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Development of SADS (Soil and Air Detector System) to Support Palm Oil Industries in Indonesia

Faisal Lubis[1], Bakti Viyata Sundawa[2)*], Cholish[3)], Abdullah[4)]
[1)] Mechanical Engineering Department, Universitas Muhammadiyah Sumatera Utara, Medan, Indonesia
[2)3)4)] Electrical Engineering Department, Politeknik Negeri Medan, Medan, Indonesia
[1)]faisallubis@umsu.ac.id, [2)*]baktisundawa@polmed.ac.id, [3)]cholish@polmed.ac.id, [4)]abdullah@polmed.ac.id

ABSTRACT

The issue of environmental damage due to the expansion of palm oil plantations in Indonesia has become a global issue. It has often hampered the development of the downstream palm oil industries in Indonesia. The European market was once closed to palm oil and derivative products from Indonesia. In fact, this industry has become a source of income and employment for millions of Indonesians. Therefore, palm oil industry must be supported with sustainable efforts. One of them is developing SADS (Soil and Air Detector System) model. Which is a tool for detecting soil and air environmental conditions around palm oil plantations. The parameters are soil PH, CO_2 levels, temperature and humidity, and sunlight. The measurement results from this tool can be accessed and displayed in real-time via the internet. This is research aims to build a smart system as a solution to environmental problems around palm oil plantations. This is useful for knowing and observing the condition of palm oil plantations and as a basis for taking mitigation actions if the condition is in a critical state.

Keywords: Palm Oil Plantation; SADS; Sensors; Internet of Things; Environmental Data;

INTRODUCTION

The palm oil commodity is increasingly showing its existence and has become the backbone of the Indonesian economy. Palm oil plantations are spread across various districts in North Sumatera including Asahan, Labuhan Batu, Labuhan Batu Utara, Labuhan Batu Selatan, Langkat and Simalungun. These areas are in accordance with the growth and development requirements for palm oil plants. Which are at an altitude of 400 meters above sea level with an optimal temperature of 25°C-27°C (Manoli et al. 2018). Palm oil plantations will also be developed in the districts of Padang Lawas, North Padang Lawas, Serdang Bedagai, Mandailing Natal and Deli Serdang. These areas are potential areas for the development of palm oil plantations.

The increasing expansion of palm oil plantation area coupled with efforts to increase production per unit of land in North Sumatera, makes this sector very promising for the future. However, environmental issues and climate change factors are still an obstacle to the development of the palm oil industry (Lim et al. 2023)(Yousefi et al. 2020). New land clearing is considered to be one of the factors increasing CO_2 levels in the air (Rosa, Souza, and Pereira 2019). Deforestation due to land conversion, carbon emissions and loss of biodiversity have become international issues (Busch et al. 2022)(Delabre et al. 2023).

This is a challenge for palm oil stakeholders in Indonesia. Palm oil plantations must serve multiple functions, namely as a high economic value crop, a source of income, employment, and non-oil and gas export revenue, and palm oil plantations must also be a medium for preserving nature and the environment, as a producer of oxygen (O_2) and absorbing carbon dioxide (CO_2) emissions.

In the process of photosynthesis, palm oil will absorb CO_2 from the air and will release O_2 into the air. This process will continue during its growth and development which can reach more than 25 years with good management. CO_2 fixation is 25.71 tons/ha/year (Aziz, Othman, and Kamaruzaman 2022)(Germer and Sauerborn 2008). Palm oil can store more than 80 tons of C/ha (Ardiansyah et al. 2023). This amount is achieved after 10-15 years of growth so that the average amount of carbon retained by palm oil plants is around 60.4 tons/ha or an average of around 2.44 tons of C/ha/year and equivalent to 8.95 tons of CO2/ha/year.

