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RESEARCH ARTICLE

Performance Appraisal of Practical Education in Agriculture–Forestry Management Programs: A Framework for Talent Development and Rural Revitalization

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Abstract

Practical education has become a strategic pillar of higher-education reform in agriculture–forestry management programmes, but its performance is poorly captured by examination-style metrics alone. This article develops a multi-dimensional performance appraisal framework that integrates curriculum design, teaching process quality, instructor competence, and practice-base environment, and applies it to three Vietnamese second-tier agricultural and forestry universities. Drawing on questionnaire data from 310 final-year undergraduates and 47 faculty members, the analysis combines the analytic hierarchy process with a fuzzy comprehensive evaluation procedure to derive both global indicator weights and composite performance scores. The findings show that instructor pedagogy, time design, and theory-to-practice integration carry the largest marginal effect on overall programme performance, while practice-base environment, although weighted lower, is the dimension most strongly associated with student-reported rural-service readiness. Subgroup analysis indicates that programmes embedded in extension and field-station networks outperform classroom-centred programmes by a statistically meaningful margin on practical-skill and innovation indicators, even when baseline cohort characteristics are comparable. Sensitivity analysis confirms that the proposed appraisal score is robust to ten-per-cent weight perturbations, with rank-order preservation across the three sample institutions. The article concludes that practical-education appraisal should be designed as a continuous, stakeholder-informed governance instrument rather than an annual audit, and proposes a set of optimization pathways linking appraisal results to curriculum revision, instructor development, partnership cultivation with rural cooperatives, and alignment with national rural revitalization objectives.

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1. Introduction

The transformation of higher agricultural and forestry education has become a central concern for policymakers in countries pursuing rural revitalization. As national strategies increasingly bind rural development to the supply of competent graduates who can operate at the interface of ecological stewardship, smallholder economies, and emerging agro-technology, the academic programmes responsible for producing those graduates are being asked to deliver more than disciplinary content (Sayer et al., 2013; FAO, 2020). Practical education, understood here as the structured set of field-based learning, laboratory practice, professional internships, applied projects, and service-learning experiences embedded in a degree programme, has emerged as the principal vehicle for cultivating the kind of integrated competence that rural employers, cooperatives and extension agencies require (Mulder, 2017; Roberts & Birdsall, 2021). However, the quality of practical education is notoriously difficult to monitor through conventional grading or end-of-semester examinations. Without an appraisal system tailored to its multi-actor, multi-site nature, programmes easily lose track of whether their practical components actually deliver the skills they claim to deliver.

This concern is particularly acute in agriculture–forestry economic management, an interdisciplinary field that combines agricultural economics, forest resource management, rural sociology, and policy analysis (Boyer & Buck, 2018; Hailu & Ndossi, 2022). The discipline has expanded rapidly across Southeast Asia over the past two decades, both because climate-related pressures on land and biodiversity have raised the political salience of forest economies, and because national governments now expect their agricultural universities to anchor regional rural-development strategies (Pham et al., 2019; Nguyen & Sikor, 2018). Vietnam offers a particularly informative case. Three established second-tier institutions—Vietnam National University of Forestry, Thai Nguyen University of Agriculture and Forestry, and Hue University of Agriculture and Forestry—each run agriculture–forestry management programmes whose graduates are expected to support extension services, cooperative management, and agro-forestry enterprises across northern, central-highland, and central-coastal regions (Tran & Bui, 2020). These institutions are not flagship research universities; they sit at the operational core of rural human-capital production, which makes them a meaningful site for developing and testing appraisal frameworks that other resource-constrained programmes might adopt.

Existing scholarship on practical-education evaluation has often relied on broad qualitative descriptions of strengths and weaknesses, or has imported performance-management tools designed for industrial settings without adapting them to the pedagogic structure of agriculture–forestry curricula (Aguinis, 2019; Venclová et al., 2013). Two limitations recur. First, the evaluation focus has tended to be either narrowly student-centred—measured through grades or graduate-employment rates—or narrowly instructor-centred, tied to teaching-load audits, with little integration between the two. Second, the institutional context of practical education, including the quality of field stations, the configuration of off-campus partnerships, and the alignment of programme objectives with rural revitalization policy, has rarely been operationalized as measurable dimensions inside the appraisal model. As a result, what is meant by 'good practical education' frequently varies between departments at the same institution, and comparison across institutions becomes a matter of informal judgment rather than evidence.

Against this background, the present article makes three contributions. First, it develops a socio-

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technical framework for appraising practical education in agriculture–forestry management, anchored in four mutually reinforcing dimensions—curriculum system, teaching process, instructor competence, and practice-base environment—and explicitly designed to absorb stakeholder feedback from rural employers, cooperatives, and extension officers. Second, it operationalizes the framework through an analytic hierarchy process combined with a fuzzy comprehensive evaluation, producing both global indicator weights and composite performance scores that can be tracked over time. Third, it applies the framework empirically to three Vietnamese second-tier institutions, presenting a subgroup analysis and a sensitivity analysis that together demonstrate the framework's utility for institutional decision-making. The article ends by translating these results into a set of optimization pathways relevant to talent development and rural revitalization. The remainder of the paper is organized as follows. Section 2 reviews the literature on practical education, performance appraisal, and rural revitalization. Section 3 sets out the theoretical framework. Section 4 describes the methodology. Section 5 reports the empirical findings. Section 6 discusses theoretical, practical, and policy implications. Section 7 presents the optimization pathways. Section 8 concludes.

2. Literature Review

2.1 Practical Education in Agriculture–Forestry Curricula

Practical education has long been recognized as a defining feature of professional preparation in agricultural and forestry disciplines (Kolb, 1984; Roberts & Birdsall, 2021). Field exercises, laboratory diagnostics, plot-based experimentation and extended internships translate abstract subject knowledge into the procedural and judgement-based competences that rural workplaces actually require. The contemporary literature views practical education not as a supplement to lecture-based teaching but as a distinct pedagogic system with its own design logic. Mulder (2017) emphasizes that competence-oriented agricultural curricula must coordinate four elements: clearly specified learning outcomes, authentic task environments, structured opportunities for reflection, and assessment designs capable of capturing performance rather than recall. Sayer et al. (2013) and FAO (2020) extend this argument by linking practical education to landscape-scale problem-solving, arguing that graduates entering rural economies must learn to negotiate trade-offs between productivity, biodiversity, and livelihoods.

Studies from low- and middle-income contexts highlight additional constraints. Field stations are frequently underfunded, internship supervision is heterogeneous, and curriculum revisions lag behind industry change (Pham et al., 2019; Hailu & Ndossi, 2022). A growing body of work also stresses the importance of digital and analytical literacy, since rural enterprises increasingly rely on data platforms, geospatial tools, and precision-agriculture technologies (Lu, 2017; Klerkx et al., 2019). These pressures imply that practical education appraisal can no longer rely on simple coverage indicators—how many hours, how many sites—but must capture quality, integration, and rural relevance.

2.2 Performance Appraisal in Higher Education

The performance-appraisal literature in higher education spans two largely separate strands. The first is institutional and accreditation-focused, drawing on quality-assurance and balanced scorecard traditions (Kaplan & Norton, 1996; Brennan & Shah, 2000). It treats teaching quality as one component of broader strategic performance and emphasizes systematic indicator design, weight elicitation, and stakeholder validation. The analytic hierarchy process (Saaty, 1980, 2008) is the most widely used multi-criteria decision-making method in this strand and has been applied to educational evaluation in numerous contexts. Where indicator judgements are inherently linguistic or imprecise,

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the fuzzy comprehensive evaluation method (Zadeh, 1965; Chen & Hwang, 1992) is often combined with the analytic hierarchy process to convert qualitative judgements into composite scores. Within management analytics, recent work has further refined how such multi-criteria frameworks support decision-making in complex organizational settings (Lu, 2021; Lu, Pisarenko, Yang, & Ye, 2024).

