

IMPLEMENTATION OF IOT-BASED E-HYDROPONIC SYSTEM TO INCREASE MELON FARMING PRODUCTIVITY IN NGANJUK DISTRICT

Muhammad Shofwan Donny Cahyono¹, Norman Ray², Reynaldo Pratama Intan³

^{1,2,3}Civil Department, Widya Kartika University, Surabaya, Indonesia

Email: shofwandonny@widyakartika.ac.id¹, normanray@widyakartika.ac.id², reynaldo@widyakartika.ac.id³

Article Info

Article history:

Received : 27 - 12 - 2024

Revised : 12 - 1 - 2025

Accepted : 16 - 1 - 2025

Keywords:

1. E-Hydroponics
2. Internet of Things (IoT)
3. Irrigation Efficiency
4. Agricultural Productivity
5. Hydroponics Training

Abstract

UD. Jajar Jaya in Nganjuk Regency is experiencing problems with irrigation and the quality of melon yields. To overcome these problems, an e-hydroponic system based on the Internet of Things (IoT) was implemented as an innovative solution.

The implementation method includes a field survey for problem identification, e-hydroponic system prototype design, device installation, farmer training, and system trials for one cropping cycle. The prototype integrates the nutrient solution's temperature, humidity, light intensity, and pH sensors with Arduino Nano microcontroller-based automatic control and a web-based monitoring platform.

Results showed that the IoT-based e-hydroponic system improved irrigation efficiency and harvest productivity. The technology also successfully produced better-quality melons with more uniform growth. Intensive training enabled farmers to understand and operate the system well. Despite the challenges of initial investment costs, this technology provides a sustainable solution for agricultural efficiency and productivity.

In conclusion, the IoT-based e-hydroponic system is an innovation that supports the transformation of precision agriculture in Indonesia. With the support of the government, private sector, and technical assistance, this technology can potentially improve farmers' welfare, the sustainability of the agricultural industry, and national food security.

This is an open-access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Corresponding Author:

Muhammad Shofwan Donny Cahyono
Civil Department
Widya Kartika University, Surabaya, Indonesia
shofwandonny@widyakartika.ac.id

1. INTRODUCTION

Agriculture has become an essential sector in the global and national economy. In addition to providing food, this sector contributes significantly to creating jobs and increasing national income. However, the agriculture industry is not free from various challenges, both traditional ones, such as weather changes and land shortages, and new ones, such as the impact of the COVID-19 pandemic (Khairad, 2020; Paksi, Musyaffa, & Iswari, 2023). The pandemic has worsened the condition of the agricultural sector, hampered supply chains, and reduced productivity in many regions. Modern technology is crucial to overcome these constraints and promote efficiency and sustainability in agricultural activities (Rinardi et al., 2019).

UD. Jajar Jaya, a farmer group located in Nganjuk Regency, East Java, is a clear example of the challenges faced by the local agricultural sector. As a major producer of melons, UD. Jajar Jaya plays a significant role in supporting the local economy through farm income and job creation for the local community. However, constraints such as inefficient irrigation systems, weather dependency, and technological limitations are significant barriers to improving productivity and crop quality (Suci et al., 2023; Sairi, Apriyani, & Arohmah, 2024).



Figure 1: Irrigation Channels Drying Up

During the dry season, water availability becomes a serious problem for UD. Jajar Jaya. Irrigation channels often dry up, forcing farmers to use diesel pumps as a solution. However, this method is not only wasteful of fuel but also leads to uneven irrigation. As a result, the growth of melon plants becomes non-uniform, with some plants experiencing a lack of water while others experience an excess, leading to rotting. These inefficiencies hurt crop yields and farmers' income.



(a)

(b)

Figure 2. (a) Melon Fruit Condition with Less Water (b) Melon Fruit Condition with More Water

In addition, the COVID-19 pandemic has worsened the situation by limiting social interactions and complicating the agricultural process (Andrianingsih & Asih, 2021). The farmers at UD. Jajar Jaya cannot access adequate health supplies, such as masks or

temperature-measuring devices (Indraningsih, Septanti, & Ar-Rozi, 2020). The risk of virus transmission among workers is a serious threat that can significantly hamper production. Technological innovation is urgently needed to ensure agricultural businesses' sustainability.

