

The Role of Human Resource Competencies in Enhancing Sustainable Performance of Aquaculture SMEs: The Mediating Effect of Adaptive Capability

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Abstract

This study examines the role of human resource competencies in enhancing sustainable performance in aquaculture small and medium-sized enterprises (SMEs) through the mediating role of adaptive capability. In increasingly competitive and uncertain business environments, many aquaculture SMEs face challenges in converting workforce competencies into sustainable long-term performance. Drawing on the Resource-Based View (RBV) and Dynamic Capabilities Theory, this study argues that human resource competencies constitute valuable organizational resources, while adaptive capability enables firms to reconfigure and utilize these resources effectively in response to environmental changes. Unlike prior studies that mainly focus on the direct relationship between human resources and performance, this research highlights adaptive capability as a key mechanism explaining how competencies contribute to sustainable outcomes within the informal human resource context of aquaculture SMEs. Data were collected from 250 owners and employees of aquaculture SMEs and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results indicate that human resource competencies significantly enhance adaptive capability ($\beta = 0.56$; $p < 0.001$), and adaptive capability significantly improves sustainable performance ($\beta = 0.39$; $p < 0.001$). Furthermore, adaptive capability partially mediates the relationship between human resource competencies and sustainable performance, suggesting that competencies contribute to performance both directly and indirectly through organizational adaptability. These findings demonstrate that sustainable performance depends not only on workforce competencies but also on the firm's ability to translate those competencies into adaptive operational practices. The study provides important implications for SME managers and policymakers in strengthening competency development and adaptive organizational routines to support long-term business sustainability and resilience.

KEYWORDS

human resource competencies; adaptive capability; sustainable performance; aquaculture smes; dynamic capabilities theory.

Introduction

Small and medium-sized enterprises (SMEs) play a crucial role in both national and global economies, particularly in emerging and developing countries. Due to their ability to stimulate innovation, enhance organizational flexibility, and create employment opportunities, SMEs are widely recognized as key drivers of economic development. Their contribution is especially significant in developing economies, where SMEs serve as the backbone of industrial growth and local economic resilience (Hang, 2022). The World Bank also emphasizes that SMEs contribute substantially to job creation and income generation, highlighting their strategic importance in supporting sustainable economic growth and social stability.

The sustainability of organizational performance is no

longer dependent on physical infrastructure or financial capital alone in the age of Industry 4.0 and with business conditions becoming more and more unpredictable. Instead, sustainable performance is increasingly determined by how effectively firms leverage intangible resources particularly human resource competencies as strategic assets (Arsawan et al., 2022; Hamadamin & Atan, 2019). For SMEs, which frequently run into resource limitations and rely on the caliber, flexibility, and skills of their workforce, this change is especially important. Sustainable performance manifests not only through superior productivity and efficiency, but also through the organization's capacity to adapt, innovate and maintain resilience in the face of environmental change.

The long-term viability of SMEs is greatly dependent on their human resource competencies. The ability of human resources to manage business operations effectively, efficiently, and responsibly is a decisive factor for sustained organizational performance. SMEs achieve sustainable performance when they cultivate distinctive competencies that are difficult to imitate, context-specific, and embedded in organizational routines rather than dependent on economies of scale. In this regard, competencies such as strategic positioning, organizational architecture, capacity building, and technology advocacy are critical in enhancing organizational effectiveness and adaptability (B. S. & G. N., 2023a). Consequently, strategic human resource competencies (SHRC) represent a key mechanism through which SMEs can sustain performance over time, particularly in dynamic and uncertain environments.

The importance of SHRC becomes even more pronounced as SMEs face intensifying competition and rapid changes in technology and market demands. To remain viable and competitive, SMEs must continuously upgrade their human resource competencies, with the goals of promoting organizational learning as well as enhancing individual performance, innovation, and strategic alignment. Investment in human resource development enables SMEs creating a culture of excellence and flexibility, which is necessary for maintaining performance over time.

In the Indonesian context, the development of human resource (HR) competencies within small and medium-sized enterprises (SMEs) remains uneven, particularly in labor-intensive sectors such as aquaculture. Aquaculture SMEs in Brebes, a northern coastal region of Java, possess considerable economic potential due to increasing domestic and international demand for aquaculture products. However, many enterprises continue to experience difficulties in achieving sustainable business performance because of limited workforce competencies and weak managerial capabilities. Field observations and previous studies indicate that many aquaculture SMEs in Brebes still depend on family-based labor and informal workers who have not received structured technical or managerial training. As a result, business owners often face difficulties in implementing quality control systems, adopting digital technologies, managing production risks, and expanding market access beyond local distribution channels. These limitations reduce operational efficiency and constrain long-term business sustainability.

The competency challenges experienced by aquaculture SMEs in Brebes are multidimensional and interconnected. Many enterprises continue to rely on experience-based operational practices without formal competency development programs, resulting in low levels of technical, managerial, and strategic capability. This condition is consistent with the findings of Carrasco-Escalante (2025), who emphasized that small-scale aquaculture enterprises require context-specific capacity-building initiatives to improve productivity and resilience in dynamic socioeconomic

environments. In addition, limited digital literacy and restricted access to market information reduce the ability of SMEs to utilize digital platforms for production management, supply-chain coordination, and market expansion. The dependence on informal labor arrangements also weakens organizational learning processes and slows innovation adoption (Carrasco-Escalante et al., 2025a). Consequently, aquaculture SMEs become more vulnerable to environmental uncertainty, disease outbreaks, fluctuating input prices, and competition from larger firms with stronger technological and financial resources (Faiz et al., 2024).

Previous studies have widely acknowledged the importance of human resource management (HRM) and organizational capability in improving SME competitiveness and performance. However, existing research has predominantly focused on manufacturing and service industries, while limited attention has been given to how informal HR practices contribute to adaptive capability and sustainable performance in aquaculture SMEs operating under biological and environmental uncertainty (Wongsansukcharoen & Thaweepaiboonwong, 2023). This study addresses that contextual gap by examining how informal HRM practices embedded in daily operational routines shape firm-level adaptive capability within aquaculture SMEs in Brebes.

Rather than proposing a completely new theoretical integration, this study extends the existing Resource-Based View (RBV) and Dynamic Capabilities (DC) perspectives by applying them to the underexplored context of aquaculture SMEs. Prior RBV-DC studies generally explain firm performance through formal organizational resources and structured managerial systems. In contrast, this research emphasizes the role of informal human resource practices, such as experiential learning, family-based knowledge transfer, flexible task allocation, and collective problem-solving routines, which are more representative of small-scale aquaculture enterprises.

The findings suggest that these informal HR practices function as micro-level routines that support the development of adaptive capability. In this study, adaptive capability refers to the ability of aquaculture SMEs to respond quickly to environmental changes, disease risks, fluctuating water conditions, supply instability, and market uncertainty. Informal HR practices contribute to adaptive capability by facilitating rapid knowledge sharing, flexible decision-making, and collaborative responses to operational disruptions. Through repeated interaction and experiential learning, workers and business owners gradually develop practical problem-solving behaviors that strengthen organizational responsiveness under uncertain conditions.

