COMMUNITY EMPOWERMENT
Vol.9 No.1 (2024) pp. 98-106
p-ISSN: 2614-4964 e-ISSN: 2621-4024

Transforming aquaculture monitoring with real-time solutions at Salman Assalam Science Islamic Boarding School, Cirebon

Trio Adiono[1], Syifaul Fuada[2,3], Infall Syafalni[4], Feiza Alfi[1], Imran Abdurrahman[1], Sandi Pamungkas[1], Najma Khansa Alya Afandi[1], Leonardi Paris Hasugian[4]
[1] Institut Teknologi Bandung, Bandung, Indonesia
[2] Universitas Pendidikan Indonesia, Bandung, Indonesia
[3] University of Oulu, Oulu, Finland
[4] Universitas Komputer Indonesia, Bandung, Indonesia

syifaulfuada@upi.edu
https://doi.org/10.31603/ce.10474

Abstract
The aim of this activity is to disseminate real-time, 24-hour aquaculture water monitoring devices remotely at the Salman Assalam Science Islamic Boarding School in Cirebon, West Java. The Salman Assalam Science Islamic Boarding School manages various types of tilapia, catfish, and pomfret cultivation ponds used to support the economy and fulfill the food needs of the students. The activities include planning, implementation, and evaluation. The results of this activity include the development of a laboratory-level device, comprising a buoy, solar panels, and electronic modules with several types of electronic sensors. The device is equipped with a dashboard to observe real-time measurements in fish ponds, including parameters such as water temperature, dissolved oxygen, turbidity, pH, air temperature, humidity, battery voltage, total dissolved density, and solar cell voltage. Data is presented in the form of graphs and tables accessible via a web browser, allowing partners to access it from laptops or smartphones.

Keywords: Fish cultivation; Water quality monitoring; Pond; Islamic boarding school

Mentransformasi pemantauan akuakultur dengan solusi real-time di Pesantren Sains Salman Assalam, Cirebon

Abstrak
Tujuan kegiatan ini adalah mendiseminasikan perangkat pemantauan air budidaya perikanan secara real-time selama 24 jam dari jarak jauh di Pesantren Sains Salman Assalam, Cirebon, Jawa Barat. Pondok Pesantren Sains Salman Assalam telah mengelola berbagai jenis kolam budidaya ikan nila, lele dan bawal yang dimanfaatkan untuk menyangga perekonomian dan menyokong pasokan kebutuhan pangan santri. Kegiatan meliputi perencanaan, pelaksanaan dan evaluasi. Hasil kegiatan ini mencakup pengembangan sebuah perangkat di tingkat laboratorium. Perangkat ini merupakan satu set alat yang terdiri dari pelampung, panel surya, dan modul elektronika dengan beberapa jenis sensor elektronik. Perangkat dilengkapi dengan dashboard untuk mengamati hasil parameter-parameter yang diukur secara real-time pada kolam ikan melalui beberapa jenis sensor yang terpasang seperti suhu air, Dissolved Oxygen, Turbidity, pH, suhu dan kelembapan udara, tegangan baterai, total kepadatan yang terlarut dan tegangan solar sel. Data berupa grafik dan tabel data melalui web browser yang dapat diakses oleh mitra dari laptop maupun smartphone.

***Kata Kunci**: Budidaya ikan; Water quality monitoring; Kolam; Pesantren*

1. Introduction

Salman Assalam Science Islamic Boarding School, a modern Islamic boarding school in Cirebon Regency, West Java (Bahijah et al., 2022), faces financial constraints, particularly in food provision for its numerous financially disadvantaged students, due to cash flow inconsistencies. A significant opportunity to enhance the school's operational funds, especially its food supply, lies in optimizing its existing fish cultivation ponds located on adjacent private land. This pesantren is part of a local fisheries group managing tilapia, catfish, and pomfret ponds, where current manual labor practices limit efficiency.

These ponds are irrigated by water from nearby rice fields, with individual areas of 24 × 9 m^2, 15 × 10 m^2, and 16 × 10 m^2 for tilapia, catfish, and pomfret, respectively. The three-stage fish rearing process (seed stocking by an external supplier, grow-out by pesantren workers, and harvesting/market sale by the supplier) provides supplementary income for the school's teachers. To improve efficiency and empower these fish farmers, we propose integrating a 24/7 remote water quality monitoring system. This technology is expected to increase food production for the students and generate additional income for the pesantren by enabling intensive, effective, and accurate pond management.