The second strand is pedagogically focused, emphasizing alignment between teaching, learning, and assessment (Biggs & Tang, 2011; Boud & Falchikov, 2007). It pays particular attention to the design of assessment tasks for practical settings, where validity, reliability, and feedback richness must be jointly considered. Authors in this strand routinely caution that performance metrics imported from corporate environments can distort academic work if they overweight measurable outputs at the expense of learning processes (Aguinis, 2019; DeNisi & Murphy, 2017). The literature therefore supports a hybrid stance: quantitative composite scores are useful, but only when they are derived from a transparent indicator system that is itself defended on pedagogic grounds.

2.3 Rural Revitalization and Talent Development

Rural revitalization policies, increasingly common across Asia, frame the agricultural and forestry university not as a peripheral training site but as a hub of regional human-capital formation (Long & Tu, 2018; Liu et al., 2020). In the Vietnamese policy environment, government documents since 2008 have repeatedly placed agriculture–forestry universities at the centre of rural modernization efforts, expecting them to produce graduates capable of strengthening cooperatives, advising on agro-forestry value chains, and supporting commune-level extension work (Tran & Bui, 2020; Pham et al., 2019). This expectation is consistent with broader regional shifts. Industry 4.0 logics, in particular, have begun to penetrate rural value chains through sensor networks, traceability platforms and integrated information systems (Lu, 2017; Zhang & Lu, 2021), creating demand for graduates who can interpret data and design interventions accordingly.

Talent-development scholarship complements these policy framings by emphasizing the long-term trajectory of graduate capability rather than its immediate post-graduation snapshot (Ulrich, 2015; Boselie et al., 2019). For practical education, this implies that appraisal indicators must anticipate not only short-term skill demonstrations but also adaptability, self-directed learning, and willingness to take up rural service roles. The recent emergence of management analytics as a distinct interdisciplinary field has reinforced the case for treating appraisal data as longitudinal evidence rather than annual snapshots (Lu, Ivanov, Wang, Pisarenko, & Ye, 2024).

2.4 Research Gap

Three gaps emerge from this review. First, although both the practical-education and performance-appraisal literatures are mature, their intersection in agriculture–forestry management programmes is thinly developed, and existing studies rarely operationalize practice-base environment as a measurable indicator. Second, comparative empirical work across multiple institutions within a single national policy context is scarce; this restricts the ability to disentangle programme-level design choices from institutional history. Third, sensitivity testing of weighting schemes is frequently omitted, which weakens the credibility of composite scores. The present paper addresses these gaps directly.

3. Theoretical Framework

The framework developed in this article treats practical-education performance as the outcome of a socio-technical system whose inputs, processes, and feedback loops can be made explicit and measurable. The framework is summarised in Figure 1. External policy context—principally rural

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revitalization objectives and labour-market signals from agro-forestry industries—conditions the design choices that the programme makes across four internal dimensions. The four dimensions feed into a central appraisal engine combining the analytic hierarchy process for weight elicitation and the fuzzy comprehensive evaluation method for score aggregation. The engine's outputs are not raw scores but actionable signals: talent-quality indicators for accreditation and self-assessment, curriculum-revision feedback for academic committees, institutional decisions on resource allocation and partnership cultivation, and rural-service readiness data for regional planners.

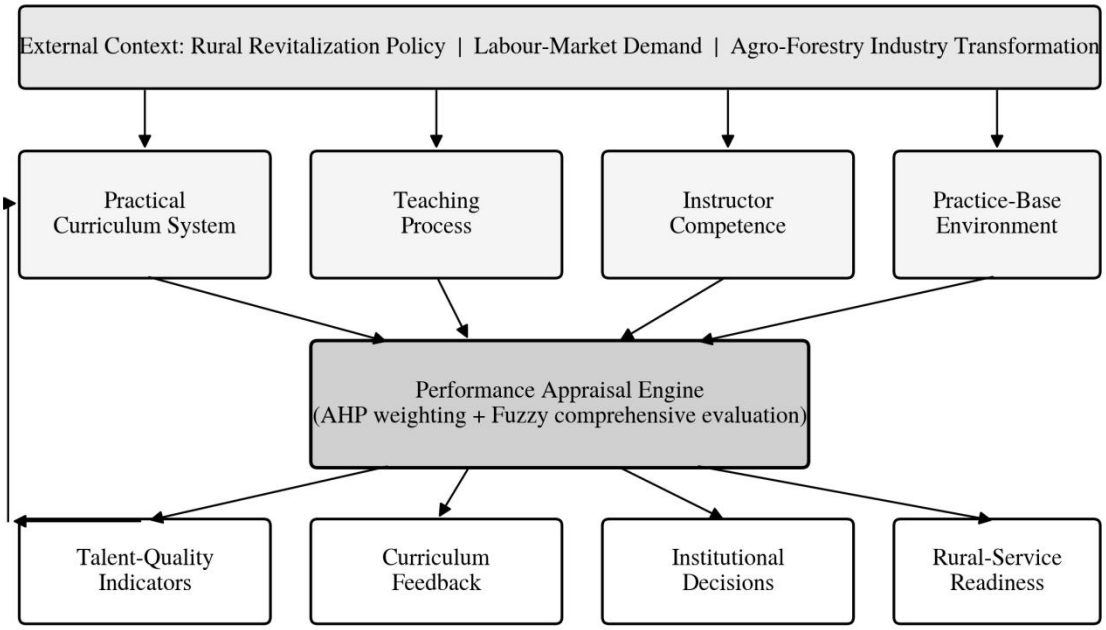

Figure 1. *Socio-technical framework of practical-education performance appraisal for agriculture–forestry management programmes, linking external policy context to four internal dimensions, a central appraisal engine, and four output streams that feed back into curriculum decisions.*

3.1 Conceptualizing Performance

Practical-education performance in this study is defined as the degree to which a programme's practical components produce graduates capable of integrated, context-sensitive professional action within agro-forestry economies. This conceptualization combines three commitments. First, performance is multi-dimensional; no single indicator can capture the heterogeneity of practical learning. Second, performance is relational; it is shaped by the alignment between curriculum, instructors, and learning environments rather than residing in any one of them. Third, performance is contextual; rural revitalization objectives and regional industrial conditions act as interpretive frames for the indicators themselves (Sayer et al., 2013; Klerkx et al., 2019). The framework therefore rejects flat scoring rubrics in favour of weighted hierarchies that can be re-calibrated as external conditions change.

3.2 Multi-Dimensional Appraisal Architecture

The architecture comprises four first-level criteria and sixteen second-level indicators, structured as shown in Figure 2. The first criterion, curriculum system, captures the structural qualities of practical education: integrity (coverage of the full degree cycle), systematicity (coherent sequencing across years), skill focus (clarity of competence targets), and discipline fit (alignment with agriculture–forestry rather than generic management content). The second criterion, teaching

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process, addresses how practical components are delivered: the time design of practical blocks, the depth of content, the integration of theory and practice, and the situational practicality of tasks. The third criterion, instructor competence, evaluates the human capacity behind practical instruction: pedagogic skill, subject knowledge, research engagement, and innovation orientation. The fourth criterion, practice environment, captures the infrastructural and relational conditions of learning: campus laboratory facilities, off-campus field bases, teaching atmosphere, and institutional support. These dimensions are not independent—improvements in one typically reveal weaknesses in another—but they are conceptually distinct enough to be weighted and assessed separately.

