







Sustainable Development of Agricultural Human Resources: A Multi-Dimensional Analysis through Islamic Boarding Schools in Indonesia

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ABSTRACT

The sustainable development of agricultural human resources (HR) is a paramount challenge in modern agribusiness, particularly within faith-based educational settings. This study assessed the sustainability of agricultural HR development within Islamic boarding schools (pesantren) in West Java, Indonesia, using a comprehensive multidimensional approach that encompassed economic, social, environmental, technological, and institutional factors. Data from 300 students across four pesantren were analyzed using the Multi-Dimensional Scaling (MDS) method, which employed Rapid Appraisal for Agribusiness Boarding School (RAPABS) analysis. The findings revealed that agricultural HR development was "moderately sustainable", with an index score of 55.79. The environmental dimension achieved the highest score (61.15), demonstrating the schools' success in cultivating ecological awareness. Conversely, the technological dimension recorded the lowest score (52.83), highlighting the need for enhanced technology adoption and more robust post-harvest training. While the social and economic dimensions exhibited promise, they encountered obstacles related to market access and equitable profit distribution. Additionally, the institutional dimension emphasized the significance of stakeholder collaboration and reinforcing microfinance support. This study illuminated the unique role of Islamic boarding schools in harmonizing religious education with sustainable agribusiness strategies. It offered valuable insights for policymakers seeking to enhance agribusiness sustainability through faith-based education and advocated for future research on regional variations and long-term socio-economic impacts.

Keywords: Multi-Dimensional Scaling, Agricultural Human Resources, Sustainability, Islamic boarding school.

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INTRODUCTION

The regeneration of human resources (HR) in the agribusiness sector remains one of the most pressing challenges of the modern era, particularly in ensuring agricultural sustainability. Globally, sustainable agriculture serves as a crucial pillar for advancing the Sustainable Development Goals (SDGs), particularly Goal 2 (Zero Hunger) and Goal 8 (Decent Work and Economic Growth). However, current trends indicate that the agricultural sector, especially in developing countries like Indonesia, faces a shortage of skilled HR regeneration, posing a threat to the sector's sustainability and future competitiveness

(Prasetyaningrum et al., 2022; Pratiwik, 2023; Fadlillah, 2024).

Over the past decades, numerous studies have investigated the challenges associated with agribusiness HR regeneration. Research findings highlight that the migration of young labour to non-agricultural sectors (brain drain) has been a primary factor hindering agricultural HR regeneration (Ercolani & Wei, 2011; Moeis et al., 2020; Ramsey et al., 2023; Wen, 2024). Conversely, studies conducted in developed countries underscore the importance of adopting modern technologies and implementing skill-based education as strategies to attract younger generations to the sector (Fejzulla, 2021; Kosenchuk et al., 2021; Unya et al., 2022).

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In response, Indonesia has introduced various policies, such as the Young Farmer Entrepreneurship Development Program (PWMP) and the Youth Entrepreneurship and Employment Support Services (YESS). However, the impact of these initiatives remains uneven, particularly in rural areas (Effendy et al., 2020).

Furthermore, research from developed countries emphasizes the potential of modern technologies and skill-based education in engaging youth in agribusiness (Fejzulla, 2021; Kosenchuk et al., 2021; Unya et al., 2022). Innovations such as precision farming, digital agriculture, and sustainability-focused education have been identified as promising strategies for boosting agricultural productivity and youth involvement. However, applying these strategies directly to the Indonesian context is often obstructed by socio-cultural and institutional barriers (Islam, 2021; Sikandar et al., 2022). This underscores the need for a comprehensive and culturally adaptive framework that seamlessly integrates educational, social, and technological dimensions to enhance agricultural human resources effectively.

Islamic boarding schools (pesantren) present significant potential as platforms for agricultural HR regeneration. Historically, pesantren have played a central role in shaping social, moral, and economic development within Indonesian communities (Izza et al., 2022; Asrol et al., 2023; Purnama, 2023). Beyond their religious education functions, many pesantren have transformed into community empowerment centres, incorporating vocational training, including agribusiness activities. This dual role positions pesantren as key agents in addressing the agribusiness HR crisis through a holistic and culturally embedded approach. In West Java—home to the largest number of pesantren in Indonesia, as can be seen in Fig. 1—several institutions have successfully integrated agribusiness into their curricula, offering a viable model for youth engagement in agriculture (Republika, 2021).

Despite their potential, existing studies on pesantren-driven agribusiness initiatives are predominantly descriptive, focusing on success stories rather than offering a structured framework for scaling and optimizing these models. The limited incorporation of sustainability dimensions—ecological, economic, social, technological, and institutional—further restricts the long-term

effectiveness of these initiatives (Miao, 2023). Previous interventions, such as technical training and financial assistance, have yielded mixed results due to their fragmented and short-term nature (OECD, 2021; World Bank Group, 2020). Addressing these shortcomings demands a more integrated and enduring model that harmonize religious education with modern agribusiness practices while leveraging local cultural values.

Sustainable agriculture, as defined by recent literature, prioritizes the efficient utilization of natural resources to ensure environmental integrity while maintaining productivity (Mulatu, 2024). Sustainable approaches, such as conservation agriculture (CA) and organic farming, enhance soil fertility, mitigate environmental degradation, and reinforce long-term food security (Adedibu, 2023; Yusriadi, 2023). Beyond environmental advantages, sustainable agriculture also fosters economic viability and social equity—two essentials for rural development (Islam, 2021; Sikandar et al., 2022). However, widespread adoption of sustainable practices faces resistance, largely due to perceived financial burdens and insufficient technical knowledge among farmers (Karunathilake, 2023).

