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OPTIMIZATION IOT TECHNOLOGY IN WEATHER STATIONS FOR IMPROVE AGRICULTURAL SUCCESS DURING EL NIÑO ERA

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Abstract— *The El Niño phenomenon is significant to global weather patterns, particularly in Indonesia, which adversely affects the agricultural sector, especially rice production. El Niño causes drastic changes in rainfall patterns, making it difficult for farmers to determine the right planting time. Limited access to accurate weather information is a major obstacle for farmers in planning their agricultural activities. This research aims to develop an Internet of Things (IoT)-based weather station capable of providing real-time and accurate weather data to support farmers' decision-making in their land management. The research method starts with observation in Babakan Jaya Village, Gabuswetan District, Indramayu Regency, to understand the local weather conditions and specific challenges faced by farmers. Next, the construction and implementation of a weather station equipped with sensors to measure various weather parameters such as temperature, humidity, wind direction and speed, and rainfall. The weather data collected by these stations is then processed and presented in real-time through a cloud platform, which allows access from computer devices and smart phones. The observation results from 1 June to 27 July 2024 showed that the air temperature ranged from 29°C to 35°C, humidity between 55% to 90%, and wind speed ranged from 0 to 7 km/h, with sporadic rainfall patterns. The developed IoT weather station successfully provides relevant and accurate weather data, which can be accessed in real-time by farmers. With this data, farmers can make more informed decisions in their land management, hopefully improving the efficiency and success of farming practices, especially in the midst of erratic weather conditions due to El Niño.*

Keywords: *agriculture, El Niño, internet of things, real-time weather, weather station.*

Intisari— *Fenomena El Niño yang signifikan terhadap pola cuaca global, khususnya di Indonesia, yang berdampak buruk pada sektor pertanian, terutama produksi padi. El Niño menyebabkan perubahan drastis dalam pola hujan, membuat petani kesulitan menentukan waktu tanam yang tepat. Keterbatasan akses terhadap informasi cuaca yang akurat menjadi kendala utama bagi petani dalam merencanakan aktivitas pertanian mereka. Penelitian ini bertujuan untuk mengembangkan stasiun cuaca berbasis Internet of Things (IoT) yang mampu memberikan data cuaca secara real-time dan akurat untuk mendukung pengambilan keputusan petani dalam pengelolaan lahan mereka. Metode penelitian dimulai dengan observasi di Desa Babakan Jaya, Kecamatan Gabuswetan, Kabupaten Indramayu, untuk memahami kondisi cuaca lokal dan tantangan spesifik yang dihadapi petani. Selanjutnya, dilakukan pembangunan dan implementasi stasiun cuaca yang dilengkapi dengan sensor untuk mengukur berbagai parameter cuaca seperti suhu, kelembaban, arah dan kecepatan angin, serta curah hujan. Data cuaca yang dikumpulkan oleh stasiun ini kemudian diproses dan disajikan secara real-time melalui platform cloud, yang memungkinkan akses dari perangkat komputer maupun ponsel pintar. Hasil pengamatan dari 1 Juni hingga 27 Juli 2024 menunjukkan bahwa suhu udara berkisar antara 29°C hingga 35°C, kelembaban antara 55% hingga 90%, dan kecepatan angin berkisar* *antara 0 hingga 7 km/h, dengan pola curah hujan yang sporadis. Stasiun cuaca IoT yang dikembangkan berhasil menyediakan data cuaca yang relevan dan akurat, yang dapat diakses secara real-time oleh petani. Dengan data ini, petani dapat membuat keputusan yang lebih tepat dalam pengelolaan lahan mereka, diharapkan dapat meningkatkan efisiensi dan keberhasilan praktik pertanian, terutama di tengah kondisi cuaca yang tidak menentu akibat El Niño.*

Kata Kunci: *pertanian, El Nino, internet of things, , cuaca waktu nyata, stasiun cuaca.*

INTRODUCTION

The El Niño phenomenon is a climate event that has a significant impact on global weather patterns, including in Indonesia [1]. El Niño is characterized by abnormal warming of sea surface temperatures in the Pacific Ocean, leading to shifts in weather patterns across different regions of the world, particularly in tropical areas[2]. Its impact is acutely felt in the agricultural sector, where drastic changes in rainfall patterns affect planting seasons and agricultural production success. Data from the National Research and Innovation Agency (BRIN) predicts that the ongoing El Niño conditions in 2024 will have a significant impact on rice planting and production in Indonesia [3]. Even with the onset of the rainy season in November 2023, the delayed start of the rainy season is expected to cause a decline in rice production by up to 30% in some regions. Additionally, historical data shows that previous El Niño events, such as the one in 2015–2016, resulted in significant agricultural losses, with crop yields declining by up to 20% in certain areas of Java and Sumatra. With increasingly unpredictable climate changes, there is an urgent need for solutions that can help farmers mitigate the risks associated with these shifting weather patterns.[4], [5].