One solution that can be adopted is hydroponic technology. Hydroponics is a method of growing crops without using soil, where plants are grown in nutrient solutions rich in nutrients (Ambarwati & Abidin, 2021; Tando, 2019). This technology has various advantages, such as efficient use of water, better environmental control, and flexibility in planting locations (Fitmawati et al., 2018) in the context of UD. Jajar Jaya, implementing a hydroponic system can be an innovative step to overcome irrigation constraints and increase melon productivity. However, conventional hydroponics alone is not enough to address modern challenges. Therefore, an Internet of Things (IoT)-based e-hydroponic system implementation activity was held (Fatori, 2022). This system is designed to integrate automation technology with efficient monitoring and management. Using various IoT sensors, the e-hydroponic system can monitor important parameters such as temperature, humidity, light intensity, and pH of the nutrient solution in real-time. The microcontroller then processes the data collected from these sensors to optimize the irrigation, lighting, and plant-growing environment settings.

By utilizing this e-hydroponic system, UD. Jajar Jaya is expected to be able to increase crop yields significantly. This technology not only helps optimize the use of water and nutrients but also reduces dependence on unpredictable weather factors. In addition, IoT-based management provides flexibility for farmers to monitor and control agricultural conditions anytime and anywhere so that efficiency and productivity can be continuously improved. The implementation also includes designing, developing, and testing a prototype e-hydroponic system tailored to local conditions in Nganjuk District. Factors affecting the successful implementation of this technology, such as training and mentoring needs for farmers, will be analyzed in depth. A sustainable technology adoption strategy will be designed to ensure that farmers can feel the benefits of this system in the long run.

In addition to technological development, improving melon quality is a top priority. Therefore, a unique training program was designed to provide farmers with knowledge and skills in nutrition management, pest control, and harvest and post-harvest techniques (Ismail & Syam, 2019). The training aims to ensure that the melons produced have high productivity and superior quality by national and international market standards. The training also covers using e-hydroponic technology so farmers can understand how the system works and optimize its use.

The implementation of IoT-based e-hydroponics technology is not only relevant in the context of post-pandemic economic recovery but also has broader positive impacts. This technology can be a model for precision agriculture in Indonesia, helping improve the quality and quantity of crop yields, reduce waste, and create new opportunities to market agricultural products with added value. Thus, the system provides technical solutions and contributes to improving farmers' welfare and the sustainability of the agricultural sector.

However, the application of this technology also faces challenges, mainly related to the high initial investment costs and the need for technical skills in operating the system. Therefore, collaboration between the government, research institutions, technology

industries, and farmers is necessary to overcome these barriers. Support in subsidies, training, and infrastructure provision will be key to successfully adopting this technology.

With this background, this activity aims to answer the challenges in the local agricultural sector by developing and implementing an IoT-based e-hydroponic system. The results of this activity are expected to significantly contribute to driving agricultural transformation towards the digital era, supporting local economic sustainability, and improving the welfare of farmers in Indonesia.

2. METHOD

The implementation of the IoT-based e-hydroponic system is carried out through several main stages as follows:

1. Initial Study and Problem Identification

This stage begins with a direct survey at the UD. Jajar Jaya to understand the constraints faced by farmers. The survey involved interviews with farmers on irrigation challenges, nutrient management, and the impact of weather on crop yields. Field observations were conducted to check the available infrastructure, such as water reservoirs, irrigation channels, and farmlands. In addition, technical data such as land area, type of melons grown, and water requirements were collected to design suitable technological solutions. The analysis results from this stage are used to determine the specifications of the e-hydroponic system to be developed.



Figure 3. Interview with the Owner of UD. Jajar Jaya

2. Prototype Design and Development

Based on the initial study results, the e-hydroponic system prototype was designed to meet the specific needs of melon farmers at UD. Jajar Jaya. The system includes sensors to measure temperature, air humidity, light intensity, and nutrient pH. Other main components are an automatic water pump, blower, and Arduino Nano microcontroller as the controlling center. Software development was also done to integrate the sensor data into a web platform so farmers can monitor crop conditions in real-time. Automatic control algorithms were designed to regulate irrigation, lighting, and air circulation based on the data obtained from the sensors.

3. System Installation and Integration

The developed prototype was installed at UD. Jajar Jaya. Temperature, humidity, and light intensity sensors were installed in the melon plant nursery house. Water reservoirs and

automatic pumps are configured to ensure a steady flow of nutrients. An Arduino Nano microcontroller was integrated with other hardware to process sensor data and execute control commands. The system was tested to ensure connectivity with the internet network, enabling remote monitoring and control. Configuration adjustments were made based on field conditions to optimize system performance.

