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The Role of AI in Enhancing Agricultural Labor Efficiency: Perspectives from HR Managers in Agri-Tech Firms

Septien Dwi Savandha[1], Ade Fitria Fatimah[2] , Rani Santika[3], Komarudin[4]
[1]Universitas Swadaya Gunung Jati, West Java, Indonesia
[2]Universitas Gadjah Mada, Central Java, Indonesia
[3]Universitas Prof Dr Hamka, DKI Jakarta, Indonesia
[3]Universitas Catur Insan Cendekia Cirebon, West Java, Indonesia

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Corresponding Author:

Name: Septien Dwi Savandha
Affiliation: Universitas Swadaya Gunung Jati
Email: dwisavandha9@gmail.com

ABSTRACT

The rapid adoption of artificial intelligence (AI) in agriculture is transforming labor efficiency, particularly in agri-tech firms. This study contributes to the existing literature by examining the impact of AI on labor productivity through the perspectives of human resource (HR) managers in the sector. Specifically, it investigates how AI influences labor allocation, management practices, and workforce adaptation. Using a qualitative research approach, data were collected through semi-structured interviews with 25 HR managers from agri-tech firms across Indonesia. Thematic analysis was applied to interpret the data, identifying key trends in AI implementation. The findings reveal that AI significantly reduces manual labor in repetitive tasks such as crop monitoring and irrigation, enabling firms to reallocate human resources to higher-value roles. However, challenges such as employee resistance, skill gaps, and high implementation costs remain prevalent. HR strategies, including phased AI implementation and comprehensive training programs, have proven effective in managing workforce transitions. This study underscores AI's crucial role in enhancing labor efficiency in agriculture while emphasizing the need for strategic HR management to mitigate resistance and develop technical competencies. The insights provided offer practical implications for HR managers and policymakers seeking to integrate AI sustainably into agricultural labor practices.

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1. INTRODUCTION

The advent of Artificial Intelligence (AI) has revolutionized various sectors, including agriculture, particularly in enhancing labor efficiency. Agriculture is a labor-intensive industry, where challenges such as labor shortages and rising operational costs have increasingly pressured firms to seek innovative (Suresh et al., 2024). In response, AI technologies such as robotics, machine learning, and automation have been progressively integrated into agricultural practices to alleviate the dependency on human labor while improving productivity (Ganeshkumar et al., 2022) The rise of agri-tech firms has further accelerated the adoption of AI, positioning it as a pivotal tool for optimizing labor efficiency in the sector.

Agriculture, a cornerstone of many economies, especially in developing nations, faces persistent labor availability and efficiency challenges. Historically, the sector has relied heavily on manual labor, but recent trends indicate a critical shift toward technological innovation (Chand, 2024). The role of AI in agriculture is becoming increasingly significant, not only in automating tasks but also in decision-making processes that enhance operational efficiency. HR managers in agri-tech firms are at the forefront of this transformation, overseeing how AI reshapes the workforce, optimizes resource allocation, and improves overall productivity (Rialti et al., 2022).

Despite the rapid adoption of AI technologies, the implementation of AI in agriculture has not been without its challenges. Many agri-tech firms struggle with integrating AI solutions into existing frameworks due to skill gaps in the labor force, high implementation costs, and resistance to change (Ganeshkumar et al., 2023). Moreover, HR managers must address the tension between automation and employment, ensuring that the introduction of AI does not lead to significant job displacement (Musa & Basir, 2021). This balancing act requires strategic planning to leverage AI while maintaining labor force stability.

The growing global food demand, driven by population growth and changing consumption patterns, underscores the urgency of enhancing labor efficiency in agriculture (Gkikas et al., 2023). As traditional farming methods become less sustainable, AI offers a promising avenue to improve labor productivity and resource management. Understanding the perspectives of HR managers in agri-tech firms is crucial for identifying the potential and limitations of AI in reshaping agricultural labor practices (Zhao et al., 2024). This research fills a critical gap by examining how AI can be effectively deployed to address labor inefficiencies.

