Foundation University Journal of Engineering and Applied Sciences

FUJEAS
Vol. 6, Issue 1, 2025
DOI:10.33897/fujeas.v6i1.930

Research Article

Article Citation:
Khan et al. (2025). "A Research-Intensive Framework to Automate the Business Operations of a Smart Water Distribution System". Foundation University Journal of *Engineering and Applied Sciences*
DOI:10.33897/fujeas.v6i1.930

Published by Foundation University Islamabad.
Web: https://fui.edu.pk/

A Research-Intensive Framework to Automate the Business Operations of a Smart Water Distribution System

M. Izhan Khan, Ali Ahmed Saleem, Mudassir Raza, Ayesha Mahmood, Talha Ahmed, Shazia Usmani, Uzma Afzal *

Department of Computer Science, Federal Urdu University of Arts, Science and Technology, Karachi, Pakistan.

* **Corresponding author**: uzma.afzal@fuuast.edu.pk

Abstract:

Typically, software solutions are developed based on generic assumptions without proper, well-defined research methodologies, leading to applications that may not satisfy the needs of a particular target market. In this paper, a combination of qualitative and quantitative approaches was designed to critically analyze the existing water distribution systems. The research-intensive approach helps to build a framework (Aquarise Intelflow) that caters to the real-world actual issues of the stakeholders. Aquarise Intelflow is a smart technology-based water delivery and distribution framework that provides a rich set of features to address the inefficiencies of existing market solutions. It gives a smooth experience to clients by offering subscription and delivery plans, request/process orders, and tracking deliveries. Vendors are equipped with an interactive management dashboard. Evaluation results of Aquarise Intelflow highlight its performance, including minimum manual intervention with enhanced customer satisfaction. In a nutshell, the proposed solution bridges the existing operational gaps in water distribution systems.

Keywords: Water distribution; IoT; Information System; Automation; Smart Technology.

1. Introduction

Rapid technology change has led numerous other industries to shift from a manual system to an automated one [1]. As a result, efficiency and service delivery are greatly enhanced. However, water distribution and management still suffer from old manual processes, which often cause inefficiency, delayed orders, and less transparency, especially in developing regions. In Pakistan, these distribution systems primarily rely on manual procedures, distributed and small networks, and obsolete record-keeping strategies. Vendors with small and medium-scale networks use paper-based order logs, phone calls, and WhatsApp messages to manage customer orders, schedules, and delivery timelines. This dependency on old methodologies introduces many business challenges, such as late deliveries, order mismanagement, pricing transparency, and overall monitoring. Customers face various setbacks in respect to ordering water, subscription management, and guarantee delivery, whereas vendors often fail to manage orders, satisfy, and coordinate customers properly [2]. Some of these problems can be summarized as: Poor Order Management; Customers can't easily make orders for the delivery of water in the absence of a proper ordering information system, which introduces order delays and confusion. Vendor Management Issues; The water suppliers track orders manually or semi-

automatically. Thus, sometimes the delivery goes missing or is delayed, and there is a hassle in managing the customer subscription. Customer Service Limitations: Customers cannot access their delivery schedules, subscription plans, and service updates easily. So, they often have to wait for the services through phone-based communication. Operational Costs: The manual record-keeping and order processing are labor-intensive and hence increase the operational costs for vendors and administrators [3].

Technology plays a fundamental role in addressing the inefficiencies of traditional water delivery systems, ensuring a more structured, automated, and customer-friendly approach. Digital solutions are adopted to normalize the concerns about water accessibility and operational inefficiencies. Several apps are available to meet the high demand for efficient and convenient water delivery services locally, but most of them lack the advanced features to improve customer experience, simplify operations for vendors, and incorporate automation (detailed in the next section). The absence of smart solutions that can understand and perceive the needs of the business environment, acquire and process timely information, exacerbates the situation and the business domain. To bridge this gap, we propose Aquarise Intelflow, a smart water delivery and management platform that digitizes the ordering and distribution process, making it seamless, efficient, and accessible. The platform consists of three integrated models. A Mobile App for Customers that allows users to select a preferred vendor, subscribe to delivery plans (daily, weekly, or monthly), and request water deliveries at their convenience. A Web-Based Vendor Dashboard to manage vendor business operations such as uploading product images, managing customer orders, monitoring order status/deliveries, and ensuring that everything runs smoothly. An Admin Dashboard which acts as a central management system and helps administrators to monitor the vendors, receive complaints from the customers, and maintain service quality.

