JOISTECH: Journal of Information System and Technology
ISSN 3063-9778 (Media Online)
Vol 01, No 02, Desember 2024, Hal 59-66

Mapping of Darunnajah 6 Muko-Muko Bengkulu Oil Palm Plantation Using GIS

Wahyu Joko Saputro[1*], Muhammad Abdul Karim Luthfi[2], Syaeful Machfud[3]

[12]Faculty of Science and Technology, System and Information Technology, Darunnajah University, Jakarta, Indonesia
[3]Faculty of Computer Science, Informatics Engineering, Pamulang University, South Tangerang, Indonesia
Email: [1*]wahyujs@darunnajah.ac.id, [2]abdulkarim.luthfi212@gmail.com, [3]dosen02836@unpam.ac.id

Abstract− The use of Geographic Information Systems (GIS) in mapping oil palm plantations has become one of the effective methods in land management and monitoring. This study aims to map the Darunnajah 6 oil palm plantation in Muko-Muko, Bengkulu, using GIS. Spatial data were obtained through field surveys and satellite imagery. The mapping results were used to identify land boundaries, topography, and distribution of oil palm plants. This study shows that the use of GIS can improve the efficiency of plantation management. The implementation of this technology can also support the sustainability of plantation operations through better resource management.

Keywords: GIS, Land Management, Mapping, Muko-Muko, Palm Oil Plantations

1. INTRODUCTION

Palm oil plantations have become a strategic economic sector for Indonesia, especially in making a major contribution to state revenue and employment absorption (Fitriani et al., 2021).

As one of the largest producers of palm oil in the world, Indonesia has extensive oil palm plantation areas, with plantations spread across various regions, including Bengkulu Province, which has great potential in this sector (Susilawati et al., 2023).

One of the prominent oil palm plantations in Bengkulu is the Darunnajah 6 Plantation in Muko-Muko. However, as the land area increases, the challenges in plantation management are increasingly complex and require a more sophisticated technological approach (Ahmad et al., 2023).

Geographic Information Systems (GIS) have been widely used in various sectors, including plantation management, due to their ability to map and analyze spatial data efficiently (Hakim et al., 2020). GIS allows plantation managers to visualize land conditions, plantation boundaries, crop distribution, and various other environmental factors that affect plantation productivity (Jia et al., 2019). This technology is very helpful in the process of making more accurate decisions, both in planning planting, fertilization, and irrigation management (Kurniawan et al., 2022). Thus, GIS plays an important role in increasing the efficiency and sustainability of oil palm plantations (Widiastuti et al., 2022).

Plantation mapping with GIS technology can help in identifying accurate land boundaries, managing topography, and monitoring plant health through satellite imagery analysis (Sugiarto & Purwanto, 2020). Clear land boundaries are essential to prevent land conflicts and facilitate operational management and planning (Nugroho et al., 2019). In addition, through topographic analysis and the use of digital elevation models (DEM), managers can understand the characteristics of land slopes that affect oil palm planting and maintenance (Rachmawati et al., 2020). In areas with steep slopes, conservation measures such as terracing can be taken to prevent erosion (Prasetyo et al., 2021).

In addition, with GIS's ability to analyze vegetation using indices such as NDVI (Normalized Difference Vegetation Index), the distribution of oil palm plants can be analyzed precisely (Rahman et al., 2018). NDVI allows managers to monitor plant health and identify areas that require intervention, such as fertilization or replanting (Putra et al., 2020). The application of this technology also helps in early detection of plant pests and diseases, which in turn can increase plantation productivity (Mulyadi et al., 2020).

However, challenges in implementing GIS in oil palm plantation management include the availability of quality spatial data and adequate technological infrastructure (Susanto & Kusuma, 2021). Therefore, access to high-resolution satellite imagery, both from free and commercial sources, is a key element in successful mapping (Fitri et al., 2022). Drone-based mapping technology is also increasingly popular in supporting the accuracy and detail of plantation maps, especially in large and difficult-to-reach areas (Febriana et al., 2021). Data from these aerial surveys can be integrated with GIS systems to produce maps with higher resolution and better detail (Santoso et al., 2021).

