INFORMASI ARTIKEL Received: January, 13, 2025 Revised: January, 22, 2025 Available online: January, 31, 2025

at: http://ejurnalmalahayati.ac.id/index.php/teknologi/index

Management of Agricultural Machinery

Fauzi Ibrahim^{1*}, Agus Apriyanto¹, Adam Wisnu Murti¹, dan Novia Utami Putri¹

¹Department of Agricultural Mechanization, Lampung State Polytechnic, Jl. Soekarno Hatta No.10, Bandar Lampung 35141, Indonesia

Korespondensi Penulis: Fauzi Ibrahim. *Email: fauziibrahim@polinela.ac.id

ABSTRACT

The integration of intelligent machinery and autonomous vehicles into agricultural operations offers opportunities for enhanced efficiency and reduced environmental impact. Innovations in sensing, actuation, and information and communication technologies (ICT) present significant potential for advancing agricultural practices. However, fully leveraging these advancements requires revisiting traditional agricultural machinery management processes. Conventional planning methodologies, such as job-shop scheduling, must be augmented with modern approaches like route optimization and sequential task scheduling. This review highlights current advancements and future needs in agricultural machinery management, focusing on five key management tasks across strategic, tactical, operational, and evaluative levels. The study identifies the importance of integrating these tasks with advanced tools and models to enable efficient and sustainable agricultural operations. Future directions emphasize adaptive planning, real-time decision-making, and enhanced system integration to address location-specific and environmental challenges.

Keywords: agricultural, machinery, management

1. INTRODUCTION

For decades, improving the physical performance of agricultural machinery has been the primary driver of advancements in agricultural productivity and efficiency. This progress was largely influenced by the benefits of economies of scale, leading to enhanced mechanical functionality. However, environmental and biological constraints, such as soil compaction, now limit further significant improvements in machinery size and weight (Rasmussen, 1982; Takeshima et al., 2013; Zhizhang & Hanlin, 2014).

Modern engineering developments in sensing and actuating technologies, combined with advancements in information and communication technologies (ICT), have the potential to revolutionize agricultural operations. technologies can enhance machine efficiency and reduce environmental impacts. However, fully exploiting these innovations requires a reevaluation of traditional agricultural machinery management processes. Current operations planning methodologies, such as job-shop planning, need to incorporate new features like route optimization and sequential task scheduling (Bello et al., 2021; Jaleta et al., 2019; Rijk, 2005; Takeshima et al., 2013).

The introduction highlights the unique challenges of agricultural machinery management compared to industrial systems. The agricultural

domain faces greater variability and unpredictability due to environmental factors, such as weather and crop growth, which make risk-based decision-making a norm. This necessitates integrating advanced tools and adaptive methodologies for effective management(Li et al., 2018; Lu et al., 2024; McNulty & Grace, 2009).

The review aims to identify and outline the current state and future needs for agricultural machinery management, preparing the field for intelligent, sustainable, and autonomous agricultural operations. Five core management tasks capacity planning, task time planning, scheduling, route planning, and performance evaluation are explored, offering a comprehensive perspective on their roles across various management levels (Amare & Endalew, 2016; Lak & Almassi, 2011; Luo, Liao, Zang, et al., 2016; Pingali, 2007).

2. METHODS

2.1 Management Phases and Levels

The management of agricultural machinery can be divided into distinct phases, as outlined by ASABE standards:

- a. Planning: Selection of system components and prediction of expected performance.
 - Maintenance plan
 Create a thorough maintenance plan and track tasks to ensure that equipment is regularly serviced.
 - Clean equipment
 Clean equipment regularly, especially at
 the end of a season or before storing it, to
 prevent rust and staining.
 - Track resources
 Track resources per crop, field, and season to help make quick decisions and mitigate risks.
 - 4) Forward and backward planning Consider how forward and backward planning can help anticipate challenges and seize opportunities.
 - 5) Agricultural maintenance
 Prevent breakdowns and accidents, and
 keep planting, fertilizing, and harvesting
 on schedule.
 - 6) Tillage equipment
 Use tillage implements to prepare a seedbed while conserving moisture, destroying weeds, and minimizing erosion.
 - 7) Planters and seeders
 Use planters and seeders to consistently
 place seeds and apply pesticides and
 fertilizers (Asoegwu & Asoegwu, 2007;

Awaluddin & Hendra, 2018; Luo, Liao, Zou, et al., 2016; Sims & Kienzle, 2017).