Aquarise Intelflow eliminates manual coordination and inefficiencies, thereby enhancing vendor management, optimizing order processing, and ensuring the seamlessness of customer experience. With its scalable and user-friendly design, the platform modernizes the water delivery process, making it more efficient, reliable, and service-oriented. Aquarise Intelflow is an automated, technology-driven platform that revolutionizes water ordering, vendor management, and administrative oversight to improve the local water distribution market. It provides a seamless, structured, and digital solution to the challenges faced by traditional systems. Modern cutting-edge technology is integrated to transform the operation of water management. Aquarise Intelflow uses cloud to ensure the safe, scalable, and centralized management of customer subscriptions, vendor operations, and administrative work. The proposed solution is used to reduce manual dependency in tasks like delivery plan subscription, new orders management, and administration to oversee the platform's operations. An easy-to-use digital platform of Aquarise Intelflow ensures efficiency and accessibility for all stakeholders.

The primary focus of the paper is to execute and employ a smart water distribution system in a real-world local environment. Performance of the proposed solution is also compared with the existing water distribution applications. For this, we pose to research questions:

Q1: Does Aquarise Intelflow have the potential to cover the existing features gap of water distribution systems?

Q2: Is the performance of Aquarise Intelflow better than existing local water distribution systems?

To answer the research question Q1, a research methodology based on market survey and critical analysis of existing solutions is developed to investigate the current features/applications gaps. For research question Q2, Aquarise Intelflow is employed in a testing environment. Anonymous feedback is acquired to evaluate the actual performance of the proposed solution. Moreover, a qualitative comparison of the proposed solution with existing water distribution systems is also presented. Results show that Aquarise Intelflow fulfills the user expectation and outclasses the existing applications by introducing a rich set of technology-aware features. The main contributions of our research work are:

- A well-developed research methodology is used to identify the research gaps of the

existing water distribution system.

- Based on the identified gaps, an application framework is proposed to solve the needs of water distribution systems.
- A qualitative comparison is presented to highlight the performance of the proposed solution.

The rest of the paper is structured as follows: Section 2 presents the detailed literature review. The research perspective of the proposed solution is presented in Section 3. The implementation and executional framework is discussed in Section 4. Evaluation strategy along with the results is described in Section 5, and the paper is concluded in the next section.

2. Literature Review

Several apps have emerged to meet the high demand for efficient and convenient water delivery services in the local market. But, unluckily, limited features and the absence of cutting-edge technology still make the water distribution system a candidate and potential work arena for researchers and developers. The Pani Wala app allows an on-demand water delivery service. It enables users to order water for delivery from the local vendors; however, automated billing or a subscription-based model of delivery cannot be availed [4]. Customers are able to make orders manually. There is no integrated system through which recurring orders can be managed, nor access to water usage data. AquaLife gives water delivery directly through a smartphone application; limited features are offered, such as placing orders followed by paying your bill. The system still requires manual handling of orders by vendors, meaning it can create inefficiencies in fulfilling orders [5].

WaterOnDemand is another water delivery app available in Pakistan. Here, customers can place orders for water bottles, but the application only allows ordering and basic billing without a detailed dashboard for the vendor or analytics [6]. Dejablue Water offers bottled mineral water delivery in Lahore city. Customers can place orders through their website or by phone. However, the service primarily focuses on order placement and delivery; features like automated subscription management and in-app billing are not offered. [7].

Aquarise Intelflow bridges the aforementioned issues by providing a rich set of features, including support for automated billing and payments. Most local apps demand manual billing processes, whereas Aquarise Intelflow has automated billing and payment systems. This helps both customers and vendors make seamless payments. Aquarise Intelflow has a vendor dashboard, thus enabling the management of orders, follow-up of deliveries, update of inventory, and customers' preferences, hence making the whole process more streamlined and with minimal manual errors. It also supports a subscription management system to help customers in setting up his/her regular water deliveries based on their needs. This gives a degree of flexibility that a local platform might not be able to provide. This mechanism also ensures a satisfactory service for its users at a low cost.