Palm oil trees will grow well at 27°C-33°C, optimal sunlight of 6 hours per day and humidity in the range of 50%-90%. Water availability for palm oils is also very important. The role of water is as a solvent for various organic compounds from the soil to the plant and as a means of transporting nutrients to the leaves. If the soil water content is reduced, it will have an impact on the growth of palm oil plants. The stigma of palm oil as a “water-hungry” crop still

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exists in the community. Various studies explain that the evapotranspiration value in palm oil plantations averages 1104.5 mm/year. The evapotranspiration value of palm oil planted on peatland is 386 mm/year.

The evapotranspiration value that occurs in the Landak Kapuas Palm oil Plantation is 4.39 mm/day or equivalent to 1580 mm/year. While palm oil requires 1500-1700 mm/year of water to meet its growth and production needs (INTARA et al. 2019)(ASYURA, JUNE, and SALMAYENTI 2023). The evapotranspiration value is comparable to various plantation crops developed in dry climates such as sugarcane 1000-1500 mm/year, banana 700-1700 mm/year and coconut 1980 mm/year (Dingre and Gorantiwar 2020)(Silva et al. 2021)(Li et al. 2024).

The process of water loss and evaporation through evapotranspiration includes plants and soil. For palm oil plants, the area of land shaded by plants has a radius of 250 cm. Then the water demand in palm oil plants can be converted in units of 91.526 liters/day.

Another factor that affects palm oil production is the PH level of the soil. Soil PH levels determine the activity of microorganisms in the soil, if the soil PH is low then the activity of microorganisms will be very low. Soil pH determines the nutrients absorbed by plants. Nutrients in the form of Nitrogen (N), Potassium (K), and Phosphorus (P), which are easily absorbed by plant roots because these nutrients are easily soluble in water. Increased soil pH is directly proportional to the increased availability of nutrients needed by plants, and will increase palm oil bunch production. Knowing the soil PH level makes it easier to determine the type and dose of fertilizer to be applied. This will increase efficiency and reduce losses due to inappropriate fertilization. The optimum soil pH value for palm oil is 5.0-5.5.

Based on these conditions in the form of CO_2 levels, temperature and humidity, sunlight, and soil PH which can affect the growth and production of palm oil plants. So this research needs to be studied further to find out how to detect environmental parameters to find out and observe the condition of palm oil plantations. Information about environmental data must be able to be displayed and accessed in real-time via the internet via smartphones and computers. This is useful for determining policies related to mitigation if environmental conditions are in an extreme state.

LITERATURE REVIEW

In 2021, it has conducted research related to the detection and monitoring system for environmental pollution levels that occur on the POLMED campus. This research has been published in reputable international proceedings (Batubara, Sundawa, and Lestari 2021). In 2022, the research is more focused on innovation in IoT-based components and specific market segments. Implementation of this device began in palm oil plantations. This research is about CO_2 level detection systems in palm oil plantations and has been published in reputable international journals (Batubara, Sundawa, and Nasution 2023). In 2023, the research focused on the detection and monitoring of environmental parameters in the air, namely dust particles in the air, temperature and humidity, light intensity, CO_2 levels in the air, noise levels and their implementation in factories and power plants (Amelia et al. 2023).

In 2024, research will focus on the detection and monitoring of environmental parameters in the air and in the soil, namely CO_2 levels, temperature and humidity, sunlight, and soil PH. Parameters that will affect the growth and production of palm oil plants. This research aims for Sustainable Development Goals in the palm oil industries.

METHOD

SADS (Soil and Air Detector System) model will be developed which consists of 5 main blocks, namely sensors, IoT gateway, GSM network, cloud server, and user applications. The sensor used is the type with a special socket to the LoRa node. So each sensor will be equipped with a LoRa node to facilitate sending measurement data to the server and also facilitate scalability if the number of parameters to be measured is increasing. The IoT Gateway block uses the LoRa node device.

The next block is the GSM network. This network was chosen because it has the advantages of a network with a strong and more stable signal and a wider network throughout Indonesia. Many plantation locations are on the outskirts of big cities, it is hoped that with the GSM network, the detection and monitoring system can be carried out properly.