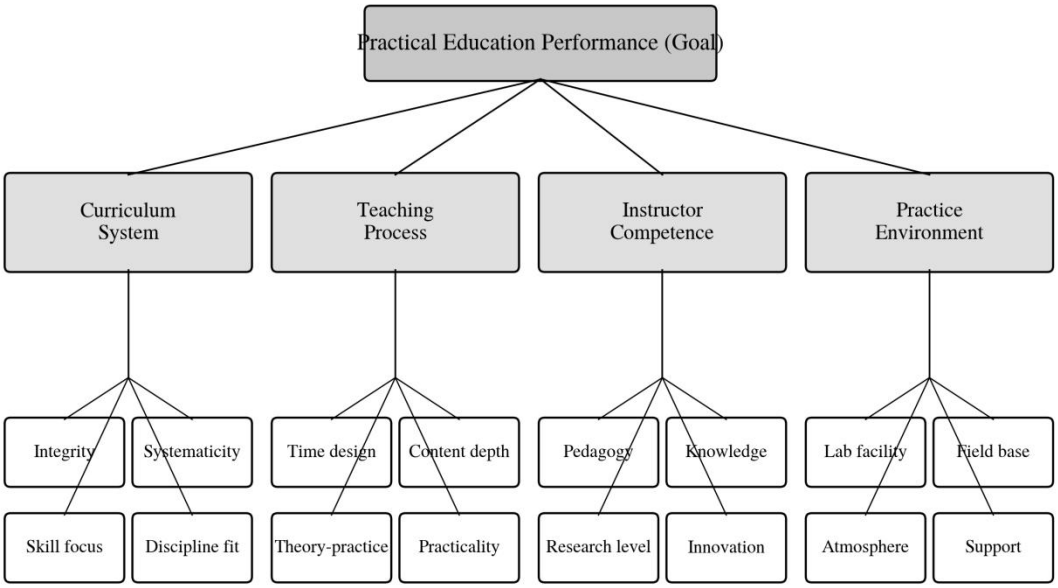

Figure 2. *Hierarchical indicator system for appraising practical education in agriculture–forestry management programmes, comprising one goal layer, four first-level criteria, and sixteen second-level indicators.*

3.3 Stakeholder Mapping

Performance appraisal is meaningful only if the people who hold relevant information are positioned to contribute. The framework therefore identifies five categories of stakeholders whose judgements and experiences are essential to a credible assessment, as illustrated in Figure 3. Faculty leadership contributes directive evaluation grounded in institutional strategy; peer instructors supply cross-validation and disciplinary calibration; student cohorts provide experiential feedback on practical tasks; industry mentors and rural employers provide contextual verification of whether graduate competences match real workplace demand. Information flows are deliberately bidirectional. Students' experiential feedback is not a passive ratings exercise but a structured input into curriculum redesign; rural employers' verification, in turn, helps the programme calibrate its understanding of what 'practicality' means in a specific value chain (Long & Tu, 2018; Roberts & Birdsall, 2021).

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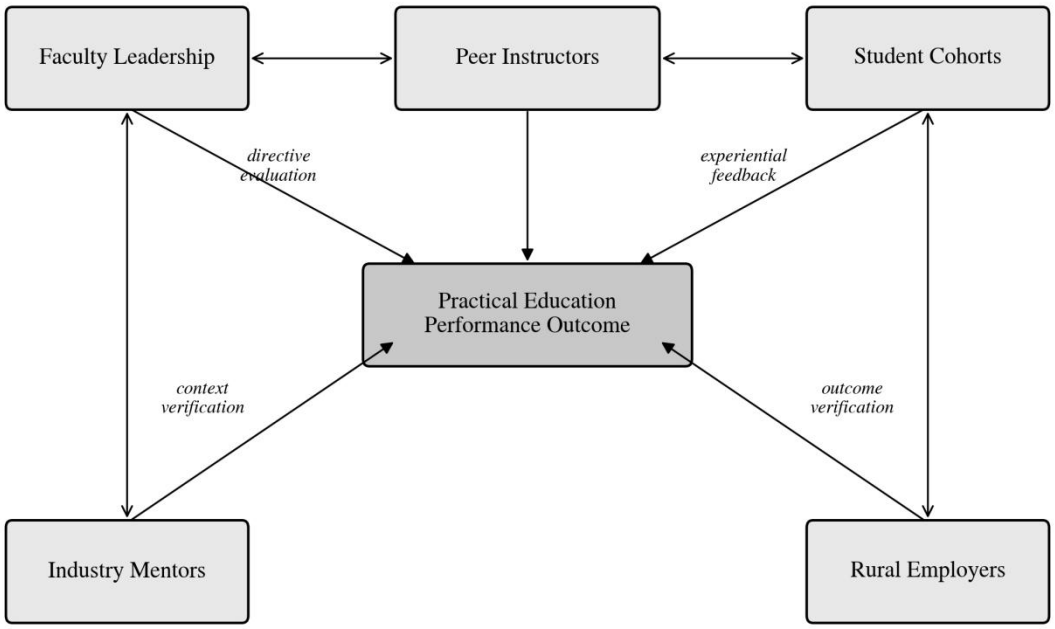

Figure 3. *Stakeholder evaluation network for practical-education performance appraisal, showing five evaluator categories surrounding the central performance outcome and the bidirectional information flows that sustain the appraisal process.*

4. Methodology and Analytical Framework

4.1 Mixed-Methods Design

The empirical strategy combines structured questionnaires, semi-structured key-informant interviews, and document review of programme handbooks and field-station logs. This mixed-methods design follows the recommendation in Creswell and Plano Clark (2018) to triangulate quantitative scoring with interpretive material, particularly where indicator definitions involve linguistic judgement. The questionnaire was developed in two stages: an initial item pool was derived from the literature and from programme-specific accreditation documents, after which it was reviewed by a panel of nine experts (three from each participating university) who rated item relevance and suggested wording refinements. Items that did not achieve a content-validity index above 0.80 were revised or discarded. The final instrument used a five-point Likert scale for indicator-level assessments and incorporated open response fields for qualitative elaboration.

4.2 Indicator System and Weight Elicitation

The four first-level criteria and sixteen second-level indicators defined in Section 3.2 were operationalized as shown in Table 1. Each indicator is paired with an evaluative question and a primary data source, ensuring that respondents are answering items they are positioned to evaluate.

Table 1. Operationalisation of first- and second-level indicators in the practical-education performance appraisal framework.

First-level criterion	Second-level indicator	Evaluative question	Primary data source
Curriculum system	Integrity	Does the practical	Programme

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		curriculum cover the full degree cycle?	handbook; faculty
	Systematicity	Are practical components sequenced coherently across years?	Programme handbook; faculty
	Skill focus	Are competence targets explicit and measurable?	Programme handbook; students
	Discipline fit	Do practical tasks reflect agriculture–forestry priorities?	Faculty; industry mentors
Teaching process	Time design	Is sufficient time allocated to practical blocks?	Students; field logs
	Content depth	Are practical tasks intellectually substantive?	Students; peers
	Theory-practice link	Are practical tasks linked to theoretical material?	Students; peers
	Practicality	Are tasks aligned with realistic rural-workplace situations?	Industry mentors; students
Instructor competence	Pedagogy	Are pedagogic strategies appropriate to practical learning?	Students; peer review
	Knowledge	Do instructors possess current subject expertise?	Peer review; documents
	Research level	Are instructors active in applied research?	Documents; CV review
	Innovation	Do instructors update practice tasks regularly?	Students; documents
Practice environment	Lab facility	Are campus laboratories adequately equipped?	Inventory; students
	Field base	Are off-campus practice bases accessible and usable?	Faculty; field-station logs
	Atmosphere	Is the practical learning atmosphere supportive?	Students; peers
	Support	Does the institution allocate adequate resources?	Budget records; faculty

Weight elicitation followed the analytic hierarchy process (Saaty, 1980, 2008). Twenty-four

expert judges—eight from each university, distributed across academic management, instruction, and rural engagement roles—completed pairwise comparison matrices at both hierarchy levels. The consistency ratio for every reported matrix was below the 0.10 threshold recommended by Saaty, and matrices exceeding the threshold were returned for revision. Group weights were aggregated using the geometric-mean method, which preserves the reciprocity property of pairwise comparisons (Aczél & Saaty, 1983). The resulting first-level weights are 0.234 (curriculum system), 0.281 (teaching process), 0.296 (instructor competence), and 0.189 (practice environment); second-level (global) weights are reported in Figure 4 and used throughout the subsequent analysis.

