IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

"Development of Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics"

Rafael B. Berte

Capiz State University-Main Campus, College of Education, Roxas City, Capiz, Philippines

Abstract: Modern agriculture, such as aquaponics, has become a well-known solution nowadays for farming, especially in Asia countries. However, it requires manpower and time to control, maintain, and monitor the system. This is why innovative farming methods are introduced to farmers to help them slowly adapt and mitigate these problems. Thus, the development and innovation of the smart fish feeder and monitoring system device for hybrid aquaponics was developed. This research used a smart automation aquaponic monitoring system that helps the users feed, maintain and monitor the system through manual operations and smartphone application. The device uses DFRobot dissolved oxygen sensor to record oxygen level, PH-4502c for pH, DS18B20 to record temperature, DFRobot analog turbidity sensor to record total dissolved solids and HC-SR04 for water level. The sensors are connected to Arduino Mega and ESP32-CAM microcontrollers for data processing. The collected data is shown in real time on both the liquid crystal display and mobile application of the device, enabling users to manipulate the parameters involved. The application facilitates the monitoring of various parameters in the fish tank, including ammonia levels, dissolved oxygen levels, pH levels, temperature, total dissolved solids, and water level. Additionally, it allows for the control of the actuator responsible for feeding the fish. The recently developed smart fish feeder and monitoring system device for hybrid aquaponics was thoroughly examined and evaluated by twenty-five (25) technical experts specialized in Electrical, Electronics, and related fields. They unanimously rated the design as "Excellent." The construction of the device was "Excellent". In addition, the device's operating performance was rated as "Very Good." In terms of safety, the device obtained an "Excellent" rating. Ten technical experts in the field of information communication technology and Agri-fisheries evaluated the developed application for the monitoring system of the device as “Excellent” in terms of functional suitability, reliability and performance efficiency. The portability, usability and security of the application was evaluated as “Very Good”.

Keywords: Agriculture, Aquaponics, Smart, Monitoring System.

I. INTRODUCTION

Aquaponics has emerged as a prominent farming solution in recent times, offering an alternate method to meet food requirements while ensuring environmental sustainability. The primary issue with aquaponics is the need for pH stabilization within the optimal range of 6.5 to 9. This is crucial because when ammonia breaks down, it forms NH4+ ions, which pose a significant threat to aquatic species. The resolution of this issue relies on various factors, including the composition of the water, the kind of fish, the growing method, and the ambient temperature. By implementing appropriate treatment and building an efficient buffer system, this problem can be effectively addressed [1]. The increasing levels of acidity and alkalinity can be mitigated using the appropriate chemicals. The water temperature for fish should be between the optimal range of 18 to 30 degrees Celsius. Ensuring temperature stability is crucial since it directly impacts both oxygen levels and ionization levels [2].

The time consumed in monitoring and resetting parameters to prerequisite levels is a major shortcoming in aquaponics systems [3]. Fish conserve flings, and it is tedious to replenish oxygen, maintain pH, temperature, and water levels or fertilize plants frequently and these metrics need to be frequently monitored to ensure fish and plant health or growth [4]. Therefore, it is necessary to build a system that incorporates appropriate solar exposure and sanitation measures, ensures pH stabilization, precisely monitors the temperature of the water tank, and measures the oxygen content in the water. This is because the current system does not integrate all of these specific requirements into a single system [5], [6]. To overcome this complex and time-consuming process of manually feeding and monitoring of plants health in an aquaponic system, a smart fish feeder and monitoring system device for hybrid aquaponics was made.

Thus, this study intends to develop an automated and Internet of Things (IoT) smart fish feeder and monitoring system which makes it easy for deployed sensors to accurately measure and transmit data on a variety of metrics such as ammonia, dissolved oxygen, pH, temperature, turbidity, water level, feeds and power consumption of the device for real-time monitoring, control, and management in aquaponics.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

Data from these sensors are transmitted from cloud services to a mobile application over Wi-Fi. With the application of Internet of Things in aquaponics system, remarkable changes can be brought in the field of agriculture by simply monitoring and maintaining the system parameters for effective growth of the fish and plants.

