These priorities are indicative, drawn from each enterprise's lowest-ranked dimensions and constructs, and should be validated against local context.

Table 12
Indicative support priorities derived from the enterprise-wise models

Enterprise	Main restraining forces (rank 9–12)	Indicative priority
IFS	None	Sustain; strengthen Government Policy linkages
Millet	Socio-personal, socio-economic, digital behaviour	Digital inclusion and capacity building; finance
Mushroom	Communicational; Finance	Extension and information access; credit
Dairy	Communication, digital behaviour; Government Policy	Digital and information outreach; policy awareness
Poultry	Digital behaviour; Finance (weakest construct)	Digital engagement; credit access
Fishery	Finance (rank 12)	Targeted finance and credit products
Goatery	Socio-economic, communicational, socio-personal; Finance, Culture	Credit, institutional integration, information access
Vegetable	Infrastructure (rank 12)	Post-harvest and market infrastructure
Nursery	Socio-personal, socio-economic, entrepreneurial behaviour, AES; Infrastructure	Infrastructure and human-capital investment
Honeybee	Socio-personal, socio-economic, entrepreneurial behaviour, AES; Market	Market and network linkages; entrepreneurial development
Fruit crops	Communicational, digital, entrepreneurial behaviour, AES; Market, Culture	Market access, information and digital support
Floriculture	Entrepreneurial behaviour, AES; Culture, Network, Human Capital	Entrepreneurial development; networks and skills

6. Limitations

Several limitations qualify the findings. First, the design is cross-sectional, and the analysis is group-comparative, so we cannot interpret differences causally. Second, group sizes are small and unequal (12 to 26), which limits the power of Tukey–Kramer contrasts; only large differences were flagged, and several adjacent ranks are not statistically distinguishable. The millet model (n = 12) is particularly tentative. Third, Levene's test indicated unequal variances for socio-economic status, digital behaviour, the AES, Network, Human Capital and Infrastructure; Welch and Kruskal–Wallis checks supported the omnibus conclusions, but post hoc contrasts on these variables carry additional uncertainty. Fourth, the MANOVA assumptions of multivariate normality and equality of covariance matrices were not separately tested, so Pillai's trace was relied upon as the robust statistic. Fifth, the four mixed-scale composites are means of standardised components, so they are not themselves unit-variance and their grouping follows

a conceptual scheme rather than a factor-analytic one. Sixth, ecosystem constructs are self-reported perceptions and may differ from objective availability. Seventh, ranks express relative standing among twelve enterprises: a "not favoured" classification does not imply weak absolute performance, as all ecosystem means lay between 2.90 and 4.07 on a 5-point scale. Finally, the study did not control for covariates such as location, gender or enterprise age, and the many tests performed (including 396 pairwise comparisons in the six-dimension analysis) mean that isolated marginal results, such as the single Infrastructure contrast and the entrepreneurial behaviour contrast ($p = 0.038$), should be treated as exploratory. Eighth, the enterprise-wise force-field classifications rest on rank thresholds that are a descriptive convention; adjacent ranks are often not statistically distinguishable, and the classifications should be read together with the effect sizes and post hoc results.

7. Directions for Future Research

Future work could (i) use larger, balanced samples within each enterprise to firm up small-group results; (ii) test multivariate assumptions explicitly and add covariates through MANCOVA or multilevel models; (iii) validate the composites with confirmatory factor analysis and report reliability; (iv) follow enterprises longitudinally to examine whether ecosystem strength precedes or follows resource accumulation; (v) combine perceptual measures with objective indicators of credit, market and infrastructure access; and (vi) examine whether the polarised profiles identified here, such as dairy and mushroom, respond to targeted interventions.