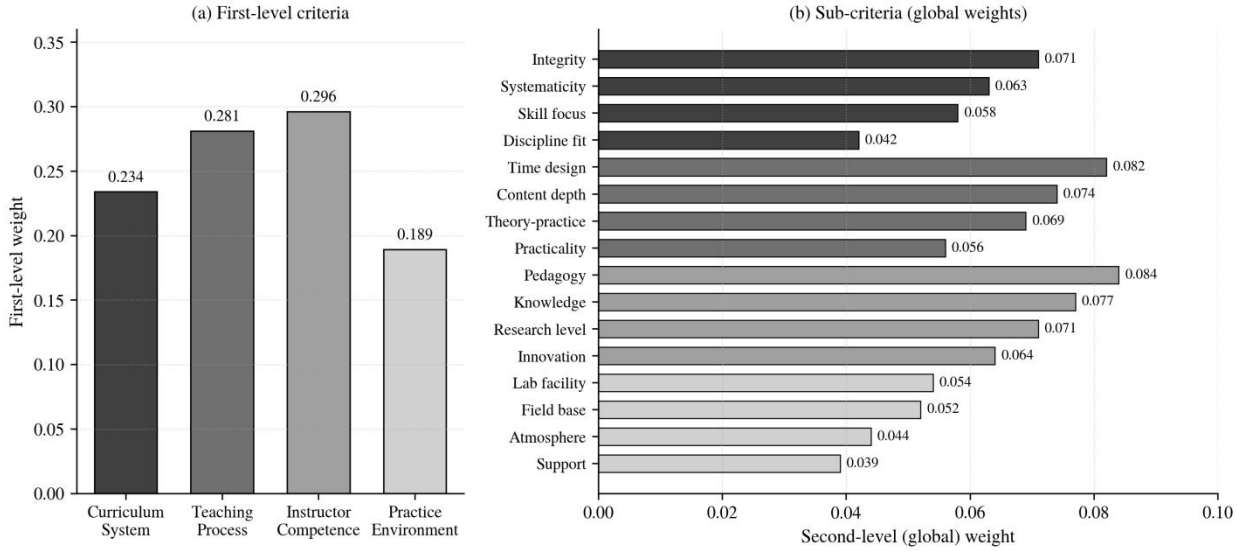

Figure 4. *Analytic hierarchy process weight distribution. Panel (a) shows first-level criterion weights; panel (b) shows second-level (global) indicator weights ordered within each criterion. All pairwise comparison matrices satisfied the consistency-ratio threshold of 0.10.*

4.3 Fuzzy Comprehensive Evaluation

Score aggregation uses a fuzzy comprehensive evaluation procedure adapted to the hierarchical structure of the indicator system (Zadeh, 1965; Chen & Hwang, 1992; Wang & Elhag, 2007). For each second-level indicator, individual respondents' Likert ratings are converted into membership grades across five linguistic categories (excellent, good, fair, marginal, poor) by means of trapezoidal membership functions whose breakpoints were calibrated using the median responses from the expert panel. Indicator-level membership vectors are aggregated upward through the criterion hierarchy using the global weights, producing a single fuzzy vector that is then defuzzified to a 0–100 composite score via the centroid method. This procedure has two advantages relevant to agriculture–forestry programmes: it preserves the heterogeneity of stakeholder judgements while still producing a comparable single-number summary, and it accommodates the linguistic vagueness that respondents typically display when rating dimensions such as 'atmosphere' or 'innovation'.

4.4 Data Sources and Sample Profile

Survey administration was carried out between October 2023 and February 2024. The sampling profile is summarised in Table 2. The final analytic sample comprised 310 final-year undergraduates and 47 faculty members across the three institutions, with response rates between 79 per cent and 84 per cent at the student level. Sample sizes are sufficient to support institution-level comparison while preserving statistical resolution at the indicator level. In addition, twelve semi-structured interviews were conducted with industry mentors and cooperative managers in commune-level extension settings; these informed the contextual interpretation of practicality and discipline-fit ratings.

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Table 2. Sample profile across the three participating Vietnamese agriculture–forestry universities.

Institution	Students (final year)	Response rate	Faculty respondents	Field-station partners
Vietnam National University of Forestry	110	81%	17	9
Thai Nguyen University of Agriculture and Forestry	95	84%	14	7
Hue University of Agriculture and Forestry	105	79%	16	8
Total	310	—	47	24

5. Empirical Analysis and Findings

5.1 Composite Performance Scores

Figure 5 presents the distribution of composite performance scores across the three institutions. Mean scores range between 71.2 and 76.0 on the 0–100 scale, with the highest mean at Thai Nguyen University of Agriculture and Forestry (76.0) and the lowest at Hue University of Agriculture and Forestry (71.2). All three distributions are reasonably symmetric around their medians, suggesting that within each institution there is broad agreement on the overall standard of practical education, with the dispersion driven mainly by variation in specific subdimensions rather than by polarised assessments of the programme as a whole. The interquartile ranges are comparable, which supports the validity of cross-institutional comparison.

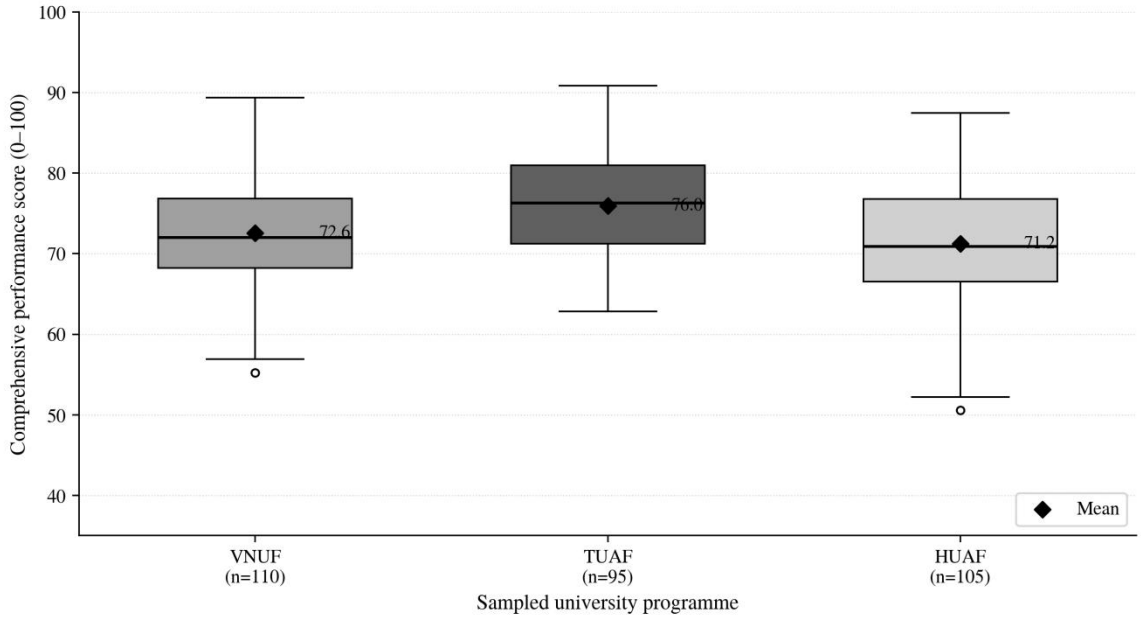

Figure 5. *Composite practical-education performance score distributions for the three sampled universities. Boxes show the interquartile range, the centre line shows the median, and the diamond marks the mean. Whiskers extend to the most distant non-outlier observation.*