Prior community engagement initiatives highlight the value of real-time IoT-based water quality monitoring in aquaculture. Institut Teknologi Sumatera (ITERA) developed a system for tilapia ponds using Biofloc technology, displaying temperature, turbidity, and pH on a smartphone app for the Sadewa Mandiri group in Lampung (Ashari et al., 2022). Similarly, ITN Malang implemented IoT sensors to monitor temperature, acidity, and turbidity for koi farmers in Blitar, including automated feeding and water management systems (Nurdina et al., 2022). Furthermore, Universitas Yarsi created a Blynk-based system to monitor temperature, turbidity, and pH in ornamental fish ponds for the ALTUM Ciseeng group in Bogor, also incorporating a camera for theft prevention (Sabiq et al., 2022). While these studies confirm the importance of water quality monitoring, their systems are species-specific and lack mobility. To address these limitations, our team developed a mobile, floating device capable of monitoring water quality for multiple fish species using a comprehensive array of sensors. Unlike the Android-based mobile applications used in the aforementioned studies, our monitoring system is accessible via a user-friendly website platform, allowing access from various devices with individual login credentials.

2. Methodology

A pre-existing water quality monitoring device, developed at the laboratory scale, was deployed in an operational aquaculture setting (tilapia, catfish, and pomfret fish ponds). Initial field observations in January 2023 involved water sample collection for subsequent sensor testing conducted between February and March 2023.

2.1. Preparation Phase

Prior to field deployment, the device's functionality was verified through laboratory testing, building upon its research and development at the Bandung Institute of Technology in collaboration with the Indonesia University of Education. This phase also included coordination with the fish pond owners.

2.2. Implementation Phase
Field implementation involved device installation and functional validation at the designated locations, identified through prior planning surveys. Logistical arrangements were made for transporting the device to the site (Salman Assalam Science Islamic Boarding School, 206 km from the Bandung Institute of Technology), accessible by vehicle (Hartanti & Hidayat, 2017). The installation process actively engaged the target community to facilitate knowledge transfer regarding the proper assembly of the multi-subsystem device. The community service team ensured the correct operation and monitoring capabilities of the installed device before leaving it in situ.

2.3. Evaluation Phase
The evaluation involved analyzing the sensor data collected by the water quality monitoring device. Additionally, unstructured interviews were conducted with the community to assess their feedback on the device dissemination resulting from this community service initiative.

3. Results and Discussion

3.1. Program Implementation
Laboratory testing at the Institut Teknologi Bandung confirmed the functional operation of the developed water quality monitoring device under simulated field conditions (Figure 1). Subsequently, the research team coordinated the installation logistics with the pond owner, Ustad Zaki Hidayat, S.Pd., Gr, Head of the Assalam Foundation at the Salman Assalam Science Islamic Boarding School. The device, comprising a waterproof-cased electronic module, solar panel mounted on an aluminum frame, and a float (Figure 2) (Bahri et al., 2023; Koparan & Koc, 2017; Trevathan & Schmidtke, 2022; Wang et al., 2014), was then transported to the site and formally handed over. Installation was completed on October 24, 2023, with partner involvement to ensure procedural understanding (Figure 3). Three units were deployed, each placed centrally in separate ponds dedicated to tilapia, catfish, and pomfret cultivation (Figure 4). The device integrates data acquisition for water quality parameters and a transmission system for relaying data to a server and subsequent interface display.

Figure 1. Coordination and observation before device installation

The device is equipped with several sensors to measure critical parameters in aquaculture, including pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), water turbidity, air humidity, air temperature, and water temperature. Additionally, the device's battery voltage and solar panel voltage can be monitored via dedicated sensors (Chidolue & Iqbal, 2023; Loniza et al., 2016; Pal et al., 2020). Overfeeding can negatively impact DO levels in ponds due to decreased dissolved oxygen concentration.