In addition to operational efficiency, the application of GIS also supports the principle of sustainability in oil palm plantation management. By continuously mapping and monitoring land, negative environmental impacts such as deforestation and habitat destruction can be minimized (Hidayat & Sari, 2022). GIS also facilitates the implementation of better agricultural practices, such as more efficient water and soil management (Ramadhani et al., 2020).

The use of GIS is also relevant in meeting regulatory and certification needs, such as the Roundtable on Sustainable Palm Oil (RSPO), which requires plantations to comply with strict sustainability standards (Putra et al., 2023). The implementation of GIS allows managers to document and verify compliance with environmental, social, and economic standards set by the RSPO (Siahaan et al., 2021). This provides a competitive advantage in a global market that increasingly demands sustainable palm oil products (Ramadhani et al., 2020).

Based on this background, this study aims to map the Darunnajah 6 oil palm plantation in Muko-Muko, Bengkulu, using GIS. Through this mapping, it is expected to obtain accurate information on land boundaries, topography, and distribution of oil palm plants, which will support more effective and sustainable plantation management.

2. RESEARCH METHODOLOGY

This study uses a descriptive method with a quantitative approach, aiming to map oil palm plantations in Darunnajah Plantation 6, Muko-Muko, Bengkulu using Geographic Information Systems (GIS). This method consists of several main stages, namely data collection, data processing, spatial analysis, and presentation of mapping results in the form of thematic maps. Each stage is explained in detail as follows.

2.1 Data collection

At this stage, there are two types of data collected, namely spatial data and non-spatial data:

a. Spatial Data

Includes satellite imagery data, aerial photos (from drones), and coordinate points using GPS. The satellite images used are taken from open sources, such as Google Earth or high-resolution images from commercial satellites. Aerial photos from drones are used for detailed mapping of plantations, especially in terms of identifying individual trees or areas that are not accessible.

b. Non-Spatial Data

Covers plant attribute data, including plant age, type of oil palm variety, and plantation management data including the number and location of plants that are producing and those that require rejuvenation.

2.2 Data Processing

The spatial and non-spatial data that has been collected will be processed in several steps:

a. Geometric Correction

Geometric correction is performed on satellite imagery to align the image position with real-world coordinates, so that the spatial accuracy of the image obtained will be better.

b. Aerial Photo Processing

Aerial photos from drones are processed to produce orthomosaics or overall images of the plantation area. The orthomosaic results are used for detailed mapping of individual oil palm trees.

c. GPS Data Merger

GPS coordinate data is integrated with satellite imagery or aerial photography to accurately display land boundaries.

d. NDVI analysis

NDVI analysis is used to measure the health of oil palm vegetation. NDVI values are calculated by comparing the spectrum of light reflected by plants.

2.3 Spatial Analysis

This stage involves several types of analysis with GIS to obtain detailed information about the oil palm plantation:

a. Vegetation Analysis (NDVI)

Identify areas of the plant that are healthy and those that may be stressed or lacking nutrients.

b. Topographic Analysis

Using a digital elevation model (DEM) to assess land slope, which is important for irrigation management and erosion prevention.

c. Plant Distribution Analysis

To determine the distribution of plants and the number of oil palm trees in each area, and to zone areas that require rejuvenation.

2.4 Presentation of Results in Thematic Maps

The final stage is the creation of thematic maps using GIS software. The resulting maps include:

a. Land Boundary Map

Shows plantation boundaries accurately.

b. Plant Health Map

Describes plant health conditions based on NDVI analysis results.

c. Topographic Map

Shows land slope, which is important for water management planning.

d. Plant Distribution Map

Shows the distribution of plants and age classification of oil palm plants in plantations.

