Human Resource Development Strategy in Realizing Integrated and Globally Competitive Agrocomplexes

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Abstract

This study aims to analyze and formulate a strategy for developing human resources (HR) in realizing an integrated agrocomplex that is globally competitive. Using a mixed methods approach that integrates quantitative and qualitative methods, the study was conducted on 350 respondents representing various actors in the agrocomplex value chain in five agricultural center provinces in Indonesia. The results of the study indicate a gap in HR competency at various agrocomplex nodes, especially in the use of digital technology, post-harvest management, understanding international standards, and global marketing. Structural Equation Modeling (SEM) analysis confirmed the significant influence of individual characteristics ($\beta = 0.437$), institutional capacity ($\beta = 0.385$), access to technology and information ($\beta = 0.324$), and government policy support ($\beta = 0.276$) on HR competency, which in turn had a strong influence on agrocomplex competitiveness ($\beta = 0.612$). Qualitative findings revealed four main themes: generation gaps in agricultural management, limitations of the agricultural innovation support ecosystem, fragmentation of agricultural HR development programs, and the digital divide. Based on the Analytic Hierarchy Process (AHP), five priority strategies for human resource development were formulated, namely: (1) revitalization of agricultural vocational education and training; (2) strengthening the agricultural extension system based on digital technology; (3) development of penta-helix partnerships; (4) increasing the institutional capacity of farmers; and (5) developing incentives for young farmer cadres. This study concludes that human resource development is a fundamental prerequisite in realizing a globally competitive integrated agrocomplex, which requires a holistic approach and integration of interventions at the individual, institutional, and ecosystem levels. Policy recommendations are directed at the orchestration of cross-sectoral programs and strengthening synergies between stakeholders within the framework of agricultural transformation towards a modern agrocomplex.

Keywords: Integrated agrocomplex, global competitiveness, agricultural human resource development, competence, penta-helix, digital transformation of agriculture

1. Introduction

The agricultural sector is one of the strategic sectors in the development of the Indonesian national economy. As an agricultural country with abundant natural resources, Indonesia has great potential to develop integrated agrocomplexes that are able to compete in the global market [1]. Integrated agrocomplexes are an agricultural development concept that integrates all agricultural

subsystems from upstream to downstream in one efficient and sustainable system [2]. In the era of globalization and free trade, the competitiveness of agrocomplexes is a determining factor in the success of the Indonesian agricultural sector in facing international competition [3].

Although Indonesia has a comparative advantage in the form of natural resource wealth and supportive agroecological conditions, the competitive advantage of national agrocomplexes still needs to be improved. One of the crucial factors that influences the competitiveness of agrocomplexes is the quality of human resources (HR) [4]. Competent and adaptive HR to technological developments and global market dynamics are the main drivers of the transformation of traditional agriculture into modern, integrated and competitive agrocomplexes [5]. However, reality shows that the quality of Indonesian agricultural HR is still faced with various problems, including low levels of education and skills of farmers, limited access to agricultural information and technology, and weak agricultural institutional capacity [6].

Various empirical studies show a positive correlation between the quality of human resources and the productivity and competitiveness of the agricultural sector. Research conducted by Sumarno et al. [7] proved that the level of education and training of farmers is closely related to the level of adoption of agricultural technology and production efficiency. Meanwhile, a study conducted by Martínez-Gómez et al. [8] revealed that countries with high investment in agricultural human resources tend to have stronger export competitiveness of agricultural products. This emphasizes the urgency of human resource development as a fundamental prerequisite in realizing an integrated agrocomplex that is globally competitive.

In the context of the Industrial Revolution 4.0 and digital transformation, the challenges of developing agricultural human resources are increasingly complex. Agricultural digitalization requires human resources who not only understand cultivation techniques, but are also able to apply information and communication technology in every stage of production to marketing [9]. In addition, the demands of the global market for quality, sustainable, and traceable agricultural products require agricultural human resources to have comprehensive competencies, ranging from technical, managerial, to the ability to adapt to international standards [10].