Conversely, during daylight hours, plankton photosynthesis can lead to relatively high DO values. Therefore, accurate and real-time measurement of this parameter is crucial for enhancing fish production (Aljehani et al., 2023; Rao et al., 2017; C. Xu et al., 2022; H. Xu et al., 2016). The float positioned at the bottom of the device allows for flexible placement of the sensors in the center, edge, or specific coordinates within the pond, as it can freely float. The device can be repositioned by attaching a rope and pulling it to the desired location. The solar panel, located at the top, serves as the power source, eliminating concerns about external power supply around the ponds as it harvests solar energy during the day. The electricity generated by the solar panel is stored in a battery, expected to have extended durability.

Figure 2. Water quality monitoring device

Figure 3. Device installation process

Figure 4. Simulation of the installed device

3.2. Evaluation and Discussion

The partner positively responded to this technological advancement in fish farming, as their previous traditional aquaculture methods involved entirely manual operations, particularly in water quality management. One partner's feedback was as follows:

> *"I am very pleased with this tool because it can help to measure water quality in fish ponds. I hope it can increase the production quality of fish, as it is a source of consumption and income for the Islamic boarding school."*

Previously, the partner relied on conventional methods for water quality checks, such as repeated manual water sampling for pH testing. Although seemingly minor, these manual activities consumed significant time, effort, and even costs if someone was hired for the task. Consequently, they often experienced delays in addressing sudden, undesirable changes in water quality, leading to decreased fish productivity.

On the other hand, all fish species are sensitive to water temperature, pH, turbidity, and other parameters. Inaccurate manual measurements can cause fish to lose appetite, resulting in low productivity. Inappropriate pH levels can lead to aquaculture failure (Nursobah et al., 2022). This device enables accurate measurements as it has been calibrated and laboratory-tested, ensuring its measurement functions align with standardized tools commonly used by fish farmers in the program's target community. Fish farmers can also save considerable effort by eliminating manual measurement activities. This device has been adapted for ponds with three different fish species: pomfret, catfish, and tilapia.

The dissemination of this device represents technology adoption as an effort to promote smart aquaculture for fish farmers in ponds, offering benefits such as human labor efficiency, effectiveness (increased production), and environmental friendliness. Optimal pond management is a crucial factor supporting successful fish farming, ensuring that production aligns with market demands (Isa et al., 2021). This community service activity also contributes to sustainable regional development (Permatasari et al., 2018) through the integration of technology in the pesantren's fisheries sector, thereby supporting community economic development (Susmawati et al., 2022). One partner commented, expressing hope for the sustainability of this initiative and support from stakeholders, including the government for operational funding and institutions for technology provision and knowledge transfer regarding its use. This aligns with the view of Yuliandani (2017) that stakeholders play a vital role in sustainable regional development.

The hope for the partners is that this device will enable them to produce fish yields that meet local market targets, thereby supporting the pesantren's economic independence, particularly in ensuring sufficient food supply for the students. The positive impacts of using this device include cost savings, reduced human resource needs, increased productivity, and lower risks. Regular monitoring by fish farmers is necessary to ensure pond water quality meets the needs of the fish (Ramdhani et al., 2023), as poor water quality can lead to reduced appetite and disease (Kilawati et al., 2021). Furthermore, capacity building efforts are needed as a follow-up to this activity, similar to those conducted by Rosyidi et al. (2021) for similar community service initiatives related to water quality management, which can be integrated through the utilization of Internet of Things (IoT) based technology.

This technology dissemination activity has demonstrated the significant impact of technology adoption on community quality of life, including increased productivity. For example, similar community service initiatives using IoT for catfish farmers have provided substantial benefits in reducing wastewater in catfish ponds, yielding promising results for the target community. The implication of optimal harvests is the resulting economic value, where optimal sales of the harvest can be achieved (Sari et al., 2023; Ujianti et al., 2022).

