MAJALAH ILMIAH UPI YPTK
LPPM Universitas Putra Indonesia YPTK Padang
Lubuk Begalung Highway, Padang, Sumatera Barat, Indonesia, Pos Code: 25221
Volume: 33, Issue: 1, Page: 74 - 80, 30/06/2026, e-ISSN: 1412-5854

Application of IoT Technology for Real-Time Monitoring and Water Quality Stabilization in Catfish (Pangasius sp.) Aquaculture Ponds for the Karya Subur Fish Farming Group

Devi Wahyuni[1]✉, Finki Dona Marleny[2], Ayu Ahadi Ningrum[3], Windarsyah[4], Nahdi Saubari[5]
Department of Informatics, Universitas Muhammadiyah Banjarmasin, Indonesia
devi_wahyuni_2355201110011@umbjm.ac.id

Abstract

Fish farming communities in Kapuas Regency, Central Kalimantan face serious challenges due to unstable pond water quality, particularly fluctuations in pH levels and high ammonia concentrations, which have caused large-scale mortality of catfish (Pangasius sp.). This community service activity aims to implement IoT-based technology to assist the Karya Subur Fish Farming Group through the development of a device called "One Fish," which monitors water quality in real-time and automatically stabilizes pond conditions. The activity was carried out through three main stages: installation of a monitoring device using pH and MQ-137 ammonia sensors connected to an Arduino ATmega328 microcontroller, implementation of an automatic water stabilization system that sprays dolomite lime or Effective Microorganisms-4 (EM-4) solution when abnormal water conditions are detected, and training of group members with an operational manual. The results indicate that the system successfully monitored pond water conditions in real-time via a website interface and responded automatically to water instability, reducing fish mortality risk and improving production efficiency.

Keywords: community service; IoT; water quality monitoring; catfish farming; water stabilization.

1. Introduction

Catfish (Pangasius sp.) farming is one of the freshwater fishery sectors with high economic value and plays an important role in supporting community livelihoods, particularly in rural areas where aquaculture is a primary source of household income. Farming success in this sector is strongly influenced by pond water quality, particularly pH and ammonia concentration parameters, since unstable water quality can cause fish stress and mass mortality.

The Karya Subur Fish Farming Group is a community-based Pangasius (catfish) farming group located in Panamas Village, Selat District, Kapuas Regency, Central Kalimantan, consisting of 30 members who jointly manage approximately 30–60 fish ponds (1–2 ponds per member). Prior to this activity, the group relied on routine manual observation to assess pond water quality. This conventional approach was time-consuming, required the continuous physical presence of farmers at the ponds, and often resulted in delayed detection of changes in water quality, particularly fluctuations in pH and ammonia levels. As a result, the group has repeatedly experienced fish mortality and reduced production due to fluctuating pH and high ammonia concentrations that went undetected until fish stress or mortality had already occurred.

This situation reflects the Karya Subur Group's core challenge: the absence of a real-time water quality monitoring system. Because water quality management is still carried out manually and reactively, corrective action is often taken only after fish have already shown signs of stress, resulting in delayed handling of sub-optimal water conditions and recurring production losses.

As a solution to these problems, the service team developed and implemented an Internet of Things (IoT)-based technology in the form of a "One Fish" device that is capable of automatically monitoring and stabilizing pond water quality. Beyond the technical installation, this activity aims to strengthen the partner group's capacity to independently manage water quality using real-time data, thereby reducing the risk of losses due to fish mortality and supporting the long-term sustainability of the group's aquaculture practice.

Accepted: 28-03-2026 | Revision: 19-04-2026 | Publication: 30-06-2026 | doi: 10.35134

2. Implementation Methods

This community service activity was conducted at the catfish farming site of the Karya Subur Group, Panamas Village, RT.011, RW.003, Selat District, Kapuas Regency, Central Kalimantan, approximately 60 km from the Universitas Muhammadiyah Banjarmasin campus.

2.1 Preparation Stage

The preparation stage began with a site visit and direct discussion with the group leader and members to gather in-depth information about pond water quality problems. The discussion results were used as the basis for designing an appropriate technological solution.