- Scheduling: Determination of the timing for various operations, considering factors like time availability, labor supply, job priorities, and crop requirements.
- Operating: Execution of operations using labor and machines.
- d. Controlling: Monitoring and adjusting systems using productivity measures and standards.
 - Inspect for damage
 Check your machinery for any signs of damage after each use, before storing, and at regular intervals. Look for loose pieces, strange noises, cracks, dents, or leaks.
 - Keep machinery clean
 Regularly clean your machinery to remove
 dirt, debris, and crop residue. This prevents
 corrosion and keeps your machinery
 running optimally.
 - Perform regular oil changes
 Regularly change the oil and check belts
 and hoses to keep your machinery running
 efficiently.
 - Be aware of manufacturer recalls
 Keep up with manufacturer recalls to ensure your machinery is safe and reliable.
 - 5) Take agricultural maintenance training Training can help you learn best practices to prevent injuries.
 - 6) Keep detailed records

 Keep accurate and organized records of your farm activities. This can help you identify areas for improvement and make informed decisions.
 - 7) Use agriculture software
 Agriculture software programs can be
 adapted to meet the needs of individual
 farms (Awaluddin & Hendra, 2018; Luo,
 Liao, Zou, et al., 2016; Melly et al., 2020).

These phases operate across multiple management levels:

- a. Strategic Level: Focuses on designing the production system for multiple years, including labor and machinery for selected crops.
- b. Tactical Level: Involves creating a detailed production plan for 1–2 years, narrowing down labor and machinery inputs for specific crop plans.
- c. Operational Level: Deals with short-term activities, scheduling specific jobs, and tasks within the cropping cycle.
- d. Execution Level: Concerned with implementing and controlling task performance in real time.

e. Evaluation Level: Compares planned operations with actual execution to identify areas for improvement.

The review excludes the execution level due to limited studies in this area, focusing instead on the other levels, which provide structured frameworks for effective machinery management in agriculture. These levels address the unique challenges of agricultural production, such as biological variability and environmental unpredictability, and emphasize the integration of data-driven and adaptive decision-making approaches (Bello et al., 2021; Lu et al., 2024; Pingali, 2007).

2.2 Agricultural Machinery Management Tasks

The review identifies five key tasks essential for effective agricultural machinery management, spanning various phases and levels of operation:

a. Capacity Planning

This task involves selecting machinery and supporting equipment to meet operational demands. It focuses on optimizing machinery size, cost, and efficiency while addressing uncertainties in agricultural settings, such as weather and crop growth variability.

b. Task Time Planning

Task time planning assigns time durations to specific activities, such as field operations and transportation. It serves as a prerequisite for scheduling, allowing for accurate predictions of labor and machinery requirements.

c. Scheduling

Scheduling allocates resources like labor and machines to tasks over specific time periods, optimizing objectives such as minimizing delays or maximizing efficiency. In agriculture, this includes addressing seasonal field operations and the sequencing of shared resource usage.

d. Route Planning

This task focuses on optimizing the movement of agricultural vehicles in the field. It includes spatial configuration planning, determining fieldwork tracks, and sequencing movements to minimize travel distance, time, and operational costs.

e. Performance Evaluation

Performance evaluation compares planned operations with actual outcomes. It involves data processing, compliance checks, and summarizing operational performance to provide feedback for future planning. These tasks address challenges unique to agriculture, such as biological variability, environmental constraints, and the need for precision. By integrating advanced tools and adaptive

methodologies, these management tasks aim to enhance the efficiency, sustainability, and adaptability of agricultural machinery operations (Asoegwu & Asoegwu, 2007; Lak & Almassi, 2011; Luo, Liao, Zang, et al., 2016; Luo, Liao, Zou, et al., 2016).

In agricultural machinery management, five core tasks play a crucial role in ensuring the success of system implementation. Each task has a specific function in supporting operational efficiency and sustainability, but they also face unique challenges. These challenges, especially in the agricultural sector, often stem from environmental variability, resource limitations, and the demand for high precision.

With advancements in modern technology, such as real-time data systems, artificial intelligence (AI)-based analysis tools, and optimization algorithms, innovative solutions can now be applied to overcome these challenges. These technologies enable better data integration, adaptive decision-making, and more structured operational execution.

The following table summarizes the five core tasks in agricultural machinery management, their key challenges, and technology-based solutions that can be implemented to enhance effectiveness and efficiency:

Tabel 1. Core Tasks, Challenges, and Technological Solutions in Agricultural Machinery Management

Machinery Management		
Core Task	Challenges	Technology Solution
Capacity Planning	Weather and crop variability.	Real-time data from weather and crop sensors.
Task Time Planning	Uncertainty in task durations.	Predictions using historical data and AI.
Scheduling	Seasonal resource synchronization.	Automated scheduling with software tools.
Route Planning	Field topography and soil moisture.	Route optimization using GPS and AI algorithms.
Performance Evaluation	Limited availability of real data.	Automated data collection with sensors.
With the a	pproaches outline	d above, each

With the approaches outlined above, each management phase can be optimized to create

smarter, more efficient, and sustainable agricultural systems.