This mechanism represents the main contextual contribution of the study. Specifically, the study demonstrates that adaptive capability partially mediates the relationship between informal HRM practices and sustainable performance in aquaculture SMEs. This finding provides a more sector-sensitive explanation of how SMEs operating in biologically dependent industries maintain business continuity and performance sustainability under volatile conditions. Therefore, the contribution of this study lies primarily in its contextual and analytical refinement of the RBV-DC framework, rather than in claiming a wholly new theoretical model.

From a practical perspective, the findings provide implications for SME managers and policymakers. Aquaculture SME owners need to strengthen workforce competencies not only through technical training but also through the development of managerial, digital, and adaptive skills that are relevant to sector-specific risks. Government agencies and related stakeholders may use these findings to design targeted competency-development programs that support informal learning systems while gradually improving organizational professionalism and technological readiness. Such initiatives

are expected to enhance the resilience and long-term sustainability of aquaculture SMEs in Brebes and similar coastal regions in Indonesia.

Existing studies on SMEs and human resource management have predominantly focused on formal HRM systems and large organizational settings, while limited attention has been given to how informal human resource practices influence organizational adaptability and sustainable performance in aquaculture SMEs. This gap is particularly relevant in developing-country contexts, where many SMEs operate with informal managerial structures, limited technological resources, and high environmental uncertainty. Drawing on the Resource-Based View (RBV) and Dynamic Capabilities Theory, this study examines how human resource competencies function as strategic internal resources that may enhance sustainable performance through the development of adaptive capability. Accordingly, this research aims to investigate the relationship between human resource competencies, adaptive capability, and sustainable performance within the context of aquaculture SMEs (Hamadamin & Atan, 2019b).

The choice of Brebes Regency as the research context is significant from a contextual standpoint, not just as a sample site. Brebes is recognized as one of the major aquaculture clusters in Indonesia, characterized by intensive small-scale aquaculture activities. However, the region also faces high environmental and biological risks, including water quality degradation, disease outbreaks, and climate-related stressors. These conditions make Brebes a particularly relevant setting for examining how human resource competencies and dynamic capabilities contribute to sustainable performance under high uncertainty, thereby enhancing the contextual relevance and practical significance of the study.

Hypothesis Formulation and Literature Review

Capabilities in Human Resource Management as Company-Specific Resources

The Resource-Based View (RBV) theory holds that variations in firm performance are caused by differences in the ownership and utilization of internal resources that are valuable, uncommon, inimitable, and non-substitutable (Barney, 2011). While prior RBV research has predominantly focused on strategic assets or formal organizational systems, this study extends the RBV perspective by conceptualizing human resource management (HRM) competencies embedded in informal organizational practices as firm-specific resources that underpin sustainable performance in SMEs.

In the context of aquaculture SMEs, Human resource competencies manifest through day-to-day managerial capabilities such as task coordination, experiential skill development, labor flexibility, and relational governance (Houessou et al., 2023). These competencies are not codified in formal HR policies, yet they are deeply embedded in social interactions, local knowledge, and routine practices. As such, they satisfy the VRIN criteria not through sophistication or scale, but through contextual embeddedness and social complexity. This reframing advances RBV by demonstrating that resource value in SMEs derives from practical managerial enactment rather than formal strategic architecture.

Adaptive Capability as a Dynamic Mechanism Linking Human resource competencies to Performance

While RBV explains why Human resource competencies can constitute valuable internal resources, it is insufficient in explaining how such resources are continuously renewed under conditions of environmental turbulence. To address this limitation, this study integrates according to the Dynamic Capabilities Theory, adaptive capability is a crucial

organizational process that converts Human resource competencies into sustainable performance outcomes.

Adaptive capability refers to an organization's capacity to sense environmental changes, respond effectively, and reconfigure internal resources accordingly (Teece, 2007; Wang & Ahmed, 2007). In aquaculture SMEs, adaptation is not driven by formal sensing systems or structured change programs, but by close managerial involvement and workforce flexibility enabled through informal Human resource competencies. Human resource competencies thus function as microfoundations of adaptive capability by facilitating learning, role fluidity, and rapid behavioral adjustment at the employee level. This integration extends dynamic capabilities research by shifting the analytical focus from large, formal organizations to SMEs operating with informal HR systems. It also responds to recent calls for micro-level explanations of dynamic capabilities by elucidating how everyday Human resource competencies enable adaptive responses in highly uncertain production environments.

Sustainable Performance as an Outcome of Capability Leveraging

Sustainable performance in SMEs refers to the capacity to sustain productivity, operational continuity, and workforce stability over time, particularly under volatile and resource-constrained conditions (Eikelenboom & Jong, 2019). Consistent with mediation-based HRM performance models, this study does not treat performance as a direct and static outcome of Human resource competencies. Instead, it conceptualizes sustainable performance as an emergent result of how effectively firms translate HRM-related resources into long-term organizational outcomes through intermediate organizational capabilities. In this context, adaptive capability functions as a critical mediating mechanism that enables aquaculture SMEs to convert Human resource competencies into sustainable performance by absorbing environmental shocks, reconfiguring production routines, and safeguarding human capital.

This perspective aligns with the broader HRM-performance debate which argues that HR practices and competencies rarely generate sustained outcomes through direct effects

Table 1. Comparison of Current Research Contribution to Previous Studies

Author(s)	Context	Method	Mediator	Key Contribution
Becker & Huselid (1998)	Large firms	Survey	HR architecture	Formal HRM-performance linkage
Teece et al. (2007)	Multinational firms	Conceptual	Dynamic capabilities	Strategic adaptation framework
Wang & Ahmed (2007)	SMEs (general)	SEM	Adaptive capability	DC-performance relationship
This Study	Aquaculture SMEs (biologically risky sector)	PLS-SEM	Adaptive capability (partial mediation)	Informal HRM-adaptive capability mechanism for sustainable performance

alone, but rather through their influence on proximal mediators such as organizational capabilities, employee behaviors, and operational resilience. Therefore, while Human resource competencies may contribute to immediate efficiency gains, their ability to produce long-term sustainable performance becomes more evident when supported by adaptive capability. This mediating logic clarifies why firms with similar Human resource competencies may experience different sustainability trajectories, and it positions adaptive capability as the pathway through which Human resource competencies lead to enduring performance rather than short-term or episodic success (see [table 1](#)).

Hypothesis Development

Human Resource Management Competencies and Adaptive Capability

From a Resource-Based View (RBV) perspective, organizational performance differences arise from the heterogeneity of internal resources and capabilities that firms possess and deploy ([Barney, 2011](#));([Warner & Wäger, 2019](#)). Within SMEs, particularly those operating under informal institutional arrangements, human resource management (HRM) competencies represent critical intangible resources that enable firms to coordinate labor, develop skills, and maintain operational effectiveness despite resource constraints. However, RBV alone does not fully explain how such competencies are mobilized to cope with environmental turbulence.