A successful deployment and market acceptance of the Aquarise Intelflow can open a door to many advanced and cutting-edge technologies for the water distributed system, such as blockchain, semantic modelling. The inclusion of these modern technologies can further improve the effectiveness and overall performance of the candidate solution [21-23]. In [21], authors combine prediction methods with blockchain to improve the user trust in subscription-based services. Employment of blockchain to record user data helps build user trust. Such transparent record-keeping can be further used to predict user retention. Similarly, in [22], a knowledge-aware model is proposed that acquires high-order semantics to produce accurate item-specific recommendations. These semantics can facilitate users to select an appropriate vendor based on service area, order history, performance, and reliability. Personalization-enabled Aquarise Intelflow can improve the overall system efficiency. In [23], a fog-based layered architecture is proposed, which advocates certain benefits over a pure cloud-centric method. In the context of Aquarise Intelflow, meter reading of water usage, bill production, system updates, along with other time-sensitive data can be processed locally on fog nodes. Local processing of the time-sensitive data can improve system reliability and scalability.

3. Aquarise Intelflow Design: A Research Perspective

The methodology for Aquarise Intelflow is designed as an organized framework that combines qualitative and quantitative research methods [8] to acquire a comprehensive understanding of user needs, system requirements, and operational efficiencies. This dual approach ensures a holistic evaluation of the platform's performance, user satisfaction, and scalability. This dual research approach is used to:

- To identify user needs and preferences for clean drinking water delivery services.
- To evaluate the efficiency and effectiveness of Aquarise Intelflow in streamlining water delivery operations.
- To assess customer satisfaction and vendor performance using the platform.
- To identify areas for improvement and scalability of the system.

Qualitative research [9] is based on understanding the underlying reasons and behaviors. The qualitative methods for this project include:

Interviews: Conducted with water resource managers and a small sample of consumers to gather insights on weaknesses and expectations.

Field Observations: Current manual processes are being analyzed to identify shortcomings and opportunities for digital automation. Quantitative research [10] is used to measure system performance, user satisfaction, and operational efficiency using statistical data.

Surveys: Distribute structured questionnaires to customers and vendors to collect data on satisfaction levels, ease of use, and delivery efficiency.

Usage Analytics: Analyze platform usage data (e.g., order volumes, delivery times, and customer retention rates) to assess system performance.

The detailed explanation of different qualitative and quantitative components is as follows: A simple random sampling method that gives an equal chance to every individual to be selected is used. This selection is based on the homogeneity of the population to minimize the selection bias. A sample size of almost ~150 participants is used to validate the exploratory and performance measures, such as interviews, surveys, and performance feedback of the existing and proposed solutions. The selected sample size meets the minimal statistical requirements and is typically used to validate research frameworks and prototypes. Exploratory and feedback surveys contain multiple-choice questions, yes/no questions, closed-ended prompts, and Likert-scale items. The interview protocol is designed to acquire the maximum in-depth information about the candidate's domain. Questions are based on the problem background, issues in the existing framework, usability, and functionalities of the existing and required system. SPSS and MS Excel are used to visualize and draw meaningful insights to evaluate the overall metrics of the water supply business domain.

Quantitative methods provide measurable and actionable data, enabling the identification of trends, patterns, and areas for improvement. To design Aquarise Intelflow, the RAD model is adopted because it is iterative, user-based, and the functional prototype can be delivered faster [11]. Moreover, high engagement of users ensures compliance with stakeholder expectations, and changes can be absorbed easily during development. The analysis of Aquarise Intelflow focuses on understanding user demographics, behavior, and feedback to evaluate the system's effectiveness and identify areas for improvement [12]. This section highlights key insights into how users interact with the platform and their perceptions of its performance.

- Demographics: A significant majority of users own smartphones, with most preferring Android devices and a smaller portion using iOS. Users are highly familiar with smart technology, having used smart devices for several years, which supports the adoption of Aquarise Intelflow.

- User Behavior: Traditional water delivery systems face challenges such as high manual effort, inaccurate billing, and inefficiencies. Aquarise Intelflow is perceived as a more efficient and time-saving solution compared to manual processes.
- Feedback: Users appreciate the app's ease of use, efficient delivery management, and transparent billing system. Desired features include seamless payment integration, predictive analytics for delivery schedules, and customizable alerts and notifications.