Within the pesantren context, integrating sustainable agribusiness principles presents a promising pathway for revitalizing agricultural HR while simultaneously fostering community-based agricultural development. This requires a multidimensional approach that encompassing policy support, farmer education, and technological innovation. Furthermore, embracing a holistic model that integrates religious teachings with sustainable agricultural practices can cultivate a new generation of agrarian leaders who are not only technically proficient but also socially responsible (Fedro et al., 2019; Murdan, 2020).

The key challenge lies in designing a systematic conceptual model that aligns with the cultural and institutional characteristics of pesantren while addressing the systemic barriers hindering agricultural HR regeneration. Existing research lacks an in-depth analysis of how pesantren can be systematically leveraged to support agribusiness HR development through a sustainability-oriented framework. This study seeks to bridge this gap by developing and testing a structured model to optimize pesantren as hubs for agribusiness HR regeneration (Hermanu et al., 2025).

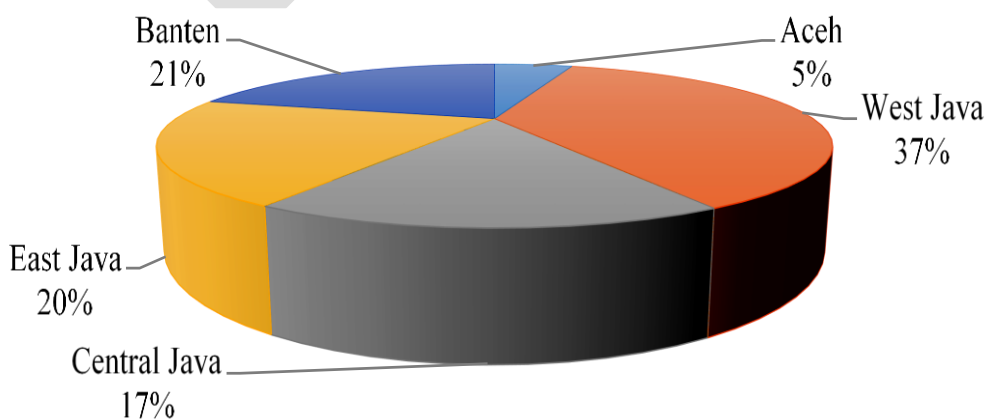


Fig. 1: The Province with the Most Islamic Boarding Schools in Indonesia (Source: Indonesian Ministry of Religion, 2022).

This study aims to construct a comprehensive and implementable model for transforming pesantren into centers for agribusiness HR regeneration. Employing a multidimensional approach, this research utilizes a modified Rapid Appraisal for HR (RAP-HR) method to assess the sustainability levels of agribusiness HR within pesantren. The novelty of this study lies in its unique integration of religious education with sustainable agribusiness practices—an aspect that has received limited scholarly attention. By bridging theoretical frameworks with practical applications, this research seeks to deliver actionable insights for policymakers, educators, and community leaders (Marlia et al., 2025).

The scope of this research encompasses an analysis of both internal and external factors influencing the sustainability of pesantren-based agribusiness HR regeneration in West Java. This includes examining institutional capacities, socio-cultural dynamics, and technological readiness. The findings are expected to contribute not only to the academic discourse on agricultural HR development but also to the formulation of policy interventions and scalable practical models applicable across Indonesia and other developing countries (Malayeri et al., 2025). By trackling the urgent need for agricultural HR regeneration through a culturally embedded and sustainability-focused framework, this research offers a transformative framework for empowering pesantren as key players in agribusiness development. This approach not only fortifies the sustainability of the agricultural sector but also enhances the socio-economic resilience of rural communities, aligning with broader national and global development agendas.

MATERIALS & METHODS

Research Design

This study employed a positivist paradigm with a quantitative approach to evaluate the sustainability of agricultural human resource (HR) development through Islamic boarding school in West Java, Indonesia. The analysis was conducted using Multi-Dimensional Scaling (MDS), specifically adapted for the agribusiness context through the Rapid Appraisal for Agribusiness Boarding School (RAPABS) technique. This methodology derived from the RAPFISH approach, which is widely used in fisheries sustainability studies and has been modified to fit the educational and agricultural context of this research (Haya & Fujii, 2020; Atufa et al., 2023; Martias, 2023; Yamin et al., 2025).

Research Location

This study focuses on four Islamic boarding schools in West Java that were selected to represent both urban and rural contexts. These institutions include Al-Kautsar Islamic Boarding School and Nurul Ihsan Islamic Boarding School in rural areas, and Hidayatul Mustafidz Islamic Boarding School and Islamic Leader School in urban areas. These locations were chosen based on their active involvement in agricultural activities and their participation in government initiatives such as the One Pesantren One Product (OPOP) program (Indonesian-Ministry-of-Religion, 2022).

Sampling Strategy

A proportional stratified random sampling technique was applied to ensure adequate representation across the four selected Islamic boarding schools. The total sample size was determined using Slovin's formula with a 10% margin of error, resulting in 300 respondents from a population of 1,055 students (Table 1). The sample distribution among the Islamic boarding schools was as follows: 82 respondents from Al-Kautsar, 72 from Nurul Ihsan, 76 from Hidayatul Mustafidz, and 70 from Islamic Leader School (Table 1). This stratification ensures the robustness of the findings and reduces sampling bias.

