A Review of Energy Management in Farm Automation: A Case of Paddy Plantation

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Abstract. Farm automation is an innovative idea that specifically manages farms via the latest technologies such as drones, robotics, and artificial intelligences with the aim to raise the quality and quantity of crops, and at the same time, optimise the labour needed by production. In other words, these technologies that are related with "smart farming" assist to make the farms more effective and automate the crops' entire cycle. Through smart farming, main agricultural threats in the country can be diminished, the public is enticed to contribute towards the agriculture sector, the income level of local farmers will be increased, and most significantly, agricultural-based economic sectors will be transformed. Although this technology is fairly new, there is an increasing trend in the adoption of farm automation among traditional agriculture companies in Malaysia. This paper aims to review the pattern of energy management in farm automation, particularly focusing on paddy plantation. The adoption of automation and mechanisation should be further expanded to other segments of the paddy and rice supply chain. Through the review, we intend to provide better understanding related to farm energy consumption and implementation of best practices to optimise energy management on the farm, leading to better environmental performance as well great economic achievements of farmers.

Keywords: energy management · farm automation · paddy plantation · Malaysia

1 Introduction

The agriculture sector has become a crucial sector in the country due to food security supply. Nowadays, the transition from conventional to modern agriculture applications can be seen across the globe. Figure 1 shows the main comparison between conventional and modern agriculture. The issue of food security provides a main significance towards the agriculture sector. At the ASEAN level, the involvement of the agriculture sector to gross domestic product (GDP) is between 0.03 and 22.8%. Myanmar and Cambodia

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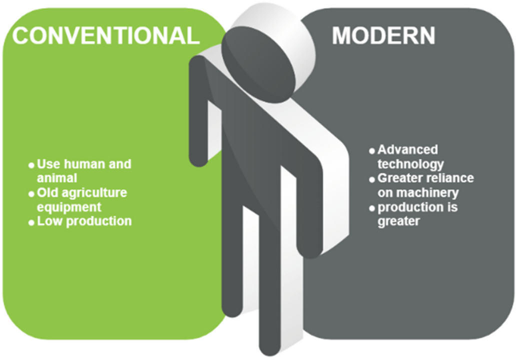

Fig. 1. Comparison between conventional and modern agriculture

contribute the uppermost GDP with 22.8%. Concerns in adaptation approaches to food security issues and policy feedback to global change, as well as opportunities for handling water quota, land usage, food trade, postharvest food processing, and food charges and safety are crucial to be observed [1].

The modern agriculture concept is related with the new technological approaches in the agriculture sector, such as precision agriculture, climate smart agriculture, digital farming, smart farming, sustainable intensification, and Agriculture 4.0 [2]. Smart agriculture, usually identified as "Agriculture 4.0", is a set of recent technologies that can increase output production while reducing energy input such as water consumption [3]. One concept under smart agriculture is farm automation or smart farming. This concept uses technology for more efficiency and automates the production of crop cycle. Farm automation is an initial idea that indicates handling farms with technologies like drones, robotics, and artificial intelligence (AI) to boost the quality and quantity of products though enhancing the labour essential by production. Through smart farming, crucial agricultural challenges can be eliminated, such as by encouraging more people to participate in these sectors, increasing farmers' income, and most importantly, transforming the agriculture sector to different standards towards developed countries.

In Malaysia, agriculture continues to be an important area in the country. According to the available data in 2020, this area contributes about 7.4%, which is RM101.5 billion, to the country. In Malaysia, the agriculture sector is dominated by smallholder planters, who face the difficulties of small production, in addition to the shortage of manpower. Various reports from industry authorities have noticed that this sector truly needs modernisation in application. According to a previous study, the typical age of farmers is 52.9 years, and about 62.1% of the farmers are between 40 and 60 years old [4]. In relation to this, the Ministry of Agriculture and Food Industries (MAFI) encourages the younger generation to take opportunities in the agriculture sector through the Young Agropreneur Grant that is worth RM126 million [5].