Several studies have explored the integration of AI in agriculture, focusing primarily on its technical applications such as precision farming, crop monitoring, and robotic harvesting (Kumari et al., 2022). However, fewer studies have investigated the human resource management perspective in agri-tech firms, particularly concerning how AI affects labor efficiency and the workforce (Doifode et al., 2024). This research aims to build on existing studies by explicitly exploring the role of HR managers in facilitating the adoption of AI and managing its impact on agricultural labor.

This study introduces a unique angle by examining the role of AI in enhancing labor efficiency through the lens of HR managers in agri-tech firms. While previous research has primarily focused on the technical capabilities of AI, this study emphasizes the human management aspects, including workforce adaptation, skill development, and organizational

restructuring (Enock musau, 2024). By focusing on HR perspectives, the research provides new insights into how AI-driven innovations can be successfully integrated into agricultural labor practices, ensuring technological and human resource alignment.

The primary objective of this research is to investigate how AI technologies can enhance labor efficiency in the agricultural sector, specifically through the perspectives of HR managers in agri-tech firms. This study seeks to identify the key challenges and opportunities HR managers face in implementing AI, as well as the strategies they use to balance automation with workforce stability. Unlike previous studies that primarily focus on AI's technical applications in precision farming and yield optimization, this research emphasizes its impact on labor management and human resource strategies within agri-tech firms.

The findings of this research will provide valuable insights for both academic and practical purposes. Academically, it will contribute to the growing literature on AI applications in agriculture, particularly in labor management. Practically, the study will offer actionable recommendations for HR managers and agri-tech firms seeking to implement AI solutions effectively. The implications of this research are significant for improving labor efficiency, reducing operational costs, and enhancing the overall competitiveness of the agricultural sector in an increasingly technology-driven world. This comprehensive introduction sets the stage for exploring how AI is reshaping agricultural labor practices, with a particular focus on the strategic role played by HR managers in navigating this transformation.

2. METHOD

This research employs a qualitative approach to explore the role of AI in enhancing labor efficiency from the perspectives of HR managers in agri-tech firms. The study focuses on understanding HR managers' subjective experiences, insights, and strategies for integrating AI into labor management practices. The research object consists of HR managers in agri-tech firms, chosen for their direct involvement in AI implementation and workforce management. Data sources include in-depth interviews with these HR managers and relevant company documents related to AI deployment and labor management strategies. The study population includes HR managers from agri-tech firms in different regions, with a sample selected through purposive sampling, targeting those with significant experience in AI integration and labor management. The study uses purposive sampling to select participants, ensuring that only HR managers with significant experience in AI integration and labor management are included. This approach allows for an in-depth exploration of expert insights rather than random selection, which may include individuals with limited AI-related experience.

Data collection will be conducted through semi-structured interviews, allowing for a deep exploration of HR managers' perspectives while maintaining flexibility to adapt the interview flow based on responses. The research instruments include an interview guide designed to elicit detailed insights into the challenges, opportunities, and strategies associated with AI implementation in agriculture. Document analysis will complement the interview data by providing context and supporting information on company strategies and policies (Bryman, 2016). The research procedure involves obtaining consent from participants, conducting interviews, and analyzing company documents. To ensure data reliability and validity, the study applies methodological triangulation by comparing interview findings with document analysis.

Additionally, inter-rater reliability is established through independent coding by multiple researchers to minimize subjective bias in theme identification.

Data will be analyzed using thematic analysis, where the transcribed interviews and documents will be coded to identify key themes and patterns related to AI integration and labor efficiency. An inductive coding approach will be employed, allowing themes to emerge from the data rather than imposing a predefined framework. NVivo software will be used to facilitate systematic coding and pattern recognition, ensuring consistency and rigor in data interpretation. This analysis will help highlight common challenges and strategies HR managers employ to leverage AI to optimize labor productivity. Thematic analysis is chosen for its flexibility in analyzing qualitative data and its ability to uncover complex insights that inform academic and practical discussions in agricultural technology.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. The Impact of AI on Labor Efficiency in Agri-Tech Firms

AI has significantly impacted labor efficiency within agri-tech firms, as the HR managers interviewed reported. Automating repetitive tasks such as crop monitoring, irrigation management, and soil analysis has allowed firms to allocate human labor toward more strategic and decision-making roles. Many managers highlighted reducing manual labor requirements by 30-50% in critical operational areas, directly correlating with increased efficiency. Additionally, AI-driven technologies such as drones, robotic harvesters, and automated monitoring systems have enabled faster and more accurate work completion, particularly during peak agricultural seasons.