Table 1: Research Sample

No	Research Location	Number of students (people)	Sample size (people)
1	Al-Kautsar Islamic boarding school	460	82
2	Nurul Ihsan Islamic boarding school	251	72
3	Hidayatul Mustafid Islamic boarding school	320	76
4	Islamic Leader School	230	70
	Amount	1,055	300

Variables and Indicators

This study analyses the sustainability of HR development through five dimensions: economic, social, environmental, technological, and institutional. Each dimension is evaluated using a set of indicators derived from existing literature and modified for the Islamic boarding school context (Logachev et al., 2021; Maia et al., 2021; Bantilan, 2024; Matkivskiy, 2024). Table 2 presents the dimensions and corresponding indicators used in this study.

Data Collection

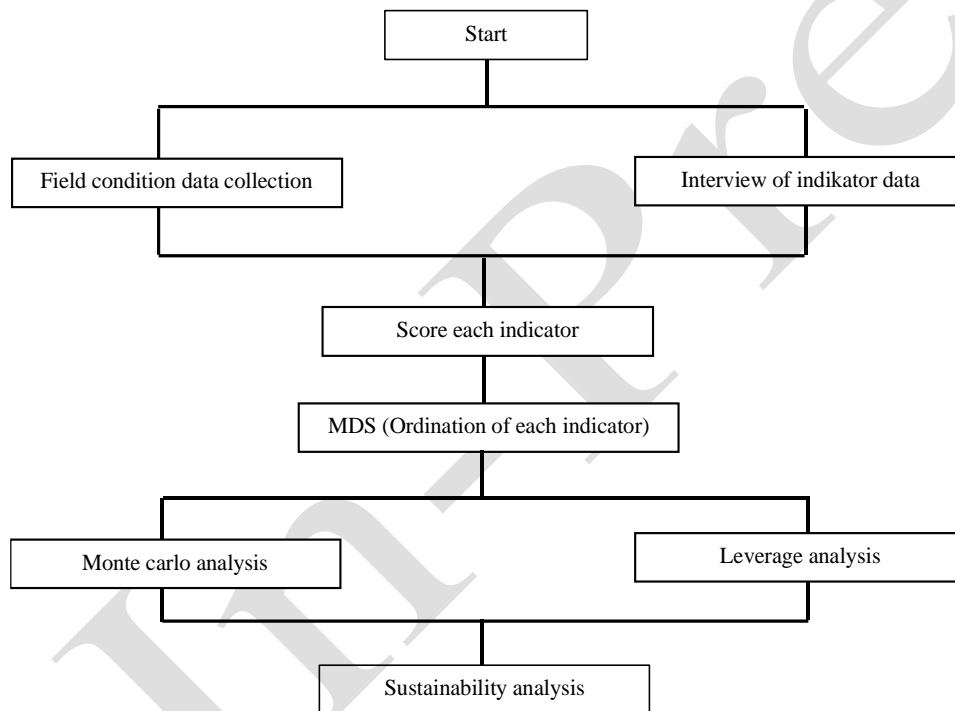
Primary data were collected using a structured questionnaire that was tested for validity and reliability. Secondary data were obtained from government statistics, academic publications, and institutional reports. Field research was conducted between March and June 2024, with interviews facilitated by trained enumerators to ensure consistency in data collection.

Analysis Techniques

- Multi-Dimensional Scaling (MDS):** MDS was employed to calculate sustainability indices for each dimension and overall HR development (Kruskal & Wish, 1978). Scores were normalized on a scale from 0 to 100, with the following categories: 0–25 (Poor), 26–50 (Less Sustainable), 51–75 (Moderately Sustainable), and 76–100 (Highly Sustainable) (Borg & Groenen, 2005).
- Leverage Analysis:** To identify the attributes most sensitive to sustainability, leverage analysis was performed. This analysis measures the impact of removing specific attributes on the overall sustainability score, thereby identifying key areas for improvement (Pitcher & Preikshot, 2001).
- Monte Carlo Simulation:** Monte Carlo simulations were conducted to test the robustness of the MDS results against uncertainty (Metropolis & Ulam, 1949). This approach estimates confidence intervals for sustainability indices and ensures that random errors do not significantly impact the findings.

Table 2: Indicator Variables

Variable/Dimension	Attribute	Score	Good	Bad	Criteria
Economic Dimensions	Agribusiness Productivity	1,2,3,4,5	5	1	1= Very Low
	Profit Distribution Balance	1,2,3,4,5	5	1	2= Low
	Income	1,2,3,4,5	5	1	3= Medium
	Market Accessibility	1,2,3,4,5	5	1	4= Good
Social Dimensions	Agribusiness Prospects by Students	1,2,3,4,5	5	1	5= Very Good
	Land Ownership Status	1,2,3,4,5	5	1	1= Very Low
	Absorption of Agricultural HR	1,2,3,4,5	5	1	2= Low
	Commitment to Islamic boarding school	1,2,3,4,5	5	1	3= Medium
Environmental Dimensions	Agricultural HR Development and Welfare	1,2,3,4,5	5	1	4= Good
	Environmental Awareness	1,2,3,4,5	5	1	5= Very Good
	Environmental Suitability	1,2,3,4,5	5	1	1= Very Low
	Environmental Carrying Capacity	1,2,3,4,5	5	1	2= Low
Technological Dimensions	Technology Adoption Rate	1,2,3,4,5	5	1	3= Medium
	Cultivation Technology	1,2,3,4,5	5	1	4= Good
	Mastery of Postharvest Technology	1,2,3,4,5	5	1	5= Very Good
	Access Science and Technology Developments	1,2,3,4,5	5	1	1= Very Low
Institutional Dimensions	Policy Understanding and Implementation	1,2,3,4,5	5	1	2= Low
	Coordination between Islamic boarding school and Agricultural HR	1,2,3,4,5	5	1	3= Medium
	Microfinance Institutions	1,2,3,4,5	5	1	4= Good
	Islamic boarding school participation	1,2,3,4,5	5	1	5= Very Good
	The Role of Islamic boarding school Institutions	1,2,3,4,5	5	1	