Moreover, numerous studies regarding aquaponics have been conducted to enhance the quality of food production, but only some of them use renewable energy as source of electricity. Thus, the device is equipped with solar energy source which automatically track the sunlight to lower the operating expenses. Additionally, the device has a backup alternating current (AC) source that can operate automatically if the solar energy is unreliable to use. The smart fish feeder and monitoring system device in hybrid aquaponics not only enhances the efficiency of resource utilization but also contributes significantly to the Sustainable Development Goal of zero hunger. By ensuring precise feeding and monitoring of fish in aquaponic systems, this innovative technology promotes optimal growth, minimizes waste, and ultimately strengthens the overall food production chain, aligning seamlessly with the global commitment to eradicate hunger and achieve a sustainable and resilient future. This present innovative research on monitoring system in aquaponics farming can help farmers to adapt new agricultural techniques that can lead to new dimensions of food production.

II. METHODOLOGY

This study employed a developmental method of research. Developmental research according to [7] aims to established an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern development. The present study explored on the possibility of integrating microprocessors, sensors and information technology to enhanced monitoring and error-correcting within the aquaponics system to produce a smart fish feeder and monitoring system device for hybrid aquaponics.

The developmental method of research is particularly well-suited for the design and implementation of a monitoring system device in aquaponics it provides a strategic framework for creating an aquaponics monitoring system that is not only technologically advanced but also adaptable, user-friendly, and aligned with the evolving needs of the aquaponics community. Moreover, this research offers a strategic and adaptive framework for creating a monitoring system device that is responsive to the dynamic nature of aquaponics. This approach ensures that the monitoring system remains at the forefront of innovation and contributes to the sustainable development of aquaponic practices.

The device evaluation was conducted based on its design, construction, operational performance, and safety utilizing an evaluation sheet. The device application underwent evaluation based on the ISO 25010 standard.

III. RESULTS AND DISCUSSION

Design of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

Table 1 shows an evaluation of the design aspect of the smart fish feeder and monitoring system for hybrid aquaponics. The highest mean score of 4.68 was observed in statement 5, where the device features are carefully planned, emphasizing thoughtful and deliberate craftmanship and evaluated as "Excellent". The lowest mean score of 4.12 was observed in statements 7 and 9, which pertain to the device is highly portable, offering convenient mobility and ease of use in various settings and boasts ease of maintenance, simplifying its upkeep for users. These statements were rated as being of "Very Good" quality.

The findings indicate that statements 1, 2, 8, and 10, which pertain to the device is original and stands out with distinct features, setting it apart from others with a similar purpose or function. Moreover, device is economically designed, consuming minimal energy during operation device is economically designed, consuming minimal energy during operation. Additionally, device features a properly laid-out parts with accurately fastened parts and components, ensuring reliable functionality, and incorporates safe-oriented features, prioritizing the well-being of the user are aforementioned statements that were considered "Excellent" by the evaluators.

This suggests that the design of the smart fish feeder and monitoring system device for hybrid aquaponics was rated as "Excellent" based on the average grand mean of 4.36 from the ten statements. This indicates that the evaluators deemed the device to be of high quality.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

This conforms to the study conducted by [8], that good design precisely describe customer-relevant functionality, while bad design primarily arise from rashly executed processes. The design is commonly used to describe the functional and non-functional characteristics of a system. In software product line engineering, design often become the prime entities of software reuse and are used to distinguish the individual products of a product line. Properly decomposing a product line into design, and correctly using design in all engineering phases, is core to the immediate and long- term success of such a system. On the other hand, ambiguous design not meeting this criterion are considered as bad features. Design have also been rated as good if they are perceived as well implemented and error-free. A good design fulfills the requirements, but does not introduce any bugs on the way or impact existing construction of the product line. It has to follow the architecture rules and the coding style. Design are also considered as good if they are well modularized, not cross-cutting multiple components.

Moreover, the use of design is motivated by the fact that customers and engineers often speak of product characteristics in terms of design a product has or delivers. A design is usually defined as “a logical unit of behavior specified by a set of functional and non-functional requirements” or “a distinguishable characteristic of a concept (system, component, etc.) that is relevant to some stakeholder of the concept”. Good design precisely describes customer-relevant functionality, while bad features primarily arise from rashly executed processes. Outlier features, serving unusual purposes, are necessary, but do not require the full engineering process of typical design. Without effective design, we would struggle with even the basic steps of working a device. Better design can increase user experiences, feedback, and market potential [8].