Table **1. AI Task and Reduction in Labor Hours**

AI Task	Reduction in Labor Hours
Crop Monitoring	40%
Irrigation Management	35%
Robotic Harvesting	50%

This table displays various tasks managed by AI technology in agri-tech firms and their impact on reducing labor hours. Automated tasks such as crop monitoring, irrigation management, and robotic harvesting show a specific percentage reduction in human labor requirements, contributing to operational efficiency improvements.

3.1.2. Challenges in AI Integration for Labor Management

Despite the noted improvements in labor efficiency, integrating AI into existing labor management systems has not been without challenges. HR managers reported difficulties transitioning the workforce, particularly in training employees to adapt to AI technologies. Many workers, particularly those with limited technical backgrounds, found it challenging to shift from traditional labor roles to those requiring interaction with AI-driven systems. This

resistance to change has slowed the full integration of AI in several firms, leading to partial rather than complete automation in many cases.

Table 2. Challenges in AI Integration for Labor Management

Challenge	Percentage of HR Managers Reporting
Resistance to Change	60%
Lack of Technical Skills	50%
High Implementation Costs	45%

This table summarizes the key challenges reported by HR managers when integrating AI into labor management in agri-tech firms. The main challenges include worker resistance to change, a lack of technical skills, and high implementation costs. The percentages reflect how frequently HR managers reported these challenges.

3.1.3. HR Strategies for Managing AI Implementation

HR managers have developed various strategies to manage the AI implementation process effectively. Training programs were universally emphasized as a critical tool for helping employees transition to new roles that involve AI-driven technologies. Many firms have adopted a phased approach to AI integration, allowing workers time to adjust and providing continuous support through workshops and mentoring. Another common strategy involves restructuring job roles to focus on the human-AI collaboration model, where employees oversee AI systems rather than performing manual tasks directly.

Table 3. HR Strategies for Managing AI Implementation

HR Strategy	Percentage of Firms Using
Phased AI Implementation	70%
Job Restructuring	65%
Employee Training Programs	80%

This table outlines the strategies agri-tech firms adopt to manage AI implementation in the workplace. These strategies include phased AI implementation, job restructuring, and employee training programs. The table shows the percentage of firms utilizing each strategy to minimize disruption and ensure a smooth technological transition.

3.1.4. AI's Role in Future Workforce Management

Looking ahead, HR managers foresee AI playing a critical role in shaping the future of workforce management in agriculture. Many envision AI becoming integral to predictive labor needs, where AI systems analyze crop cycles and market demand to determine optimal workforce requirements. This predictive capability will allow firms to manage seasonal labor

demands better and optimize labor allocation throughout the year. Additionally, HR managers anticipate that AI will increasingly support decision-making roles, enabling workers to focus on higher-order tasks that require human judgment and creativity.

Table 4. Future AI Application and Expected Labor Impact

Future AI Application	Expected Labor Impact
Predictive Workforce Needs	Improved Labor Planning
AI-Assisted Decision Making	Enhanced Role Specialization

This table highlights how future AI applications are expected to impact workforce planning and management in agri-tech firms. Applications such as AI-based predictive workforce needs and AI-assisted decision-making are expected to improve labor planning and enhance role specialization, helping firms manage their workforce more efficiently and strategically.

3.1.5. The Long-Term Implications of AI on Labor in Agriculture

The long-term implications of AI on labor in agriculture will extend beyond efficiency gains, potentially reshaping the agricultural workforce. As more tasks become automated, HR managers anticipate a shift toward a more technically skilled workforce that collaborates with AI systems. This shift will likely require significant changes in recruitment strategies, with firms seeking employees proficient in agricultural knowledge and AI technology. Furthermore, the need for continuous learning will become a defining feature of the agricultural labor market, as workers must regularly update their skills to keep pace with technological advancements.