**Fig. 2:** Stages of Sustainability Index and Status Analysis Using MDS with RAPABS.

d. Goodness-of-Fit Test: Goodness-of-fit for the MDS analysis was evaluated using the S-Stress value and R^2 . S-Stress values below 0.25 and R^2 values above 0.90 indicate a strong model (Borg & Groenen, 2005).

Data analysis was performed using Rapfish 3.1 software, downloaded from www.Rapfish.org, and compressed as an add-in in MS Excel for data processing. Based on indicator scores entered into the Rap Scores matrix in MS Excel, data processing was executed using the software (Fig. 2).

The output of this analysis is a sustainability index for agricultural HR development through Islamic boarding schools based on the five dimensions analysed, represented as scores on a 0–100 scale and visualized in a kite diagram. This sustainability index serves as a reference

to determine sustainability levels according to predefined categories (Table 3).

Table 3: Sustainability Level Categories Based on Rap-Food System Index Results

Index Value	Category
0 – 25	Poor (Unsustainable)
25.01 – 50	Less Sustainable
50.01 – 75	Moderately Sustainable
75.01 – 100	Highly Sustainable

Source: (Saragih et al., 2020)

Another outcome of the MDS analysis includes the S-Stress value (Standardized Residual Sum of Squares) and the coefficient of determination (R^2), both reflecting the accuracy (goodness-of-fit) of the MDS analysis. These

values are used to assess whether additional attributes are required or if existing attributes accurately reflect each analysed dimension. Low S-Stress values indicate a good fit, while high values suggest otherwise. The model is deemed reliable if the S-Stress value remains below 0.25 and R^2 approaches 100%, signifying that the attributes effectively explain the model.

Leverage analysis identifies sensitive attributes that significantly influence the sustainability score. These sensitive attributes are determined by changing the Root Mean Square (RMS) ordination on the X-axis or sustainability scale. The larger the RMS change resulting from the removal of an attribute, the greater its influence on the sustainability index. Subsequently, Monte Carlo simulations evaluate the impact of random error on all dimensions. This method estimates the confidence interval at a 95% confidence level, accounting for uncertainty. The Monte Carlo index is then compared with the MDS index, with closer alignment indicating minimal error in the MDS analysis.

RESULTS

This study effectively addressed the core question concerning the sustainability of agricultural human resource development through Islamic boarding schools in West Java (Fig. 5). Utilizing the Multi-Dimensional Scaling (MDS) analysis through the RAP-Agribusiness Boarding School (RAPABS) method, the multidimensional sustainability index determined to be 55.79, categorizing it as "Moderately Sustainable". Among the assessed dimensions, the environmental factor achieved the highest score at 61.15, whereas the technological dimension lagged behind at 52.83. These findings underscore notable progress in certain areas while highlighting the need for further advancements, particularly in the technological capabilities.

Regeneration is a fundamental prerequisite for sustainability, as it directly correlates with renewal and future resilience (Capra, 2002; Glauben et al., 2002). The sustainability status of agricultural human resource development within Islamic boarding schools in West Java was evaluated through the multidimensional RAPABS method, encompassing five sustainability dimensions: economic, social, environmental, technological, and institutional. The statistical parameters employed in this study include Monte Carlo analysis, S-Stress, and R^2 values. RAPABS analysis further demonstrates that the goodness-of-fit measure reflects the magnitude of the S-Stress and R^2 values (Kavanagh & Pitcher, 2004).

Based on the Multi-Dimensional Scaling (MDS) analysis using the RAPABS method, as presented in Table 4, the sustainability of agribusiness human resource development in Islamic boarding schools falls within the "moderately sustainable" category, with an overall index of 55.79. According to the classification by Saragih et al. (2020) in Table 3, this indicates that while the system exhibits a reasonable degree of sustainability, further refinements are essential to bolster long-term stability and efficacy.

Table 4: Results (Goodness of Fit) from RAPABS Analysis and Sustainability Status of Agricultural Human Resources in Islamic Boarding Schools in West Java

Criteria	MDS	Monte Carlo	Difference	S-Stress	R^2
Multidimensional	55.79	55.56	0.23	0.18	0.93
Economy	54.45	54.22	0.23	0.18	0.93
Social	55.00	54.78	0.22	0.19	0.92
Environment	61.15	60.51	0.64	0.19	0.91
Technology	52.83	51.91	0.92	0.19	0.92
Institutional	53.18	52.32	0.86	0.18	0.93

Among the five dimensions, the environmental dimension attained the highest score (61.15), reflecting robust ecological awareness and implementation of sustainable agricultural practices. However, a 0.64 variance between MDS and Monte Carlo results suggests inconsistency in environmental management, underscoring the need for more cohesive strategies. Conversely, the technological dimension recorded the lowest score (52.83), revealing persistent challenges in technology adoption, infrastructure constraints, and limited access to modern agricultural innovations. A 0.92 variance in this dimension signifies a higher degree of uncertainty, reinforcing the urgency for investment in technological advancement.