Therefore, agricultural human resource development strategies need to be designed systematically, comprehensively, and future-oriented to answer the challenges and opportunities in realizing integrated agrocomplexes that are globally competitive. The strategy must consider various aspects, including strengthening agricultural vocational education and training, increasing extension capacity, strengthening farmer institutions, and developing a conducive agricultural innovation ecosystem [11]. Thus, this article aims to analyze and formulate effective human resource development strategies within the framework of developing integrated agrocomplexes that are globally competitive, by considering technical, managerial, and socio-cultural aspects in the Indonesian context.

2. Methods

This study uses a mixed methods approach that integrates quantitative and qualitative methods to gain a comprehensive understanding of HR development strategies in realizing a globally competitive integrated agrocomplex. The mixed methods approach was chosen based on the complexity of the research problem involving technical, managerial, social, and institutional aspects [12]. A sequential explanatory research design was used, where quantitative data collection and analysis were carried out first, followed by qualitative data collection and analysis to deepen understanding of the phenomena studied [13].

Primary data were obtained through a survey of 350 respondents representing various actors in the agrocomplex value chain, including farmers (200 respondents), agricultural extension workers (50 respondents), agricultural product processing industry players (50 respondents), and agricultural product exporters (50 respondents). Respondents were spread across five agricultural center provinces in Indonesia, namely West Java, East Java, North Sumatra, South Sulawesi, and West Nusa Tenggara. The sampling technique used stratified random sampling to ensure the representation of each respondent group in the population [14]. The research instrument was a structured questionnaire that had undergone validity tests (r> 0.361) and reliability (Cronbach's Alpha> 0.7) to ensure the validity of the data collected.

Secondary data is obtained from various official publications such as reports from the Central Statistics Agency (BPS), the Ministry of Agriculture, the Food and Agriculture Organization (FAO), and relevant previous research results. Secondary data includes information on agricultural sector productivity, agricultural product exports and imports, agricultural workforce education and skills levels, and agricultural human resource development policies that have been implemented. The availability of comprehensive secondary data allows researchers to conduct historical trend analysis and comparisons with other countries that have highly competitive agrocomplexes [15].

To deepen the understanding of the results of the quantitative analysis, this study used qualitative data collection techniques through in-depth interviews with 25 key informants who have expertise and experience in the development of agricultural and agrocomplex human resources. Key informants consisted of policy makers at the central and regional levels (8 people), academics and researchers (7 people), practitioners and agrocomplex business actors (6 people), and representatives of farmer organizations and communities (4 people). Interviews were conducted using semi-structured interview guidelines that allowed for in-depth exploration of strategic issues in the development of agricultural human resources [16].

Quantitative data analysis was conducted using descriptive and inferential statistical methods. Descriptive analysis was used to identify the profile of respondents, the level of agricultural human resource competency, and the characteristics of agrocomplexes at the research location. Meanwhile, inferential analysis used Structural Equation Modeling (SEM) to test the causal relationship between the variables studied, including: (1) individual characteristics, (2) institutional capacity, (3) access to technology and information, (4) government policy, (5) agricultural human resource competency, and (6) agrocomplex competitiveness [17]. The use of SEM allows researchers to analyze complex relationships between latent variables by considering measurement and structural aspects simultaneously.

Qualitative data from in-depth interviews were analyzed using thematic analysis methods. The analysis process includes interview transcription, coding, code categorization, identification of themes and patterns, and interpretation. To increase the validity of qualitative data, this study applies source and method triangulation techniques [18]. Integration of quantitative and qualitative analysis results is carried out at the interpretation stage to produce a comprehensive understanding of HR development strategies in realizing globally competitive integrated agrocomplexes.