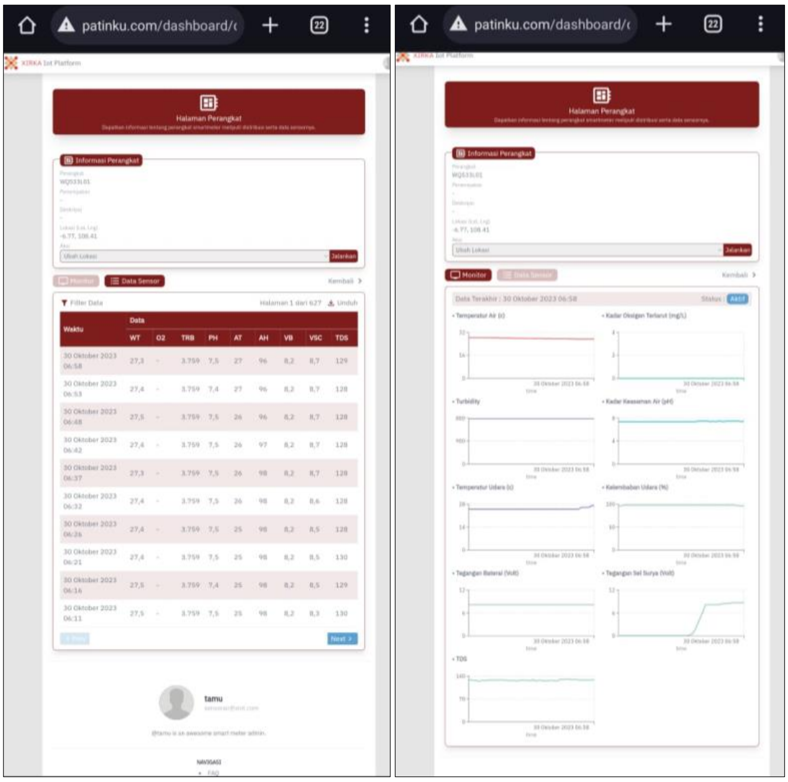

Figure 5. Post-installation device evaluation activity

After the device installation on October 24, 2023, the team conducted testing and evaluation to ensure the water quality monitoring device operated correctly before leaving it in place. The device was connected to a web browser application at http://patinku.com/login. Following a specific procedure, the device could then be monitored via a smartphone accessing the website. The web browser displayed device information, location, and mode. Monitoring results showed that the measurement of critical parameters could be performed remotely, anytime and anywhere with internet access. For example, on October 30, 2023, at 06:11 WIB, the measured values were: WT = 27.5 °C, TDS = 130, AH = 98, and so forth. Subsequently, on the same date, around 06:58 WIB, the values for WT, TDS, and AH changed to 27.3 °C, 129, and 27, respectively.

Figure 5 illustrates the monitor mode displaying quantitative data from the nine installed sensors on the device: WT = Water Temperature, O2 = Dissolved Oxygen, TRB = Turbidity, PH = pH level, AT = Air Temperature, AH = Air Humidity, VB = Voltage of Battery, VSC = Voltage of Solar Cell, and TDS = Total Dissolved Solids. The presentation shows the sensor data in graphical mode, with the y-axis representing the measurement results and the x-axis representing time.

4. Conclusion

The dissemination and initial operationalization of an automated water quality monitoring device for fish farming at Salman Assalam Science Islamic Boarding School, Cirebon Regency, West Java, have been successfully conducted. The system integrates multiple sensors (pH, DO, TDS, turbidity, air/water temperature, air humidity, voltage) for continuous and remote surveillance, accessible through a web-based interface for timely management responses. This initial phase confirmed device functionality. Future research should focus on a comprehensive follow-up program encompassing regular monitoring, maintenance strategies, and user training on SOPs (supported by a detailed manual). Furthermore, longitudinal studies are required to evaluate the long-term impact of this technology on fish production yield and quality, providing valuable insights for future device iterations and broader implementation.

Acknowledgement

This program was funded by the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) in 2023, under Contract Nos. 086/E5/PG.02.00.PM/2023 and 446/IT1.B07.1/SPP-LPPM/VII/2023.