Table I Design of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The device is original and stands out with distinct features, setting it apart from others with a similar purpose or function.	4.48	Excellent
2. The device is economically designed, consuming minimal energy during operation.	4.44	Excellent
3. The device is easy to use and built to withstand damage, ensuring durability and longevity.	4.20	Very Good
4. The device is designed for seamless usability in local situations.	4.16	Very Good
5. The device features are carefully planned, emphasizing thoughtful and deliberate craftmanship.	4.68	Excellent
6. The device priorities ergonomics, ensuring a comfortable, efficient, and safe user experience.	4.20	Very Good
7. The device is highly portable, offering convenient mobility and ease of use in various settings.	4.12	Very Good
8. The device features a properly laid-out parts with accurately fastened parts and components, ensuring reliable functionality.	4.52	Excellent
9. The device boasts ease of maintenance, simplifying its upkeep for users.	4.12	Very Good
10. The device incorporates safe-oriented features, prioritizing the well-being of the user.	4.64	Excellent
Grand Mean	**4.36**	Excellent

Construction of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

The evaluation of the construction of the smart fish feeder and monitoring system for hybrid aquaponics is presented in Table 2. Statement 9, which pertains to the device that is technically built based on a well-executed plan and design, ensuring precision and performance, had the highest mean score of 4.80, indicating a high level of satisfaction among respondents. The lowest mean of 4.16 was observed in statement 2, which it utilizes locally available materials, showcasing a decisive approach to resource efficiency. This statement was categorized as "Very Good". The results indicate that the device's construction aligns with its intended function, allowing for customization and careful

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

craftsmanship. The device is compact yet rigid, ensuring the safety of its mechanical and electrical components. Furthermore, it adheres precisely to the building technique. The aforementioned assertions were considered to be "Excellent" by the experts. The results indicate that the construction of the smart fish feeder and monitoring system for hybrid aquaponics was rated as "Excellent" by the evaluators. This rating was derived from the average of the 10 statement grand means, which was 4.47.

This agrees in the study of [9], that in constructing or purchasing the infrastructure for an aquaponic system can be expensive. Costs may include fish tanks, grow beds, plumbing, lighting, and temperature control. The size and complexity of the system will affect the initial investment. Acquiring the necessary equipment for monitoring and maintaining water quality, such as pH meters, ammonia/nitrate test kits, and thermometers, adds to the initial setup costs. Many materials can be used to construct aquaponic systems. Budget limitations often lead to the selection of inexpensive materials. Fiberglass is the best construction material for rearing tanks, sumps and filter tanks. Fiberglass tanks are sturdy, durable, non-toxic, movable and easy to plumb. Polyethylene tanks are also very popular for fish rearing and gravel hydroponics because of their low cost. NFT troughs made from extruded polyethylene are specifically designed to prevent the puddling and water stagnation that lead to root death and are preferable to makeshift structures such as PVC pipes. Plastic troughs are commercially available for floating hydroponic subsystems, but they are expensive. A good alternative is the 20-mil polyethylene liners that are placed inside concrete block or poured-concrete side walls. They are easy to install, relatively inexpensive and durable, with an expected life of 12 to 15 years. A soil floor covered with fine sand will prevent sharp objects from puncturing the liners. Lined hydroponic tanks can be constructed to very large sizes hundreds of feet long and up to 30 feet wide. Plasticizers used in vinyl manufacture but are toxic to fish, so these liners must be washed thoroughly or aged with water for several weeks before fish can be added safely to a tank of clean water.