Based on the results of quantitative and qualitative analysis, this study uses the Analytic Hierarchy Process (AHP) approach to formulate priority strategies for agricultural human resource development. AHP is a multi-criteria decision-making method that allows researchers to determine the relative importance of various alternative strategies based on expert assessments

[19]. A total of 15 experts were involved in the AHP process, consisting of policy makers, academics, practitioners, and representatives of farmer organizations. The criteria used in AHP include effectiveness, efficiency, sustainability, and feasibility of implementation. The results of AHP produce a hierarchy of agricultural human resource development strategies that can be used as policy recommendations for relevant stakeholders.

3. Results

Respondent Characteristics and Conditions of Agricultural Human Resources

The results of the descriptive analysis show that the characteristics of the respondents are quite varied. Of the 200 farmer respondents, the majority (67.5 %) are in the age range of 40-60 years with the dominant education level being elementary school (43.5%) and junior high school (31.5%). Only 5.5 % of farmers have a bachelor's degree. These data confirm the findings of previous studies indicating that the Indonesian agricultural sector is still dominated by older farmers with relatively low levels of formal education [20]. Meanwhile, the profile of agricultural extension workers shows a better condition with 68% of respondents having a bachelor's degree, although there is a gap between the number of extension workers and the area of their supervised area where the ratio of extension workers to supervised villages reaches 1: 3.5, far above the ideal standard of 1: 1-2 villages per extension worker.

Analysis of processing industry players and exporters shows that 78.5 % of respondents are small and medium-scale businesses with limited access to modern technology and international markets. The main obstacles identified in the development of agrocomplex businesses are limited human resources who have competence in supply chain management (64.3 %), understanding of international standards and regulations (73.2%), and the ability to utilize digital technology for global marketing (81.5%). These findings indicate a significant competency gap between industry needs and the qualifications of human resources available at various agrocomplex nodes.

Human Resource Competency Analysis at Agrocomplex Nodes

Measurement of the level of human resource competency at various agrocomplex nodes using a Likert scale of 1-5 showed varying results. At the production node (on-farm), farmer competency in cultivation techniques obtained a fairly high average value (3.86) , but competency in the use of digital technology (2.14), post-harvest management (2.48), and farm business analysis (2.32) was relatively low. The competency gap also occurs spatially, where farmers in Java have a higher average competency level (3.42) than farmers outside Java (2.87). Comparative analysis based on age shows that young farmers (<40 years) tend to have better competency in adopting digital technology and farm business management than older farmers, despite having more limited experience in conventional cultivation techniques.

At the processing node (off-farm), HR competencies in product diversification (3.56) and quality control (3.42) are quite good, but there are still significant weaknesses in the application of modern processing technology (2.78), food safety assurance systems (2.65), and development of export-oriented packaging (2.47). Meanwhile, at the marketing node, HR competencies in expanding domestic distribution networks (3.58) are relatively better than competencies in digital marketing (2.86), international business negotiations (2.51), and mastery of international trade regulations (2.34). These findings indicate that HR competencies at the downstream agrocomplex node still require significant strengthening to increase the competitiveness of Indonesian

agricultural products in the global market.

Causal Relationship Analysis through Structural Equation Modeling

The results of the Structural Equation Modeling (SEM) analysis showed a valid measurement model with factor loading values for all indicators > 0.5 and Average Variance Extracted (AVE) values > 0.5, indicating adequate convergent validity. Construct reliability was also met with Composite Reliability (CR) and Cronbach's Alpha values > 0.7 for all latent variables. The structural model showed good goodness of fit with RMSEA = 0.053 (<0.08) , CFI = 0.942 (> 0.90), and SRMR = 0.062 (<0.08).

Based on path analysis, it was found that individual characteristics significantly influence HR competency (β = 0.437, p < 0.01) , with formal and non-formal education as indicators that have the highest loading factors (0.785 and 0.756). Institutional capacity also significantly influences HR competency (β = 0.385, p < 0.01) , mainly through the indicator of the quality of extension and training services (loading factor = 0.823). Access to technology and information has a positive effect on HR competency (β = 0.324, p < 0.01) , while government policy support has a moderate but significant effect (β = 0.276, p < 0.05). HR competency is proven to have a strong influence on agrocomplex competitiveness (β = 0.612, p < 0.01) , confirming the research hypothesis that HR development is a key determinant in realizing integrated agrocomplexes that are globally competitive.