8. Conclusion

This study examined whether twelve agri-enterprise models differ on six agripreneurial dimensions and seven ecosystem constructs, using MANOVA, univariate ANOVA, Tukey–Kramer post hoc tests and enterprise-wise force-field models. Enterprise type had a significant and large multivariate effect (Wilks' $\Lambda = 0.403$, $p < 0.001$) and all six dimensions differed significantly, with the strongest separation on socio-economic status ($\eta^2 = 0.20$). Post hoc evidence showed that IFS stands apart from all other enterprises on socio-economic status and exceeds floriculture and fruit crops on entrepreneurial behaviour and the ecosystem. Among ecosystem constructs, market, finance, culture, network and infrastructure varied by enterprise, whereas government policy and human capital did not. The enterprise-wise models showed that IFS is consistently favoured; mushroom, fishery, and dairy have strong but uneven profiles; honeybee, nursery, and fruit crops face the strongest restraining forces; and floriculture is weakest on entrepreneurial behaviour and the ecosystem. The central message is that rural agripreneurship support should be differentiated by enterprise type rather than offered as one uniform pathway: uniform programmes will miss the finance gap in fishery, the infrastructure gap in vegetables, and the culture, network and entrepreneurial-development gaps in floriculture and fruit crops. Because of small group sizes and the cross-sectional design, these conclusions are best treated as well-supported patterns for further testing rather than definitive causal statements.

Declarations

Conflict of Interest:

The authors declare no conflict of interest.

Ethics approval:

Ethical approval for the study was obtained from the appropriate Institutional Ethics Committee. The study was conducted in accordance with the ethical guidelines and regulations stipulated by the approving committee, and all methods were performed in accordance with these relevant guidelines and regulations, including the Declaration of Helsinki. The study's ethical protocol was duly approved by the Research Advisory Committee, Department of Agricultural Extension, Palli Siksha Bhavana, Visva-Bharati University, Sriniketan, West Bengal, India. Informed consent was obtained from all individual participants included in the study. The purpose, procedures and voluntary nature of this study were fully explained to all participants prior to data collection. Agripreneurs participating in the research were assured that their responses would remain completely confidential and anonymous. Participants were assured that their responses would remain confidential and anonymous

Consent to Participate

declaration: We obtained informed consent from all individual participants included in the study before data collection.

Consent to Publish

declaration: Not applicable.

Clinical trial number

Not applicable

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Funding:

This research received funding from the Indian Council of Social Science Research (ICSSR), New Delhi.

Author Contribution

Shaktiranjan Das: Conceptualisation, Methodology, Data collection and analysis, Formal Analysis, Visualisation, Writing — Original Draft. Dr Darshan N.P: Supervision, Review and Editing, Methodology guidance. Dr Arti: Supervision, Conceptualisation, Review and Editing, Resources.

Acknowledgement

Acknowledgements. The authors thank the agripreneurs who gave their time to the survey.

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author upon reasonable request.

References

1. Brown MB, Forsythe AB. Robust tests for the equality of variances. J Am Stat Assoc. 1974;69(346):364–7. https://doi.org/10.1080/01621459.1974.10482955.
2. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Lawrence Erlbaum Associates; 1988.
3. Holm S. A simple sequentially rejective multiple test procedure. Scand J Stat. 1979;6(2):65–70.
4. Isenberg DJ. The big idea: How to start an entrepreneurial revolution. Harvard Business Rev. 2010;88(6):40–50.
5. Kramer CY. Extension of multiple range tests to group means with unequal numbers of replications. Biometrics. 1956;12(3):307–10. https://doi.org/10.2307/3001919.
6. Kruskal WH, Wallis WA. Use of ranks in one-criterion variance analysis. J Am Stat Assoc. 1952;47(260):583–621. https://doi.org/10.1080/01621459.1952.10483441.
7. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. Front Psychol. 2013;4., Article 863. https://doi.org/10.3389/fpsyg.2013.00863.
8. Levene H. Robust tests for equality of variances. In: Olkin I, editor. Contributions to probability and statistics. Stanford University Press; 1960. pp. 278–92.
9. Lewin K. Field theory in social science: Selected theoretical papers. Harper & Brothers; 1951.
10. Lix LM, Keselman JC, Keselman HJ. Consequences of assumption violations revisited: A quantitative review of alternatives to the one-way analysis of variance F test. Rev Educ Res. 1996;66(4):579–619. https://doi.org/10.3102/00346543066004579.
11. Lumpkin GT, Dess GG. Clarifying the entrepreneurial orientation construct and linking it to performance. Acad Manage Rev. 1996;21(1):135–72. https://doi.org/10.5465/amr.1996.9602161568.