Table II Construction of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The device is appropriately designed for its intended purpose, ensuring optimal functionality and performance.	4.76	Excellent
2. The device utilizes locally available materials, showcasing a decisive approach to resource efficiency.	4.16	Very Good
3. The device is durable, making it likely to withstand prolonged use with resilience and reliability.	4.20	Very Good
4. The device is configured for customized design, allowing users to tailor it to their specific preferences and needs.	4.32	Excellent
5. The device is skillfully crafted, showcasing meticulous attention to detail in its design and construction.	4.72	Excellent
6. The device is compact and rigid, offering a sturdy and space-efficient solution for various applications.	4.52	Excellent
7. The device is secured with robust mechanical and electrical components, ensuring reliability and safety in its operation.	4.40	Excellent
8. The device is cost-effective, providing efficient functionality without compromising on affordability.	4.20	Very Good
9. The device is technically built based on a well-executed plan and design, ensuring precision and performance.	4.80	Excellent
10. The device is built accurately, following a meticulous construction procedure to ensure precision and quality,	4.60	Excellent
Grand Mean	**4.47**	**Excellent**

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

Operating Performance of the Developed Smart Fish Feeder and Monitoring System for Hybrid Aquaponics

Table 3 presents an evaluation of the operational performance of the smart fish feeder and monitoring system developed for hybrid aquaponics. The highest mean value of 4.24 was observed in statements 2, 3, and 6. These statements indicate that the device ensures accurate reading of water parameters, staying within a tolerance value of ±5%. Additionally, the device provides reliable readings of water level inside the water tank, ensuring accuracy and dependability and performed effectively, meeting its designed specifications and functionality. These findings suggest that the device's performance can be interpreted as being " Excellent". The lowest mean of 4.12 was seen in statement 8, where the device is easily maintained to prevent danger, ensuring the safety of its components and parts, ensuring the safety of its components and parts was regarded as being "Very Good".

The findings indicate that statement 9 which the device is versatile and maintains a good working condition, adapting to various needs with reliability also deemed to be “Excellent” to the experts, surpassing the established standards. This suggests that the development of a smart fish feeder and monitoring system device for hybrid aquaponics demonstrated superior operating performance. The average of the 10 statement grand means, which was 4.20, indicated that the evaluators assessed the equipment as surpassing the expected standards. Similarly, the findings suggest that the system is capable of maintaining continuous operation of the water quality sensors, actuators, and motors for 40 minutes, while also exhibiting a surplus of power following the operation.

This result affirms to the study [10], the operational performance of the device in aquaponics stands as a critical determinant of system efficiency and ecological balance. By seamlessly integrating advanced monitoring and control functionalities, the device optimizes key parameters such as water quality, nutrient levels, and environmental conditions. This not only ensures the well-being of both aquatic life and plants but also empowers aquaponic practitioners with real-time insights for informed decision-making. The device's reliability, precision, and adaptability contribute to the overall success of aquaponic systems, fostering sustainable and high-yield agricultural practices.

Table III Operating Performance of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The device is capable of performing its function effectively, meeting the required specifications and expectations.	4.20	Very Good
2. The device ensures accurate reading of water parameters, staying within a tolerance value of ±5%.	4.24	Excellent
3. The device provides reliable readings of water level inside the water tank, ensuring accuracy and dependability.	4.24	Excellent
4. The device is capable of automatically feeding fish according to a set schedule, dispensing the required amount of feed with ease.	4.20	Very Good
5. The device is capable of monitoring both feed and energy consumption, providing valuable insights into operational efficiency.	4.20	Very Good
6. The device performed effectively, meeting its designed specifications and functionality.	4.24	Excellent
7. The device excels in performing repetitive operations with consistency and efficiency.	4.16	Very Good
8. The device is easily maintained to prevent danger, ensuring the safety of its components and parts.	4.12	Very Good
9. The device is versatile and maintains a good working condition, adapting to various needs with reliability.	4.20	Very Good
10. The device excels in performance, delivering excellent results with efficiency.	4.16	Very Good
Grand Mean	**4.20**	**Very Good**

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

Safety of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

The safety evaluation of the smart fish feeder and monitoring system for hybrid aquaponics is presented in Table 4. Statement 7, which pertains to the provision of the device which is equipped with an emergency switch for immediate shutdown during operation, enhancing safety protocols, garnered the highest mean rating of 4.60 and was evaluated as being "Excellent". The statement indicates that the lowest mean of 4.12 was observed in statement 4, where the device maintains tolerable and acceptable noise levels, enhancing user comfort during operation was evaluated as being "Very Good".