The server block uses cloud technology. This cloud system is easily customized according to the designation in this research. Furthermore, the application block uses a dashboard that has a KPI (key performance index) menu. This dashboard is generally used for business activities, but can be used for monitoring activities because this dashboard is interactive, accurate, real-time and analytical. The block diagram is shown in Fig.1.

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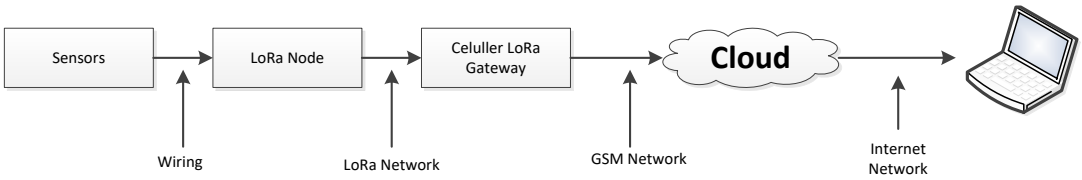

Fig. 1 Block diagram of SADS

RESULT

The measurement location is in the palm oil plantation and the Telecommunications Engineering Laboratory of POLMED. The implementation time starts from August 2024. Here they are shown at Fig.2 until Fig.6.

4.1 Data

Measurement result on average of soil PH is shown in Fig.2. Measurement result on average of temperature is shown in Fig.3. Measurement result on average of CO_2 levels is shown in Fig.4. Measurement result on average of humidity is shown in Fig.5. Measurement result on average of solar lighting is shown in Fig.6.

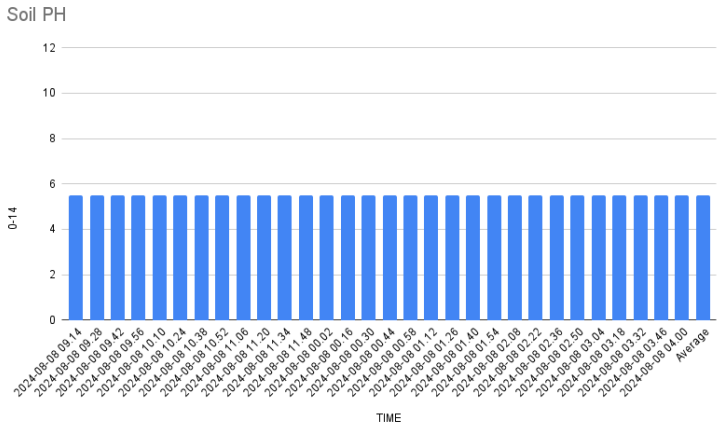

Fig. 2. Measurement result of soil PH

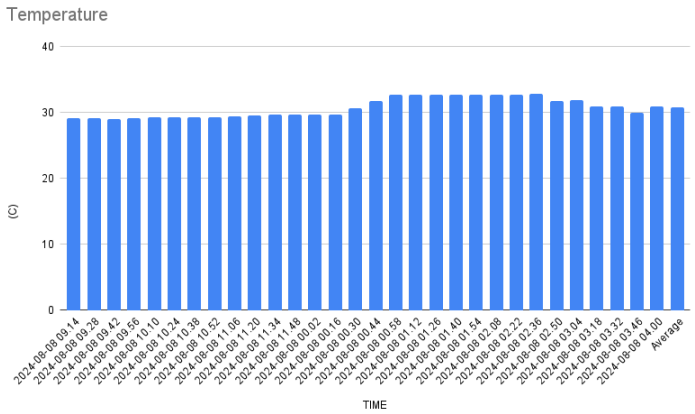

Fig. 3. Measurement result of temperature

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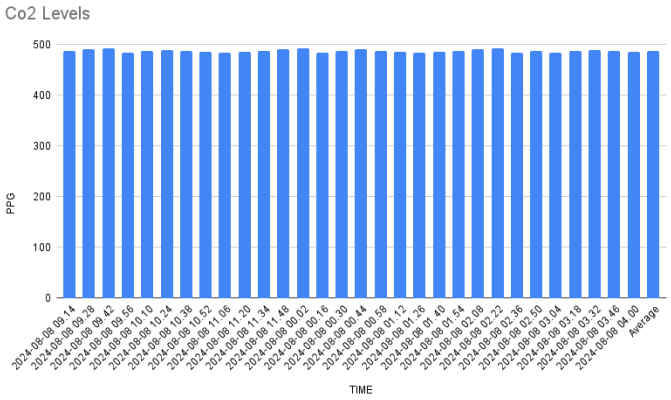