12. Mason C, Brown R. Entrepreneurial ecosystems and growth oriented entrepreneurship. Final report to OECD). OECD; 2014.
13. Olson CL. Comparative robustness of six tests in multivariate analysis of variance. J Am Stat Assoc. 1974;69(348):894–908. https://doi.org/10.1080/01621459.1974.10480224.
14. Pillai KCS. Some new test criteria in multivariate analysis. Annals Math Stat. 1955;26(1):117–21. https://doi.org/10.1214/aoms/1177728599.
15. Rogers EM. Diffusion of innovations. 5th ed. Free; 2003.
16. Spigel B. The relational organization of entrepreneurial ecosystems. Entrepreneurship Theory Pract. 2017;41(1):49–72. https://doi.org/10.1111/etap.12167.
17. Stam E. Entrepreneurial ecosystems and regional policy: A sympathetic critique. Eur Plan Stud. 2015;23(9):1759–69. https://doi.org/10.1080/09654313.2014.949661.
18. Tukey JW. Comparing individual means in the analysis of variance. Biometrics. 1949;5(2):99–114. https://doi.org/10.2307/3001913.
19. Welch BL. On the comparison of several mean values: An alternative approach. Biometrika. 1951;38(3–4):330–6. https://doi.org/10.1093/biomet/38.3-4.330.
20. Wilks SS. Certain generalisations in the analysis of variance. Biometrika. 1932;24(3–4):471–94. https://doi.org/10.1093/biomet/24.3-4.471.