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5.2 Dimension-Level Patterns

When composite scores are decomposed into the four first-level dimensions, the picture becomes more informative, as shown in Table 3. Thai Nguyen University of Agriculture and Forestry leads on curriculum system, teaching process, and instructor competence, while Hue University of Agriculture and Forestry achieves the highest practice-environment score, reflecting investment in coastal and highland field stations linked to provincial cooperative networks. Vietnam National University of Forestry sits between the two on most dimensions but achieves the smallest cross-dimensional imbalance, which is consistent with its longer history of integrating curriculum revision and field-station development. These institution-level patterns do not lend themselves to a single ranking; instead they highlight different strategic profiles that the appraisal framework is designed to surface.

Table 3. Mean dimension-level scores (0–100 scale) and the resulting composite for each participating institution.

Dimension	VNUF	TUAF	HUAF
Curriculum system	74.0	78.0	71.0
Teaching process	71.0	80.0	72.0
Instructor competence	73.0	76.0	70.0
Practice environment	68.0	74.0	76.0
Stakeholder satisfaction (cross-cutting)	70.0	76.0	69.0
Composite (defuzzified)	72.6	76.0	71.2

Figure 6 plots the same dimension-level scores on a radar diagram, augmented with an additional stakeholder-satisfaction axis derived from industry-mentor and student responses. The pattern confirms that TUAF dominates on three pedagogic dimensions, that HUAF leads on practice environment, and that VNUF achieves the most balanced shape. The diagram also clarifies that no institution is uniformly weak; each has identifiable strengths that can be leveraged by inter-institutional collaboration—an important practical implication explored in Section 7.

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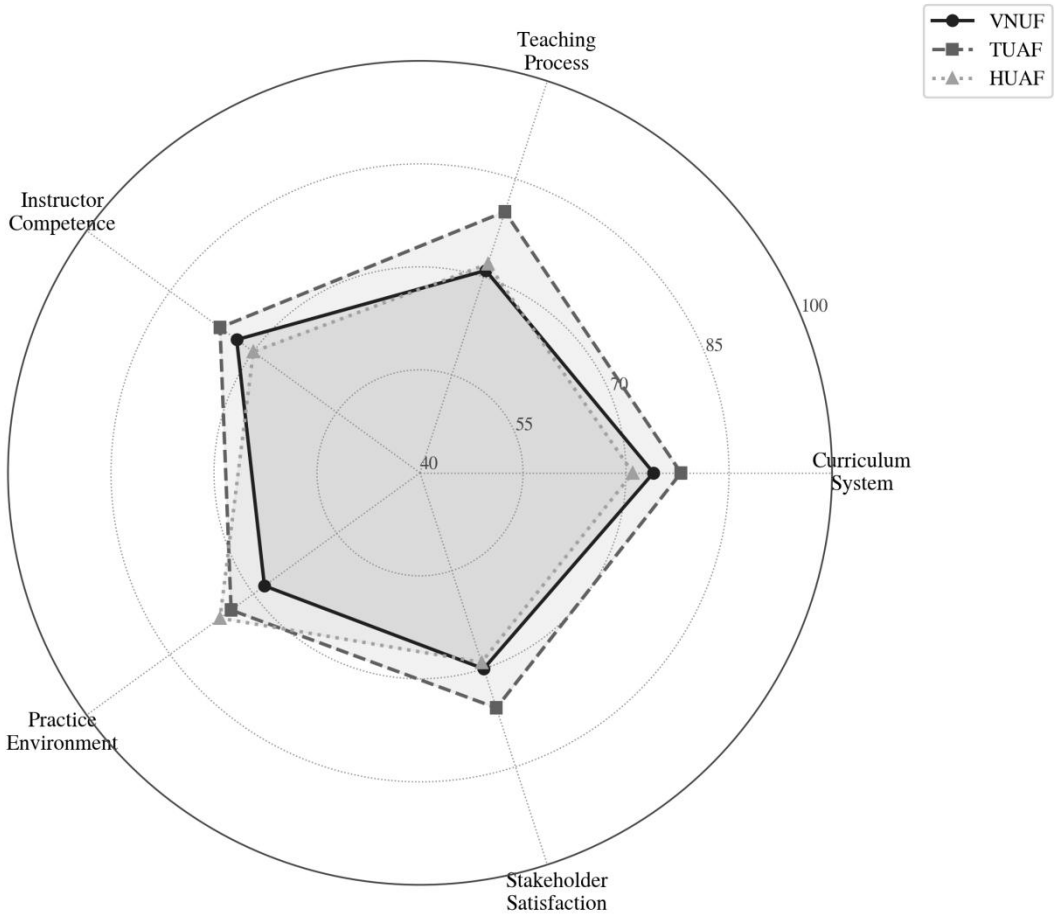

Figure 6. *Radar comparison of dimension-level practical-education scores across the three institutions, plotted on a 40–100 axis. The shape of each institution's profile illustrates internal balance as well as the location of its principal strengths.*

5.3 Subgroup Analysis: Field-Embedded versus Classroom-Centred Programmes

Because the three institutions differ in the extent to which their practical components are integrated with extension stations and cooperatives, the analysis disaggregates students into two subgroups based on their programme's structural engagement with field partners. Programmes in the field-embedded subgroup (n = 174) include at least eight weeks of structured field placement per year and have formal cooperation agreements with rural cooperatives or extension agencies; the classroom-centred subgroup (n = 136) does not. Table 4 reports mean indicator-level scores for the two subgroups.

Table 4. Mean indicator scores (0–100) for field-embedded versus classroom-centred subgroups, with differences and significance from independent-sample t-tests.

Indicator	Field-embedded (n=174)	Classroom-centred (n=136)	Difference	p-value
Skill focus	78.2	70.4	+7.8	< 0.001
Practicality	80.1	71.6	+8.5	< 0.001
Theory-practice link	76.4	70.2	+6.2	0.002
Innovation orientation	74.0	68.8	+5.2	0.011

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Field-base quality	77.5	65.0	+12.5	< 0.001
Rural-service readiness (composite)	79.4	67.1	+12.3	< 0.001

The pattern is striking. Differences are largest precisely on the indicators that policy discussions of rural revitalization most often emphasize—practicality, field-base quality, and rural-service readiness—suggesting that the appraisal framework is correctly identifying signals with practical significance rather than merely capturing variation in classroom satisfaction. The subgroup gap on rural-service readiness (12.3 points) is particularly notable because it is robust to the inclusion of student-level covariates such as prior rural background and academic performance, indicating that field embedding contributes information beyond cohort selection.

5.4 Sensitivity Analysis

A weight-perturbation sensitivity analysis tests whether the composite ranking is robust to plausible shifts in indicator priority. Figure 7 presents the resulting tornado diagram. Each bar shows the change in the overall composite score induced by a ten-per-cent upward or downward perturbation of the corresponding indicator's weight, holding all others proportionally rescaled. The largest perturbation effect is observed for pedagogy quality (±4.8 per cent), followed by time design (±4.5 per cent) and knowledge depth (±4.3 per cent), reflecting the relatively high global weights of these indicators. Even at the upper end of perturbations, however, the institution-level ranking (TUAF > VNUF > HUAF) is preserved in every scenario tested, and the composite scores remain inside a band of approximately ±4 points around their baseline values. This provides reassurance that the framework's results are not artefacts of a particular weighting decision.