The findings indicate that the aforementioned statement, encompassing factors such as safety features, prioritizing user well-being and security, includes the presence of safety features, has secured enclosure for its parts and components, ensuring protection for the operator, comes with an operating manual, providing clear guidelines for users to ensure optimal usage, secured electrical wire connections for various electronic components, ensuring safety and reliability, equipped with an emergency switch for immediate shutdown during operation, enhancing safety protocols, equipped with an emergency switch for immediate shutdown during operation, enhancing safety protocols and provided with safety signs to enhance awareness and promote safe usage. The aforementioned claims were deemed to be "Excellent" by the evaluators.

This suggests that the development of a smart fish feeder and monitoring system device for hybrid aquaponics demonstrated a high level of operating performance in terms of safety. The average grand mean of 4.38, derived from the evaluation of ten statements, indicated that the evaluators perceived the device as being "Excellent".

In the study of [11], electrical safety awareness for the electrical becomes necessary that people start learning to use electrical safety. Most of the accident that occurs is due either to carelessness or lack of awareness of some basic rules that should be observed when using electricity. The use of electricity is something taken for granted, but using it safely is very important. By understanding how electricity work and where it is found can prevent electrical danger wherever a person may be.

Table IV Safety of the Developed Smart Fish Feeder and Monitoring System for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The device is user-friendly, offering a straightforward and intuitive experience for users.	4.20	Very Good
2. The device is provided with safety features, prioritizing user well-being and security.	4.48	Excellent
3. The device features a secured enclosure for its parts and components, ensuring protection for the operator.	4.56	Excellent
4. The device maintains tolerable and acceptable noise levels, enhancing user comfort during operation.	4.12	Very Good
5. The device comes with an operating manual, providing clear guidelines for users to ensure optimal usage.	4.52	Excellent
6. The device incorporates secured electrical wire connections for various electronic components, ensuring safety and reliability.	4.24	Excellent
7. The device is equipped with an emergency switch for immediate shutdown during operation, enhancing safety protocols.	4.60	Excellent
8. The device is designed to be free from electrical leakages, ensuring safe and reliable operation.	4.56	Excellent
9. The device is equipped with precautionary measures to ensure the safety of its parts during operation.	4.16	Very Good
10. The device is provided with safety signs to enhance awareness and promote safe usage.	4.36	Excellent
Grand Mean	**4.38**	**Excellent**

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

Functional Suitability of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

The criteria provided in ISO 25010 were used to evaluate of the application, as shown in Table 5. The system obtained a score of "Excellent" in terms of functional suitability with a grand mean of 4.47, which shows that it can adapt to many kinds of hardware, software, and other operational or usage contexts effectively and efficiently.

This conforms in the study of [12], the functional suitability of the application for aquaponics is a testament to its adept design and meticulous development, aligning seamlessly with the diverse and dynamic requirements of aquaponic systems. Through a comprehensive set of features, the application demonstrates unparalleled adaptability to various scales and configurations of aquaponics setups. Its intuitive interface empowers users with real-time insights into crucial parameters, promoting efficient management of water quality, nutrient cycles, and environmental conditions.

By prioritizing precision, reliability, and user-friendly functionality, our application not only meets but exceeds the functional needs of aquaponics practitioners, contributing to the overall success and sustainability of modern aquaponic practices.

Table V Functional Suitability of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The set of functions in the application covers all specified tasks and user objectives, ensuring comprehensive usability.	4.50	Excellent
2. The function of the application provides correct results with the required degree of precision, ensuring accurate outcomes.	4.40	Excellent
3. The function of the application facilitates the accomplishment of specified tasks and objectives with efficiency and effectiveness.	4.50	Excellent
Grand Mean	**4.47**	**Excellent**

Reliability of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

Table 6 presents the evaluation of the application's reliability. The reliability of the system was evaluated and found to be "Excellent" with a grand mean score of 4.28. This result suggests that the application consistently enables the completion of designated tasks and objectives across all water quality sensors, motors and actuators. Within the category of reliability, the sub-statements pertaining to operational functionality and accessibility when needed received the highest cumulative score.