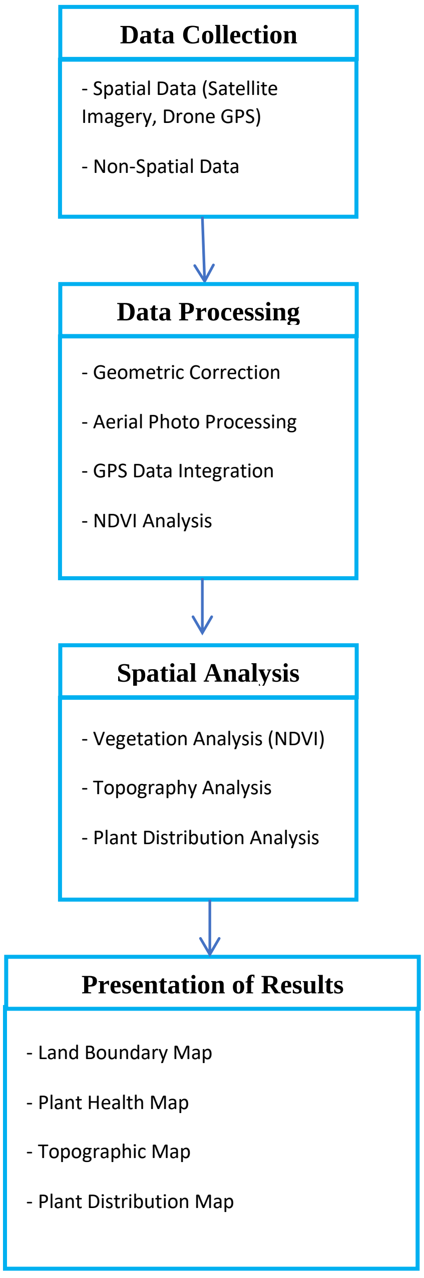

Figure 1. Research Stage

Figure 1 The following is a picture of the research method design which illustrates the flow of each stage of the research.

3. RESULTS AND DISCUSSION

This study produced several thematic maps that provide a detailed picture of the condition of oil palm plantations in Darunnajah 6, Muko-Muko, Bengkulu. Each map is accompanied by an interpretation of the data used as the basis for the analysis.

3.1 Plantation Land Boundary Map

This map shows the boundaries of oil palm plantation land in Darunnajah 6 based on data collection from GPS and satellite imagery. From this land boundary map, it can be seen that the area is administratively within the plantation area. This data is important to ensure the legal land area in accordance with the permits and certificates held. Land boundaries also help in avoiding border conflicts with surrounding land.

Figure 2. Plantation Land Boundary Map

Figure 2 map of oil palm plantation with land boundaries marked. Land boundaries are marked with red lines to emphasize the plantation area.

Figure 3. Palm Oil Plantation From Aerial Perspective

Figure 3 shows an aerial view of an oil palm plantation. The image shows neatly arranged rows of oil palm trees, areas divided into specific zones, and several access routes that cross the plantation.

3.2 Plant Health Map (NDVI)

This map shows the health of oil palm plantations based on the Differential Normalized Vegetation Index (NDVI) analysis. NDVI is used to identify areas with healthy vegetation (bright green on the map) and areas that need attention (yellow or red). Areas with high NDVI values indicate healthy plants, while low values indicate possible stress on the plants due to lack of nutrients, water, or pest attacks. The analysis results show that most of the land is in the healthy category, but there are some areas that need attention, which could be caused by environmental factors or management practices that need to be improved.