Figures

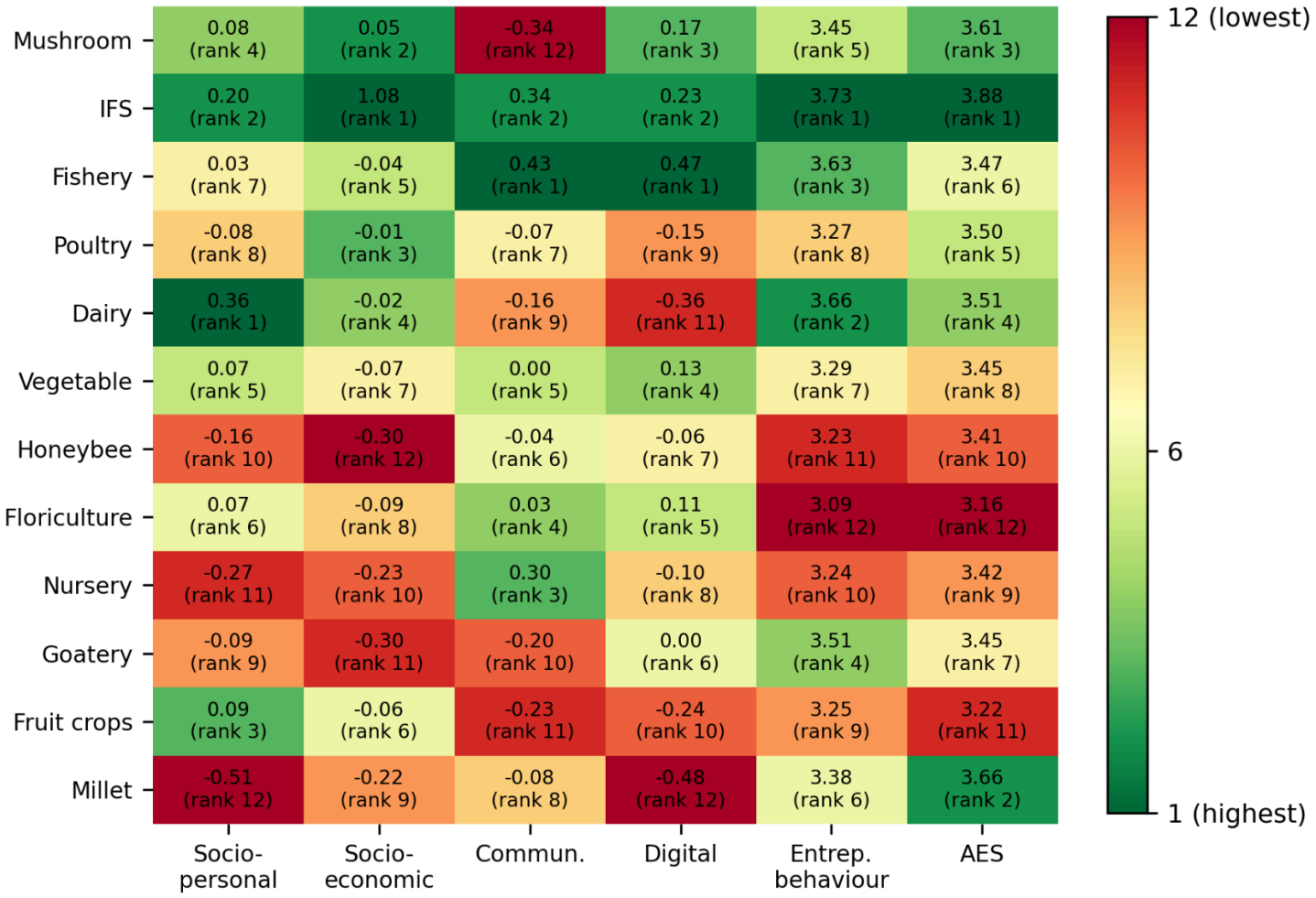


Figure 1

Mean score and rank (in parentheses) of each enterprise on the six dimensions; cell shading indicates rank from highest (1) to lowest (12). SP, SE, COM and DB are in z-score units; EB and AES are on the 1–5 scale

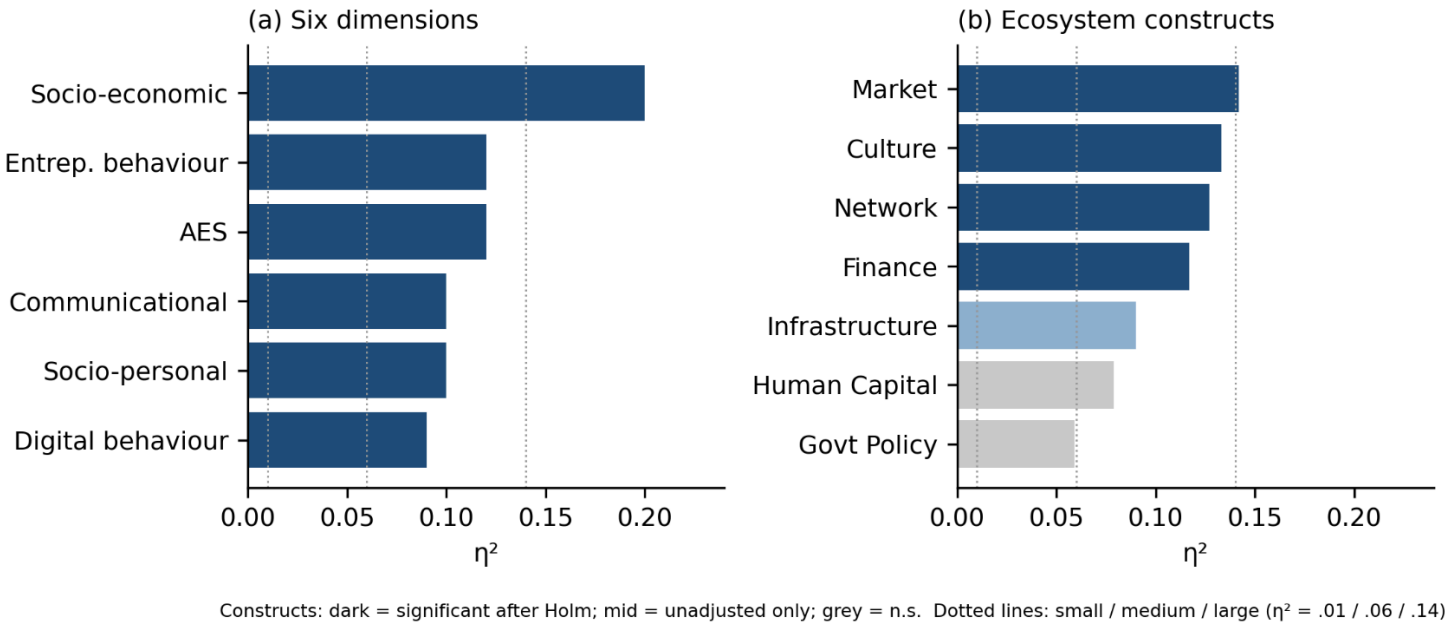


Figure 2

Effect sizes (η²) of enterprise type for (a) the six dimensions and (b) the seven ecosystem constructs