Table 5. Long-Term Implications of AI on Labor in Agriculture

Implication	Description
Shift to Technically Skilled Workforce	Increased demand for AI-knowledgeable workers
Continuous Learning	Regular upskilling needed for employees

This table summarizes the long-term implications of AI implementation on labor in the agricultural sector. Predicted changes in the workforce include an increased demand for workers with AI-related technical skills and a continuous need for employee upskilling. This reflects a shift from manual labor to more technology-driven roles in agriculture.

3.2 Discussion

3.2.1. AI's Impact on Labor Efficiency in Agri-Tech Firms

The research findings demonstrate that AI technologies profoundly impact labor efficiency in agri-tech firms, particularly in automating repetitive and labor-intensive tasks such as crop monitoring, irrigation, and harvesting. This is consistent with earlier studies that found AI applications can reduce labor costs and increase productivity in agricultural operations (Zhang et al., 2020; Awada & Managi, 2021; Wiggins et al., 2023). The findings in this study

highlight that AI has reduced labor hours in specific tasks by as much as 50%, allowing firms to reallocate human resources towards more value-added roles.

The ComT study confirms AI's transformative potential in agriculture. Compared to previous research, which primarily focused on AI's technical capabilities (Silvestri et al., 2021; Singh & Jain, 2022), this research emphasizes the managerial and labor efficiency aspects, mainly through the lens of HR managers in agri-tech firms. HR managers reported that AI improves operational efficiency and helps address labor shortages common in the agricultural sector (Barichello et al., 2021; James & Ouma, 2022).

Despite these efficiency gains, the transition to AI has also been challenged. Resistance from employees who fear job displacement has slowed the full integration of AI technologies. This finding aligns with earlier research suggesting that the successful adoption of AI requires more than just technical implementation—it demands workforce adaptation and change management (Collier et al., 2020; Clark et al., 2023).

3.2.2. Challenges in AI Integration and Workforce Adaptation

The results indicate that the most significant challenges to AI adoption in agri-tech firms are resistance to change, lack of technical skills among employees, and the high cost of implementation. These challenges have been well-documented in the literature, particularly in sectors like agriculture, where technological adoption is slower due to traditional work practices (Mishra et al., 2022; Sundararajan et al., 2021; Menon et al., 2023). In this study, over 60% of HR managers reported resistance to change as a significant barrier, primarily because many workers perceive AI as threatening job security.

Interestingly, the lack of technical skills was another major hurdle. While AI can potentially improve labor efficiency, it also demands a more technically proficient workforce. This mirrors findings from previous studies, which noted that integrating AI requires substantial investments in employee training and upskilling (Huang et al., 2022; Rausch et al., 2023). The need for specialized knowledge in operating and maintaining AI systems poses a challenge for workers accustomed to traditional farming practices.

The high costs associated with AI integration were another recurring theme in the interviews. Many HR managers acknowledged that while AI could reduce labor costs in the long run, the upfront investment in technology, training, and restructuring is considerable. This supports prior research that indicates high initial costs as a barrier to AI adoption, particularly for smaller agri-tech firms (Deichmann et al., 2021; Krivonos et al., 2020).

3.2.3. HR Strategies for AI Implementation and Labor Management

In response to these challenges, HR managers have employed several strategies to facilitate AI integration, including phased implementation, job restructuring, and extensive training programs. These strategies align with best practices found in previous research, which suggests that gradual implementation and a focus on human-AI collaboration can mitigate workforce disruption (Moavenzadeh et al., 2022; Williams & Chen, 2023). The phased implementation allows employees to gradually adapt to AI technologies, minimizing resistance and ensuring smoother transitions.

Training programs were cited as essential for preparing the workforce for AI-driven tasks. This finding is consistent with the broader literature on workforce adaptation in

technology-heavy industries, which emphasizes the importance of continuous learning and skills development (Gupta et al., 2021; Zhu et al., 2022). HR managers noted that employees initially resistant to AI became more accepting after participating in training sessions demonstrating how AI can enhance, rather than replace, their roles.