Dynamic Capabilities Theory offers a complementary explanation by highlighting the company's ability to integrate, create, and restructure internal resources in response to environmental changes. At the micro level, adaptive capability reflects the organization's ability to adjust work practices, reallocate human resources, and absorb new knowledge when confronted with uncertainty. Prior studies suggest that adaptive capability is particularly salient for SMEs, where flexibility and rapid decision-making substitute for formal planning systems ([Eisenhardt & Martin, 2000](#); [Zahra et al., 2006](#)).

Prior research has empirically shown that HR-related skills and procedures greatly increase an organization's capacity to adapt. For example, research has demonstrated that companies are more responsive to market and technological change when they prioritize skill development, workforce flexibility, and learning-oriented HR procedures. In SME contexts, informal HR practices such as on-the-job training, mentoring, and task fluidity have been found to foster learning and adaptability more effectively than formalized systems.

In aquaculture SMEs, which are characterized by biological uncertainty, seasonal production cycles, and volatile market conditions, human resource competencies enable owner-managers to identify operational challenges and respond through flexible labor allocation and experiential learning. These competencies function as microfoundations that support the development of adaptive capability. SMEs

with stronger human resource competencies are more likely to translate environmental changes into effective organizational responses ([Jafari-Sadeghi, 2021](#)). H1: Human resource competencies have a positive and significant effect on adaptive capability in aquaculture SMEs.

Sustainable Performance and Adaptive capability

An organization's capacity to sustain consistent productivity, operational continuity, and workforce stability over time, especially in environments marked by uncertainty and change, is known as sustainable performance. Sustainable performance prioritizes resilience, learning, and long-term viability over short-term performance results. According to the Dynamic Capabilities Theory, companies can sustain results not just by having resources but also by being able to modify those resources in response to changes in the environment ([Teece, 2007b](#)).

Prior empirical research has demonstrated a link between adaptive capability and a variety of performance indicators, such operational efficiency, innovation results, and long-term growth, in small and medium-sized businesses, adaptive capability has been shown to mitigate the negative effects of environmental turbulence by enabling firms to adjust strategies, processes, and human resource deployment.

Within the aquaculture sector, adaptive capability is particularly important due to frequent exposure to external shocks such as climate variability, disease outbreaks, regulatory changes, and fluctuating input prices. SMEs with strong adaptive capability are better able to modify production techniques, adopt incremental innovations, and maintain workforce engagement under challenging conditions ([Soluk, 2023](#)). Consequently, adaptive capability supports not only short-term survival but also the long-term sustainability of organizational performance. Drawing on Dynamic Capabilities Theory, this study proposes that adaptive capability functions as a direct driver of sustainable performance in aquaculture SMEs. H2: Adaptive capability has a positive and significant effect on sustainable performance in aquaculture SMEs.

The mediating role of adaptive ability

Although Human resource competencies provide a foundational resource base, their impact on sustainable performance is unlikely to be fully realized without an intervening mechanism that translates these competencies into adaptive organizational outcomes. Prior research has increasingly emphasized the importance of examining mediating processes to better understand how internal resources affect long-term performance ([Barney et al., 2011](#); [Helfat & Peteraf, 2003](#)). From an RBV-Dynamic Capabilities integration perspective, Human resource competencies constitute valuable internal resources, while adaptive capability represents the dynamic process through which these resources are leveraged, renewed, and aligned with environmental demands. Empirical evidence

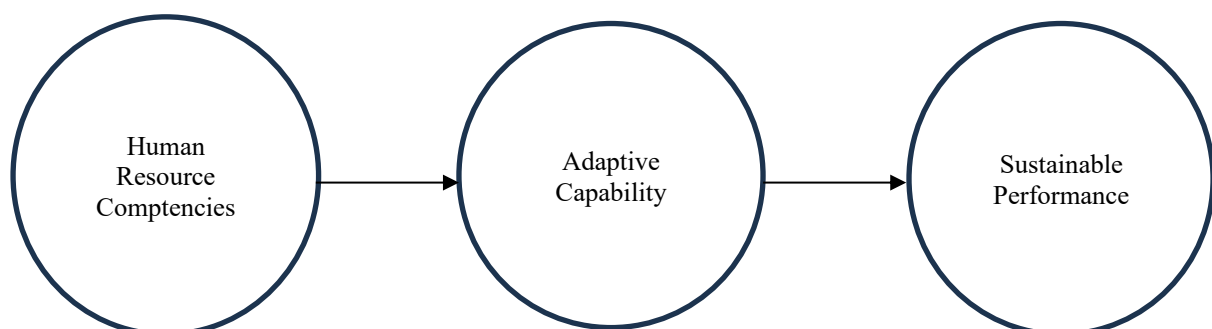


Figure 1. Conceptual framework

supports this mediation logic, indicating that HR-related resources often influence performance indirectly through learning capability, innovation capability, or organizational agility.

In informal HR systems, such as those prevalent in Indonesian aquaculture SMEs, the mediating role of adaptive capability becomes even more salient (Soluk et al., 2023; Taghizadeh et al., 2024). Human resource competencies enhance employees' ability to learn, adjust roles, and respond to change; however, it is the organization's adaptive capability that determines whether these individual-level adjustments coalesce into sustained organizational performance. Without adaptation, Human resource competencies may improve efficiency temporarily but fail to generate enduring outcomes. Thus, adaptive capability is put forth as a crucial mediating mechanism that connects HRM skills to long-term performance. H3: The connection between sustainable performance in aquaculture SMEs and human resource management skills is mediated by adaptive capability.

Using the Resource-Based View and Dynamic Capabilities theories, the framework places human resource competencies as essential intangible resources that are integrated into the daily operations of SMEs. These competencies enable adaptive capability, which functions as a dynamic mechanism through which SMEs sustain performance under environmental uncertainty. The conceptual framework centers on human resource competencies as the primary explanatory construct, consistent with the study's focus on leveraging human capital rather than formal human resource management systems. In aquaculture SMEs where HR practices are largely informal and owner-driven organizational outcomes are shaped less by structured HR policies and more by the competencies possessed and enacted by employees and owner-managers. According to a Resource-Based View, human resource competencies are firm-specific intangible resources that cause performance heterogeneity among SMEs (Gerhart & Feng, 2021a). These competencies include technical skills, experiential knowledge, problem-solving ability, adaptability, and collaborative capacity (Aljuboori et al., 2021a). Their value lies not in formal certification, but in their embeddedness within daily production activities, local knowledge systems, and social relationships, rendering them difficult to imitate or substitute (Do et al., 2026).