The economic (54.45) and social (55.00) dimensions exhibit relatively balanced sustainability levels. The economic dimension highlights market accessibility and financial resilience, yet price volatility and capital constraints pose ongoing challenges. Meanwhile, the social dimension reflects strong community engagement and workforce regeneration, though expanding social networks could further enhance long-term sustainability.

The institutional dimension (53.18) indicates that while existing governance structures provide a foundation for agribusiness, gaps persist in regulatory frameworks, partnerships, and policy efficacy. A 0.86 variance signals relative stability, but further institutional reinforcement is necessary to enhance governance effectiveness and ensuring long-term resilience.

The sustainability index for each dimension is depicted in the flyover diagram (Fig. 4), where greater distance from zero correspond to higher sustainability value. Flight charts, commonly referred to as radar diagrams, illustrate that sustainability decrease as the analysis point moves closer to zero increases as it moves outward. Based on the analysis results presented in Fig. 3 and 4, the technological dimension exhibits lowest sustainability index among all assessed factors, followed by the institutional, economic, social, and environmental dimensions. In contrast, the environmental dimension achieves the highest sustainability scores. The flyover diagram effectively visualizes the integrated sustainability status of agricultural human resource development in Islamic boarding schools across five key dimensions—economic, social, environmental, technological, and institutional—highlighting areas that require targeted improvements.

The sustainability of each dimension analysed in this study is evaluated based on a range of attributes specific to each category. Subsequently, the most sensitive attribute values across the five analysed dimensions—representing the sustainability of agricultural human resource development in Islamic boarding schools in West Java—are computed and illustrated in Fig. 6.

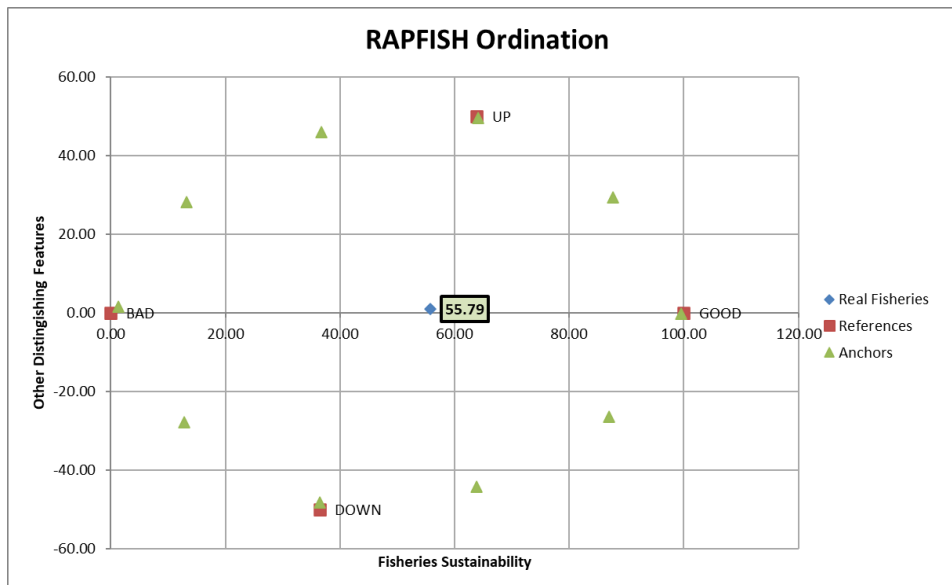


Fig. 3: Sustainability Index for Agricultural Human Resources Development through Islamic Boarding Schools

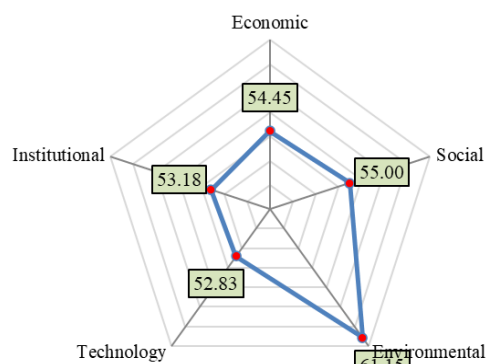


Fig. 4: Flyover diagram of the Sustainability Index for Agricultural Human Resources Development through Islamic Boarding Schools.

DISCUSSION

Economic Dimension

In this study, the economic dimension attained a sustainability index score of 55.00, classifying it as "moderately sustainable". The two most influential factors were income stability (RMS 1.78) and market accessibility (RMS 1.20). A stable income level among students engaging in agribusiness played a pivotal role in sustaining participation, as financial returns served as strong incentives for continued involvement. Additionally, enhanced market access facilitated better sales opportunities, ensuring the economic viability of agribusiness activities within Islamic boarding school.

These findings align with existing research on economic sustainability in agribusiness education, which underscores the significance of income stability and market integration in fostering long-term resilience. For instance, studies have demonstrated that integrating agribusiness training with practical market engagement enhances financial independence and overall economic sustainability (Surya et al., 2021; Boye et al., 2024). Similarly, research on e-commerce platforms in Sub-Saharan Africa has shown that improved market access leads to higher prices, reduced post-harvest losses, and the promotion of sustainable practices (Morepje et al.,

2024). In Brazil, market access variables have been identified as key drivers of crop diversification—an essential factor for agricultural sustainability (Perosa et al., 2024). A comprehensive review of market access interventions in low- and middle-income countries further revealed that such initiatives boost farm incomes and encourage adoption of improved agricultural practices, although their impact on food and nutrition security remains inconclusive (Marion et al., 2024).