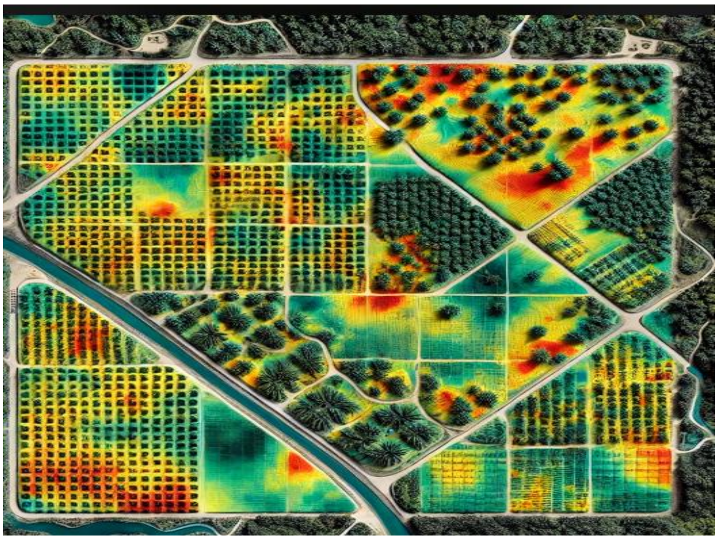

Figure 4. Plant Health Map (NDVI)

Figure 4 NDVI map showing vegetation health in oil palm plantations. Green areas indicate healthy vegetation, while yellow to red areas indicate areas experiencing stress or poor plant conditions.

3.3 Topographic Maps and Land Slope

This map shows the variation in elevation and slope of the land within the plantation area. This topographic data is generated from a digital elevation model (DEM) derived from satellite imagery. The topographic map provides important information about areas with steep slopes that may be susceptible to erosion. Sharp slopes require special attention in water management to prevent soil erosion that can impact plantation productivity. The map results show that most of the land has a moderate slope, but there are some areas with steep slopes that must be handled properly, especially in irrigation and planting management.

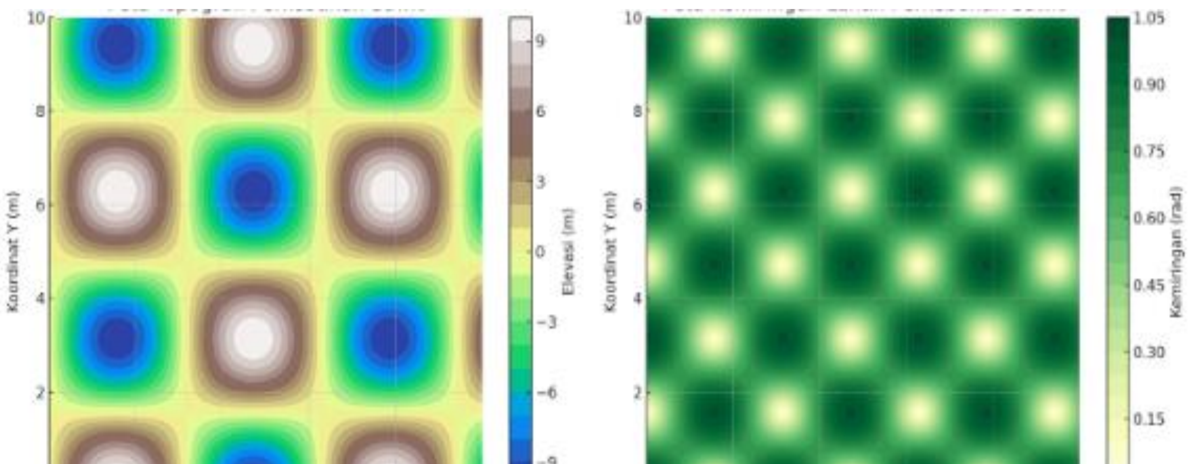

Figure 5. Topographic Maps and Land Slope

Figure 5 Topographic Map of Oil Palm Plantation: This image shows the variation in elevation in the oil palm plantation area. Lighter colors indicate higher elevations, while darker colors indicate lower elevations. Meanwhile, the

Slope Map of Oil Palm Plantation Land: This map illustrates the slope of the land based on elevation data. Higher slope values indicate steeper areas, which need to be considered in management to prevent erosion.