Figure 1. Initial needs assessment and discussion with the Karya Subur Fish Farming Group prior to system implementation.

Component procurement, hardware and software system design, and fabrication of the "One Fish" prototype were subsequently carried out on campus before field deployment. The activity involved five Informatics students under the guidance of a supervising lecturer, together with one representative of the Karya Subur Fish Farming Group, namely the group leader, as an active participant. The implementation method consisted of three main stages.

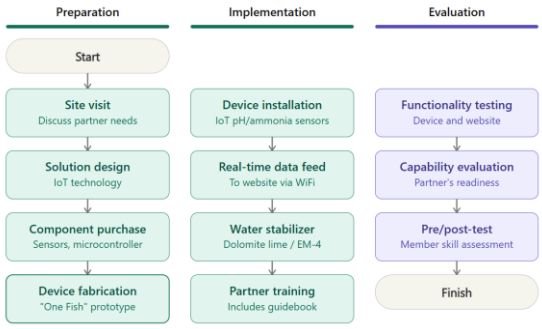


Figure 2. Flowchart of the "One Fish" System

Figure 2 illustrates the operational workflow of the proposed "One Fish" system. The process begins with real-time measurement of pond water quality using pH and MQ-137 ammonia sensors. The sensor readings are processed by the Arduino ATmega328 microcontroller and transmitted to the web server through a WiFi module, enabling real-time monitoring via a web-based dashboard. When abnormal pH or ammonia levels are detected, the system automatically activates the stabilization mechanism by controlling the pump, servo motor, and sprinklers to distribute dolomite lime or EM-4 solution into the pond.

The main components used include an Analog pH Sensor/Kit Meter V2, MQ-137 ammonia sensor, Arduino ATmega328 microcontroller, WiFi module, relay, servo motor, water pump, sprinklers, storage tank, and distribution pipes [5], [6], [7].

2.2 Implementation Stage

The implementation stage consisted of two main sub-activities. The first sub-activity was the installation of the IoT-based pond water monitoring and stabilization device. The "One Fish" device was installed at the edge of the catfish pond with pH and MQ-137 sensors placed inside the pond using a styrofoam board as a floating medium. Data from the sensors were transmitted to the Arduino microcontroller, which then forwarded the data to a web server via WiFi, enabling partners to monitor pond conditions in real-time anytime and from anywhere.

The second sub-activity was the implementation of an automatic water stabilization system. When a sensor detects that pH or ammonia levels exceed the preset normal threshold, the system automatically activates the pump to draw water from the pond and transfer it to the storage tank. Inside the tank, water is mixed with dolomite lime to stabilize pH or with Effective Microorganisms-4 (EM-4) solution to reduce ammonia levels [9]. The mixture is then sprayed back into the pond through two sprinklers installed at opposite corners to ensure uniform distribution of the solution across the entire pond area. In addition to automatic mode, the system also provides a manual mode through the website interface.

2.3. Evaluation Stage

The evaluation stage was conducted to assess the success of the community service program from two perspectives: the technical performance of the system and the improvement of the partner's operational capacity. Technical evaluation included functional testing of the device, covering the accuracy of the pH and MQ-137 sensors, the response time of the automatic stabilization system, and the uniformity of solution distribution by the sprinklers.

Partner evaluation was carried out through hands-on training, live demonstrations, and on-site mentoring involving the group leader as the representative of the Karya Subur Fish Farming Group, followed by periodic mentoring. The evaluation focused on the representative's ability to independently access the website dashboard, interpret pH and ammonia monitoring data, switch between automatic and manual operating modes, perform routine maintenance, and operate the monitoring system without assistance. Program success was determined based on the representative's ability to complete these operational tasks independently after the training session. To support long-term knowledge transfer and ensure program sustainability, an operational manual was distributed to all members of the partner group as a practical reference for operating and maintaining the "One Fish" system.