The significance of these findings lies in their potential to strengthen rural economies. By equipping students with agribusiness competencies and facilitating market linkages, Islamic boarding schools can enhance economic self-sufficiency in local communities. However, challenges persist, particularly in maintaining stable market access and securing adequate policy support for infrastructure development. Recent studies highlight the critical role of integrating smart farming technologies to optimize resource utilization and further enhance economic sustainability in agricultural education (Balyan et al., 2024; Tagarakis et al., 2021).

Social Dimension

The social dimension of this study also recorded a sustainability index score of 55.00, placing it within the "moderately sustainable" category. The most influential attributes in this dimension were students' commitment to the Islamic boarding school (RMS 2.57) and land ownership status (RMS 1.58). The students' dedication to the agribusiness programs was evident in their participation in training sessions and agribusiness activities. Additionally, the land management system within the Islamic boarding school provided students with unrestricted access to resources, allowing them to develop their agribusiness skills without ownership constraints.

A key factor supporting the social sustainability is combination of student commitment and land tenure security. Research has shown that secure land tenure is fundamental to sustainable agriculture, as uncertainty in ownership can impede long-term development (Ekpodessi & Nakamura, 2022). Furthermore, strong student

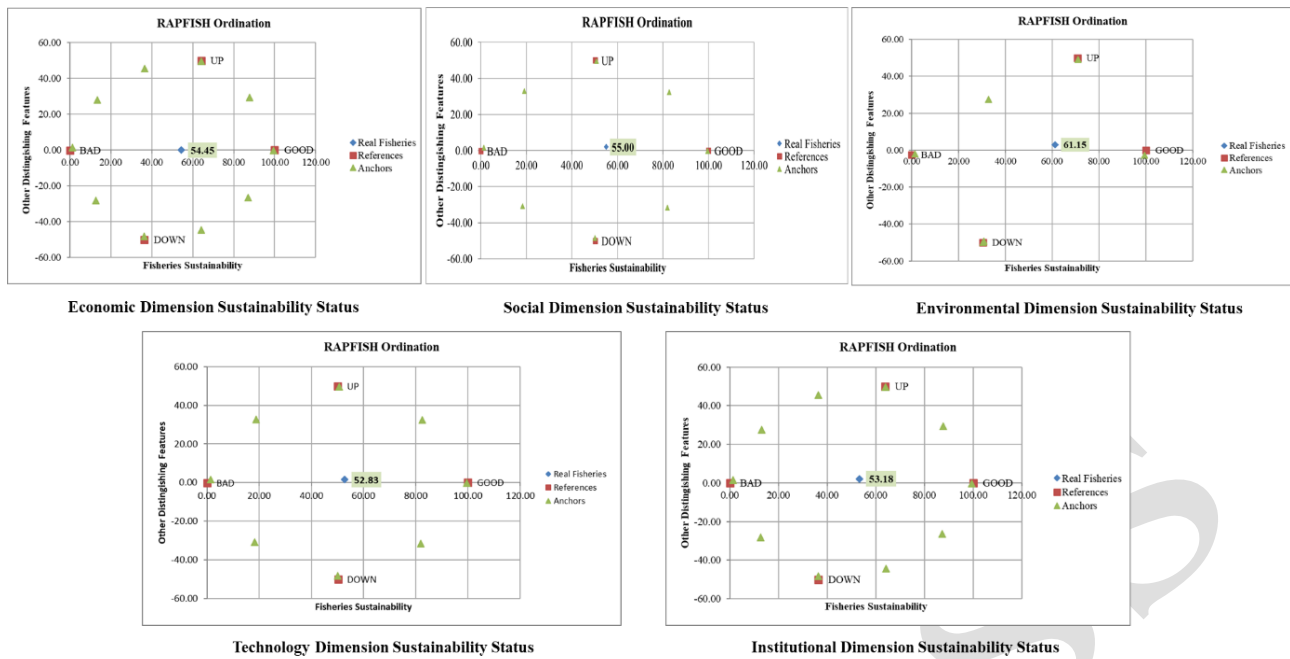


Fig. 5: Sustainability Position for Each Dimension.