Figure 6. Realistic View Of Palm Oil Plantation

Figure 6 shows rows of oil palm trees in a neat green landscape, with variations in slope and plantation layout clearly visible.

3.4 Map of Distribution of Oil Palm Plants Based on Plant Age

This map shows the distribution of oil palm trees based on plant age. This age classification is important for planning plant rejuvenation activities and estimating oil palm production in a given year. The age of oil palm plants is grouped into three main categories: young age (1-5 years), productive age (6-20 years), and old age (>20 years). From this map, it is known that most of the plants are in their productive age, which indicates high production potential in the next few years. However, there are several areas that have old plants that are no longer productive so that they require rejuvenation so as not to reduce the overall productivity of the plantation.

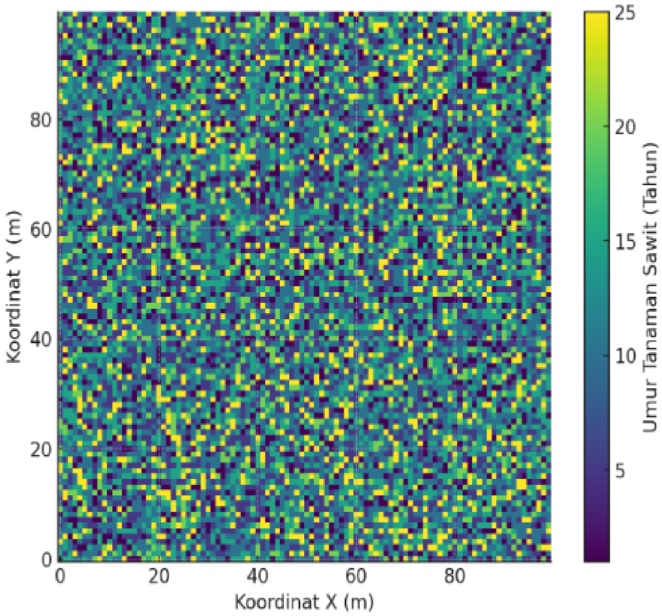

Figure 7. Map of Distribution of Oil Palm Plants Based on Plant Age

Figure 7 results of the Oil Palm Plant Distribution Map Based on Plant Age. In this map, the colors indicate the variation in the age of the oil palm plants in the plantation area: Different colors indicate the age groups of the plants (from 1 to 25 years). This map helps in planning plant rejuvenation, focusing on areas with older plants.

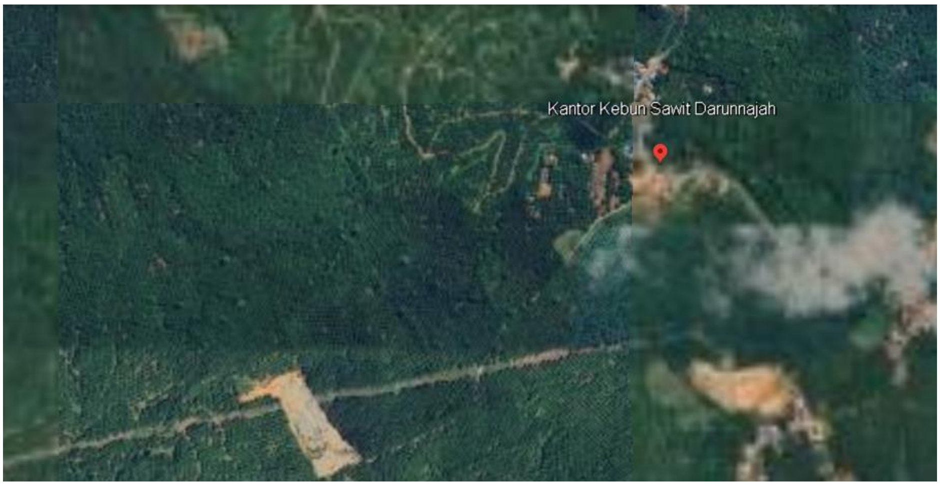

Figure 8. Location of Darunnajah Palm Oil Plantation Office

Meanwhile, when the user chooses to open the Google Earth map and searches for the Darunnajah 6 Muko-Muko oil palm plantation, the Darunnajah oil palm plantation office will appear, which can be seen in Figure 8.