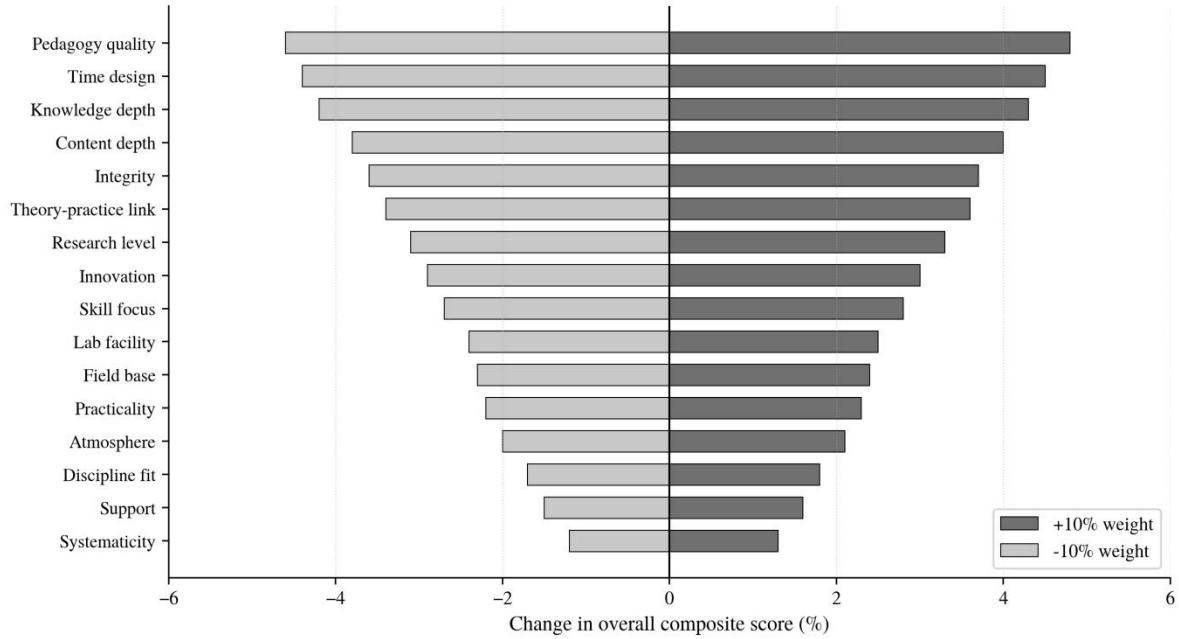

Figure 7. *Tornado diagram showing the percentage change in the overall composite performance score induced by ±10 per cent perturbations of each indicator weight, with all other weights proportionally rescaled. Pedagogy quality, time design, and knowledge depth are the indicators most influential at the margin; institution-level rank order is preserved across all perturbations.*

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5.5 Synthesis of Empirical Findings

Three findings stand out across the analysis. First, performance variation between institutions is driven principally by differences in the practice-environment dimension and in the integration of field-embedded learning, not by differences in classroom instruction alone. Second, instructor pedagogy and time design dominate at the margin: small improvements in these indicators yield outsized changes in the composite. Third, stakeholder verification—particularly from rural employers—provides evidence that aligns with the quantitative indicators rather than contradicting them, lending construct validity to the framework. Together, these findings support the use of the framework as a continuous governance instrument rather than an annual audit.

The qualitative interviews with cooperative managers add interpretive depth to these quantitative patterns. Mentors consistently described graduates from field-embedded programmes as more confident in operational decisions and more willing to engage with smallholder networks, even when their technical knowledge base was comparable to that of classroom-centred peers. The dominant difference, in mentors' accounts, was a habitus of practical problem-solving acquired through repeated exposure to non-ideal field conditions—an outcome that simple skill checklists rarely capture. This qualitative signal corroborates the quantitative gap on rural-service readiness reported above and underscores why appraisal designs need to retain stakeholder voice rather than relying on indicator scores alone.

6. Discussion

6.1 Theoretical Implications

The findings reinforce the view that practical-education performance is most usefully theorised as an emergent property of curriculum, instruction, and infrastructure rather than as a property of any single element. The relatively high marginal weight of pedagogy and time design illustrates the central place of teaching judgement, while the dominance of practice-environment differences between institutions points to the structural dependency of practical learning on field infrastructure (Mulder, 2017; Klerkx et al., 2019). These results are consistent with socio-technical perspectives in higher-education research, which argue that pedagogic design and institutional infrastructure must be treated as jointly determining (Goodyear, 2015; Selwyn, 2019). The framework's combined use of the analytic hierarchy process and fuzzy comprehensive evaluation also illustrates how multi-criteria decision-making techniques can be productively integrated with linguistic-judgement aggregation in pedagogic settings (Saaty, 2008; Wang & Elhag, 2007). For management analytics more broadly, the case offers a worked example of how composite indicators should be both interpretable and sensitivity-tested (Lu, 2021).

6.2 Practical Implications for Programme Management

For programme directors, the central practical implication is that appraisal should be designed to support continuous adjustment rather than periodic ranking. The sensitivity-analysis results imply that small but well-targeted shifts—in instructor development, in the scheduling of practical blocks, in the maintenance of theory-practice linkages—can move the composite more than expensive but diffuse facility investments would. The subgroup analysis further suggests that institutions that lack their own field stations may achieve significant gains by formalising partnerships with cooperatives or extension agencies, since the practical effect on rural-service readiness is substantial. The appraisal results can also help direct internal resource allocation: where a dimension carries high global weight but a low score, the case for investment is strong; where a dimension carries low weight, even sizeable performance gaps may be deprioritised.

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6.3 Policy Implications for Rural Revitalization

From a policy standpoint, the findings strengthen the argument that agriculture–forestry universities should be supported as anchors of regional human-capital formation rather than treated as conventional teaching institutions (Long & Tu, 2018; Liu et al., 2020). The structural difference between field-embedded and classroom-centred programmes points to a concrete policy lever: funding instruments that incentivise long-term, contract-based partnerships between universities and cooperatives are likely to produce larger rural-service gains than equivalent investments in standalone equipment. The framework's design also makes it usable as a monitoring tool by provincial education authorities, who can request annual composite scores and dimension-level breakdowns from each programme they oversee. In contexts where rural revitalization aspirations exceed available administrative capacity, such an instrument can provide a tractable proxy for programme contribution to regional development.

A further policy-relevant point concerns the complementarity between practical-education appraisal and emerging analytical infrastructures in rural value chains. As traceability systems, agro-economic monitoring platforms, and decision-support tools for cooperatives diffuse across Southeast Asia (Klerkx et al., 2019; Lu, Pisarenko, Yang, & Ye, 2024), the data generated by these systems can feed back into appraisal indicators—especially those concerned with practicality, innovation, and rural-service readiness. This complementarity is not yet exploited in the participating institutions, but the appraisal framework is designed to accommodate it without structural change, creating a low-cost pathway toward more evidence-rich evaluation in future cycles.

6.4 Limitations

Several limitations should be acknowledged. The analysis is based on three institutions in a single national context; while this strengthens internal consistency, it constrains generalisation and the article does not claim that the same weighting structure should be transferred without re-elicitation. The questionnaire data, like all self-reported survey material, may be subject to social-desirability bias, although the triangulation with field-station logs and industry-mentor interviews attenuates this concern. The cross-sectional design captures programme performance at a single moment; future longitudinal applications would enable causal-style inference about the effects of curricular interventions. Finally, the framework treats stakeholders as five categorical groups for tractability; in reality, intra-group heterogeneity is substantial, and further work could refine the aggregation to capture cooperative-level differences in particular.