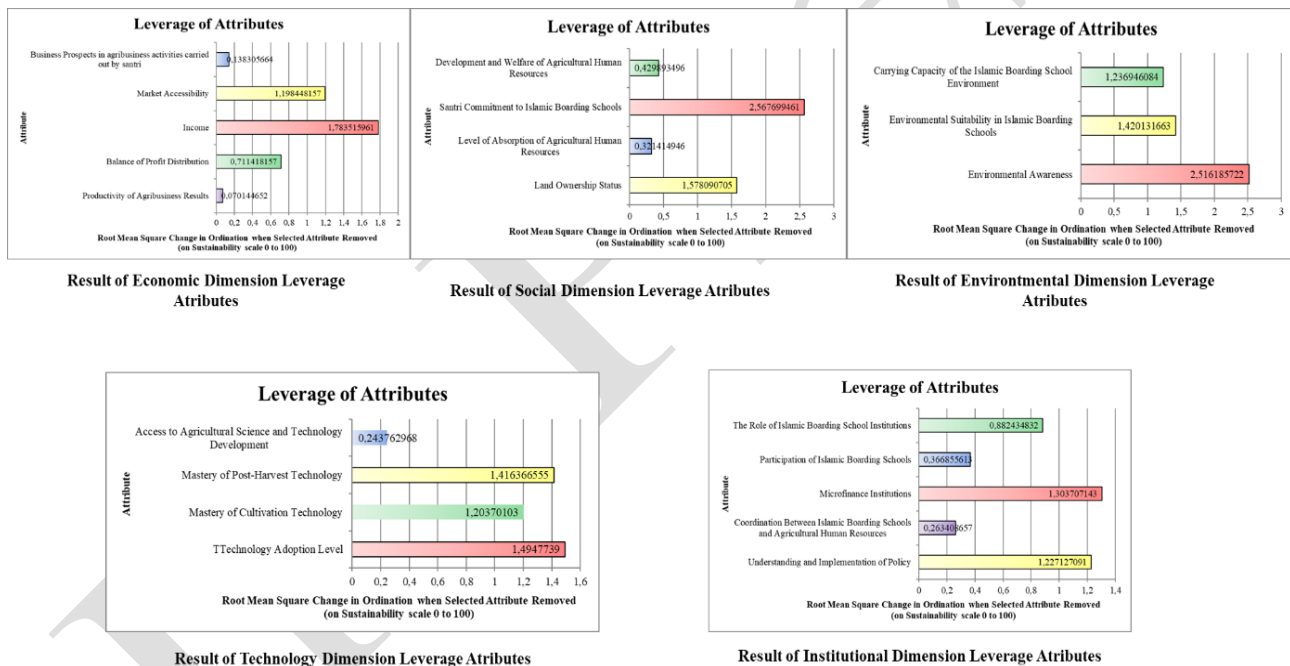


Fig. 6: Results for Each Dimension Based on Leverage Value.

engagement in educational institutions has been linked to increased sustainability awareness, particularly when reinforced through institutional sustainability programs and stakeholder collaboration (Wang et al., 2020).

This study builds upon previous research by exploring how Islamic boarding schools promote sustainability through religious and value-based education. These institutions create an environment that fosters student participation while embedding social values into agribusiness practices, reinforcing both personal and community development. This approach offers a promising model for education-driven poverty alleviation in rural areas. By equipping students with agribusiness competencies, Islamic boarding schools

contribute to local economic growth and self-sufficiency. However, ensuring the long-term sustainability of these programs necessitates integrated policies that enhance access to resources and infrastructure (Malayeri et al., 2025). While the study provides valuable insights into the social dimension of sustainability, further research is needed to explore the interconnections between social sustainability and other dimensions. Future studies should examine how these dimensions collectively influence the regeneration of agricultural human resources. Strengthening collaborations between Islamic boarding schools, government entities, and local communities could help scale this model to other regions, fostering broader agribusiness sustainability.

Environmental Dimension

The environmental dimension achieved the highest sustainability index in this study, scoring 61.15 and placing it within the "moderately sustainable" category. This reflects a relatively stronger performance compared to the other dimensions. The most influential factors in this category were environmental awareness (RMS 2.52), the environmental suitability of the Islamic boarding school (RMS 1.42) and the carrying capacity of the environment (RMS 1.24). Students demonstrated a high level of environmental consciousness through active participation in ecological initiatives, such as organic farming and basic waste management practices within the Islamic boarding school. Additionally, the rural settings of many Islamic boarding schools, surrounded by natural landscapes, facilitated the implementation of sustainable agribusiness activities. This study highlights how these institutions integrate environmentally friendly practices by embedding religious values and ecological awareness into their curricula. This unique approach leverages local potential to enhance sustainability, distinguishing Islamic boarding schools as key contributors to community-based environmental stewardship.

Previous research has established a strong correlation between environmental awareness and sustainable thinking (Al-Dosari & Abdellatif, 2024). Furthermore, studies suggest that mass media exposure and education levels significantly influence environmental consciousness in developing countries (Aşıksoy et al., 2020). These findings reinforce the argument that Islamic boarding schools, by embedding sustainability principles into their curricula, play a crucial role in promoting environmental stewardship while maximizing local resources for sustainable development. The implications of these findings are substantial, as they indicate that Islamic boarding school can serve as community-based educational models that integrate environmental awareness into agribusiness practices (Alotibi, 2024). This model not only nurtures environmentally responsible agricultural professionals but also contributes to the preservation of local ecosystems. The success of this approach presents an opportunity for replication in other regions, particularly in rural areas with similar environmental conditions.

Despite these achievements, some limitations remain. The absence of advanced waste management systems may hinder the full potential of environmental programs in Islamic boarding schools. Therefore, greater technological support and enhanced training for students in environmental management are necessary to optimize sustainability efforts. While this research effectively evaluates the environmental dimension's sustainability, further studies are needed to explore the interplay between environmental attributes and other sustainability dimensions. Ensuring long-term viability of environmental programs will require policy reinforcement and strategic collaboration between the government, the private sector, and Islamic boarding school. With holistic and well-supported approach, these institutions can emerge as pivotal agents of change in fostering community-based

agribusiness sustainability (Razzaq et al., 2024; Etongo et al., 2025).