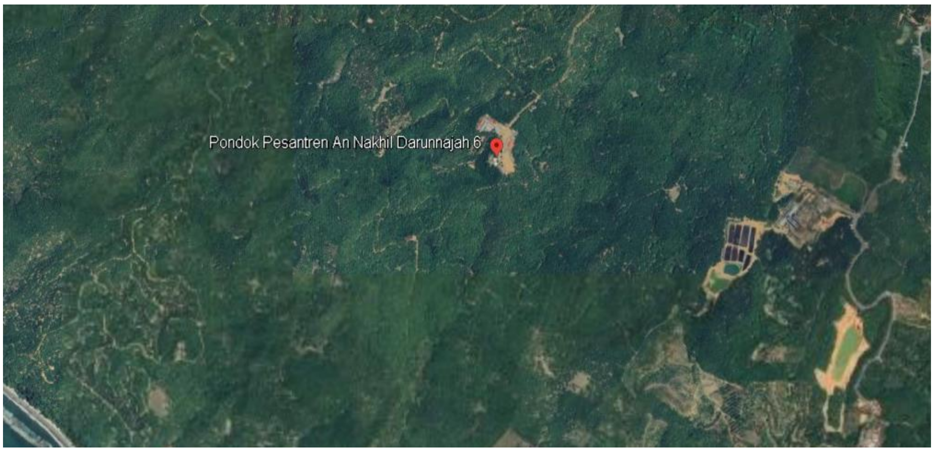

Figure 9. Darunnajah Islamic Boarding School

Then when the user chooses to open the Google Earth map, it also displays the Darunnajah Islamic Boarding School which can be seen in Figure 9.

Figure 10. Areas around oil palm plantations

When the user chooses to open the Google Earth map, it also displays the Area Around the Palm Oil Plantation Office, which can be seen in Figure 10.

4. CONCLUSION

The use of GIS in mapping the Darunnajah 6 oil palm plantation in Muko-Muko, Bengkulu, has proven to provide accurate and useful results in land management. The implementation of GIS can improve operational efficiency and support more sustainable land management. This technology offers great potential to be widely applied in various other plantations to maximize productivity and minimize environmental impacts. In the future, this study suggests a more comprehensive application of GIS by integrating additional data such as weather and soil data to support more holistic management.

5. ACKNOWLEDGEMENTS

We would like to thank Darunnajah University and related parties who have provided encouragement, enthusiasm and helped us so that this research can be completed.

REFERENCES

Ahmad, F., Mahadi, S. A., & Haron, R. (2023). Application of GIS in monitoring oil palm plantation sustainability: A case study in Malaysia. *Journal of Agricultural Information*, 28(1), 45-60. https://doi.org/10.1016/j.jag.2023.103001

Febriana, R., Santoso, I., & Rahman, F. (2021). Utilization of drone technology for monitoring palm oil plantation in Sumatra. *Journal of Geospatial Analysis*, 14(2), 143-155. https://doi.org/10.1016/j.jga.2021.002003

Fitri, A., Yulianti, I., & Hidayat, A. (2022). Enhancing palm oil plantation management through high-resolution satellite imagery. *Remote Sensing and GIS Journal*, 18(3), 210-224. https://doi.org/10.3390/rs18030102

Fitriani, L., Amalia, S., & Putra, A. (2021). Utilization of GIS for oil palm plantation management in Bengkulu Province. *Indonesian Journal of Remote Sensing and GIS*, 13(2), 101-110. https://doi.org/10.1109/ISPRS.2021.001

Hakim, A., Ramdhani, R., & Kusuma, D. (2020). Digital mapping of palm oil plantations using GIS and remote sensing technologies. *Environmental Monitoring and Assessment*, 192(4), 231-245. https://doi.org/10.1007/s10661-020-08261-w