3. Results and Discussion

3.1 The "One Fish" Monitoring and Water Stabilization Device

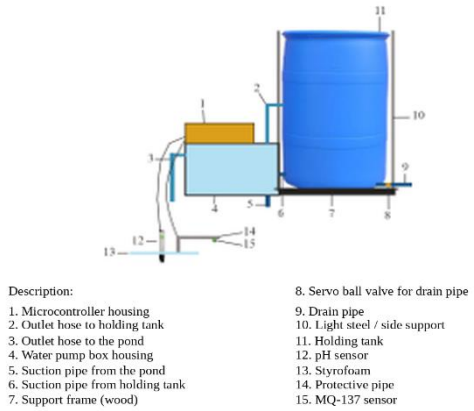
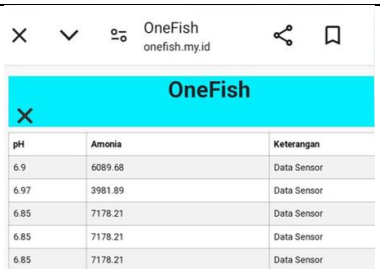


Figure 3. Prototype of the "One Fish" Device

The outcome of this service activity is the "One Fish" device, successfully designed, fabricated, and implemented in a partner pond. It comprises four integrated subsystems: a sensor unit (pH and MQ-137 sensors on a floating styrofoam board), a microcontroller unit (Arduino ATmega328, WiFi module, and relay in a weatherproof housing), a stabilization unit (storage tank with dolomite lime and EM-4 compartments and a servo-driven mixer), and a distribution unit (two opposite-corner sprinklers for even solution dispersion).

3.2 Real-Time Monitoring Website



pH	Amonia	Keterangan
6.9	6089.68	Data Sensor
6.97	3981.89	Data Sensor
6.85	7178.21	Data Sensor
6.85	7178.21	Data Sensor
6.85	7178.21	Data Sensor

Figure 4. Website Dashboard Display

The "One Fish" monitoring website (onefish.my.id) was successfully developed and is fully functional, displaying real-time pH and ammonia readings with status labels, automatic/manual mode controls, and lime/EM-4 fill-level indicators. A data page logs the history of measurements and system actions. This lets partners monitor pond conditions remotely, without needing to be physically present.

3.3 System Functionality Testing

Figure 5. Device Testing Process in the Pond

Functional testing in the field confirmed that the pH sensor read water acidity accurately and responsively, and the MQ-137 sensor detected ammonia fluctuations within its operational range [10]. When readings exceeded the preset threshold, the system triggered stabilization automatically, without manual intervention; the two opposite-corner sprinklers distributed the solution evenly across the 9x10 meter pond.

3.4 Partner Training and Response

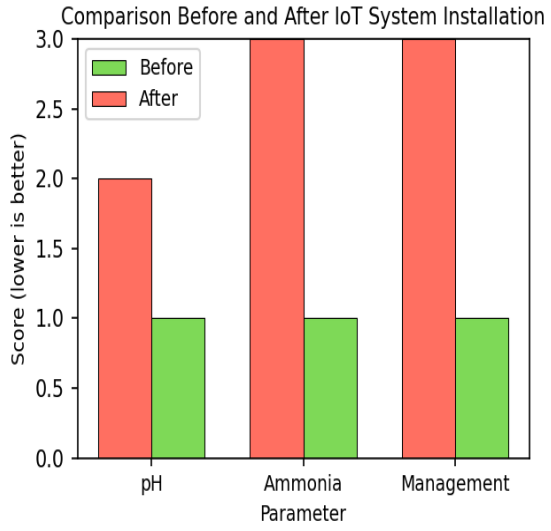
Figure 6. Explanation of "One Fish" device operation to Karya Subur Group members

After the device installation was completed, the implementation team provided direct, hands-on training to the group leader, who represented the Karya Subur Group, on how to operate the "One Fish" system in both

automatic and manual modes through the website. An easy-to-understand user guide was also handed over to the whole partner group as a long-term operational reference, extending this knowledge beyond the directly trained representative. The partner group responded positively to the technology, and the trained representative was able to operate the system independently after completing the training. Information about this program was also disseminated through the Instagram social media account @onefish.umbjm to reach a wider audience.

To observe the impact of the "One Fish" device on pond water quality, a comparison of conditions before and after device installation was conducted qualitatively, based on field observations and interviews with the partners, as presented in Table 1.