Qualitative Findings from In-depth Interviews

Thematic analysis of in-depth interview data produced several main themes that enriched understanding of the quantitative analysis results. The first theme is related to the "generation gap in agricultural management", where informants expressed the phenomenon of aging farmers as a serious challenge to the sustainability of the agricultural sector. An official from the Ministry of Agriculture said: "We are facing a farmer regeneration crisis. Young people are more interested in working in other sectors that are considered more prestigious and economically promising. In fact, they are the ones who should be the agents of transformation of our agriculture." This theme correlates with quantitative data that shows the dominance of elderly farmers in the demographic structure of respondents.

The second theme relates to the "limited ecosystem supporting agricultural innovation" which results in slow transfer of technology and knowledge from research institutions to the farmer level. An academic stated: "We have a lot of good agricultural research results, but too little of it has been successfully commercialized and applied by farmers. There is a missing link between research, extension, and application in the field." This is in line with quantitative findings that show low levels of adoption of modern and digital technologies among farmers.

The third theme discusses the "fragmentation of agricultural human resource development programs" that causes inefficiency and inconsistency of interventions. Several informants highlighted the lack of coordination between ministries and institutions in agricultural human resource development. A representative of a farmer organization stated: "Often the training programs we receive are sporadic and unsustainable. Each agency brings its own program without coordination, so we as farmers are confused by various approaches that are sometimes contradictory." This finding explains why despite the existence of various training programs, the improvement of agricultural human resource competencies has not been optimal.

The fourth theme is related to the "digital divide" which is a barrier to the adoption of

modern agricultural technology. Informants stated that limited digital infrastructure in rural areas, coupled with low digital literacy among farmers, are major obstacles to the digital transformation of agriculture. The director of an agritech startup stated: "We develop various technological solutions for farmers, but are often constrained by limited internet access and low digital skills of farmers. A gradual approach and intensive mentoring are needed to overcome this gap." This finding supports the results of the quantitative analysis which showed low digital competence of farmers (average score of 2.14 on a scale of 5).

Strategic Priority Analysis through AHP

The results of the Analytic Hierarchy Process (AHP) involving 15 experts identified five priority strategies for human resource development in realizing a globally competitive integrated agrocomplex, with the following priority order: (1) Revitalization of agricultural vocational education and training (weight: 0.286); (2) Strengthening the agricultural extension system based on digital technology (weight: 0.241); (3) Development of penta-helix partnerships in agricultural human resource development (weight: 0.195); (4) Increasing the institutional capacity of farmers (weight: 0.158); and (5) Development of incentives for young farmer cadres (weight: 0.120).

Based on expert assessment, the strategy of revitalizing agricultural vocational education and training is the highest priority with a good consistency value (Consistency Ratio = 0.036 <0.1) . This strategy is considered the most effective in the long term to systematically improve the quality of agricultural human resources. Meanwhile, the strategy of strengthening the agricultural extension system based on digital technology is seen as a solution to overcome the gap in access to information and knowledge, while bridging the limited number of field extension workers. The strategy of developing a penta-helix partnership involving academics, businesses, communities, government, and the media is considered important to create an innovation ecosystem that supports the development of agricultural human resources in an integrated manner.

4. Discussion

The research findings reveal the complexity of human resource development issues in the context of integrated agrocomplexes in Indonesia. The dominance of elderly farmers with low levels of formal education confirms the aging agriculture phenomenon that has been reported in previous studies [21]. However, a more in-depth analysis shows that this problem is not only related to demographic structure, but also reflects a systemic failure in creating an agricultural ecosystem that is attractive to the younger generation. The low interest of the younger generation in the agricultural sector as revealed in qualitative interviews indicates the need for a paradigm shift in positioning agriculture, from a traditional sector that is synonymous with poverty to a modern industry that is economically and socially promising. This is in line with the findings of Wang et al. [22] who identified a positive image of the agricultural sector as a prerequisite for attracting quality young talent.