Technological Dimension

The technological dimension recorded a sustainability index score of 52.83, classifying it as "moderately sustainable." However, it ranked the lowest among all dimensions. Leverage analysis identified the most sensitive factors affecting sustainability: the rate of technology adoption (RMS 1.49), mastery of post-harvest technologies (RMS 1.42), and proficiency in cultivation technologies (RMS 1.20). Although students exhibited a strong interest in agricultural technologies, their access to advanced tools and comprehensive training remained limited. Given that technology is a fundamental component of modern agricultural production (Tolmacheva et al., 2024), addressing these gaps is critical.

This study stands out by integrating technology training directly into the Islamic boarding school curriculum. This approach not only exposes students to agricultural technologies but also allows them to apply their knowledge in real-world agribusiness activities within the school setting. Previous research underscores the role of technology in enhancing business sustainability (Hrustek, 2020; Santiteerakul et al., 2020). Moreover, the integration of advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), and precision agriculture has been shown to significantly improve sustainability outcomes in agricultural practices (Kalfas et al., 2024; Sampaothong, 2024).

The significance of these findings lies in the potential to accelerate the development of agribusiness human resources through the adoption of technologies tailored to the specific needs of Islamic boarding school. This model holds promise for wider application, particularly in rural areas where access to technology remains limited. By introducing simple yet effective technological solutions, Islamic boarding school can become catalysts for transforming community-based agribusiness. Nevertheless, the low sustainability score in this dimension highlights the challenges posed by inadequate technological infrastructure and external support, including funding for equipment and advanced training. To address these issues, fostering partnerships with the government agencies, the private enterprises, and higher education institutions is essential for improving technological access and ensuring continuous skill development. While this study successfully evaluates the sustainability of the technological dimension, certain findings—such as the lack of expertise in post-harvest technologies—warrant further investigation. Future research should examine the impact of technological integration on student productivity and income growth for students. With the appropriate support, Islamic boarding school can play a pivotal role in advancing technological sustainability within the agribusiness sector.

Institutional Dimension

In this study, the institutional dimension recorded a sustainability index score of 53.18, categorizing it as "moderately sustainable". Leverage analysis identified the

most influential attributes in this dimension: the role of microfinance institutions (RMS 1.30), the understanding and implementation of policies (RMS 1.23), and the role of Islamic boarding school institutions (RMS 0.88). Islamic boarding school played a crucial role in fostering agribusiness activities among students, particularly through the coordination of government programs such as One Pesantren One Product (OPOP). However, restricted access to microfinance remains a significant challenge, limiting students' ability to expand agribusiness ventures.

This finding build upon to the work of (Effendy et al., 2020), who emphasized the importance of institutional synergy in sustaining agribusiness initiatives. Prior studies have highlighted the multifaceted role of institutions in agricultural sustainability. Local institutions contribute to strengthening social capital, trust and community networks, all of which promote sustainable agricultural practices (Nguyen et al., 2020). Furthermore, institutional linkages and efficient information flows among agricultural organizations are critical for addressing sustainability challenges and driving innovation, with agricultural extension services playing a pivotal role (Kassem et al., 2022). What sets this study apart is its comprehensive assessment, not only of the institutional role in policy-making but also of its direct influence on the economic viability of Islamic boarding schools. The collaboration between Islamic boarding school and microfinance institutions has proven instrumental in improving sustainability, particularly by facilitating access to financial capital for student-led agribusiness ventures.

The significance of these findings lies in the potential to strengthen the institutional capacity of Islamic boarding school, enabling them to serve as both educational centres and economic drivers within local communities. By establishing robust, school-based institutional policies, there is an opportunity to replicate this model in other regions, expanding its impact on agribusiness sustainability. However, several limitations persist, particularly in securing adequate funding and ensuring the availability of skilled professionals to support policy implementation. Addressing these challenges will require enhanced coordination among Islamic boarding schools, government agencies, and the private sector. Providing specialized training in policy management and expanding access to microfinance could be effective strategies for bolstering institutional sustainability. While this study successfully evaluates the sustainability of the institutional dimension, further research is needed to examine the influence of national policies on local institutions. Future studies should explore the interplay between institutional and economic dimensions and their collective impact on the sustainability of Islamic boarding school-based agribusiness initiatives. Strengthening these linkages could position Islamic boarding schools as a national model for developing sustainable agribusiness institutions.

Conclusion

This study makes a significant contribution to assessing the sustainability of agricultural human resource development through Islamic boarding school in West

Java, utilizing the Multi-Dimensional Scaling (MDS) method based on RAPABS. With an overall sustainability index of 55.79, categorized as "moderately sustainable," the findings highlight the environmental dimension as the strongest contributor, while the technological dimension requires substantial improvement. The results underscore the pivotal role of Islamic boarding school in fostering the regeneration of sustainable agricultural human resources by integrating religious values with agribusiness practices. The social dimension demonstrates considerable potential, driven primarily by students' commitment to the programs. However, the critical challenge lies in the technological dimension, where low adoption rates of agricultural innovations and limited mastery of post-harvest technologies hinder progress. Institutionally, strengthening microfinance access and policy support is imperative for ensuring long-term sustainability. This research enhances the literature by elucidating the intersection of Islamic boarding school-based education and agribusiness sustainability, offering valuable insights for policymakers and agribusiness stakeholders. Its implications extend beyond West Java, presenting a scalable model for other regions seeking to integrate education with sustainable agricultural development. For future research, a deeper exploration of the interconnections among sustainability dimensions is recommended, particularly examining their long-term effects on the broader agricultural sector. Additionally, the adoption of advanced agricultural technologies and a focused analysis of the gender dimension in agribusiness sustainability present promising avenues for further study.

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