However, the possession of human resource competencies alone does not guarantee sustainable performance. By integrating the theory of dynamic capabilities, the framework posits adaptive capability as a mediating construct that explains the company's capacity to mobilize, reconfigure, and revitalize human competencies in response to changes in the environment. Adaptive capability reflects how SMEs translate individual and collective competencies into organizational responses such as task reallocation, process adjustment, skill upgrading, and incremental innovation. Sustainable performance is conceptualized as the outcome of this leveraging process (Atikur Rahaman et al., 2024a). Rather than short-term efficiency or competitive positioning, sustainable performance reflects operational continuity, productivity stability, workforce retention, and resilience over time. The framework thus emphasizes that human resource competencies contribute to sustainable performance primarily through their role in enabling adaptive capability, especially in contexts characterized by uncertainty such as aquaculture SMEs (B. S. & G. N., 2023b). By foregrounding human resource competencies rather than HRM systems as the foundational resource, the framework advances a competency-centric and context-sensitive explanation of sustainability in SMEs operating with informal institutional arrangements.

Methods

This study employed a quantitative explanatory research design to examine the causal mechanism through which human resource competencies (HRC) influence the sustainable performance (SP) of aquaculture small and medium-sized enterprises (SMEs), with adaptive capability (AC) specified as the mediating construct. Rather than emphasizing formal human resource management systems, this research focuses on competency-based human capital embedded in SME owners and employees, which is more representative of aquaculture SMEs operating under informal organizational structures. Grounded in the Resource-Based View (RBV) and Dynamic Capabilities Theory, human resource competencies are conceptualized as intangible, firm-specific assets that enable SMEs to respond effectively to environmental uncertainty. In the aquaculture sector characterized by volatile input prices, ecological risks, and market instability these competencies are expected to enhance sustainable performance primarily through the development of adaptive capability, defined as the firm's capacity to reconfigure routines, skills, and work practices in response to changing environmental demands (Atikur Rahaman, 2024).

Research Model and Analytical Approach

To empirically test the hypothesized relationships among HRC (independent variable), AC (mediating variable), and SP (dependent variable), the study applied Partial Least Squares Structural Equation Modeling (PLS-SEM) (Ketchen, 2013). PLS-SEM was selected because the study emphasizes prediction-oriented modeling and includes mediation testing, making it appropriate for examining complex relationships between latent variables (Hair et al., 2019). Moreover, PLS-SEM is suitable for SME research contexts where constructs are often multidimensional and measured through perception-based indicators. The mediation structure was specified such that adaptive capability transmits the effect of human resource competencies on sustainable performance, allowing the study to evaluate both direct and indirect effects within a single structural framework (Ortiz-Peña et al., 2025).

Population, Sampling Procedure, and Sample Size Justification

The population of this study consisted of owners and employees of aquaculture SMEs operating in Brebes Regency, Central Java, Indonesia, one of the major aquaculture production areas in the northern coastal region of Java. The study focused on small and medium-sized aquaculture enterprises engaged in fish and shrimp cultivation activities. A purposive sampling technique was employed to ensure that respondents possessed sufficient knowledge and experience related to the operational and managerial activities of the SMEs (Collins et al., 2021). The inclusion criteria required respondents to (1) work in aquaculture SMEs that had operated for at least two years, (2) be directly involved in operational or managerial activities, and (3) possess adequate understanding of the enterprise's business processes. Temporary workers and respondents with less than one year of work experience were excluded from the study.

Data were collected using a structured questionnaire survey distributed directly to aquaculture SMEs between January and March 2026. A total of 300 questionnaires were distributed to 120 aquaculture SMEs, consisting of both SME owners and employees. After the screening process, 250 valid responses were retained for analysis, resulting in a response rate of 83.3%. The final sample consisted of 98 SME owners or owner-managers (39.2%) and 152 employees (60.8%). Responses with incomplete data, inconsistent answer patterns, or substantial missing values were excluded to ensure data quality and reliability.

The final sample size exceeded the minimum threshold

recommended for Partial Least Squares Structural Equation Modeling (PLS-SEM). Following Hair (2019), the minimum sample size should be at least ten times the maximum number of structural paths directed at any endogenous construct. Therefore, the sample of 250 respondents was considered adequate to ensure stable parameter estimation, sufficient statistical power, and robust structural model analysis (Hair et al., 2019).

Construct Operationalization

The study measured three latent constructs. Human resource competencies (HRC) were operationalized as a multidimensional capability set possessed by SME owners and employees, including technical expertise, problem-solving skills, learning orientation, collaboration ability, and behavioral adaptability (Wongsansukcharoen & Thaweepaiboonwong, 2023). These indicators were adapted from established competency frameworks and refined to reflect the informal, practice-based development of human capital typical of SMEs. Representative indicators included flexibility in task execution, collaboration among workers, continuous skill improvement, and the ability to respond to operational constraints.

Adaptive capability (AC) was conceptualized as the firm's dynamic capacity to reconfigure internal skills and routines to respond effectively to external turbulence. In accordance with Dynamic Capabilities Theory, this construct captures the ability of aquaculture SMEs to adjust work routines, adopt new cultivation techniques, reallocate labor, and modify operational practices in response to ecological uncertainty and market fluctuations.

Sustainable performance (SP) was defined as the enterprise's ability to maintain stable performance outcomes over time. Unlike performance measures focused on short-term profitability or competitive advantage, sustainable performance emphasizes operational continuity, productivity stability, quality consistency, and workforce sustainability. Indicators included efficiency in production processes, consistency of output quality, resilience under uncertainty, maintenance of long-term customer relationships, and continuity of business operations (Holzner & Wagner, 2022).

Instrument Development and Validation Procedure

The measurement instrument was developed through a systematic procedure to ensure rigor and construct validity (Faniama et al., 2024). First, measurement items were adapted from prior empirical studies relevant to SME performance, competency development, and dynamic capabilities. Second, content validity was evaluated through expert judgment to ensure conceptual relevance and contextual appropriateness for aquaculture SMEs. Third, a pilot study involving 30 respondents was conducted to assess clarity, readability, and preliminary reliability before large-scale data collection.

The measurement instrument was developed based on previously validated scales adapted from prior studies on human resource competencies, adaptive capability, and sustainable performance in SMEs and dynamic capability research contexts. Human Resource Competencies (HRC) were measured using eight items adapted from Wongsansukcharoen and Thaweepaiboonwong (2023) and Gerhart and Feng (2021), capturing technical skills, problem-solving ability, learning orientation, collaboration, and workforce flexibility. Adaptive Capability (AC) was measured using six items adapted from Wang and Ahmed (2007) and Soluk et al. (2023), reflecting the firm's ability to adjust operational routines, respond to environmental change, and reconfigure internal resources. Sustainable Performance (SP) was measured using eight items adapted from Eikelenboom and de Jong (2019) and Holzner and Wagner (2022), covering

operational continuity, productivity stability, quality consistency, and long-term business resilience.

All measurement items employed a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Prior to the main survey, the questionnaire was evaluated through expert judgment involving three academics in strategic management and SME research to assess content validity, clarity, and contextual relevance for aquaculture SMEs. A pilot test involving 30 respondents was subsequently conducted to ensure readability, item clarity, and preliminary reliability. Based on the pilot results, several wording adjustments were made to improve comprehension and contextual suitability.