The main problem faced by farmers during El Niño seasons is the uncertainty in determining the right time to plant, caused by drastic changes in rainfall patterns. The lack of access to accurate and timely weather information makes it difficult for farmers to plan their agricultural activities, which can lead to reduced yields or even crop failures. Furthermore, technological limitations in providing real-time weather data and accurate weather forecasts pose a significant barrier to farmers' ability to tackle this challenge.

Based on predictions from the National Research and Innovation Agency (BRIN), the ongoing El Niño conditions and their resulting climatic impacts in Indonesia are expected to have a significant effect on rice production, with a substantial potential decline by the end of 2023 and early 2024. The delayed onset of the rainy season also poses additional challenges for farmers in managing their planting seasons. Therefore, the development of Internet of Things (IoT)-based weather stations tha\t can provide real-time and more accurate weather information is highly necessary to assist farmers in making the right decisions regarding the management of their agricultural land [4]

The role of IoT weather stations in agriculture is diverse, significantly enhancing the precision and efficiency of agricultural practices [6]. These advanced systems provide local weather data in real-time, which is crucial for making informed decisions about crop management and reducing weather-related risks. For example, IoT-based weather monitoring networks, as described by Hassan [7] provide farmers with reliable weather data via smartphones, as well as alerts for specific weather situations, thereby aiding better risk management. In the same way, Wang's [8] research shows how IoT technology can be used in smart agricultural meteorological stations to allow the uploading and recording of meteorological data in real time through cloud platforms, allow simultaneous access from multiple stations that are spread out, and make local maintenance easier through mobile apps. A comprehensive review by Ganesan et al. underscores the revolutionary impact of IoT on traditional weather monitoring systems, enabling seamless data collection, analysis, and dissemination, which is essential for addressing the challenges posed by climate change and improving weather forecasting [9], [10].

Moreover, IoT weather stations equipped with high-accuracy sensors can monitor various climate variables, such as temperature, humidity, barometric pressure, wind speed, and air quality, as demonstrated by Bibi and Khan [11], who also emphasize the use of photovoltaic power to sustain these systems. The practical applications of these systems are further illustrated by [6] who developed a model that makes weather data accessible to users through various methods, ensuring low power consumption and cost-effectiveness. Furthermore, Mathew and Dida's [12] work demonstrates the significant influence of meteorological conditions on agriculture, emphasizing the need for reliable weather monitoring systems, especially in areas where existing stations are non-functional. The advanced

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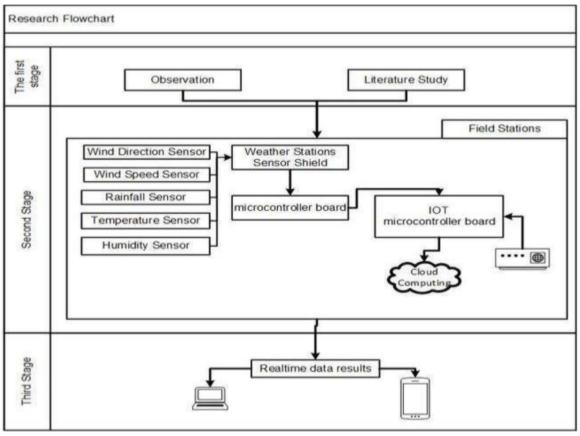
IoT weather monitoring systems proposed by [13] include sensors to monitor temperature, humidity, moisture, UV radiation, and carbon monoxide levels, with data stored in the cloud and accessible from anywhere, providing timely alerts to farmers about weather changes. Furthermore [14], discuss a new handheld IoT-enabled weather station that measures various environmental parameters with high precision, allowing real-time data uploads to customized websites, which is highly useful for both outdoor and indoor agricultural settings [15], [16]. Collectively, these IoT weather stations play a crucial role in smart agriculture by providing accurate real-time data, enhancing decision-making, optimizing resource use, and ultimately contributing to sustainable agricultural practices[17], [18], [19], [20]