This results agrees in the study of [13], that reliability of application for aquaponics is paramount in ensuring the consistent and uninterrupted operation of aquaponic systems. Built on a foundation of robust engineering and rigorous testing, the application demonstrates unwavering dependability in monitoring and controlling critical parameters essential for the well-being of fish and plants. Its resilience in handling diverse environmental conditions, coupled with proactive alert mechanisms, safeguards against potential disruptions.

Table VI Reliability of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The system meets the needs for reliability under normal operation, ensuring consistent performance of the application.	4.20	Very Good
2. The system is operational and accessible when required for use, ensuring timely availability of the application.	4.50	Excellent
3. The system operates as intended despite the presence of hardware or software faults in the application, demonstrating resilient performance.	4.30	Excellent
4. In the event of an interruption or failure, the system can recover the data directly affected and re-establish the desired state of the application.	4.10	Very Good
Grand Mean	**4.28**	**Excellent**

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

Portability of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

The evaluation of the application's portability is presented in Table 7 The application scored an overall rating of "Very Good" in terms of portability, with a grand mean of 4.20. The statement pertaining to the efficiency and productivity resulting from the reduction of time and costs associated with giving instructions received the greatest overall score under the portability category. This indicates that the program has the potential to adjust and function effectively across various hardware, software, and operational standards.

This result conforms in the study of [14], the portability of the application for aquaponics stands as a hallmark of its design, facilitating accessibility and convenience for users across diverse settings. The user-friendly interface and mobile compatibility, it empowers aquaponics enthusiasts to manage their systems effortlessly, whether at home or on the go, enhancing the accessibility and convenience of sustainable farming practices.

Whether managing a small-scale home aquaponics system or overseeing a large commercial operation, the application's inherent portability ensures seamless integration into various environments. With compatibility across multiple devices and platforms, aquaponics practitioners can effortlessly monitor and control their systems on-the-go, enhancing flexibility in system management. This portability empowers users to stay connected and responsive, promoting efficient decision-making and fostering a new level of accessibility in the realm of aquaponics technology. With intuitive features and mobile accessibility, it ensures flexible management for sustainable and efficient cultivation allowing users to efficiently manage.

Table VII Portability of the Developed Smart Fish Feeder and Monitoring System for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The system can effectively and efficiently be adapted for different or evolving hardware, software, or other operational environments in the application.	4.20	Very Good
2. The system can withstand technology evolution and changes without costly redesign, reconfiguration, or reprogramming of the application.	4.10	Very Good
3. The system can be successfully installed and/or uninstalled in a specified environment of the application, ensuring seamless deployment and removal.	4.20	Very Good
4. The system can replace another specified software product for the same purpose in the environment of the application, providing versatility and interoperability.	4.20	Very Good
5. The system enhances efficiency and productivity by minimizing the time and costs associated with delivering instructions in the application.	4.30	Excellent
Grand Mean	**4.20**	**Very Good**

Usability of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

Table 8 shows the evaluation of the application, which was conducted in accordance with the ISO 25010 standards. The application earned a rating of "Very Good" in terms of usability, with a grand mean of 4.13. The system facilitates user learning and proficiency in emergency situations. Its attributes prioritize ease of operation and control and are classified as the most important factors within the Usability category.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

This is due to the application's provision of extensive features and capabilities that empower users to exert greater control and accomplish specific objectives within a defined context of use.

This is particularly relevant given that the majority of users possess prior knowledge and have access to the most recent advancements in technology such as mobile devices and social media, which have been seamlessly incorporated into the system.

This affirms to the study of [15], usability the application for aquaponics takes center stage, characterized by an intuitive design and user-centric features that empower practitioners of all skill levels. With a user-friendly interface and streamlined functionalities, the application provides a seamless and enjoyable experience for aquaponics enthusiasts.

From straightforward navigation to easily accessible controls, the design prioritizes clarity and simplicity, ensuring efficient operation without the need for extensive training.

The application's usability not only enhances user satisfaction but also promotes widespread adoption, democratizing the benefits of advanced aquaponics management for both novices and experienced practitioners alike.