Table 1. Comparison of Water Quality Conditions Before and After System Implementation



Based on Table 1, it is evident that the implementation of the "One Fish" IoT technology improved pond water quality stability. The previously unstable pH values became more consistent within the optimal range, while ammonia levels decreased and were better controlled. In addition, the previously manual management system transitioned to an automatic and responsive system, making it easier for partners to maintain pond water quality.

This demonstrates that the implemented system is effective in improving pond water management quality and supports the sustainability of catfish farming more optimally.

Beyond the qualitative comparison in Table 1, the service team also tracked measurable indicators of pond condition and fish survival throughout the implementation period, obtained through structured interviews with the partner and review of pond records. Table 2 summarizes these indicators.

Table 2. Observed Operational Indicators Before and After "One Fish" Implementation (May–July 2024)

Indicator	Before	After
Pond water pH	Fluctuating, especially during the rainy season and periods of soil acidity	Maintained consistently within the optimal range (6–7)
Ammonia level	Elevated due to accumulated feed residue; frequently undetected until fish were stressed	Reduced and kept within safe limits through automatic dolomite/EM-4 dosing
Visible fish stress symptoms	Frequent (slow swimming, reduced appetite, surfacing behavior)	Markedly reduced, based on partner observation
Mortality, fish ≥ 5 months old	≈ 5 individuals/week	No weekly mortality recorded after implementation
Mortality, fish < 3 months old	≈ 30 individuals/week	Substantially reduced, though not fully eliminated

The most notable outcome is the elimination of weekly mortality among fish aged five months and older, and a substantial, though not complete, reduction in mortality among younger fish. These figures were gathered through partner interviews and field records rather than a formal, instrument-based pre-/post-test; establishing a structured evaluation instrument (e.g., a standardized survey of partner competency and satisfaction) is noted as a direction for the next phase of the program.

3.5 Improvement in Partner Capacity

Beyond the technical performance of the device, this community service activity also strengthened the

partner group's capacity to independently manage pond water quality. Hands-on training was provided to the group leader, who served as the representative of the 30-member Karya Subur Fish Farming Group. The training included live demonstrations, guided practice, and on-site mentoring covering the operation of the "One Fish" system in both automatic and manual modes.

During the training, the representative successfully operated the monitoring system by accessing the website dashboard, interpreting pH and ammonia data, switching between automatic and manual modes, and performing routine maintenance under the guidance of the service team. To facilitate knowledge transfer to the remaining group members, an illustrated operational manual was distributed as a long-term reference for system operation and maintenance. The service team also coordinated with the Kapuas Regency Fisheries Office to ensure continued access to technical guidance and recommendations regarding dolomite lime and EM-4 application after the completion of the program.

The improvement in partner capacity was evaluated through direct observation during practical training and follow-up discussions with the partner representative. Although no standardized pre-test or post-test instrument was employed, the representative was able to independently perform the main operational procedures by the end of the training. These findings indicate that the community service activity not only introduced an IoT-based monitoring technology but also enhanced the partner group's practical capacity to operate and maintain the system independently.

3.6 Program Sustainability

Figure 7. Operational Manual Provided to Partners

To ensure the sustainability of the program after the community service activity was completed, several follow-up measures were prepared. Members of the partner group received training and were provided with an operational manual, enabling them to independently operate and maintain the device. The implementation team also plans to establish cooperation with the Kapuas Regency Agriculture and Fisheries Office to provide continuous technical support for the partner group. The operational manual serves as a long-term reference to assist partners in using, maintaining, and troubleshooting the "One Fish" system, ensuring that the technology can continue to be utilized effectively and sustainably. Routine device maintenance, including regular sensor cleaning, inspection of the pumping and sprinkler system, and periodic refilling of the dolomite and EM-4 solution reservoirs, will be carried out independently by the partner group, while the service team plans to conduct periodic monitoring visits and technical consultation during the initial operational period to ensure the group's readiness to operate the system without external assistance.