Previous research has proven that IoT-based weather stations can enhance the efficiency of agricultural practices, but there are still some gaps that have not been addressed. These studies often focus on general applications without considering the specific challenges faced by farmers in Indonesia during the El Niño phenomenon. Moreover, the integration of weather data with local agricultural activities, such as determining planting times and irrigation, has not been extensively explored. This research adds a new dimension by developing predictive models based on machine learning, which have not been widely applied in this context. Additionally, the solutions offered by previous research tend to be more suitable for large-scale farming, whereas this study focuses on developing weather stations that are affordable and easily accessible to small-scale farmers. Thus, this research fills these gaps by offering solutions that are more relevant and adaptive to local needs, thereby enhancing the resilience and sustainability of agriculture in Indonesia.

MATERIALS AND METHODS

The development of Internet of Things (IoT)-based weather stations aims to help farmers anticipate the adverse effects of the El Niño season. By leveraging IoT technology, this research is designed to produce real-time weather data that can be easily accessed by users. The research workflow consists of three main stages: observation and literature review, the construction and implementation of weather stations in the field, and finally, the collection and presentation of real-time data results[21] [22].



Source: (Research Results, 2024)
Figure. 1 Research Flow Diagram

Based on Figure 1, the Research Flow Diagram explains the following 3 stages[23],[24]:

First Stage: Observation and Literature Review. This research begins with direct field observations to identify the needs and challenges faced by farmers in relation to weather and planting seasons. Through these observations, the researchers gain a clear understanding of the environmental conditions and how weather affects agricultural activities. In addition, a literature review is conducted to gather information from various sources related to weather sensor technology, IoT systems, and methods that have been applied in previous research. This literature review provides a strong theoretical foundation as well as inspiration for the development of innovative solutions in this research [25].

Second Stage: Field Weather Station Construction and Implementation. Following observations and a literature review, the next stage is the construction and implementation of weather stations in the field. At this stage, various weather sensors, such as wind direction, wind speed, rainfall, temperature, and humidity sensors, are selected and installed at the weather station. These sensors are connected to a Weather Stations Sensor Shield, which is then linked to a microcontroller board for data processing. Additionally, an IoT microcontroller board is used to transmit the processed data to cloud computing services, enabling real-time data access from anywhere. This implementation is carried out at strategic locations to obtain accurate and relevant weather data for farmers.

Third Stage: Real-time Data Collection and Presentation. The final stage of this research is the collection and presentation of data in real-time. The data collected by the weather stations in the field is processed by the microcontroller and then sent to cloud computing. From there, the weather data can

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be accessed by farmers through computers or smartphones, providing relevant and up-to-date information about weather conditions. With this data, farmers can make more informed decisions about managing their land and crops, which is expected to help reduce the negative impact of extreme weather events like El Niño.

RESULTS AND DISCUSSION

First Stage: Observation and Literature Review The observations in this research were conducted to understand the weather conditions, climate, and challenges faced by farmers during the El Niño season. The observation activities were carried out with the SRI JAYA farmer group located in Babakan Jaya Village, Gabuswetan Subdistrict, Indramayu Regency, West Java. Based on field observations, it was found that farmers often face difficulties in determining the right planting time due to unpredictable rainfall patterns caused by the El Niño phenomenon. Farmers in this area also experience limited access to accurate and timely weather information, which is crucial for making important decisions in agricultural practices. The need for a system that can provide real-time weather information and more accurate weather forecasts has become increasingly important to help farmers plan and manage their agricultural activities more effectively.

Source: (Research Results, 2024)
Figure 2. Observation

Source: (Research Results, 2024)
Figure 3. Observation 2

Second Stage: Construction and Implementation of Weather Stations in the Field.