The government of Malaysia through MAFI has introduced the Digital Agriculture Programme. This programme shows a crucial part in serving Malaysian farmers on how to adopt digital agricultural practices for improving efficiency and crop revenue. Consequently, Telekom Malaysia Berhad has launched a programme known as TM One

Smart Agriculture Solutions to digitalise the agriculture sector towards Agriculture 4.0 in Malaysia. Although this technology is fairly new, there is an increasing trend of the adoption of farm automation among traditional agriculture companies in Malaysia.

This paper aims to review the pattern of energy management in farm automation, particularly focusing on paddy plantation. The adoption of automation and mechanisation should be further expanded to other segments of the paddy and rice supply chain. Through the review, we intend to provide better understanding related to farm energy consumption and implementation of best practices to optimise energy management on the farm, leading to better environmental performance as well great economic achievements of farmers.

2 Methodology

This research was carried out using the narrative literature review (NLR) method. This type of method has no specific protocol or guidelines that need to be followed [6], hence we formulated the research in four steps. The four steps are: (1) Searching activity - A variety of research database such as ScienceDirect and JSTOR database, (2) Keywords – Using a similar keyword for each database that is pertinent to the research questions, (3) Review – All the documents (articles) that are relevant to the study are reviewed, starting with the abstract and ignoring the irrelevant articles, (4) Documentation - Summarize and synthesize the finding of the articles.

3 Results and Discussion

3.1 Farm Automation

Automation system penetration in agriculture systems could possibly change the landscape of the entire chain of agriculture and the agricultural business. Recently, the terminology of incorporated intelligence has been immensely drawn in the agriculture sector in the context of smart farming, smart crop management, smart irrigation, and smart greenhouses [7]. Smart farming is the idea of a farm integrated with information and communications technologies (ICT) that can monitor the progress of crops and livestock by distantly and automatically associating information technologies to orchards, greenhouses, and livestock barns.

Automation farming covers all the practices that help with planting and harvesting with the aid of machines and other devices. An example of automation in farming are irrigation drones, planting robots, automated tractors, and monitoring farming tools. Figure 2 shows the applications in farm automation. As of now, advanced farming technology can be an important part of farmers' daily work. According to [8], some of these innovative technological developments of autonomous farming machinery for potential operation in digital farming are GPS-enabled tractors, GPS-based remote-controlled robots, auto-steering tractors, and harvesting machinery. In Europe, precision agriculture (PA) and the integration of digital technology are established to become the most significant tendency in these sectors, as seen by the increasing number of planters who have begun to use digital technologies to operate their farms [9]. Precision farming is a

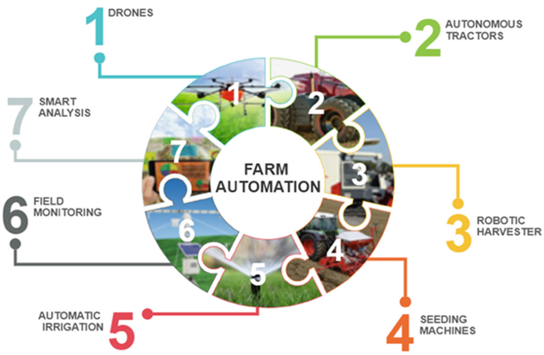

Fig. 2. Applications of farm automation

sustainable option that will improve production by equipping a specific amount of energy input, and thus can reduce overuse that can potentially harm the environment due to use of pesticides and other inputs. In China, research on smart agriculture is comparatively established, whereby their move is from experience-based management to data-based management due to the development of Industry 4.0 [10].

3.2 Energy Management in Agriculture

Smart or modern agriculture requires more energy input than conventional agriculture due to high energy consumption in machinery and appliances [11]. The agriculture sector currently has huge innovations in technical and commercial resolutions that enhance the energy efficiency of farms which, therefore, point to cost reduction, especially in electricity bills [12]. According to a study in China regarding conventional agriculture [13], about 70% of energy are contributed by indirect energy use such as production of chemical fertilisers, pesticides, seeds, and others, while 30% of energy are from direct energy usage for land preparation, cultivation, and irrigation (on-site). As suggested from [14], reducing the use of fossil fuels and fertilisers has a significant outcome on energy consumption. It is stated that about 83.2% decrease in energy consumption from the grid can be reached, equalling to 5,527 kg CO_2 savings, and eight years of return on investment (of RM170,528.24) [12]. Agriculture and energy grids have been facing substantial challenges, such as the deficiency of electricity supply to agricultural farms and the straits of renewable energy usage in the electricity sector [15]. A smart farm is, then, a structure that integrates complex and strategic purposes based on some energy resources offered locally. As agricultural systems have become more sophisticated and automated, the electrical demands of many farms' mechanisation have increased, requiring enhancement needs for high quality electric to power equipment. Nevertheless, the limitations of these advanced technologies are high energy consumption and complicated user interface [16].