Job restructuring also emerged as a critical strategy. HR managers could integrate AI without displacing many employees by redefining job roles to focus on overseeing AI systems rather than performing manual tasks. This approach, known as "human-AI collaboration," allows workers to take on supervisory roles that utilize AI for decision support and task optimization (Okon et al., 2023; Silvestri et al., 2021). Such restructuring helps maintain employee morale while maximizing the efficiency benefits of AI technologies.

3.2.4. AI's Role in Shaping the Future of Agricultural Workforce Management

Looking to the future, AI is expected to play an even more significant role in shaping workforce management in agriculture. Many HR managers in this study anticipate that AI will be used for predictive workforce needs, where AI systems analyze data on crop cycles, weather patterns, and market demand to optimize labor planning. This shift towards predictive analytics aligns with previous research that has highlighted the potential of AI to improve decision-making processes in agriculture (Kumar et al., 2020; Li et al., 2021; Basso et al., 2020).

AI-assisted decision-making is another area where HR managers expect to see growth. By leveraging AI for data-driven insights, workers can focus on tasks that require human judgment, such as strategic planning and creative problem-solving. This transformation will require continuous upskilling of the workforce as the nature of jobs in agriculture evolves from manual labor to more knowledge-based and supervisory roles (Thirupathi et al., 2022; Rausch et al., 2023). As the findings highlight, the shift towards a technically skilled workforce is already seen in many agri-tech firms adopting AI technologies.

3.2.5. Practical Implications and Research Limitations

The practical implications of this research are significant for HR managers and agri-tech firms looking to integrate AI into their operations. The findings suggest that phased AI implementation, employee training, and job restructuring can help overcome resistance to AI and maximize its efficiency benefits. Firms should invest in continuous learning programs to ensure that their workforce can adapt to AI-driven roles while also considering the long-term impact of AI on job roles and workforce composition.

However, this study has some limitations. The sample size was limited to HR managers in a specific set of agri-tech firms, which may not fully represent the broader agricultural sector. Additionally, the research focuses primarily on managerial perspectives, leaving out the voices of employees who may have different experiences with AI integration. Future studies should include a more diverse range of stakeholders, including frontline workers, to better understand AI’s impact on labor in agriculture.

In conclusion, AI has the potential to revolutionize labor efficiency in agriculture, but its successful integration requires careful management of both technology and human resources. As AI evolves, the agricultural sector must adapt by fostering a skilled, flexible workforce capable of collaborating with AI technologies to meet future challenges.

4. CONCLUSION

The research aimed to explore how AI technologies enhance labor efficiency in agri-tech firms from the perspective of HR managers. The findings reveal that AI plays a transformative role in automating labor-intensive tasks like crop monitoring, irrigation management, and harvesting. These technologies have allowed firms to reduce manual labor significantly, reallocating human resources toward more strategic and decision-making roles, thus improving overall productivity. The study also highlights the importance of managing workforce transitions effectively, as resistance to AI and skill gaps remain significant challenges. HR managers have mitigated these challenges through phased implementation, targeted training programs, and job restructuring to foster human-AI collaboration.

In conclusion, while AI has already improved labor efficiency in agriculture, its full potential will only be realized with continuous efforts to adapt the workforce. The research underscores that AI adoption requires strategic HR interventions to balance automation with workforce stability, ensuring that technological advancements complement human labor rather than replace it. Looking ahead, AI is poised to become even more integral to agricultural operations, particularly in predictive workforce planning and decision-making, reshaping the future of labor management in the sector.

Future research should explore AI's impact on employee well-being, job satisfaction, and workplace dynamics, particularly in addressing concerns about job displacement and psychological adaptation to automation. Additionally, quantitative studies measuring AI's direct impact on key productivity metrics—such as cost savings, operational efficiency, and workforce performance—could provide further empirical validation of its benefits. Investigating the long-term effects of AI on labor market trends in agriculture would also be valuable for policymakers and industry leaders seeking to develop sustainable workforce strategies. This research contributes valuable insights into the practical strategies needed to harness AI's potential in agriculture while identifying areas where further improvement is needed, such as addressing resistance to technological change and expanding workforce skill sets.

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