Table 1. Hardware

Specifications	Details
Power	AC 220VAC DC 12 – 24VDC 3A
Brand Sensor	DF Robot
Wind Speed Sensor	Hall Effect Sensor
Wind Direction Sensor	0 -360 derajat
Temperature Sensor	-40 - 125℃
Humidity Sensor	0~100%
Microcontroller	1. The ATmega2560 is a Microcontroller 2. The operating voltage of this microcontroller is 5volts 3. The recommended Input Voltage will range from 7volts to 12volts 4. The input voltage will range from 6volts to 20volts 5. The digital input/output pins are 54 where 15 of these pins will supply PWM o/p. 6. Analog Input Pins are 16 7. DC Current for each input/output pin is 40 mA 8. DC Current used for 3.3V Pin is 50 mA 9. Flash Memory like 256 KB where 8 KB of flash memory is used with the help of bootloader 10. The static random access memory (SRAM) is 8 KB 11. The electrically erasable programmable read-only memory (EEPROM) is 4 KB 12. The clock (CLK) speed is 16 MHz 13. The USB host chip used in this is MAX3421E 14. The length of this board is 101.52 mm 15. The width of this board is 53.3 mm 16. The weight of this board is 36 g 17. LAN Card Support
Modem	Huawei B312 Modem Wifi Home Router 4G Telkomsel Orbit Star 2 1. Input = 100-240V - 50/60Hz = 0.5A 2. Output = 12V=1A (12W) 3. Power cable length = 160cm 4. Support 4G Frequency FDD 1800 / 2100) 5. RJ45 Ethernet Port 6. Support Max 32 users 7. Wifi 802.11b/g/n 2*2 MIMO 2.4GHz 8. Size 125 x 125 x 25.35 mm 9. SIM Card = Nano SIM 10. External Antenna Port = 1

Source: (Research Results, 2024)

1. Installation:
   Install the sensors. Mount the sensors at a height free from obstructions. Align the sensors' directions with the cardinal points. Position the part marked "N" facing north, "E" facing east, and so on.

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Source: (Research Results, 2024)
Figure 4. Censorship

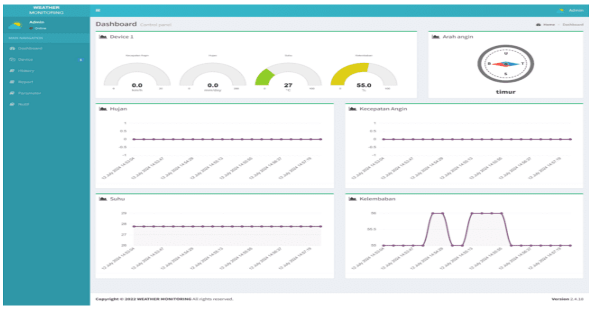
2. Connect the Sensors to the ESP32
   Follow the wiring instructions to connect the sensors to the ports inside the panel.


Source: (Research Results, 2024)
Figure 4. Connecting

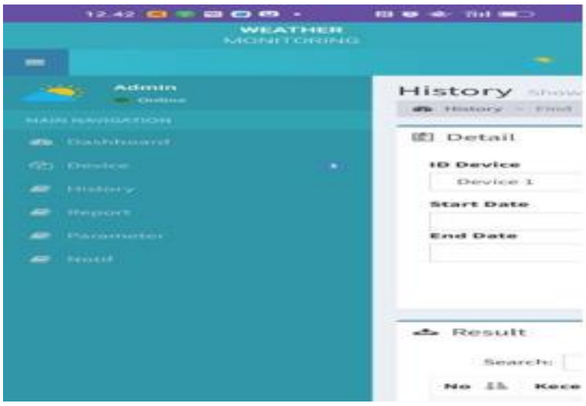
3. Power On the Device
   Connect the power source to the ESP32 and ensure that the reset button is not pressed.


Source: (Research Results, 2024)
Figure 5. Panel Boxes

Third Stage: Real-time Data Collection and Presentation The results of the Internet of Things (IoT) implementation can be accessed through a website.


Source: (Research Results, 2024)
Figure 6. Website Display

The results of the Internet of Things (IoT) implementation can be accessed through a website.