3.7 Comparison with Related Community Service Programs

The approach taken in this activity is consistent with, and extends, findings from other recent IoT-based aquaculture community service programs. Similar to the water-quality-focused empowerment program for the Mina Ngremboko fish farming group in Yogyakarta, which implemented IoT-based control of pH, dissolved oxygen, and temperature to support member welfare [12], the "One Fish" program links real-time monitoring directly to farmer decision-making. It also parallels community programs that combine IoT monitoring with structured pre-test/post-test evaluation of farmer competence, such as the "Cara Budidaya Ikan yang Baik" program that measured knowledge gains before and after training [13]. Compared with these programs, the "One Fish" device contributes an additional feature that is less commonly reported in the community-service literature: automatic water stabilization through dolomite lime and EM-4 dosing, rather than monitoring alone. This distinguishes the present activity by directly closing the loop between detection and corrective action, reducing farmers' dependence on manual intervention once abnormal conditions are detected [14], [15].

4. Conclusion

This community service activity successfully implemented the "One Fish" IoT device to help the Karya Subur Fish Farming Group monitor and stabilize pond water quality in real time. The main achievements were twofold: technically, the device reliably detected pH and ammonia fluctuations and automatically triggered dolomite lime or EM-4 dosing to correct unstable conditions; and socially, partner group members improved their ability to manage pond water quality through hands-on training, demonstrations, and

operational guidance, enabling them to operate the system independently. These outcomes reduced the risk of fish mortality, shortened the response time to unstable water conditions, and improved the efficiency of pond management for the partner group. Building on this program, further development is recommended to extend the "One Fish" system to other catfish farming groups in Central Kalimantan and to integrate additional water quality parameters relevant to local farming conditions.

Acknowledgment

The authors would like to express their gratitude to the Directorate of Learning and Student Affairs (BELMAWA), Ministry of Education, Culture, Research, and Technology, through the Student Creativity Program (PKM) under the Applied Science and Technology scheme (PKM-PI) in 2024 for the support provided. The authors also extend their appreciation to the "Karya Subur" fish farming group in Panamas Village, Kapuas Regency, for serving as partners in this activity. The authors declare no conflict of interest in this research.

Funding Information

This activity was funded by the Directorate of Learning and Student Affairs (BELMAWA), Ministry of Education, Culture, Research, and Technology through the Student Creativity Program (PKM) under the Applied Science and Technology scheme (PKM-PI) in 2024.

Conflict of Interest Statement

The authors declare that there is no financial or personal conflict of interest that could have influenced the work reported in this article.

Data Availability

The data supporting the findings of this activity are available from the corresponding author (D.W.) upon reasonable request.

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Biography of Authors

Devi Wahyuni

is an undergraduate student in the Informatics Study Program at Universitas Muhammadiyah Banjarmasin, Indonesia. Her research interests include the Internet of Things (IoT), embedded systems, and smart environmental monitoring, particularly for aquaculture applications. She actively participates in community service and technology-based innovation projects.Email: devi_wahyuni_2355201110011@umbjm.ac.id

Finki Dona Marleny

is a lecturer in the Informatics Study Program at Universitas Muhammadiyah Banjarmasin, Indonesia. Her research interests include information systems, software engineering, and the application of digital technologies to education and community development. She has been involved in various research and community service activities related to information technology.

Email: finkidona@umbjm.ac.id

Ayu Ahadi Ningrum

is a lecturer in the Informatics Study Program at Universitas Muhammadiyah Banjarmasin, Indonesia. Her research interests include software engineering, information systems, and digital technology implementation. She actively contributes to research and community service projects focusing on information technology applications.

Email: ayuahadi@umbjm.ac.id

Windarsyah

is a lecturer in the Informatics Study Program at Universitas Muhammadiyah Banjarmasin, Indonesia. His research interests include the Internet of Things (IoT), embedded systems, automation, and smart monitoring technologies. He has participated in various research and community service projects involving IoT-based solutions for environmental and industrial applications.

Email: windarsyah@umbjm.ac.id

Nahdi Saubari

is a lecturer in the Informatics Study Program at Universitas Muhammadiyah Banjarmasin, Indonesia. His research interests include microcontroller programming, automation systems, embedded systems, and IoT-based monitoring technologies. He is actively involved in research and community service activities focusing on the application of digital technologies to solve practical problems.

Email: nahdi@umbjm.ac.id