References

Aljehani, F., N'Doye, I., & Laleg-Kirati, T.-M. (2023). Fish Growth Tracking and Mortality Monitoring: Control Design and Comparisons. *Proceedings of the American Control Conference*, *2023-May*, 3790–3796. https://doi.org/10.23919/ACC55779.2023.10156119

Ashari, I. F., Untoro, M. C., Praseptiawan, M., Afriansyah, A., & Nur'azmi, E. (2022). Sistem Pantau dan Kontrol Budidaya Ikan Nila Berbasis IoT dengan Bioflok (Studi Kasus: Kelompok Budidaya Ikan Sadewa Mandiri, Pringsewu). *Suluah Bendang: Jurnal Ilmiah Pengabdian Kepada Masyarakat*, *22*(2), 417–427. https://doi.org/10.24036/sb.02760

Bahijah, I., Rahmatika, N., Ahmad, A., & Ishak, S. N. S. (2022). Kurikulum Pesantren Berbasis Sains di Pondok Pesantren Sains Salman Assalam: sebagai Model Moderasi Agama dalam Pendidikan. *Edukasi Islami Jurnal Pendidikan Islam*, *11*(001), 81–89. https://doi.org/10.30868/ei.v11i4.3549

Bahri, A. Q. S., Yusof, Y. W. M., & Kassim, M. (2023). Solar Powered Smart Water Monitoring System Based on IoT and Blynk Platform. *2023 IEEE International Conference on Automatic Control and Intelligent Systems, I2CACIS 2023 - Proceedings*, 189–194. https://doi.org/10.1109/I2CACIS57635.2023.10193008

Chidolue, O., & Iqbal, T. (2023). System Monitoring and Data logging using PLX-DAQ for Solar-Powered Oil Well Pumping. *2023 IEEE 13th Annual Computing and Communication Workshop and Conference, CCWC 2023*, 690–694. https://doi.org/10.1109/CCWC57344.2023.10099099

Hartanti, R. D., & Hidayat, W. (2017). Pengaruh Kualitas Produk, Kualitas Pelayanan, Dan Harga Terhadap Keputusan Pembelian Honda Mobilio Pada Honda Semarang Center. *JIAB: Jurnal Ilmu Administrasi Bisnis*, *6*(1). https://doi.org/10.14710/jiab.2017.14570

Isa, I. G. T., Mayasari, R., & Putra, R. R. (2021). Diseminasi Teknologi Pembudidaya Ikan pada Kelompok Pembudidaya Ikan di Kelurahan Demang Lebar Daun. *Community Development Journal: Jurnal Pengabdian Masyarakat*, 2(3), 951–961. https://doi.org/10.31004/cdj.v2i3.2780

Kilawati, Y., Maimunah, Y., Muttaqin, A., Kartikasari, D. P., Bhawiyuga, A., & Amrillah,

A. (2021). Memanfaatkan Internet of Aquaculture dalam Meningkatkan Kualitas Produksi pada Kelompok Pembudidaya Ikan Koi di Blitar. *JIAT: Journal of Innovation and Applied Technology*, *07*(02), 1321–1325.

Koparan, C., & Koc, A. B. (2017). Development of a UAV-assisted water quality measurement system. *2017 ASABE Annual International Meeting*. https://doi.org/10.13031/aim.201701352

Loniza, E., Situmorang, J. A., Kusuma, D. D. A., Cahyadi, A. I., & Wahyunggoro, O. (2016). Passive balancing of battery lithium polymer using shunt resistor circuit method. *AIP Conference Proceedings*, *1755*. https://doi.org/10.1063/1.4958529

Nurdina, A. K., Sasmito, A. P., & Vendyansyah, N. (2022). Penerapan Internet of Things (IoT) Monitoring dan Controlling Perawatan Anakan Ikan Koi Berbasis Website. *JATI: Jurnal Mahasiswa*, *6*(2), 1115–1125. https://doi.org/10.36040/jati.v6i2.5349

Nursobah, Salmon, Lailiyah, S., & Sari, S. W. (2022). Prototype Sistem Telemetri Suhu dan pH Air Kolam Budidaya Ikan Air Tawar (Ikan Nila) Berbasis Internet of Things (IOT). *Sebatik*, *26*(2), 788–797. https://doi.org/10.46984/sebatik.v26i2.2053

Pal, P., Devabalaji, K. R., & Priyadarshini, S. (2020). Design of battery management system for residential applications. *International Journal of Engineering Trends and Technology*, *68*(3), 12–17. https://doi.org/10.14445/22315381/IJETT-V68I3P203S

Permatasari, Sopanah, & Hasan. (2018). Pengelolaan Alokasi Dana Desa dalam Meningkatkan Pembangunan dan Pemberdayaan Masyarakat Desa. *Conference on Innovation and Application of Science and Technology (CIASTECH)*, 186–194.