Source: (Research Results, 2024)
Figure 7. Android Display

Based on figures 6 and 7, the interface displays the dashboard of a weather monitoring website. At the top, there is a navigation panel on the left that contains various menus such as Dashboard, Devices, History, Analysis, Report, and Profile, allowing users to access different features and weather-related data. In the main section of the dashboard, information from "Device 1" is shown with visual indicators in the form of gauges displaying various weather parameters such as temperature and humidity, although some data appears to be unavailable. There is also a compass display showing the current wind direction, which is indicated towards the "East." At the bottom of the dashboard, graphs provide more detailed weather data, including rainfall, wind speed, temperature, and humidity over a certain period. These graphs help users visually monitor weather changes and understand ongoing weather trends. In the footer, information about copyright and the application version is provided, indicating that this application might be developed for professional weather monitoring purposes.
The features available in this dashboard include:
1. Main Dashboard : Displays a summary of weather data from the monitored devices.
2. Devices: Allows users to view and manage devices connected to the weather monitoring system.
3. History : Provides access to view historical data of the monitored weather parameters.
4. Analysis : This feature is likely used for conducting deeper analysis of the collected weather data.
5. Report : Possibly used to generate reports based on the monitored weather data.
6. Profile : For user account settings and profile information.

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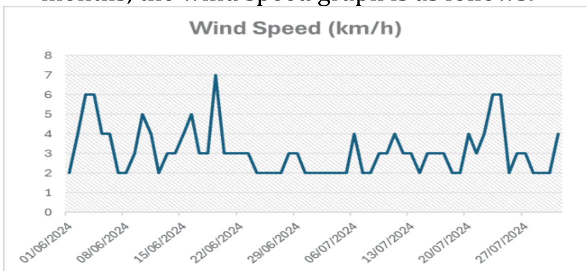
Overall, this dashboard is designed to provide ease in monitoring and analyzing weather data, with various features that support efficient device and data management.

Data sampling and validation for Short period

Data is collected every day for 24 hours and used to evaluate the sensor's functionality. Data is collected from June 1, 2024, to July 2024 from the Gabus Wetan Weather Station Report, which contains information about time, wind speed (km/h), wind direction, rainfall (mm/day), temperature (°C), and humidity (%).

1. Wind Speed: Based on observations over two months, the wind speed graph is as follows:



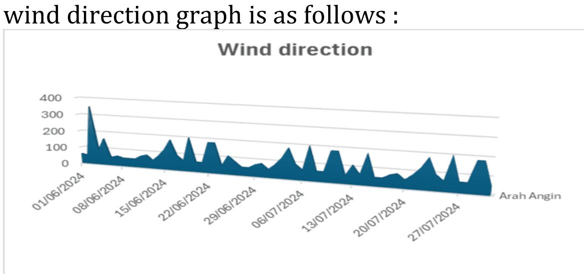
Source: (Research Results, 2024)
Figure 8. Wind Speed

The results of weather station monitoring over two months, displayed in the wind speed graph (km/h), show the variation in wind speed from June 1, 2024, to July 27, 2024. The graph reveals that the wind speed ranged from 0 km/h to approximately 7 km/h during the observation period. There were significant fluctuations in wind speed, with some peaks occurring in mid-June and late July.

At the beginning of the observation, wind speed tended to show higher variation, with some days recording stronger wind speeds, reaching up to around 7 km/h. However, over time, it appears that wind speed tended to decrease, with some days recording lower wind speeds, even approaching 0 km/h on a few occasions.

2. Wind Direction.

Based on observations over two months, the wind direction graph is as follows :

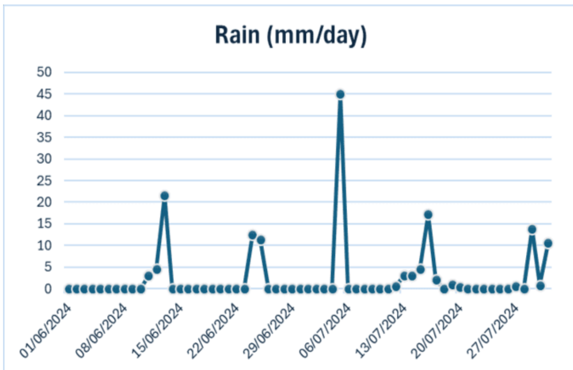


Source: (Research Results, 2024)
Figure 9. Wind Direction

The results of weather station monitoring over two months, displayed in the wind direction graph, show the variation in wind direction from June 1, 2024, to July 27, 2024. The graph indicates significant fluctuations in wind direction intensity. In early June, wind direction intensity peaked, which then gradually decreased over time. After this peak, wind direction intensity tended to decline but continued to show fluctuations until the end of the observation period. In general, wind direction during the observation period tended to fluctuate, which may reflect changing atmospheric conditions, such as the presence of low- or high-pressure systems affecting the monitored area. These wind direction fluctuations could also be related to daily or weekly weather changes, including rainfall events or temperature changes.