3.3 Paddy Production in Malaysia

Figure 3 indicates the trend of paddy production for selected countries. China had the highest production yield with 7.04 tonne per hectare (t/ha) in 2020, while Malaysia only produced about 3.59 t/ha in the same year. Paddy plantations provide significant products as most of the ASEAN countries consume rice as their staple food. Figure 4 depicts Malaysia's paddy production from 1980 until 2019.

For almost 40 years, the increment of paddy production was only 29.8%. Recently, the harvested areas showed a decreasing pattern, especially in the last ten years. Different strategies should be explored in order to increase the production of yield. According to [17], the extension of cropland alone is surely inadequate. Agriculture automation has been developed to improve production and efficiency. Crop production and farm structure must be extended, along with a technologically innovative approach. Therefore, for a rapid transition and significant approach, reengineering farm operations at an enormous size and speed can be the solution. The comprehensive studies on paddy plantation could help the development of paddy production in Malaysia. The current paddy plantation management in Malaysia is shown in Fig. 5.

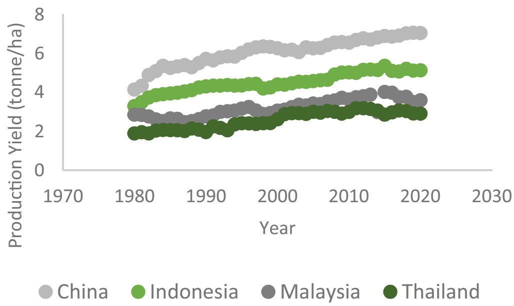

Fig. 3. Trend of paddy production yield for selected countries

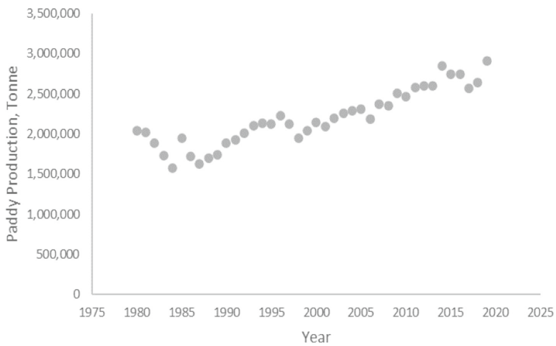

Fig. 4. Paddy production 1980–2019

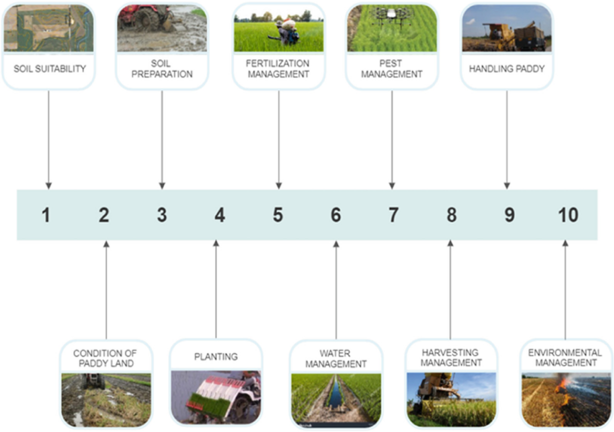

Fig. 5. Paddy plantation management

Table 1. Companies related with smart agriculture in Malaysia

Name of Company	Function	Website
TM One	Smart agriculture solutions for real-time data for better crops and higher profitability	https://www.tmone.com.my/solutions/smart-services/smart-agriculture/
REDTONE	Provides smart farming solution	https://www.redtone.com/smart-farming/
PLANTOS	Integrated digital precision agriculture solutions	https://www.plant-os.com/
Braintree Technologies	Drone services and automation to precision agriculture	https://braintreex.com/#service
Kambyan Network	Digital agriculture	https://www.kambyan.net/
Propick	Smart and efficient agriculture using drone and AI	http://propick.com.my/digital-agriculture.html
FGV Prodata	Precision agriculture	https://fgvprodata.com.my/?page_id=15
Singularity Aerotech Asia	SM4RT TANI^{TM}	https://singularityaerotech.asia/technology/smart-tani/