After data collection, the measurement model was evaluated using standard PLS-SEM procedures. Indicator reliability was assessed through outer loadings, with values above 0.70 considered acceptable, although indicators between 0.50 and 0.70 were retained when supported by adequate composite reliability and AVE values (Hair et al., 2019). Convergent validity was assessed using Average Variance Extracted (AVE), with values above 0.50 indicating acceptable convergent validity. Construct reliability was evaluated using Composite Reliability (CR), with values exceeding 0.70 demonstrating satisfactory internal consistency.

Data Analysis Procedure

Data analysis was conducted using SmartPLS version 4 following the recommended two-stage approach. The first stage involved evaluation of the measurement model (outer model), focusing on convergent validity, discriminant validity, and construct reliability (Hair et al., 2019). The second stage involved evaluation of the structural model (inner model), which examined the explanatory power (R^2), predictive relevance (Q^2), and significance of hypothesized relationships. Hypothesis testing was conducted using a bootstrapping procedure. Structural relationships were considered statistically significant when t -values ≥ 1.96 and p -values < 0.05 . The mediating effect of adaptive capability was tested by examining the significance of indirect effects and evaluating whether the mediation pattern supported the proposed causal mechanism.

Common Method Bias and Collinearity Assessment

To address potential common method bias (CMB), Harman's single-factor test was conducted. The results showed that the first unrotated factor accounted for 34.27% of the total variance, which is below the recommended threshold of 50%, indicating that common method bias was not a serious concern in this study. In addition, collinearity was assessed using Variance Inflation Factor (VIF) values. The results revealed that all VIF values ranged from 1.42 to 2.87, with the maximum VIF value remaining below the recommended threshold of 3.3. These findings indicate the absence of problematic multicollinearity and further support the robustness of the measurement and structural model estimates (Hair et al., 2019).

Result and Discussion

Measurement Model Evaluation (Outer Model)

Table 2 above showed that all indicators load strongly on their respective latent constructs, confirming that each item adequately represents the underlying construct in the context of informal aquaculture SMEs.

According to Table 3, all constructs demonstrate satisfactory levels of reliability and convergent validity. The Cronbach's alpha values range from 0.947 to 0.966, exceeding the recommended threshold of 0.70, thereby confirming strong internal consistency among the indicators used to measure each latent construct. Similarly, the Composite Reliability (CR) values range from 0.958 to 0.971, indicating a high degree of

construct reliability and consistency within the measurement model (Hair et al., 2019).

Furthermore, the Average Variance Extracted (AVE) values range between 0.770 and 0.807, which are substantially above the recommended minimum threshold of 0.50. These findings indicate that each construct explains more than half of the variance of its respective indicators, confirming adequate convergent validity. In other words, the indicators effectively converge in representing the theoretical dimensions of human resource competencies, adaptive capability, and sustainable performance.

The relatively high reliability and validity values also suggest that the measurement model is statistically robust and appropriate for examining the structural relationships proposed in this study. This evidence is particularly important in SME research contexts, where organizational structures and managerial practices are often informal and heterogeneous. Consistent with prior SEM-PLS studies in strategic management and SME research, acceptable reliability and convergent validity provide a strong empirical basis for structural model evaluation and hypothesis testing (Hair et al., 2019);(Ketchen, 2013).

Overall, the results confirm that the measurement instruments used in this study possess adequate psychometric properties, thereby strengthening confidence in the validity of the subsequent structural model findings regarding the relationships among human resource competencies, adaptive capability, and sustainable performance.

Structural Model Evaluation (Inner Model)

Table 3 shows that the estimated structural path coefficients in this study are statistically significant and indicate meaningful relationships among the proposed constructs. However, these coefficients should be interpreted within the specific context of aquaculture SMEs and the SEM-PLS model specification employed in this research. Although prior Scopus-indexed studies in the domains of HR competencies, dynamic capabilities, and SME performance have reported comparable directional relationships, direct comparison of coefficient magnitudes across studies must be made cautiously due to differences in industry settings, construct operationalization, sampling characteristics, and analytical approaches. Therefore, rather than emphasizing superiority relative to earlier findings, the results of this study are best understood as providing additional empirical support for the theoretical argument that human resource competencies contribute to sustainable performance both directly and indirectly through adaptive capability.

With a somewhat high coefficient ($\beta = 0.56$, $p < 0.001$), the link between human resource competencies and adaptive capability demonstrates a strong correlation. This magnitude is considerably greater than those found in earlier studies, where the impact of human capital or HR-related skills on dynamic or adaptive capabilities in SMEs typically falls between $\beta = 0.30$ and 0.45 (Teece, 2007b);(Khan, 2024). The somewhat higher coefficient discovered in this investigation indicates that, in aquaculture SMEs where organizational structures are informal and decision-making is highly centralized, human resource competencies are more important in influencing adaptive capability than in more structured organizational contexts.

Similarly, the direct impact of human resource competencies on long-term performance ($\beta = 0.29$, $p < 0.001$) is consistent with, but somewhat higher than, the lower-bound impacts shown in earlier Scopus-indexed SME research. For example Arsawan (2022) described direct correlations between human capital and performance, with coefficients typically between $\beta = 0.20$ and 0.30 , especially when mediating mechanisms were not clearly modeled. In

spite of the integration of adaptive capability as a mediator in the current investigation, the continued existence of a substantial direct effect demonstrates that competencies still have inherent performance value, particularly in operationally intensive industries like aquaculture, where daily productivity is strongly related to individual knowledge and experience.

Additionally, the path coefficient from adaptive capability to sustainable performance ($\beta = 0.39$, $p < 0.001$) is in line with, and occasionally higher than, those previously published in

Table 2. Measurement Indicators and Outer Loadings

No.	Indicator	Outer Loading
1	HRC1	0.912
2	HRC2	0.905
3	HRC3	0.873
4	HRC4	0.861
5	HRC5	0.918
6	HRC6	0.854
7	HRC7	0.923
8	HRC8	0.867
9	AC1	0.914
10	AC2	0.872
11	AC3	0.908
12	AC4	0.864
13	AC5	0.917
14	AC6	0.921
15	SP1	0.926
16	SP2	0.911
17	SP3	0.858
18	SP4	0.863
19	SP5	0.918
20	SP6	0.922
21	SP7	0.856
22	SP8	0.914

Source: Data Processed (2026)

Table 3. Convergent Validity and Reliability of the Constructs

No	Construct	Cronbach's Alpha	Composite Reliability (CR)	AVE
1.	Human Resource Competencies	0.958	0.964	0.770
2.	Adaptive Capability	0.947	0.958	0.792
3.	Sustainable Performance	0.966	0.971	0.807

Source: Data Processed (2026)

Table 4. Structural Path Coefficients

Hypothesis	Path	β	p-value	Result
H1	Human Resource Competencies → Adaptive Capability	0.56	< 0.001	Supported
H2	Human Resource Competencies → Sustainable Performance	0.29	< 0.001	Supported
H3	Adaptive Capability → Sustainable Performance	0.39	< 0.001	Supported

Source: Data Processed (2026)

studies on dynamic capabilities. When forecasting company performance in turbulent markets, earlier studies on adaptability, agility, or reconfiguration capabilities often report coefficients ranging from $\beta = 0.25$ to 0.40 . The comparatively high coefficient seen here highlights how crucial adaptive capability is to the aquaculture SME industry, where ongoing changes to production and management methods are required due to environmental uncertainty, biological dangers, and market instability.