3. Rain

Based on the results of observations for two months, the following rain graph is obtained:



Source: (Research Results, 2024)
Figure 10. Rain

The results of weather station monitoring over two months, displayed in the daily rainfall graph (mm/day), show an uneven precipitation pattern, with some intense but sporadic rainfall events. Overall, during the observation period from June 1, 2024, to July 27, 2024, there were a few days with significant rainfall, while most days recorded low or no rainfall at all.

The highest rainfall was recorded in early July, where in one day, the rainfall reached nearly 45 mm, indicating a very heavy rainfall event on that date. Furthermore, there were other days with lower but still significant rainfall, such as in mid-June and mid-July, when rainfall reached 10 to 20 mm.

4. Temperature

Based on observations over two months, the temperature graph is as follows:

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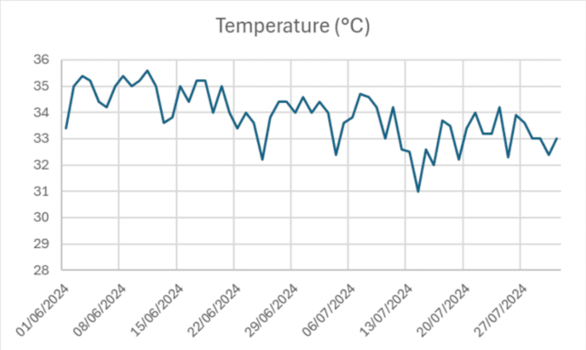


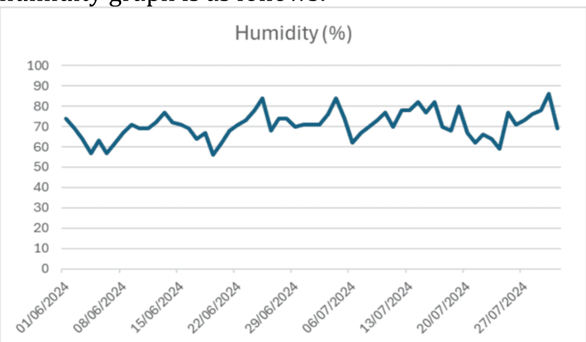
Source: (Research Results, 2024)

Figure 11. Temperature

The results of weather station monitoring over two months, displayed in the air temperature graph (°C), show relatively stable daily temperature variations with some significant fluctuations. Generally, the air temperature ranged between 29°C and 35°C during the observation period from June 1, 2024, to July 27, 2024. In early June, temperatures tended to be higher, around 34°C to 35°C, indicating fairly hot weather conditions. The temperature showed a slight decline over time, with fluctuations still within the same range, between 32°C and 35°C, until the end of June. Moving into July, there was a clearer trend of temperature decrease, with minimum temperatures starting to approach 30 °C, especially from mid to late July

5. Humidity

Based on observations over two months, the humidity graph is as follows:



Source: (Research Results, 2024)

Figure 12. Humidity

The results of weather station monitoring over two months, displayed in the relative humidity graph (%), show quite dynamic humidity level variations. Overall, humidity ranged between 55% and 90% during the observation period from June 1, 2024, to July 27, 2024. There were significant daily fluctuations, with humidity levels tending to rise and fall within relatively short timeframes. At the beginning of the observation, humidity was around 60%, then increased and decreased periodically, reaching its peak around mid-to-late June, with humidity nearing 90%. After that, there was a decrease in humidity towards the range of 60%–70%, with fluctuations continuing to be observed until the end of July.

Based on the analysis of weather data, including time, wind speed, wind direction, rainfall, temperature, and humidity over two months, there are indications that the monitored area is experiencing the impact of the El Niño phenomenon. The relatively high and consistent temperatures, ranging between 29°C and 35°C, indicate prolonged hot conditions, which are common characteristics of El Niño. The fluctuating but consistently high humidity, along with sporadic and uneven rainfall, suggests unstable weather patterns. The recorded rainfall pattern, with isolated heavy rain events and most days with low or no rainfall, supports the precipitation pattern associated with El Niño, where drought and irregular rain often occur. Additionally, the generally low wind speeds with minor fluctuations and varying wind directions reflect unstable atmospheric pressure systems that could also be influenced by El Niño. Overall, this analysis strongly indicates that the region is being affected by the El Niño phenomenon, influencing temperature, humidity, rainfall patterns, and overall wind patterns.