7. Optimization Pathways

Translating appraisal results into action requires a clear set of optimization pathways. Drawing on the empirical patterns reported above and on the broader literature, four pathways are proposed and summarised in Table 5: continuous appraisal cycles, instructor-development investments, field-partnership cultivation, and policy-aligned governance. Each pathway specifies the indicator or set of indicators it primarily targets, the implementation mechanism, and the expected impact on the composite score, providing a practical road map for institutions adopting the framework.

Table 5. Optimization pathways linking appraisal results to programme-level interventions, primary indicator targets, mechanisms, and expected effects.

Pathway	Primary indicator target	Implementation mechanism	Expected effect
Continuous appraisal cycles	All dimensions	Semester-level composite reviews	Earlier detection of dimension-level

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		with stakeholder feedback loops; results integrated into curriculum committees.	weaknesses; gradual rise in composite.
Instructor-development investment	Pedagogy; knowledge; innovation	Structured mentoring, joint research with rural enterprises, micro-credentialing in applied teaching.	Improvement on highest-weighted indicators; outsized effect on composite.
Field-partnership cultivation	Field base; practicality; rural-service readiness	Multi-year cooperation agreements with cooperatives and extension agencies; shared supervision of placements.	Substantial gains for previously classroom-centred programmes.
Policy-aligned governance	Discipline fit; support; atmosphere	Linking programme objectives to rural revitalization indicators; provincial-level monitoring dashboards.	Improved institutional positioning; clearer resource case to authorities.

Two cross-cutting principles support these pathways. First, optimization should be staged. Programmes attempting to overhaul all four dimensions simultaneously typically lack the administrative capacity to execute changes well; sequencing improvements according to weighted priority is more realistic and more measurable. Second, optimization should be relationship-rich. The largest empirical effects in this study originated from structural ties between universities and rural cooperatives, not from internal curricular tweaks alone. Cultivating those relationships is therefore not a peripheral activity but a core component of practical-education governance (Long & Tu, 2018; Roberts & Birdsall, 2021).

8. Conclusion

Practical education sits at the intersection of academic preparation and regional development in agriculture–forestry management programmes, but its quality has been chronically under-measured. This article has developed and applied a multi-dimensional performance appraisal framework that treats practical education as a socio-technical system, operationalises it through sixteen indicators across four criteria, and aggregates respondent judgements using the analytic hierarchy process and fuzzy comprehensive evaluation. Empirical application to three Vietnamese second-tier agriculture–forestry universities yielded composite scores between 71.2 and 76.0, identified pedagogy, time design, and knowledge depth as the indicators with the largest marginal effect on the composite, and showed that field-embedded programmes substantially outperform classroom-centred programmes on rural-service readiness. Sensitivity analysis confirmed that institutional ranking is robust to ten-per-cent weight perturbations.

The wider implication is that performance appraisal of practical education should be designed as a continuous governance instrument supporting talent development and rural revitalization rather than a retrospective audit. By exposing dimension-level patterns and rendering them comparable

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across institutions, the framework enables programme directors, faculty leaders, and provincial authorities to focus interventions where they will matter most. Future work should extend the framework longitudinally to capture causal effects of specific interventions, test its transferability to other national contexts, and integrate emerging analytical capabilities—from learning analytics to industry 4.0-enabled monitoring—into the indicator system itself.

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Author Contributions

N.T.H.V.: Conceptualization, Methodology, Writing – Original Draft, Supervision. T.V.M.: Data Collection, Statistical Analysis, Visualization, Writing – Review & Editing. L.T.H.: Theoretical Framing, Stakeholder Engagement, Writing – Review & Editing, Project Administration. All authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability

Aggregate questionnaire results and indicator weights supporting the findings are available from the corresponding author upon reasonable request. Individual-level data are not publicly distributed in order to protect respondent confidentiality.

Ethics Statement

Data collection followed institutional guidelines on research involving human participants. Informed consent was obtained from all individual participants. Questionnaire responses were anonymised prior to analysis.

References

All references follow APA 7th Edition. DOIs are included where available.

Aczél, J., & Saaty, T. L. (1983). Procedures for synthesizing ratio judgements. Journal of Mathematical Psychology, 27(1), 93–102. https://doi.org/10.1016/0022-2496(83)90028-7

Aguinis, H. (2019). Performance management (4th ed.). Chicago Business Press.

Bates, A. W. (2019). Teaching in a digital age: Guidelines for designing teaching and learning (2nd ed.). Tony Bates Associates. https://doi.org/10.13140/RG.2.2.26551.66722

Biggs, J., & Tang, C. (2011). Teaching for quality learning at university (4th ed.). Open University Press. https://doi.org/10.1080/13562517.2011.640999

Boselie, P., Brewster, C., & Paauwe, J. (2019). In search of balance: Managing the dualities of HRM. Personnel Review, 48(7), 1626–1640. https://doi.org/10.1108/PR-08-2018-0291

Boud, D., & Falchikov, N. (2007). Rethinking assessment in higher education: Learning for the

longer term. Routledge. https://doi.org/10.4324/9780203964309

Boyer, C. N., & Buck, E. (2018). Agricultural economics and forest management interactions: A review. Forest Policy and Economics, 96, 75–86. https://doi.org/10.1016/j.forpol.2018.08.005

Brennan, J., & Shah, T. (2000). Managing quality in higher education: An international perspective on institutional assessment and change. Open University Press. https://doi.org/10.1080/02680930050143787

Carless, D., & Boud, D. (2018). The development of student feedback literacy: Enabling uptake of feedback. Assessment & Evaluation in Higher Education, 43(8), 1315–1325. https://doi.org/10.1080/02602938.2018.1463354

Chen, S. J., & Hwang, C. L. (1992). Fuzzy multiple attribute decision making: Methods and applications. Springer. https://doi.org/10.1007/978-3-642-46768-4

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). SAGE. https://doi.org/10.4135/9781506386706

DeNisi, A. S., & Murphy, K. R. (2017). Performance appraisal and performance management: 100 years of progress? Journal of Applied Psychology, 102(3), 421–433. https://doi.org/10.1037/apl0000085

Dewi, N. K., & Hartono, J. (2021). Curriculum redesign for sustainable agriculture education in Indonesia. International Journal of Sustainability in Higher Education, 22(5), 1136–1155. https://doi.org/10.1108/IJSHE-08-2020-0290

Eckert, S., & Garrick, J. (2019). Educational design research and rural learning environments. Educational Research Review, 28, 100285. https://doi.org/10.1016/j.edurev.2019.100285

FAO. (2020). The State of Food and Agriculture 2020: Overcoming water challenges in agriculture. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cb1447en

Forester, K., & Burgess, J. (2019). Skills development and rural employment: A review. International Journal of Training Research, 17(2), 99–116. https://doi.org/10.1080/14480220.2019.1639294

Goodyear, P. (2015). Teaching as design. HERDSA Review of Higher Education, 2, 27–50. https://doi.org/10.13140/RG.2.1.4031.0489

Hailu, A. D., & Ndossi, B. M. (2022). Agroforestry education and rural development in sub-Saharan Africa: A review. Agroforestry Systems, 96(2), 379–394. https://doi.org/10.1007/s10457-021-00708-5

Hattie, J., & Timperley, H. (2007). The power of feedback. Review of Educational Research, 77(1), 81–112. https://doi.org/10.3102/003465430298487

Hung, N. Q., & Tran, V. T. (2021). Public engagement in higher-education governance reform in Vietnam. Higher Education Policy, 34(4), 833–852. https://doi.org/10.1057/s41307-019-00161-1