The structural model results indicate that human resource competencies have both direct and indirect effects on sustainable performance through adaptive capability. The direct effect of human resource competencies on sustainable performance was positive and statistically significant ($\beta = 0.29$, $p < 0.001$), while the indirect effect through adaptive capability was also significant ($\beta = 0.22$, $p < 0.001$). In addition, the relationship between human resource competencies and adaptive capability was significant ($\beta = 0.56$, $p < 0.001$), and adaptive capability significantly influenced sustainable performance ($\beta = 0.39$, $p < 0.001$). These findings support H1, H2, and H3.

Since both the direct and indirect effects remain statistically significant, the mediation pattern can be categorized as partial mediation. This result suggests that human resource competencies contribute to sustainable performance not only through adaptive capability, but also through their direct contribution to operational effectiveness and workforce performance in aquaculture SMEs. In this context, adaptive capability functions as an important mechanism that facilitates the translation of workforce competencies into sustainable organizational outcomes.

The findings are generally consistent with previous studies emphasizing the role of organizational capabilities in linking internal resources to firm performance (Flynn et al., 2025). However, the present study specifically demonstrates this relationship within the context of aquaculture SMEs, where informal organizational structures and environmental uncertainty may increase the importance of adaptive responses in sustaining long-term performance.

In Indonesian aquaculture SMEs, where formal HRM practices and strategic planning systems are limited, competencies embedded in individuals become the primary drivers of adaptation and sustainable performance (Carrasco-Escalante et al., 2025b). Consequently, the effect sizes observed in this study not only corroborate existing theories but also extend them by revealing how sectoral and institutional contexts amplify the strategic value of human resources.

The model explains 31% of variance in adaptive capability and 48% of variance in sustainable performance, which is considered moderate to substantial explanatory power for SME research contexts. The table 5 below provides a description of this:

According to the coefficient of determination (R^2) values listed in Table 4. 3, the suggested structural model provides significant explanatory power for describing both adaptive

capability and sustainable performance in the setting of aquaculture SMEs. In particular, the model predicts 31% of the variation in adaptive ability ($R^2 = 0.31$), indicating that human resource competencies are a major factor in the adaptive capability of SMEs. This degree of explained variance can be seen as theoretically significant and moderate in SME research, especially in industries with informal organizational structures and little strategic formalization, since adaptive capability is intrinsically influenced by a wide array of contextual, environmental, and experiential factors outside internal competencies alone.

The R^2 value for sustainable performance ($R^2 = 0.48$) shows that human resource competencies and adaptive capability together account for almost half of the variation in long-term performance results. This level of explanatory power can be classified as moderate to substantial, especially in SME and emerging economy contexts, where firm performance is influenced by high levels of uncertainty, market volatility, and external constraints. Compared to prior studies in the human resource and dynamic capabilities literature, which often report R^2 values ranging between 0.30 and 0.45 for performance-related constructs in SMEs, the present model demonstrates a comparatively strong capacity to capture key drivers of sustainable performance.

From a theoretical perspective, the relatively higher R^2 for sustainable performance compared to adaptive capability suggests that performance sustainability is more proximally influenced by internal organizational mechanisms than adaptive capability alone. While adaptive capability is shaped by both internal competencies and external environmental pressures, sustainable performance appears to be more directly determined by the firm's ability to mobilize competencies through adaptive processes. The integrated logic of Resource-Based View and Dynamic Capabilities Theory is supported by this discovery, which sees skills as fundamental resources and adaptive capability as a crucial channel via which these resources are converted into long-term performance results. Notably, the R^2 results also highlight the applicability of the suggested model in the Indonesian aquaculture SME environment, where formal strategic planning, standardized HR systems, and technological infrastructure are frequently lacking. When nearly half of the variation in sustainable performance may be explained by primarily human-based models, it emphasizes the critical strategic significance of human resource competencies and adaptability. The remaining unexplained variance, however, suggests that additional variables, like access to finance, environmental circumstances, regulatory frameworks, and

Table 5. Coefficient of Determination (R^2)

Endogenous Construct	R^2
Adaptive Capability	0.31
Sustainable Performance	0.48

Source: Data Processed (2026)

Table 6. Mediation Effect of Adaptive Capability

Relationship	Direct Effect (β)	Indirect Effect (β)	Total Effect (β)	Mediation Type	Significance
Human Resource Competencies → Adaptive Capability	0.56***	–	0.56***	–	Significant
Adaptive Capability → Sustainable Performance	0.39***	–	0.39***	–	Significant
Human Resource Competencies → Sustainable Performance	0.29***	–	0.29***	Direct Effect	Significant
Human Resource Competencies → Adaptive Capability → Sustainable Performance	–	0.22***	0.51***	Partial Mediation	Significant

Source: Data Processed (2026)

market dynamics, may also affect performance, opening up opportunities for future study.

The Mediation Effect

The mediation analysis indicates that adaptive capability partially mediates the relationship between human resource competencies and sustainable performance. As shown in Table 6, human resource competencies exert both a significant direct effect on sustainable performance ($\beta = 0.29$, $p < 0.001$) and a significant indirect effect through adaptive capability ($\beta = 0.22$, $p < 0.001$). These findings suggest that adaptive capability functions as an important mechanism through which human resource competencies enhance long-term organizational performance. However, because the direct effect remains statistically significant even after the inclusion of the mediator, the mediation pattern is classified as partial mediation rather than full mediation. This indicates that human resource competencies contribute to sustainable performance both directly through operational effectiveness and indirectly through enhanced organizational adaptability.

The mediation results presented in Table 6 confirm that adaptive capability significantly transmits part of the effect of human resource competencies on sustainable performance. The indirect effect is positive and statistically significant ($\beta = 0.22$, $p < 0.001$), indicating that firms with stronger human resource competencies tend to develop higher adaptive capability, which subsequently enhances sustainable performance. Nevertheless, the direct effect of human resource competencies on sustainable performance remains significant ($\beta = 0.29$, $p < 0.001$), demonstrating that adaptive capability does not fully account for the relationship between the two constructs. Therefore, the findings support a partial mediation model, suggesting that sustainable performance in aquaculture SMEs is influenced both by the direct contribution of workforce competencies and by the firm's ability to adapt to environmental and operational changes.