Design and implementation of Aquarise Intelflow is based on the above-discussed key findings.

4. Design and System Implementation

Design and system implementation are the realization of a technical specification or algorithm as a program, software component, or computer system [13]. This involves using tools and frameworks to create an efficient system. Below is a detailed implementation process tailored for Aquarise Intelflow. Table 1 discusses the selection of the tools along with their justification. The table is self-explanatory, so we are not expounding on it here.

Table 1. Tools and justification

Tool	Purpose
React native[14]	Cross-platform mobile app development.
Node.js [15]	Real-time backend for managing data streams.
Firebase [16]	Secure database, authentication, and cloud storage.
Redux [17]	State management for consistent app behavior.
MongoDB [18]	Reliable database for billing and smart meter data.
Expo [19]	Tools for rapid mobile app prototyping and testing.

These tools were chosen based on their ability to provide a seamless, scalable, and user-friendly mobile experience, while ensuring efficient backend management. React Native, in particular, is crucial for achieving cross-platform compatibility, allowing Aquarise Intelflow to reach a wider audience while maintaining development efficiency. A combination of these tools also ensures security and scalability of the Aquarise Intelflow. Firebase controls access management, user and payment authentication, and also provides encrypted storage. Node.js supports scalability by managing multiple requests, while MongoDB guarantees reliable data management by replication and sharding.

Along with all the technology-oriented benefits, Aquarise Intelflow has some architectural limitations too. The proposed framework is cloud-based, which means it needs continuous internet coverage. Areas with poor network connectivity may experience system unavailability. Additionally, a seamless integration of Aquarise Inteflow with legacy systems can also pose challenges to its acceptance.

As shown in Figure 1, this system effectively handles water delivery services by connecting Admin, Vendors, and Customers in an organized and controlled form. The main modules of the solution are as follows:

- Admin (Dashboard Webpage) – Linked to Both Vendor & Customer: It has management features to coordinate vendor and customer transactions for effective and smooth communication. It also provides system monitoring to ensure quality in services and operational efficiency on the platform.