The identified gap in human resource competency at various agrocomplex nodes reflects the misalignment between the agricultural education system and industry needs. Although farmers have adequate technical cultivation competency, low competency in the use of digital technology, post-harvest management, and farm business analysis are significant obstacles in adapting to the demands of modern agriculture. This finding is consistent with the study by Lowenberg-DeBoer and Erickson [23] which highlights the importance of digital literacy and managerial skills in the transformation of conventional agriculture to precision agriculture.

Meanwhile, weak competency in the application of international standards, food safety assurance systems, and digital marketing at processing and marketing nodes hinders the penetration of Indonesian agricultural products into the increasingly competitive global market with strict requirements related to food quality and safety.

The results of the SEM analysis showing a significant influence of individual characteristics (β = 0.437) and institutional capacity (β = 0.385) on HR competency underscore the importance of integrating individual and institutional approaches in agricultural HR development strategies. This finding strengthens the argument of Klerkx et al. [24] that agricultural capacity development requires multi-level interventions that target both individual and institutional capacity. The strong influence of HR competency on agrocomplex competitiveness (β = 0.612) strengthens the resource-based view theory that places HR capability as a source of sustainable competitive advantage [25]. In the context of agrocomplexes, HR competency not only plays a role in increasing production efficiency, but also in encouraging innovation, adaptation to market changes, and the implementation of sustainable agricultural practices that are increasingly demanded by global consumers.

Qualitative findings on the fragmentation of agricultural human resource development programs and weak coordination between stakeholders reveal structural challenges in agricultural sector governance in Indonesia. Isolation between agricultural research, extension, and education institutions results in inefficiencies in the flow of knowledge and technology. This condition is exacerbated by the sectoral approach in development policies that tend to place agriculture as the sole domain of the Ministry of Agriculture, whereas agrocomplex development requires the involvement of various ministries and related institutions such as education, industry, trade, and information technology. Therefore, a whole-of-government approach is needed in agricultural human resource development that involves the orchestration of various sectoral policies to create an integrated agrocomplex supporting ecosystem.

The priority strategy for revitalizing agricultural vocational education and training as produced through AHP (weight: 0.286) reflects the urgency of reforming the agricultural education system to meet the needs of industry. This finding is consistent with the FAO recommendation [26] on the transformation of agricultural education which emphasizes the importance of a competency-based learning approach, strengthening industry-academia partnerships, and integrating entrepreneurship into the agricultural curriculum. This revitalization does not only involve updating the curriculum and learning methods, but also strengthening the capacity of agricultural education institutions and improving the quality of teaching staff. In the Indonesian context, the revitalization of agricultural education needs to be directed at strengthening agricultural polytechnics and agricultural vocational high schools as producers of skilled workers who can be directly absorbed by the agrocomplex industry.

The second priority strategy is strengthening the agricultural extension system based on digital technology (weight: 0.241) recognizing the limitations of conventional extension approaches in reaching a widespread farmer population. The ratio of extension workers to assisted villages of 1:3.5 as revealed in this study is far from ideal, indicating the need to utilize technology as a force multiplier in the dissemination of agricultural information and knowledge. In line with the concept of Agriculture 4.0, digital extension can facilitate distance learning, the provision of real-time consultation services, and the exchange of information between farmers through digital platforms [27]. However, the implementation of this strategy needs to consider the digital divide which is still a challenge in rural areas of Indonesia, so a gradual approach and adequate

infrastructure support are needed.