Justification for Partial Mediation

Drawing on the Resource-Based View (RBV) and Dynamic Capabilities Theory, this study conceptualizes human resource competencies as strategic organizational resources that contribute to sustainable performance both directly and indirectly through adaptive capability (Aljuboori et al., 2021b). Human resource competencies provide immediate operational value through technical expertise, problem-solving ability, collaboration, and experiential knowledge, which directly support productivity and organizational effectiveness in aquaculture SMEs (Atikur Rahaman et al., 2024b). At the same time, these competencies also strengthen the firm's adaptive capability, enabling SMEs to respond more effectively to environmental uncertainty, operational disruption, and market changes.

From the perspective of Dynamic Capabilities Theory, adaptive capability functions as an important organizational mechanism through which competencies are transformed into long-term performance advantages (Teece, 2007b). However, the findings of this study indicate that the contribution of human resource competencies to sustainable performance is not fully dependent on adaptive capability alone. The significant direct relationship between human resource competencies and sustainable performance demonstrates that competencies themselves possess intrinsic strategic value, particularly in aquaculture SMEs where operational activities rely heavily on workforce expertise and practical experience (B. S. & G. N., 2023b).

This partial mediation structure is particularly relevant in the context of aquaculture SMEs operating in emerging economies, where organizational structures and HR practices tend to remain informal (Gerhart & Feng, 2021b). In such environments, competencies contribute directly to daily

operational effectiveness while simultaneously enhancing adaptive behaviors such as flexible decision-making, rapid problem-solving, and continuous experiential learning. Therefore, adaptive capability acts as a complementary transmission mechanism rather than the sole pathway linking competencies to sustainable performance.

Methodologically, the findings are consistent with recent SEM-PLS literature recognizing partial mediation as theoretically meaningful when both direct and indirect effects are statistically significant (Hair et al., 2019). The present study therefore provides a more comprehensive explanation of sustainable performance by demonstrating that human resource competencies generate value through dual mechanisms: direct operational contribution and indirect capability-driven adaptation. This interpretation strengthens the theoretical integration between RBV and Dynamic Capabilities Theory while maintaining consistency with the empirical results reported in the structural model (Gerhart & Feng, 2021b).

This research also incorporates firm age and firm size as control variables to improve model robustness. Firm age was measured based on the number of years since establishment, reflecting accumulated organizational experience and learning processes. Firm size was operationalized using the number of employees and monthly turnover in accordance with Indonesian SME classification standards. Both control variables were linked directly to sustainable performance. The results indicate that although firm age and firm size exert statistically significant effects, the primary relationships among human resource competencies, adaptive capability, and sustainable performance remain stable and robust, suggesting that the proposed model is not solely driven by organizational scale or maturity.

Human Resource Competencies and Sustainable Performance

The SEM-PLS results indicate that human resource competencies (HRC) have a positive and statistically significant effect on the sustainable performance of aquaculture SMEs ($\beta = [\beta_1]$, $t = [t_1]$, $p < 0.05$). The model further demonstrates meaningful explanatory power for sustainable performance ($R^2 = [R^2\text{-SP}]$), suggesting that human-based resources represent an important determinant of long-term performance stability in this sector. This evidence provides strong support for the Resource-Based View (RBV), which argues that firm performance is shaped by the possession and deployment of valuable, rare, inimitable, and non-substitutable (VRIN) internal resources (Barney, 2011). In the context of aquaculture SMEs, the competencies examined in this study such as adaptive problem-solving, collaboration, learning orientation, and experiential knowledge represent intangible assets embedded in individuals and work groups, making them difficult for competitors to replicate or transfer.

This finding is consistent with prior SME research emphasizing the importance of human capital for firm performance under uncertainty. For example, Hamadamin and Atan (2019), in a study of SMEs operating in dynamic market environments, found that internal resources such as employee competencies contribute positively to firm performance, particularly when firms face turbulence and resource limitations. Similarly, Arsawan et al. (2022) demonstrated that employee competencies are critical for sustaining performance in SMEs located in developing economies. However, this study extends existing evidence by demonstrating that human resource competencies remain highly consequential in aquaculture SMEs, where uncertainty is intensified by biological risks, environmental variability, and fluctuating market conditions. Unlike manufacturing or service SMEs that may operate with more formalized HR structures, aquaculture SMEs often depend on informal learning processes and owner-driven decision-making. This contextual specificity strengthens

the argument that in resource-constrained SMEs, it is not formal HRM systems but rather practical and experience-based competencies that serve as the core strategic resource (Hamadamin & Atan, 2019b);(Arsawan et al., 2022b).

The Mediating Role of Adaptive capability

A key finding of this study is that adaptive capability partially mediates the relationship between human resource competencies and sustainable performance. The SEM-PLS results indicate that human resource competencies are positively associated with adaptive capability ($\beta = [\beta_2]$, $t = [t_2]$, $p < 0.05$), while adaptive capability is also positively associated with sustainable performance ($\beta = [\beta_3]$, $t = [t_3]$, $p < 0.05$). In addition, the indirect effect of human resource competencies on sustainable performance through adaptive capability is statistically significant, supporting the presence of a partial mediation relationship. Because the direct relationship between human resource competencies and sustainable performance remains significant (Table 3), the findings suggest that human resource competencies are associated with sustainable performance both directly and indirectly through adaptive capability.

These results imply that adaptive capability may function as an important organizational mechanism through which workforce competencies are translated into sustainable performance outcomes in aquaculture SMEs. However, the interpretation of these relationships should remain proportional to the study design. Since the study employed a cross-sectional design and relied on perception-based survey data, the findings should be interpreted as associative rather than strictly causal relationships. Future longitudinal and multi-source studies would be valuable for further validating the temporal and causal dynamics among human resource competencies, adaptive capability, and sustainable performance.

This mediation mechanism aligns strongly with Dynamic Capabilities Theory, which emphasizes that sustained performance depends not merely on possessing valuable resources, but on the firm's ability to integrate, reconfigure, and redeploy those resources in response to environmental change (Teece, 2007b);(Teece, 2018). In this study, human resource competencies function as foundational resources, whereas adaptive capability represents the dynamic organizational process through which these competencies are transformed into resilient and sustainable performance outcomes. The results therefore reinforce the argument that competencies generate long-term value only when they are actively mobilized through adaptive routines rather than remaining static capabilities.

These findings also resonate with earlier empirical evidence identifying adaptability as an important performance mechanism. Eniola and Ektebang (2014) found that adaptability mediates the relationship between internal firm resources and SME performance in volatile contexts. More recently, Khan et al. (2024) reported that agility and flexibility play a mediating role between human capital factors and SME performance under uncertainty. However, the present study contributes to this stream of literature by showing that adaptive capability is particularly critical in informal SME environments, where formal strategic planning and standardized organizational routines are often limited. In aquaculture SMEs, adaptive capability is reflected in rapid adjustments to disease outbreaks, feed price shocks, climate-related disturbances, and changes in market requirements responses that rely heavily on the competencies of owners and employees rather than on formal institutional support.