3. RESULTS AND DISCUSSION

The future of agricultural machinery management lies in adaptive planning and the seamless integration of data and technologies across management levels. Key requirements for each management task are highlighted as follows:

a. Capacity Planning

Future models should incorporate real-time data and feedback from other management levels, allowing for adaptive and precise machinery selection and planning tailored to specific farm conditions.

b. Task Time Planning

Task time planning needs to evolve to include stochastic measures, such as reliability and availability, and enable precise predictions using automated data collection from past operations.

c. Scheduling

Sequential scheduling approaches must address the complexities of large-scale operations, integrating diverse machinery types, biological constraints, and field conditions for optimized resource allocation.

d. Route Planning for Agricultural Vehicles Route planning must evolve into mission planning for autonomous machines, considering dynamic conditions like yield variability and trafficability. Integration of planning for primary and supporting units will enhance collaborative efficiency.

e. Performance Evaluation

Future systems should automate performance evaluation using activity recognition and advanced fault detection for both individual machines and cooperative systems. This will enable real-time adjustments and improved planning cycles. Overall, the future of agricultural machinery management emphasizes real-time decision-making, adaptive tools, and integration across strategic, tactical, and operational levels. These advancements will support sustainable and efficient agricultural practices, addressing environmental challenges and site-specific needs.

4. CONCLUSION

The review highlights advancements in agricultural machinery management, emphasizing the integration of industrial engineering approaches such as vehicle routing, job-shop scheduling, and advanced optimization techniques. It underscores the growing focus on planning for cooperative multi-machine systems, paving the way for autonomous operations. Real-time decision support systems are identified as critical for adaptive and precise machine control. However, a lack of integration across strategic, tactical, and operational levels limits the full exploitation of location-specific data. Future research must prioritize adaptive planning, automated data collection, and cross-level integration to enhance efficiency, sustainability, and resilience in addressing agricultural environmental challenges.

REFERENCES

- Amare, D., & Endalew, W. (2016). Agricultural mechanization: Assessment of mechanization impact experiences on the rural population and the implications for Ethiopian smallholders. *Engineering and Applied Sciences*, 1(2), 39–48.
- Asoegwu, S. N., & Asoegwu, A. O. (2007). An overview of agricultural mechanization and its environmental management in Nigeria. *Agricultural Engineering International:* CIGR Journal.
- Awaluddin, A., & Hendra, H. (2018). Fungsi manajemen dalam pengadaan infrastruktur pertanian masyarakat di desa watatu kecamatan banawa selatan kabupaten donggala. *Publication*, 2(1), 1–12.
- Bello, R. S., Onyeanula, P. E., & Saidu, M. J. (2021). Agricultural Mechanization. Agricultural Technology for Colleges, 511.
- Jaleta, M., Baudron, F., Krivokapic-Skoko, B., & Erenstein, O. (2019). Agricultural mechanization and reduced tillage: antagonism or synergy? *International Journal* of Agricultural Sustainability, 17(3), 219– 230.
- Lak, M. B., & Almassi, M. (2011). An analytical review of parameters and indices affecting decision making in agricultural mechanization. *Australian Journal of Agricultural Engineering*, 2(5), 140–146.
- Li, W., Wei, X., Zhu, R., & Guo, K. (2018). Study on factors affecting the agricultural mechanization level in China based on

- structural equation modeling. *Sustainability*, 11(1), 51.
- Lu, F., Meng, J., & Cheng, B. (2024). How does improving agricultural mechanization affect the green development of agriculture? Evidence from China. *Journal of Cleaner Production*, 472, 143298.
- Luo, X., Liao, J., Zang, Y., & Zhou, Z. (2016). Improving agricultural mechanization level to promote agricultural sustainable development. Transactions of the Chinese Society of Agricultural Engineering, 32(1), 1– 11.
- Luo, X., Liao, J., Zou, X., Zhang, Z., Zhou, Z., Zang, Y., & Hu, L. (2016). Enhancing agricultural mechanization level through information technology. *Transactions of the Chinese Society of Agricultural Engineering*, 32(20), 1–14.
- McNulty, P., & Grace, P. M. (2009). *Agricultural Mechanization and Automation-Volume II* (Vol. 2). EOLSS Publications.
- Melly, S., Ernita, Y., Novita, S. A., & Zulnadi, Z. (2020). MANAJEMEN MESIN PERTANIAN 1 (Kajian Konsep Dasar Manajemen Mesin Pertanian). THE JOURNAL PUBLISHING I.

- Pingali, P. (2007). Agricultural mechanization: adoption patterns and economic impact. *Handbook of Agricultural Economics*, 3, 2779–2805.
- Rasmussen, W. D. (1982). The mechanization of agriculture. *Scientific American*, 247(3), 76–89
- Rijk, A. G. (2005). Agricultural mechanization strategy.
- Sims, B., & Kienzle, J. (2017). Sustainable agricultural mechanization for smallholders: What is it and how can we implement it? *Agriculture*, 7(6), 50.
- Takeshima, H., Nin-Pratt, A., & Diao, X. (2013). Mechanization and agricultural technology evolution, agricultural intensification in sub-Saharan Africa: Typology of agricultural mechanization in Nigeria. *American Journal of Agricultural Economics*, 95(5), 1230–1236.
- Zhizhang, W., & Hanlin, S. U. N. (2014). Empirical research of agricultural mechanization on the effect of increasing famers' income. *Management Science and Engineering*, 8(2), 7