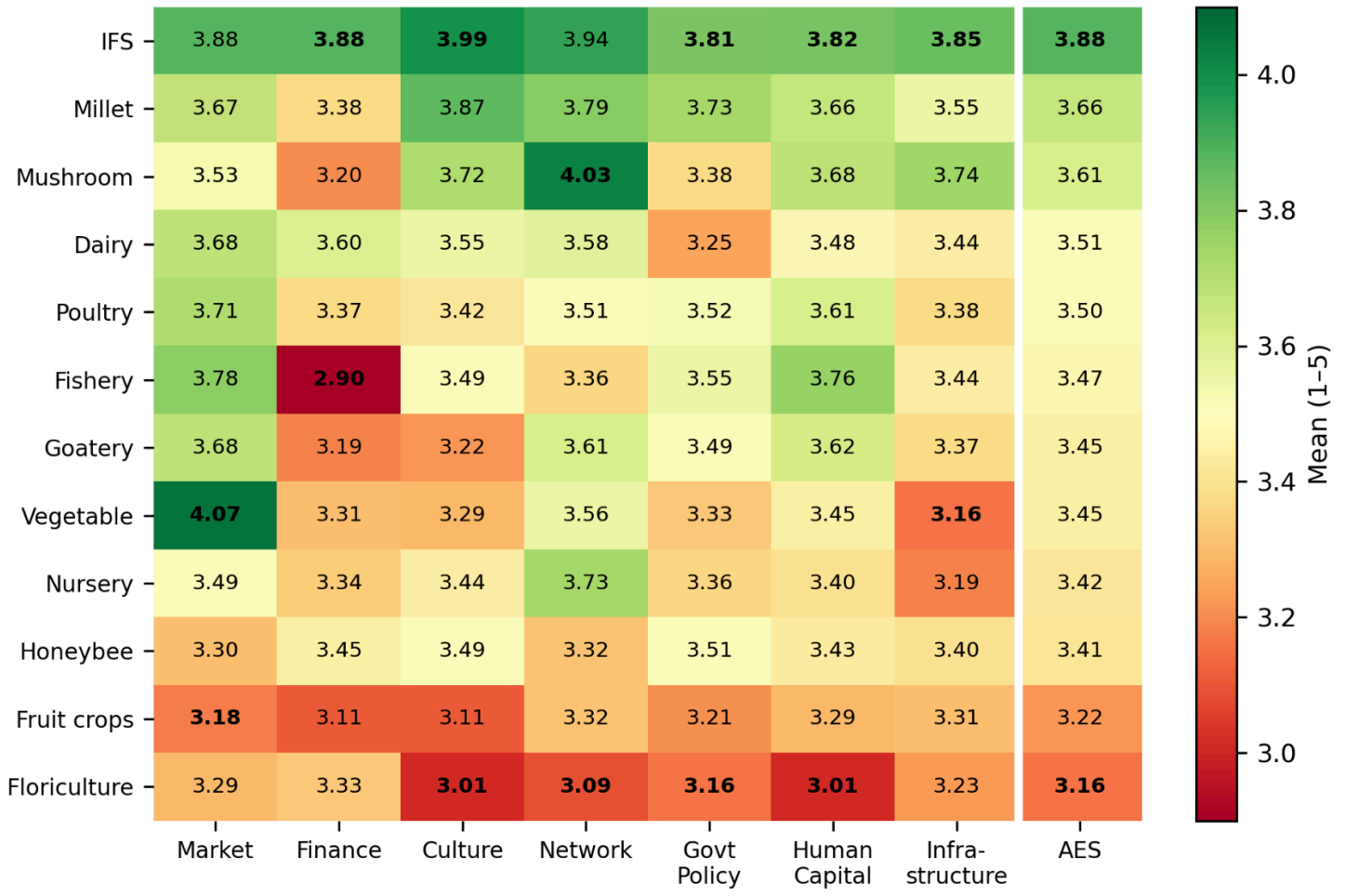


Figure 3

Mean ecosystem-construct scores by enterprise (scale 1–5); bold values mark the highest and lowest enterprise on each construct