4. Farmer Training and Education

Farmers were given intensive training on how to use the e-hydroponic system. The training sessions included fundamental theories on hydroponics and IoT and hands-on practice in device operation. Farmers were taught to read sensor data, set up automatic irrigation, and utilize the web platform for remote monitoring. In addition, they were involved in simulations of nutrient management and environmental control. Written guides and video tutorials were provided as references to help farmers understand this new technology.



Figure 4. Farmer Education

5. Testing and Monitoring

The e-hydroponic system was tested for one complete cropping cycle to evaluate its performance. Real-time sensor data was collected to analyze irrigation efficiency, nutrient usage, and plant growth. Comparisons were made between crop yields using the conventional method and the e-hydroponic method. The trial results showed an increase in resource use efficiency and crop quality, which are indicators of the successful implementation of the technology.



Figure 5. Tool Testing

6. Evaluation and Improvement

Trial results were evaluated through discussions with farmers and the technical team. Feedback was used to identify system shortcomings in terms of hardware and software. If weaknesses are found, modifications are made to improve system performance. This process ensures that the implemented technology truly fits the needs of farmers and can deliver optimal results.

7. Long-term Adoption Strategy

To ensure the sustainability of the technology, a financing model involving the government, private sector, and farmers was designed. Technical support services were set up to assist farmers in system maintenance. A scalability development plan was designed to expand the use of this system to other farmers so that the benefits can be widely felt. The strategy also includes advanced training to improve farmers' ability to manage the system independently.

3. RESULT DAN DISCUSSION

The development of the IoT-based e-hydroponic system resulted in several important achievements, including success in design, installation, system trials, and farmer training. The prototype successfully integrated temperature, humidity, light intensity, and water reservoir height sensors with an Arduino Nano microcontroller. All hardware components functioned well, and the web-based platform enabled real-time monitoring and control of the system.

Test results of the system on melon fields showed an increase in irrigation efficiency of up to 30% compared to conventional methods. Plant nutrients can be better managed, resulting in more uniform melon growth. In addition, the system successfully maintained air humidity and temperature within the optimal range for plant growth. Harvest data showed an increased productivity of up to 25% with better fruit quality, both in size and flavor.

The training results showed farmers could operate the e-hydroponic system well after intensive education sessions. Farmers learned to read sensor data, set up an automatic irrigation system, and utilize the web-based platform in this training. Hands-on simulations helped increase farmers' confidence in using this new technology. Most participants stated that the technology made it easier to manage their land and provided better yields compared to traditional methods.

The successful implementation of the IoT-based e-hydroponic system shows that this technology has great potential in supporting precision agriculture. In the trial phase, the irrigation efficiency achieved was due to the sensor's real-time ability to detect water demand. Thus, water application can be done optimally without waste. The web-based platform provides data transparency, allowing farmers to make informed decisions promptly.

In addition, the stability of the growing environment generated by the e-hydroponic system plays an important role in improving the quality of melons. Using blowers to maintain consistent air humidity reduces the risk of environmental stress in plants. The light intensity sensor works harmoniously with the supplementary light system, which provides

optimal lighting for the plants even in cloudy weather. This combination results in more uniform and high-quality melon growth.

The training results show farmers' understanding of the e-hydroponic system has significantly improved. Farmers not only learn to operate the system but also understand the basics of nutrient management and sensor data monitoring. Hands-on simulations helped farmers apply the theory to their daily activities. Challenges such as fear of using new technology were minimized through an interactive approach during the training.

However, implementing this system also faces challenges, especially regarding high initial investment costs. Some farmers stated that the cost of hardware and installation could be a barrier to widespread implementation. To address this issue, more affordable financing schemes or government subsidies are needed to help smallholder farmers access this technology.

In addition, continued use of the e-hydroponic system also requires ongoing technical assistance. While initial training helps improve understanding, some farmers still require assistance addressing complex technical issues. Regular technical support services can ensure the system continues operating optimally and provide long-term benefits.

Overall, the results of this activity show that IoT-based e-hydroponic systems have a significant positive impact on crop productivity and quality. By overcoming cost challenges and providing adequate technical support, this technology can be a long-term solution to improve sustainability and efficiency in the agricultural sector. Collaboration between the government, private sector, and farming community is key to accelerating this technology's adoption and further development.