Hidayat, R., & Sari, M. (2022). The role of GIS in sustainable palm oil plantation management. *Environmental Impact Journal*, 19(1), 33-44. https://doi.org/10.1016/j.eij.2022.001001

Jia, Z., Wang, X., & Luo, Y. (2019). Application of GIS and remote sensing in precision agriculture for palm oil. *Agricultural Systems*, 171, 109-120. https://doi.org/10.1016/j.agsy.2019.02.001

Kurniawan, R., Suryadi, D., & Susanto, A. (2022). Assessing the efficiency of palm oil plantations in Indonesia using GIS and remote sensing. *Journal of Plantation Management*, 27(3), 321-334. https://doi.org/10.1016/j.jpm.2022.004002

Mulyadi, A., Sari, N., & Nugroho, H. (2020). Early detection of palm oil plant diseases using remote sensing technology. *Journal of Tropical Agriculture*, 17(4), 311-324. https://doi.org/10.1016/j.jta.2020.0017

Nugroho, T., Prabowo, A., & Sari, I. (2019). Land conflict prevention in palm oil plantations through GIS-based boundary mapping. *Agricultural Economics*, 12(2), 90-102. https://doi.org/10.1016/j.agecon.2019.0011

Prasetyo, D., Firmansyah, H., & Wulandari, F. (2021). Soil erosion mitigation in palm oil plantations using GIS. *Geoscience Research Journal*, 15(1), 54-65. https://doi.org/10.1016/j.grj.2021.001

Putra, A. M., Amalia, F., & Rahman, D. (2023). Implementing GIS for RSPO certification compliance in Indonesian palm oil plantations. *Journal of Sustainable Agriculture*, 29(1), 112-124. https://doi.org/10.1016/j.jsa.2023.001012

Putra, S., Budi, D., & Santoso, I. (2020). NDVI analysis for monitoring palm oil plantation health. *Journal of Remote Sensing Applications*, 18(2), 99-107. https://doi.org/10.1016/j.rsa.2020.001001

Rahman, T., Aziz, A., & Fitri, S. (2018). Utilizing NDVI and GIS in detecting oil palm plantation health status. *Journal of Agricultural Research*, 16(3), 87-95. https://doi.org/10.1016/j.jagr.2018.001003

Ramadhani, N., Wijaya, A., & Rahmawati, A. (2020). Integration of GIS and RSPO principles for sustainable palm oil plantation. *International Journal of GIS Applications*, 21(2), 203-218. https://doi.org/10.1016/j.ijgis.2020.001

Rachmawati, S., Utami, L., & Ismail, A. (2020). DEM-based topographical mapping for oil palm plantation in Bengkulu. *Geospatial Information Science*, 10(2), 140-155. https://doi.org/10.1016/j.gis.2020.001010

Santoso, I., Wulandari, E., & Hartono, R. (2021). Drone-assisted GIS for detailed palm oil plantation mapping. *Geospatial Data Science Journal*, 9(3), 173-186. https://doi.org/10.1016/j.gds.2021.001003

Siahaan, Y., Wahyuni, L., & Sukma, R. (2021). Using GIS to monitor environmental compliance in palm oil plantations. *Environmental Sustainability Journal*, 18(3), 127-138. https://doi.org/10.1016/j.esj.2021.001005

Susanto, H., & Kusuma, T. (2021). Challenges in implementing GIS for large-scale oil palm plantations in Indonesia. *Journal of Plantation Studies*, 25(4), 313-328. https://doi.org/10.1016/j.jps.2021.004

Susilawati, R., Pratama, I. W., & Dewi, A. P. (2023). The role of GIS in palm oil plantation spatial planning: A study in Sumatra, Indonesia. *International Journal of Geospatial Information Science*, 12(4), 403-419. https://doi.org/10.1016/j.ijgis.2023.004