The effects of the El Nio phenomenon on rice farmers in Indramayu can be quite significant. Prolonged high temperatures can cause stress on rice plants, reducing their productivity and accelerating the evaporation of water from both soil and plants. This can exacerbate drought conditions, especially if rainfall decreases or becomes uneven, which often occurs during El Nino. Prolonged drought can lead to limited irrigation water availability, affecting the rice planting cycle that depends on a sufficient water supply. Additionally, sporadic and unpredictable rainfall can make it difficult for farmers to plan optimal planting and harvesting times, as rice plants are highly sensitive to changes in water conditions.

CONCLUSION

This research successfully developed an Internet of Things (IoT)-based weather station capable of providing real-time and accurate weather data. The research findings show that the developed IoT weather station can deliver relevant and easily accessible information to farmers through a cloud platform. With the weather data provided, farmers can make more informed decisions in managing their agricultural land, particularly in facing the unpredictable weather challenges caused by the El Niño phenomenon. The implementation of this technology is expected to enhance the efficiency and success of agricultural practices, and assist farmers in anticipating the negative impacts of climate change. Thus, this IoT weather station becomes an effective solution in supporting food security and the sustainability of the agricultural sector in Indonesia.

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REFERENCE

[1] T. B. Onofre, C. W. Fraisse, J. McNair, J. Judge, L. Zotarelli, and N. A. Peres, "A Design and Development Experience of an Internet of Things Platform to Monitor Site-Specific Weather Conditions at the Farm Level," *Appl Eng Agric*, vol. 37, no. 4, pp. 691–700, 2021, doi: 10.13031/AEA.14005.

[2] Akilan T, Durgadevi P, Singh P, Verma P, Chaubey VK "Development of Agricultural Productivity through Realtime Weather Prediction over IoT," In2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), pp. 1330-1334. IEEE 2022, doi: 10.1109/icac3n56670.2022.10074281.

[3] Badan Riset dan Inovasi Nasional (BRIN), *Prediksi Dampak El Niño terhadap Produksi Padi di Indonesia*. Jakarta: BRIN, 2024.

[4] Kementerian Pertanian Indonesia, *Data historis kerugian sektor pertanian akibat El Niño pada tahun 2024*. Jakarta: Kementrian Pertanian, 2024.

[5] T. T. Rajapaksha, A. Alexander, L. Fernando, A. Than, and H. Le Nguyen, "Real-Time Weather Monitoring and IoT-Based Palmtop Device for Smart Agriculture," vol. 3, no. 1, pp. 1–6, 2022, doi: 10.1007/S42979-021-00961-6.

[6] T. Akilan, P. Durgadevi, P. Singh, P. Verma, and V. Chaubey, "Development of Agricultural Productivity through Realtime Weather Prediction over IoT," 2022, pp. 1330–1334. doi: 10.1109/ICAC3N56670.2022.10074281.

[7] A. Hassan, A. A. Farooque, F. Abbas, R. Yaqub, A. Abdalla, and P. Soora, "An IoT based Weather Monitoring System for Smart Agriculture," pp. 1330-1334. IEEE, 2024, doi: 10.1109/sustech60925.2024.10553425.

[8] Y. Wang, "Design of IoT monitoring platform for intelligent agricultural weather station," *In International Conference on Internet of Things and Machine Learning (IoTML 2022), vol. 12640, pp. 76-81*, 2022, doi: 10.1117/12.2673516.

[9] S. Ganesan, "IoT-enabled Smart Weather Stations: Innovations, Challenges, and Future Directions," *Malaysian Journal of Science and Advanced Technology*, pp.180-190, Apr 2024, doi: 10.56532/mjsat.v4i2.293.

[10] T. B. Onofre, C. W. Fraisse, J. McNair, J. Judge, L. Zotarelli, and N. A. Peres, "A Design and Development Experience of an Internet of Things Platform to Monitor Site-Specific Weather Conditions at the Farm Level," *Appl Eng Agric*, vol. 37, no. 4, pp. 691–700, 2021, doi: 10.13031/AEA.14005.

[11] U. Bibi and S. Khan, "Design and Development of IoT Based Weather and Air Quality Monitoring Station," 2023, pp. 1–7. doi: 10.1109/ICRAI57502.2023.10089568.