Table VIII Usability of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The system enables users to learn how to use it effectively and efficiently, especially in emergency situations in the application.	4.40	Excellent
2. The system has attributes that make it easy to operate and control in the application, ensuring user-friendly interaction.	4.40	Excellent
3. The system protects users against making errors in the application, enhancing overall user experience and reliability.	4.00	Very Good
4. The system's user interface enables pleasing and satisfying interactions for the user in the application, promoting a positive user experience.	3.40	Good
5. The system can enhance efficiency and productivity by minimizing the time and costs associated with delivering instructions in the application.	4.30	Excellent
6. The system can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use in the application, promoting inclusivity and accessibility.	4.30	Excellent
Grand Mean	**4.13**	**Very Good**

Performance Efficiency of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

The application was evaluated using the ISO 25010 criteria, as depicted in Table 9 The application achieved a performance efficiency rating of "Very Good" with a grand mean score of 4.20. During the application testing process, the users were granted access to a consistent and reliable bandwidth, ensuring a minimum Internet connectivity speed of 5 to 10Mbps. Increased bandwidth will result in improved reaction time, processing capabilities, and overall throughput for the application during its operations. Moreover, the performance efficiency of the application is contingent upon the specific resources employed for accessing said application.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

The result of this study agrees in the study of [14], the performance efficiency of the application for aquaponics sets a high standard, leveraging cutting-edge technology to optimize the functionality and responsiveness of aquaponic systems. Through meticulous engineering and innovative design, the application delivers swift data processing, real-time monitoring, and prompt execution of control commands.

This efficiency not only enhances the overall productivity of aquaponics operations but also contributes to resource conservation and system resilience. By prioritizing speed, accuracy, and resource utilization, our application elevates the performance efficiency of aquaponics, marking a significant stride toward sustainable and high-yield agricultural practices.

With real-time monitoring, automated controls, and data-driven insights, it enhances overall system productivity. Users benefit from streamlined operations, resource optimization, and the ability to make informed decisions, contributing to the success and sustainability of their aquaponics ventures.

Table IX Performance Efficiency of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The system's response and processing times, along with its throughput rates when performing functions, meet the requirements of the application, ensuring efficient performance.	4.30	Excellent
2. The system's amounts and types of resources used when performing its functions meet the requirements of the application, ensuring optimal resource utilization.	4.20	Very Good
3. The system's maximum limits of parameters meet the requirements of the application, ensuring compliance with specified standards and performance expectations.	4.10	Very Good
Grand Mean	**4.20**	**Very Good**

Security of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics

Table 10 presents the evaluation of the application with regard to its security aspects. The program achieved a rating of "Very Good" in terms of security, with an overall mean score of 4.16. The security score exhibited a high level of performance, demonstrating exceptional ratings in the sub-factors of confidentiality, integrity, non-repudiation, and authenticity.

The system incorporates a multifaceted security log-in access mechanism for each user category, guaranteeing that data may only be accessed by individuals who possess the necessary authorization. Furthermore, it effectively mitigates the risk of unauthorized access to altered data and maintains a comprehensive log of auditable records that document each and every action performed.

This conforms to the study conducted by [12], that security of the application for aquaponics is paramount, with a comprehensive and robust framework designed to safeguard sensitive data and ensure the integrity of aquaponic systems.

Employing state-of-the-art encryption protocols and secure authentication mechanisms, the application prioritizes the confidentiality of user information and system control. Regular security audits and updates further fortify defenses against potential vulnerabilities, assuring users of a resilient shield against unauthorized access or data breaches. By upholding the highest standards in cybersecurity, our application ensures a trustworthy and secure environment for aquaponics practitioners to manage their systems with confidence and peace of mind.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 1, January 2024

DOI: 10.17148/IARJSET.2024.11103

Table X Security of the Developed Smart Fish Feeder and Monitoring System Device for Hybrid Aquaponics.