Ramdhani, Y., Hariyanti, I., Sandini, D., Susanti, S., & Najiyah, I. (2023). Perancangan Sistem IoT Smart Fisher untuk Kelompok Budidaya Ikan Kaliwungu Rahayu. *Jurnal Sosial Dan Abdimas*, *5*(1), 32–39. https://doi.org/10.51977/jsa.v5i1.1071

Rao, W., Yang, W., Wei, Y., & Li, D. (2017). Temporal and Spatial Variability of Water Dissolved Oxygen with Influence Factors in Aquaponics System. *Nongye Jixie Xuebao/Transactions of the Chinese Society for Agricultural Machinery*, *48*, 374–380. https://doi.org/10.6041/j.issn.1000-1298.2017.S0.057

Rosyidi, M. I., Saifuzzaman, F., Malik, F. A., Dila, J. S., Davidsyah, R., & Arifi, Y. (2021). Pengembangan Kreativitas Ekonomi Masyarakat Melalui Rintisan Wisata Edukasi Perikanan di Dusun Ngrajek 1 Kabupaten Magelang. *Community Empowerment*, *6*(3), 498–504. https://doi.org/10.31603/ce.4260

Sabiq, A., Fathurahman, M., & Wicaksono, H. (2022). Penerapan Pemantauan Kualitas Air Dan Keamanan Berbasis Internet of Things (IoT) Pada Budidaya Ikan Hias di Desa Ciseeng Kabupaten Bogor. *Dharma Jnana*, *2*(3), 175–184.

Sari, Y., Wijaya, E. S., Baskara, A. R., Fath, M. S. Al, & Firdaus, M. A. (2023). Internet of Things untuk Sistem Pemantauan Kualitas Air pada Kolam Ikan Lele pada Pembudidaya TDR Sultan Adam Banjarmasin. *Jurnal Pengabdian Ilung*, *3*(1), 203–213. https://doi.org/10.20527/ilung.v3i1.9772

Susmawati, E., Sugiono, & Subagyo. (2022). Creative Economic Development Strategies and Contributions to the Economic Development of Kediri City 2016-2019. *International Journal of Humanities Education and Social Sciences*, *2*(1), 113–119. https://doi.org/10.55227/ijhess.v2i1.216

Trevathan, J., & Schmidtke, S. (2022). Open-source Internet of Things remote aquatic environmental sensing. *HardwareX*, *12*. https://doi.org/10.1016/j.ohx.2022.e00336

Ujianti, R. M. D., Muflihati, I., & Nada, N. Q. (2022). Online Marketing Assistance With E-commerce At UKM Athaya Kitchen Semarang. *Community Empowerment*, *7*(9), 1538–1542. https://doi.org/10.31603/ce.7750

Wang, Y. W., Zhang, B., Feng, F., & Shuai, Z. (2014). Designing and realization of a water quality detecting instrument based on solar power. *Applied Mechanics and Materials*, *672–674*, 127–130. https://doi.org/10.4028/www.scientific.net/AMM.672-674.127

Xu, C., Luo, P., Wu, P., Song, C., & Chen, X. (2022). Detection of periodicity, aperiodicity, and corresponding driving factors of river dissolved oxygen based on high-frequency measurements. *Journal of Hydrology*, *609*. https://doi.org/10.1016/j.jhydrol.2022.127711

Xu, H., Liu, S., Xie, Q., Hong, B., Zhou, W., Zhang, Y., & Li, T. (2016). Seasonal variation of dissolved oxygen in Sanya Bay. *Aquatic Ecosystem Health and Management*, *19*(3), 276–285. https://doi.org/10.1080/14634988.2016.1215743

Yuliandani, T. (2017). *Integrasi Kepentingan Stakeholder Dalam Pembangunan Berkelanjutan di Kabupaten Bojonegoro*. Universitas Airlangga.