4. CONCLUSION

Based on the results of this activity, it can be concluded that implementing the IoT-based e-hydroponic system significantly impacts agricultural products' efficiency, productivity, and quality. This technology successfully increased irrigation efficiency and crop productivity while improving the quality of melon fruits. Through practical training, farmers could operate the system properly, improve their understanding of the new technology, and apply precision farming methods independently.

Despite challenges such as high initial investment costs and the need for ongoing technical assistance, these solutions offer promising prospects for agricultural sustainability in Indonesia. Support from the government, academia, and the private sector is essential to expand the adoption of this technology, whether through subsidies, affordable financing schemes, or integrated technical services.

By overcoming existing obstacles, IoT-based e-hydroponic systems can transform agriculture towards the digital era, helping to create a more productive, efficient, and sustainable agricultural ecosystem. This technology is not only relevant for local farmers but also has the potential to be widely applied on a national scale, supporting economic growth and food security in the future.

REFERENCES

- Ambarwati, D., & Abidin, Z. (2021). Rancang Bangun Alat Pemberian Nutrisi Otomatis Pada Tanaman Hidroponik. *Jurnal Teknologi dan Sistem Informasi*, 2(1), 29-34.
- Andrianingsih, V., & Asih, D. N. L. (2021). Dampak Pandemi COVID-19 terhadap Pendapatan Petani Tembakau di Desa Palongan. *Jurnal Pertanian Cemara*, 18(2), 55-62.
- Fatori, M. M. F. (2022). Aplikasi IoT Pada Sistem Kontrol dan Monitoring Tanaman Hidroponik. *Jurnal Pendidikan Sains dan Komputer*, 2(02), 350-356.
- Fitmawati, F., Isnaini, I., Fatonah, S., Sofiyanti, N., & Roza, R. M. (2018). Penerapan Teknologi Hidroponik Sistem Deep Flow Technique sebagai Usaha Peningkatan Pendapatan Petani di Desa Sungai Bawang. *Riau Journal of Empowerment*, 1(1), 23-29.
- Indraningsih, K. S., Septanti, K. S., & Ar-Rozi, A. M. (2020). Penyuluhan Pertanian dalam Upaya Pemberdayaan Petani pada Era Pandemi Covid-19. *Pusat Sosial Ekonomi dan Kebijakan Pertanian*, 3(2), 613-633.
- Ismail, I., & Syam, A. (2019). Edukasi Teknologi Hidroponik untuk Pemberdayaan Lahan Pekarangan. *Jurnal Dedikasi*, 21(2), 105-109.
- Khairad, F. (2020). Sektor Pertanian di Tengah Pandemi COVID-19 Ditinjau dari Aspek Agribisnis. *Jurnal Agriuma*, 2(2), 82-89.
- Paksi, A. K., Musyaffa, N. F., & Iswari, R. D. (2023). Pandemi COVID-19: Dampak Global dan Peluang bagi Sektor Pertanian Indonesia. *Intermestic: Journal of International Studies*, 7(2), 677-700.
- Rinardi, H., Masruroh, N. N., Maulany, N. N., & Rochwulaningsih, Y. (2019). Dampak Revolusi Hijau dan Modernisasi Teknologi Pertanian: Studi Kasus pada Budi Daya Pertanian Bawang Merah di Kabupaten Brebes. *Jurnal Sejarah Citra Lekha*, 4(2), 125-136.
- Sairi, A. P., Apriyani, A., & Arohmah, L. D. (2024). Pembuatan Alat Pompa Air Tenaga Surya untuk Sistem Irigasi Pertanian: Uji Coba di Laboratorium. *Juwara Jurnal Wawasan dan Aksara*, 4(1), 160-169.
- Suci, Y. T., Saputra, E., Egra, S., & Santoso, D. (2023). Pemanenan Air Hujan untuk Sistem Irigasi dan Kendali Iklim Mikro di Greenhouse. *AgriHumanis: Journal of Agriculture and Human Resource Development Studies*, 4(2), 53-64.
- Tando, E. (2019). Pemanfaatan Teknologi Greenhouse dan Hidroponik sebagai Solusi Menghadapi Perubahan Iklim dalam Budidaya Tanaman Hortikultura. *Buana Sains*, 19(1), 91-102.