[12] G. L. Mathew and Dr. M. A. Dida, "Agro-Meteorological data Collection using a LoRa WAN-Based IoT Sensor Network," *International journal of advances in scientific research and engineering*, vol. 08, no. 02, pp. 110–118, 2022, doi: 10.31695/ijasre.2022.8.2.15.

[13] Prof. D. U, C. Ns, B. Gs, A. A. Rao, and . Bhagyashree, "Iot based weather monitoring system for smart agriculture," *International Journal of Engineering Applied Sciences and Technology*, vol. 7, no. 1, pp. 298–301, 2022, doi: 10.33564/ijeast.2022.v07i01.045.

[14] T. T. Rajapaksha, A. Alexander, L. Fernando, A. Than, and H. Le Nguyen, "Real-Time Weather Monitoring and IoT-Based Palmtop Device for Smart Agriculture," vol.

VOL. 10. NO. 2 NOVEMBER 2024
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
DOI: 10.33480/jitk.v10i2.5851

3, no. 1, pp. 1–6, 2022, doi: 10.1007/S42979-021-00961-6.

[15] I. Ezzahoui, R. A. Abdelouahid, K. Taji, and A. Marzak, "Hydroponic and Aquaponic Farming: Comparative Study Based on Internet of things IoT technologies.," in *Procedia Computer Science*, Elsevier B.V., 2021, pp. 499–504. doi: 10.1016/j.procs.2021.07.064.

[16] N. A. Ubina *et al.*, "Digital twin-based intelligent fish farming with Artificial Intelligence Internet of Things (AIoT)," *Smart Agricultural Technology*, vol. 5, Oct. 2023, doi: 10.1016/j.atech.2023.100285.

[17] G. H. Elva Rizky and I. Fitrianto Rahmad, "Perancangan Alat Weather Station Berbasis Internet of Things (IoT)," *JID*, vol. 1, no. 2, pp. 701-710, 2023, [Online]. Available: http://kti.potensi-utama.ac.id/index.php/JID

[18] K. William *et al.*, "Sistem Kendali dan Pemantauan Budidaya Ikan Koi Berbasis Internet of Things Internet of Things based Control and Monitoring System for Koi Fish Cultivation," *Journal of Computing Engineering, System and Science)*, vol. 8, no. 1, 2023, [Online]. Available: www.jurnal.unimed.ac.id

[19] O. Nerella, "Internet of Things (IOT) Based Weather Monitoring system", doi: 10.17148/IJARCCE.2016.5966.

[20] K. Ioannou, D. Karampatzakis, P. Amanatidis, V. Aggelopoulos, and I. Karmiris, "Low-cost automatic weather stations in the internet of things," Apr. 01, 2021, *MDPI AG*. doi: 10.3390/info12040146.

[21] X. Hou, X. Liu, and M. Zeng, "A Water Pollution Monitoring System Based on the Internet of Things," *Procedia Comput Sci*, vol. 228, pp. 2–13, 2023, doi: 10.1016/j.procs.2023.11.002.

[22] A. I. Arafat, T. Akter, M. F. Ahammed, M. Y. Ali, and A. Al Nahid, "A dataset for internet of things based fish farm monitoring and notification system," *Data Brief*, vol. 33, p.106457, Dec. 2020, doi: 10.1016/j.dib.2020.106457.

[23] P. Megantoro *et al.*, "Development of an internet of things-based weather station device embedded with O2, CO2, and CO sensor readings," *International Journal of Electrical and Computer Engineering*, vol. 14, no. 1, pp. 1122–1134, Feb. 2024, doi: 10.11591/ijece.v14i1.pp1122-1134.

[24] P. Megantoro *et al.*, "Development of an internet of things-based weather station device embedded with O2, CO2, and CO sensor readings," *International Journal of Electrical and Computer Engineering*, vol. 14, no. 1, pp. 1122–1134, Feb. 2024, doi: 10.11591/ijece.v14i1.pp1122-1134.

[25] T. B. Onofre, C. W. Fraisse, J. McNair, J. Judge, L. Zotarelli, and N. A. Peres, "A Design and Development Experience of an Internet of Things Platform to Monitor Site-Specific Weather Conditions at the Farm Level," *Appl Eng Agric*, vol. 37, no. 4, pp. 691–700, 2021, doi: 10.13031/AEA.14005.