Fig. 4. Measurement result of CO_2 levels

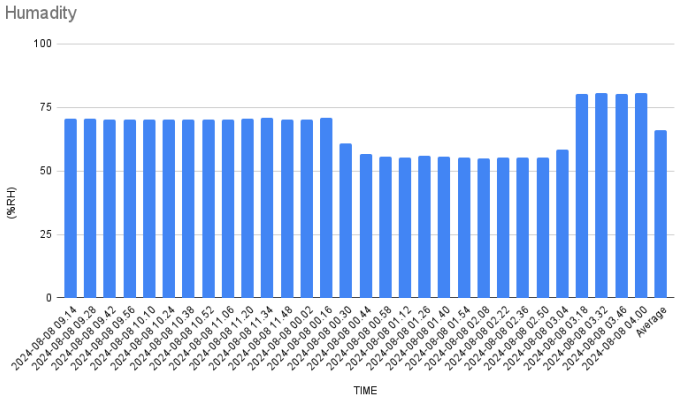

Fig. 5. Measurement result of CO2 humidity

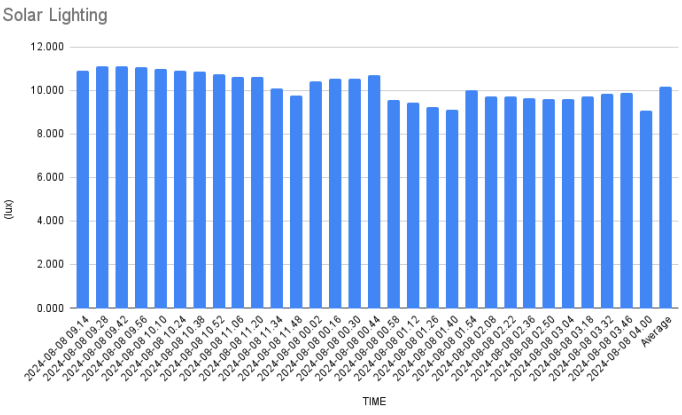

Fig. 6. Measurement result of solar lighting

DISCUSSIONS

Measurement data results must be compared with regulation standards set by the government. This is to find out whether the environmental conditions are normal or dangerous. Regulation of Manpower, Transmigration and Cooperation Ministry No.1/1978 : temperature 26ºC-30ºC and humidity 65% -95%RH. Regulation of Health Ministry

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No.70/2016 : light intensity min. 150 lux. Regulation of Environmental Ministry No.12/2010 : CO_2 level max. 3180 ppm. According to measured data results. The result is in average value, soil PH is 5.7. Temperature is 33.48ºC. Humidity is 77.80 %RH. Solar lighting is 10,642 lux. CO_2 level is 487 ppm (parts per million). Temperature is high but it still normal.

CONCLUSION

The palm oil commodity is increasingly showing its existence and has become the backbone of the Indonesian economy. Starting from the east end to the west end of North Sumatera. However, environmental issues and climate factors are still obstacles to the development of the palm oil industry. The problem of environmental damage caused by the palm oil industry has become a global issue. This often becomes an obstacle to the development of the palm oil industry in Indonesia. In fact, millions of Indonesians work in the palm oil sector and are a source of non-oil and gas state revenue. For this reason, efforts to support a sustainable palm oil industry need to be carried out. One of them is the implementation of a smart system in SADS (Soil and Air Detector System). It is important to know these parameters because they are affected by the expansion of palm oil plantations. The measurement results can be accessed and displayed in real-time web-based. It will be a solution to environmental problems and related parties can determine mitigation actions in the most extreme conditions.

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