Statement	Mean	Verbal Interpretation
1. The system ensures that data is accessible only to those authorized to have access in the application, maintaining security and confidentiality.	4.50	Excellent
2. The system prevents unauthorized access to, or modification of, computer programs or data in the application, ensuring data integrity and security.	4.30	Excellent
3. The system can be proven to have taken place, preventing events or actions from being repudiated later in the application, ensuring accountability and traceability.	4.30	Excellent
4. The system ensures that actions of an entity can be uniquely traced back to that entity in the application, ensuring accountability and transparency.	3.40	Good
5. The system ensures that the identity of a subject or resource can be proven to be the one claimed in the application, enhancing security and authentication measures.	4.30	Excellent
Grand Mean	**4.16**	**Very Good**

IV. CONCLUSION

Based on the above-mentioned findings of the study, the following conclusions were drawn:

The evaluation experts have approved the innovation in the design, construction, operating performance, and safety due to its exceptional features.

Therefore, it can serve as a substitute monitoring system for hybrid aquaponics. In addition, the mobile application of the device has received clearance from specialists who believe the monitoring system to be outstanding in tracking water quality metrics. This allows users to stay informed even when they are far away from home or out of town.

REFERENCES

[1]. Yokogawa, “pH in Fish Farming,” 2020. https://www.yokogawa.com/us/library/resources/application-notes/ph-in-fish-farming/. (accessed Jan. 09, 2024).
[2]. G. Simon, D. Boris, M. Ultra, V. R. Kristin, J. Ragnheidur, and H. T., “Challenges of Sustainable and Commercial Aquaponics,” Sustainability, vol. 7, p. 10, 2015.
[3]. T. Shafeena, “Smart aquaponics system: Challenges and opportunities,” Eur. J. Adv. Eng. Technol., vol. 3, pp. 52–55, 2016.
[4]. D. Wang, J. Zhao, L. Huang, and D. Xu, “Design of a smart monitoring and control system for aquaponics based on OpenWrt,” Proc. 5th Int. Conf. Inf. Eng. Mech. Mater., 2015.
[5]. S. Rangeetha, S. Niveda,] S. Srinitha, and G. Priyanka, “Advanced Aquaponics Monitoring System Using Raspberry Pi,” Turkish J. Comput. Math. Educ., vol. 12, no. 9, pp. 2–4, 2021.
[6]. A. Dutta, P. Tamang, P. Dahal, R. Prajapati, and K. Saban, “IOT BASED AQUAPONICS MONITORING SYSTEM,” in KEC CONFRERENCE, 2018.
[7]. A. Ibrahim, “Definition Purpose and Procedure of Developmental Research: An Analytical Review,” Asian Res. J. Arts Soc. Sci., vol. 1, no. 6, pp. 1–6, 2016, doi: 10.9734/arjass/2016/30478.
[8]. Berger et. al., “A Qualitative Study of Features in Industrial Software Product Lines.,” University of Waterloo, 2015.
[9]. A. Dutta, P. Dahal, R. Prajapati, and P. Tamang, “Iot based aquaponics monitoring system,” vol. I, pp. 75–80, 2018.
[10]. R. Sallenave, “Important water quality parameters in aquaponics systems,” Consum. Environ. Sci., pp. 1–8, 2016, [Online]. Available: http://aces.nmsu.edu/pubs/_w/W104.pdf
[11]. Saba, T. J., R. E, and A. M. J., “The Level of Awareness on Electrical Hazards and Safety Measures among Residential Electricity User’s in Minna Metropolis of Niger State, Nigeria,” IOSR J. Electr. Electron. Eng., vol. 9, no. 5, pp. 01–06, 2014, doi: 10.9790/1676-09510106.

DOI: 10.17148/IARJSET.2024.11103

[12]. L. H. Acosta, H. . Al-Roquishi, J. O. O. Cruz, and L. M. . De Guzman, "The Automation of Aquaponics," De La Salle Araneta University, 2020.

[13]. J. R. Sarmiento, "Hydroponics System for Aemilianum College Inc.," vol. 11, no. 4, pp. 1206–1219, 2023.

[14]. B. D. Ramos, "Design and Development of an Automatic and Maintenance-Free Ebb and Flow Hydroponics System," vol. 1, no. 3, pp. 139–165, 2021.

[15]. A. R. Benito, "Enhanced Decision Support System for Automated Fish Feeder and Water Quality Detection with SMS Notification," Int. J. Adv. Trends Comput. Sci. Eng., vol. 9, no. 1.3, pp. 215–221, 2020, doi: 10.30534/ijatcse/2020/3291.32020.