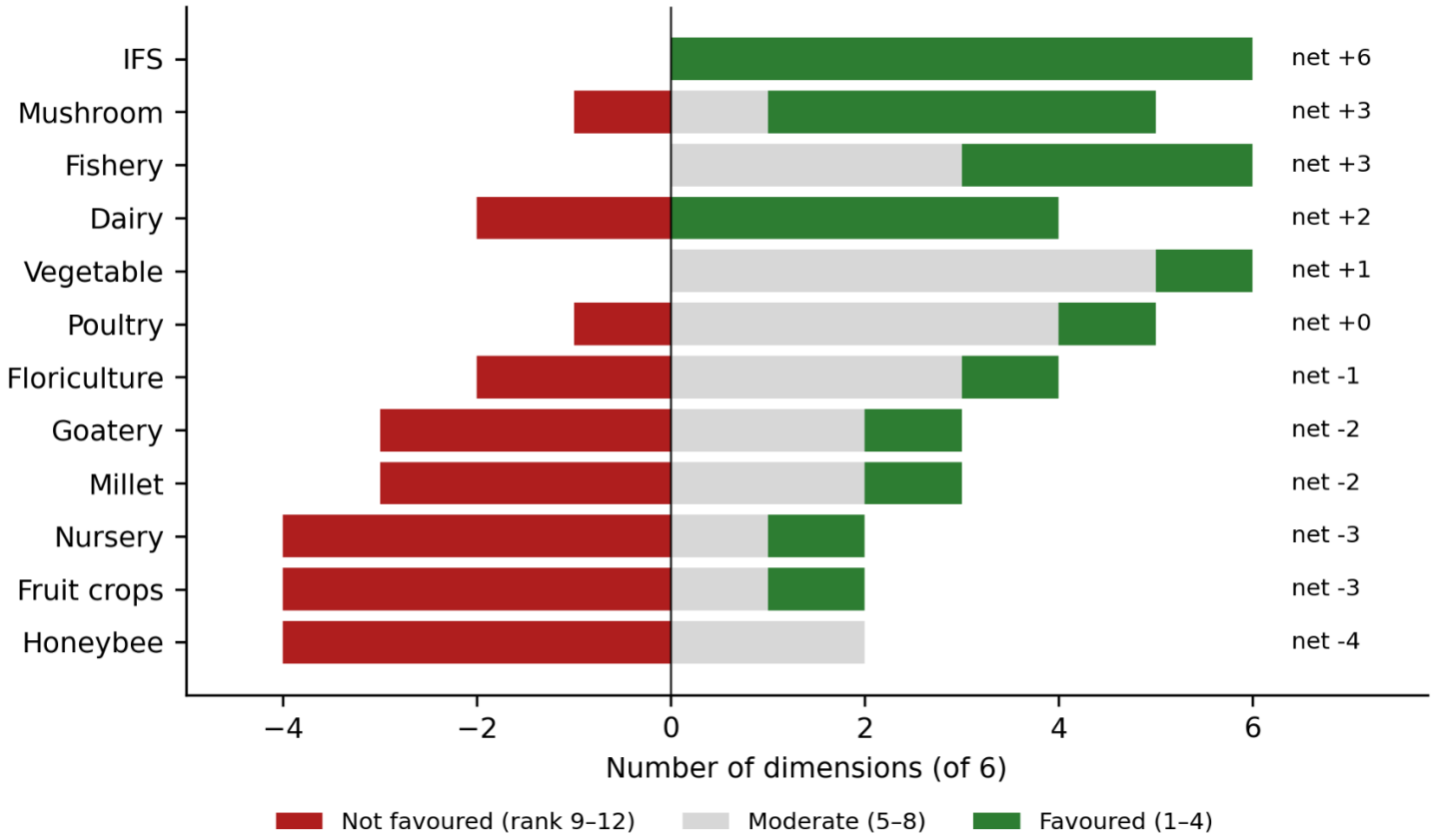


Figure 4

Number of dimensions on which each enterprise is favoured, Moderate or not favoured, with the net force-field score