On-farm automation for paddy farming in Malaysia in the last decade has been well implemented, specifically in land preparation and harvesting processes. For example, a Malaysian company, Kambyan Network, was recognised in 2018 for offering autonomous provision to agricultural enterprises over its apperceptive platform called Man Using Intelligent Applications (ManUsIA™). They devoted RM30 million to develop their Autonomous Harvesting, Fertilisation, Weeding, and Transportation (AutoHaFeWeT™) for the agriculture sector, beginning with oil palm estates [18]. The Malaysian government through MAFI has introduced the Large-Scale Smart Field Project or SMART SBB, with the aim to increase the productivity and facilities of paddy. According to [19], the success of all these smart technologies integrated in the agriculture sector is due to the speed of data transfer. In Malaysia, telecommunication service providers are also included in the smart agriculture sector as their potential plan. Furthermore, Telekom Malaysia Berhad has launched a programme known as TM One Smart Agriculture Solutions for real-time data for better crops and higher profitability. REDTONE is also one of the leading innovator and provider of smart farming in order to digitalise the agriculture sector in Malaysia. Table 1 lists the companies that are related with smart agriculture in Malaysia, while Fig. 6 summarises the farm automation practices in Malaysia.

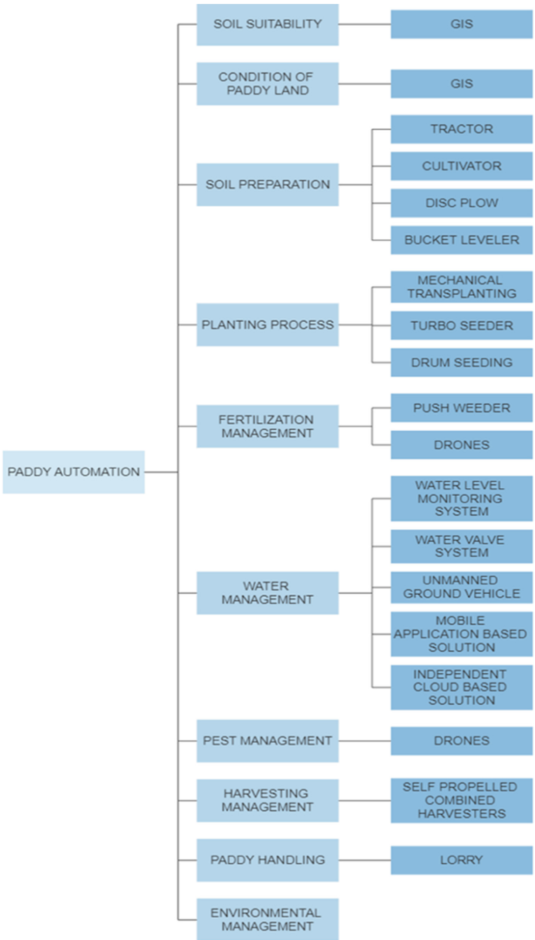

Fig. 6. Malaysian farm automation practices

4 Conclusion

The adoption of automation and mechanisation should be further expanded to other segments of the paddy and rice supply chain, especially on understanding farm energy consumption and implementation of best practices to optimise energy management on the farm. This would then lead to better environmental performance as well great economic achievements of farmers. The current farming procedures need a large workforce, which is uninteresting as well as exhausting. Automation in the agriculture sector could overcome the challenges and increase the productivity of crop production.