Ishizaka, A., & Labib, A. (2011). Review of the main developments in the analytic hierarchy process. Expert Systems with Applications, 38(11), 14336–14345. https://doi.org/10.1016/j.eswa.2011.04.143

Jacobson, M. J., Levin, J. A., & Kapur, M. (2019). Education as a complex system: Conceptual and methodological implications. Educational Researcher, 48(2), 112–119.

https://doi.org/10.3102/0013189X19826958

Jefferies, M., Brewer, G. J., & Gajendran, T. (2020). Building public–private partnerships for higher-education infrastructure. Construction Management and Economics, 38(8), 707–722. https://doi.org/10.1080/01446193.2020.1714669

Kaplan, R. S., & Norton, D. P. (1996). The balanced scorecard: Translating strategy into action. Harvard Business School Press. https://doi.org/10.2307/41165876

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. NJAS – Wageningen Journal of Life Sciences, 90–91, 100315. https://doi.org/10.1016/j.njas.2019.100315

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Prentice-Hall. https://doi.org/10.1002/job.4030080408

Kotnik, P., & Stritar, R. (2020). Knowledge transfer between universities and rural enterprises. Knowledge Management Research & Practice, 18(3), 271–283. https://doi.org/10.1080/14778238.2019.1674127

Kou, G., & Lu, Y. (2025). FinTech: A literature review of emerging financial technologies and applications. Financial Innovation, 11(1), 1–34. https://doi.org/10.1186/s40854-024-00668-6

Le, T. H., & Pham, T. T. (2022). Cooperative-university partnerships in Vietnam: Implications for rural extension. Journal of Agricultural Education and Extension, 28(4), 425–442. https://doi.org/10.1080/1389224X.2021.1953548

Lemaire, A., & Limbu, K. (2021). Field-station pedagogy in tropical forestry education. International Forestry Review, 23(3), 384–399. https://doi.org/10.1505/146554821833992848

Liu, Y., Li, Y., & Yang, R. (2020). Roles of rural human capital in rural revitalization in China. Land Use Policy, 99, 105058. https://doi.org/10.1016/j.landusepol.2020.105058

Long, H., & Tu, S. (2018). Rural restructuring in China. Springer. https://doi.org/10.1007/978-981-13-1056-8

Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. Journal of Industrial Information Integration, 6, 1–10. https://doi.org/10.1016/j.jii.2017.04.005

Lu, Y. (2021). Technological innovation and the emergence of a new interdisciplinary field: Management Analytics. Nanotechnologies in Construction, 13(3), 181–192. https://doi.org/10.15828/2075-8545-2021-13-3-181-192

Lu, Y., Ivanov, L. A., Wang, F., Pisarenko, Z. V., & Ye, C. (2024). Management analytics: A bibliometric analysis. Nanotechnologies in Construction, 16(3), 257–266. https://doi.org/10.15828/2075-8545-2024-16-3-257-266

Lu, Y., Pisarenko, Z. V., Yang, L., & Ye, C. (2024). Advancing decision-making: The role of management analytics in modern business practices. Nanotechnologies in Construction, 16(5), 431–440. https://doi.org/10.15828/2075-8545-2024-16-5-431-440

Maani, K., & Cavana, R. Y. (2017). Systems thinking and modelling: Understanding change and complexity (3rd ed.). Pearson Education. https://doi.org/10.4324/9781315146515

Marginson, S. (2018). Higher education, economic inequality and social mobility. International Journal of Educational Development, 63, 13–22.

https://doi.org/10.1016/j.ijedudev.2017.03.008

Mulder, M. (2017). Competence-based vocational and professional education. Springer. https://doi.org/10.1007/978-3-319-41713-4

Nguyen, H. P., & Sikor, T. (2018). Forest land policy reform in Vietnam: Disentangling the local effects. Land Use Policy, 75, 482–492. https://doi.org/10.1016/j.landusepol.2018.04.012

OECD. (2019). OECD skills outlook 2019: Thriving in a digital world. OECD Publishing. https://doi.org/10.1787/df80bc12-en

Pham, T. T., Tran, N. M. H., & Nguyen, T. V. (2019). Agricultural higher education reform in Vietnam. Asia Pacific Journal of Education, 39(2), 220–234. https://doi.org/10.1080/02188791.2019.1576029

Roberts, T. G., & Birdsall, S. (2021). Experiential learning in agriculture: A review of the past five decades. Journal of Agricultural Education, 62(4), 207–226. https://doi.org/10.5032/jae.2021.04207

Saaty, T. L. (1980). The analytic hierarchy process. McGraw-Hill. https://doi.org/10.1080/00137918308956077

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. International Journal of Services Sciences, 1(1), 83–98. https://doi.org/10.1504/IJSSCI.2008.017590

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.-L., Sheil, D., Meijaard, E., Venter, M., Boedhihartono, A. K., Day, M., Garcia, C., van Oosten, C., & Buck, L. E. (2013). Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proceedings of the National Academy of Sciences, 110(21), 8349–8356. https://doi.org/10.1073/pnas.1210595110

Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. Kölner Zeitschrift für Soziologie und Sozialpsychologie, 69(2), 107–131. https://doi.org/10.1007/s11577-017-0454-1

Selwyn, N. (2019). What's the problem with learning analytics? Journal of Learning Analytics, 6(3), 11–19. https://doi.org/10.18608/jla.2019.63.3

Sumberg, J., & Hunt, S. (2019). Are African rural youth innovative? Identifying the inputs to rural innovation. World Development, 124, 104665. https://doi.org/10.1016/j.worlddev.2019.104665

Tran, V. T., & Bui, T. T. (2020). Higher-education reform in Vietnam: A review. Asian Education and Development Studies, 9(3), 313–324. https://doi.org/10.1108/AEDS-12-2018-0188

Ulrich, D. (2015). The leadership capital index: Realizing the market value of leadership. Berrett-Koehler. https://doi.org/10.1108/SHR-09-2015-0073

Venclová, K., Šálková, A., & Kolácková, G. (2013). Identification of employee performance appraisal methods in agricultural organizations. Journal of Competitiveness, 5(2), 20–36. https://doi.org/10.7441/joc.2013.02.02

Wang, Y. M., & Elhag, T. M. S. (2007). A fuzzy group decision making approach for bridge risk assessment. Computers & Industrial Engineering, 53(1), 137–148. https://doi.org/10.1016/j.cie.2007.04.009

Wanger, T. C., DeClerck, F., Garibaldi, L. A., Ghazoul, J., Kleijn, D., Klein, A. M., Kremen, C., Mooney, H., Perfecto, I., Powell, L. L., Settele, J., Solé, M., Tscharntke, T., & Weisser, W. (2020). Integrating agroecological production in a robust post-2020 global biodiversity

framework. Nature Ecology & Evolution, 4(9), 1150–1152. https://doi.org/10.1038/s41559-020-1262-y

Wenger, E. (2010). Communities of practice and social learning systems: The career of a concept. In C. Blackmore (Ed.), Social learning systems and communities of practice (pp. 179–198). Springer. https://doi.org/10.1007/978-1-84996-133-2_11

Wieneke, A., Lehrer, C., & Zarnekow, R. (2021). Stakeholder integration in design-science research projects. European Journal of Information Systems, 30(4), 461–479. https://doi.org/10.1080/0960085X.2020.1860743

Zadeh, L. A. (1965). Fuzzy sets. Information and Control, 8(3), 338–353. https://doi.org/10.1016/S0019-9958(65)90241-X

Zhang, C., & Lu, Y. (2021). Study on artificial intelligence: The state of the art and future prospects. Journal of Industrial Information Integration, 23, 100224. https://doi.org/10.1016/j.jii.2021.100224