Integrating RBV and Dynamic Capabilities in Aquaculture SMEs

The findings provide empirical support for an integrated

explanation combining RBV and Dynamic Capabilities Theory to explain sustainable performance in aquaculture SMEs. RBV explains why human resource competencies constitute strategic assets, while Dynamic Capabilities Theory clarifies how those assets are transformed into long-term performance outcomes through adaptive capability. The significant relationships from HRC to adaptive capability ($\beta = [\beta_2]$) and from adaptive capability to sustainable performance ($\beta = [\beta_3]$), alongside the explanatory strength of the model for sustainable performance ($R^2 = [R^2\text{-SP}]$), suggest that sustainable performance is not generated solely by possessing competencies but by the firm's ability to mobilize and reconfigure them under uncertainty.

This integrated perspective refines RBV in an important way. While RBV traditionally highlights the strategic value of rare resources, the present findings emphasize that in highly uncertain and resource-constrained contexts, the value of human competencies is realized primarily when these competencies are activated through adaptive processes. Thus, this study extends RBV by demonstrating that VRIN resources alone may be insufficient unless supported by dynamic capability mechanisms. At the same time, the study extends Dynamic Capabilities Theory by providing evidence from micro-level, informal SMEs, a context often underrepresented in dynamic capability research, which tends to focus on larger and more formal organizations.

Contextual Contribution to Aquaculture SMEs

The aquaculture sector represents a unique empirical setting due to its combination of market turbulence and biological uncertainty. The findings demonstrate that adaptive capability strengthens the strategic value of human resource competencies in such conditions, enabling SMEs to sustain productivity and operational continuity despite ecological shocks. This sector-specific contribution is important because much of the HRM-performance literature has been developed in relatively stable industries where environmental risks are less severe. By focusing on aquaculture SMEs, this study highlights that performance sustainability depends heavily on competencies that enable firms to respond to both market and ecological instability. Therefore, the results emphasize the importance of contextualizing HR-based strategic management theories within industries characterized by high operational risk.

Theoretical Contributions

This study offers several theoretical contributions. First, it challenges large-firm-centric assumptions within strategic management by demonstrating that, in SMEs, informal competency-based HR development can function as a VRIN resource even without formal HRM systems (Fabrizio, 2022). This supports the view that competitive advantage in SMEs may emerge from tacit knowledge, experiential learning, and informal collaboration rather than from structured HR policies.

Second, by establishing adaptive capability as a partial mediator, this study advances Dynamic Capabilities Theory by clarifying the mechanism through which HR-related resources contribute to sustainable performance. Specifically, the findings show that competencies enhance performance not only through direct operational improvements but also through their contribution to organizational flexibility and resource reconfiguration. This process-oriented explanation responds to calls for stronger integration between RBV and capability-based perspectives.

Third, the study contributes to the SME sustainability literature by conceptualizing sustainable performance as a capability-driven outcome rather than a function of scale, formalization, or technological sophistication. In line with Eikelenboom and de Jong (2019), sustainable performance is better understood as the ability to maintain stable outcomes

over time, especially under uncertainty, and this study demonstrates how such sustainability is supported through competency-driven adaptation.

Practical Implications

The findings provide practical implications for aquaculture SME owners, policymakers, and development agencies. First, aquaculture SMEs should prioritize competency development in technical aquaculture practices, environmental management, and problem-solving skills, as these competencies directly contribute to sustainable performance. Second, SMEs should strengthen adaptive routines by implementing continuous monitoring systems for water quality, developing rapid response mechanisms for disease outbreaks, and encouraging learning practices that enable flexible operational adjustments. Third, government agencies and extension services can enhance SME sustainability by providing targeted training programs, facilitating access to technology and financing, and strengthening collaborative networks among SMEs, research institutions, and policymakers. These initiatives are likely to improve both human resource competencies and adaptive capability, thereby strengthening long-term performance resilience in the aquaculture sector.

Conclusion

This study provides empirical evidence that human resource competencies contribute significantly to the sustainable performance of aquaculture SMEs, both directly and indirectly through adaptive capability. The SEM-PLS results show that human resource competencies have a strong positive effect on adaptive capability ($\beta = 0.56$; $p < 0.001$), and adaptive capability, in turn, significantly enhances sustainable performance ($\beta = 0.39$; $p < 0.001$). The explanatory power of the model is moderate to substantial, explaining 31% of the variance in adaptive capability and 48% of the variance in sustainable performance, indicating that the proposed framework captures an important proportion of performance variation in aquaculture SMEs.

Importantly, the findings confirm that adaptive capability serves as a partial mediator, meaning that human resource competencies improve sustainable performance not only through strengthened organizational adaptability but also through their direct contribution to operational effectiveness. This result supports the Resource-Based View and Dynamic Capabilities Theory by demonstrating that competencies represent valuable firm-specific resources, while adaptive capability functions as a capability that enables SMEs to reconfigure and mobilize these resources under ecological and market uncertainty. In the context of aquaculture SMEs, where production risks and environmental turbulence are substantial, adaptive capability plays a critical role in reinforcing the long-term value of human resource competencies.

Overall, this study advances understanding of sustainable

performance in resource-constrained SMEs by validating a competence capability performance pathway and highlighting the importance of combining human capital development with adaptive organizational processes. The findings imply that SME owners and policymakers should focus not only on strengthening workforce competencies but also on fostering adaptive routines that enable rapid adjustment to environmental change.

Despite its contributions, this study has several limitations that provide opportunities for future research. First, the cross-sectional research design limits the ability to draw strong causal conclusions. Future studies may apply longitudinal approaches to better capture how competencies and adaptive capability evolve over time and shape sustainable performance trajectories. Second, because the study focuses on aquaculture SMEs within a specific regional context, generalizability may be limited. Replication across different industries and geographical settings would strengthen external validity. Third, future research may extend the model by incorporating additional mediators or moderators such as digital capability, organizational learning culture, or environmental turbulence to provide a more comprehensive explanation of the competence performance relationship. Finally, combining perceptual measures with objective performance indicators would enhance the robustness of the findings and deepen insight into sustainability-oriented performance outcomes.

Author contributions

The first author, Mei Rani Amalia, came up with the research concept, created the theoretical framework, designed the research methodology, collected and analyzed data using SEM-PLS, and wrote the first draught of the paper. In addition, she oversaw the entire research procedure and communication with the journal. The second author, Agus Suroso, was responsible for overseeing the data analysis procedure, refining the research design, providing essential insights into the theoretical integration of the Resource-Based View and Dynamic Capabilities, and reviewing and revising the text for crucial intellectual material. The third author, Ratno Purnomo, helped create the study model, confirmed the validity of the methodology, and offered valuable input on how to analyze the data and draw conclusions. Additionally, he helped to enhance the manuscript's academic rigor and consistency. The last version of the manuscript has been read and approved by all of the authors, who also agree to accept responsibility for every element of the project.

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