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References

1. IFPRI. (2022, June 27). Food Security. Retrieved from International Food Policy Research Institute: https://www.ifpri.org/topic/food-security
2. Gras, C., & MCáceres, D. (2020). Technology, nature's appropriation and capital accumulation in modern agriculture. Current Opinion in Environmental Sustainability, 45, 1–9.
3. Pathan, M., Patel, N., Yagnik, H., & Shah, M. (2020). Artificial cognition for applications in smart agriculture: A comprehensive review. Artificial Intelligence in Agriculture, 4, 81–95.
4. Alam, M. M., Siwar, C., Murad, M. W., Molla, R. I., & Toriman, M. E. (2010). Socioeconomic profile of farmer in Malaysia: Study on integrated agricultural development area in North-West Selangor. Agricultural Economics and Rural Development, 7(2), 249–265.
5. Kanagaraj, P. (2021, June 21). Revolutionising Malaysia's agriculture industry. Retrieved from Business Today: https://www.businesstoday.com.my/2021/06/21/exclusive-revolutionising-malaysias-agriculture-industry/
6. Demiris, G., Debra, P. O., Karla, T.W. (2019) Defining and Analyzing the Problem. Behavioral Intervention Research in Hospice and Palliative Care. https://doi.org/10.1016/B978-0-12-814449-7.00003-X
7. Jha, K., Doshi, A., Patel, P., & Shah, M. (2019). A comprehensive review on automation in agriculture using artificial intelligence. Artificial Intelligence in Agriculture, 2, 1–12.
8. Ontiri, G. K., & Amuhaya, L. L. (2022). Integration of mechatronic and automation technology in sustainable farming for achieving food security in Kenya. EJECE, European Journal of Electrical Engineering and Computer Science, 6(1), 66–71.
9. Lamborelle, A., & Álvarez, L. F. (2016, November 7). Farming 4.0: The future of agriculture? Retrieved from EURACTIV: https://www.euractiv.com/section/agriculture-food/infographic/farming-4-0-the-future-of-agriculture/
10. Liu, W., Long, S., Wang, S., Tang, O., Hou, J., & Zhang, J. (2021). Effects of smart agricultural production investment announcements on shareholder value: Evidence from China. Journal of Management Science and Engineering.
11. Rahman, M. M., Khan, I., Field, D. L., Techato, K., & Alameh, K. (2022). Powering agriculture: Present status, future potential, and challenges of renewable energy applications. Renewable Energy, 188, 731–749.
12. Pereira, F., Caetano, N. S., & Felgueiras, C. (2022). Increasing energy efficiency with a smart farm—An economic evaluation. Energy Reports, 8, 454–461.

13. Fan, X., Zhang, W., Chen, W., & Chen, B. (2020). Land–water–energy nexus in agricultural management for greenhouse gas mitigation. Applied Energy, 265, 114796.
14. Ghorbani, R., Mondani, F., Amirmoradi, S., Feizi, H., Khorramdel, S., Teimouri, Aghel, H. (2011). A case study of energy use and economical analysis of irrigated and dryland. Applied Energy, 88(1), 283–288.
15. Lin, X., Sun, X., Manogaran, G., & Rawal, B. S. (2021). Advanced energy consumption system for smart farm based on reactive energy utilization technologies. Environmental Impact Assessment Review, 86, 106496.
16. Sreekantha, D. K., & Kavya, A. M. (2017, January). Agricultural crop monitoring using IOT-a study. In 2017 11th International conference on intelligent systems and control (ISCO) (pp. 134–139). IEEE.
17. Subeesh, A., & Mehta, C. R. (2021). Automation and digitization of agriculture using artificial intelligence and internet of things. Artificial Intelligence in Agriculture, 5, 278–291.
18. Dayangku, S. (2019, September 18). Meet The tech startup that's utilising drones to revolutionise the M'sian farming industry. Retrieved from Vulcan Post: https://vulcanpost.com/675536/kambyan-network-drone-robotics-farming-agriculture-malaysia/
19. Mohamed, E. S., Belal, A. A., Abd-Elmabod, S. K., El-Shirbeny, M. A., Gad, A., & Zahran, M. B. (2021). Smart farming for improving agricultural management. The Egyptian Journal of Remote Sensing and Space Science, 971–981.