The development of penta-helix partnerships as the third priority strategy (weight: 0.195) is a response to the complexity of the challenges of agricultural human resource development that require collaboration between various stakeholders. The penta-helix model involving academics, businesses, communities, governments, and the media offers an integrative framework for optimizing the flow of knowledge, technology, and resources in the agricultural innovation ecosystem [28]. Academics play a role in the development of new knowledge and technology, businesses provide market perspectives and commercialization opportunities, communities ensure social relevance, governments create a conducive policy environment, while the media assist in the dissemination of information and the formation of public perceptions of agriculture. The synergy of these five actors can create the dynamic capability needed to adapt to rapid and uncertain changes in the business environment.

Although the strategy of increasing the institutional capacity of farmers (weight: 0.158) and developing incentives for young farmer cadres (weight: 0.120) have lower priorities based on the AHP, these two strategies are still important in the framework of comprehensive agricultural human resource development. Strengthening farmer institutions such as farmer groups, cooperatives, and commodity associations can improve farmers' bargaining position in the value chain, facilitate access to technology and capital, and create the economies of scale needed to increase production efficiency [29]. Meanwhile, young farmer cadre programs are needed to ensure the sustainability of the agricultural sector in the long term. Various incentives such as easy access to land, capital support, and technical assistance need to be specifically designed to attract the younger generation to the agricultural sector, especially through the introduction of the agripreneur concept that combines agriculture with entrepreneurship and digital technology.

Overall research findings underline that human resource development is a fundamental prerequisite in realizing a globally competitive integrated agrocomplex. However, this effort requires a holistic approach that focuses not only on improving technical knowledge and skills, but also on building a supporting ecosystem that includes institutional aspects, policies, infrastructure, and multi-party partnerships. In an increasingly competitive and dynamic global context, the quality of human resources is the main determinant of agrocomplex competitiveness, determining the ability to adapt to climate change, market volatility, and evolving consumer demands. Therefore, strategic investment in agricultural human resource development needs to be viewed as a long-term investment that will determine the resilience and sustainability of the national food system in the future.

5. Conclusion

Based on the results of the research and discussion, it can be concluded that human resource development is a crucial factor in realizing an integrated agrocomplex that is globally competitive. The current condition of Indonesian agricultural human resources is still faced with various problems, including: the dominance of elderly farmers with low levels of formal education, competency gaps at various agrocomplex nodes, limited farmer regeneration, and weak supporting institutional capacity. Competency gaps mainly occur in aspects of digital technology utilization, post-harvest management, understanding of international standards and regulations, and global marketing capabilities.

The results of the SEM analysis show that HR competency is significantly influenced by

individual characteristics, institutional capacity, access to technology and information, and government policy support. HR competency is proven to have a strong influence on agrocomplex competitiveness, confirming the research hypothesis that HR development is a key determinant in agrocomplex transformation. Qualitative findings reveal the complexity of agricultural HR development problems that are not only related to individual aspects, but also involve institutional, structural, and cultural dimensions.

The five priority strategies for agricultural human resource development identified through AHP offer a comprehensive framework to address human resource issues at various levels. Revitalizing agricultural vocational education and training is a fundamental strategy to build a foundation for long-term competency. Strengthening the agricultural extension system based on digital technology offers an innovative solution to overcome the limited reach of conventional extension services. Developing penta-helix partnerships can create an innovation ecosystem that supports sustainable agricultural human resource development. Increasing the institutional capacity of farmers plays a role in strengthening farmers' bargaining position in the agro-complex value chain. Meanwhile, developing incentives for young farmer cadres is an important strategy to ensure the sustainability of the agricultural sector.

This study concludes that the development of agricultural human resources requires a holistic approach that combines interventions at the individual, institutional, and ecosystem levels. In the context of globalization and the industrial revolution 4.0, the quality of human resources is a differentiating factor that determines the competitiveness of agrocomplexes. Therefore, investment in the development of agricultural human resources needs to be viewed as a strategic priority in sustainable agricultural development that supports national food security and sovereignty.

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