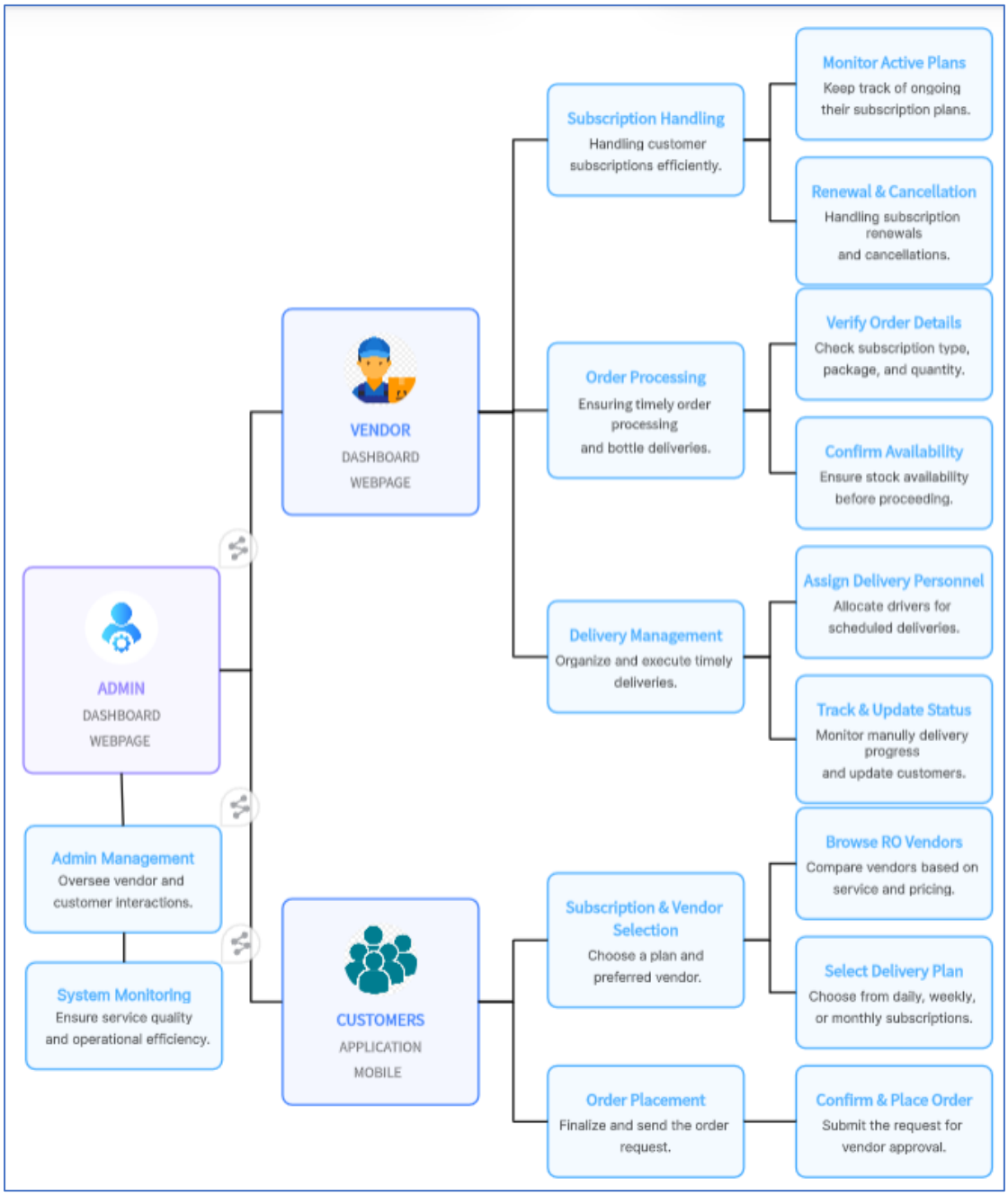

Figure 1: Aquarise Intelflow – a modular perspective

- Vendor (Dashboard Webpage) – Linked to Both Admin & Customer: It handles subscriptions to support system efficiency. Vendor can also monitor the active/inactive subscription and manage the renewal and cancellation plan of the customer subscriptions. It also contains features to process the orders to ensure timely delivery. Verification of order details, their types, and the amount is also available. Moreover, conformance of available stock is also done prior to any further order processing. Different plans are available to manage deliveries. Designated personnel can also be assigned for planned deliveries.
- Customer (Application - Mobile) – Only Connected to Vendor: It enables the selection of a subscription plan and vendor. Customers can browse and compare vendors on service and cost. Moreover, a daily, weekly, or monthly subscription plan is available to give users flexibility. Order placement and confirmation are also added to smooth the primary workflow of the water distribution application.

The primary workflows of the framework are as follows:

- Customer to Vendor: Orders are placed through the app and are forwarded to the vendor dashboard.
- Vendor to Admin: Vendors update the status of orders, and admins periodically review performance.
- Admin to Customer: Admins handle complaints manually and ensure service quality.
- Delivery to Feedback Loop: Delivery confirmation triggers customer feedback, which drives improvements.

Aquarise Intelflow has an intuitive user interface (UI) optimized for mobile devices, as shown in Figure 2. Details of the key interfaces are as follows:

- Home Interface: The home screen provides easy navigation to the main features, including water usage monitoring, bill payment, and customer support.
- Signup Page: Users will be able to register securely using their mobile number or email, with integration of OTP (One-Time Password) for additional security.
- Login Page: The app allows users to securely log in using credentials set during registration, with options for fingerprint or face recognition authentication for convenience
- Available Vendors Page and My Subscriptions: Displays a list of vendors, organized by city or category, with water availability, services, pricing details, and also the vendor you subscribed to.
- Selected Vendor Page: Shows the vendor's detailed offerings, including products/services, pricing, and real-time updates on orders or bookings.
- Booking/Service Request Page: Users can request services (like maintenance or new connections) through an easy-to-use booking system.
- Payment Methods: Various payment options are integrated, including:
  - Cash on Delivery (COD) for post-service payment.
  - Online Payment via JazzCash, Easypaisa, Nayapay, Sadapay, Bank transfer.

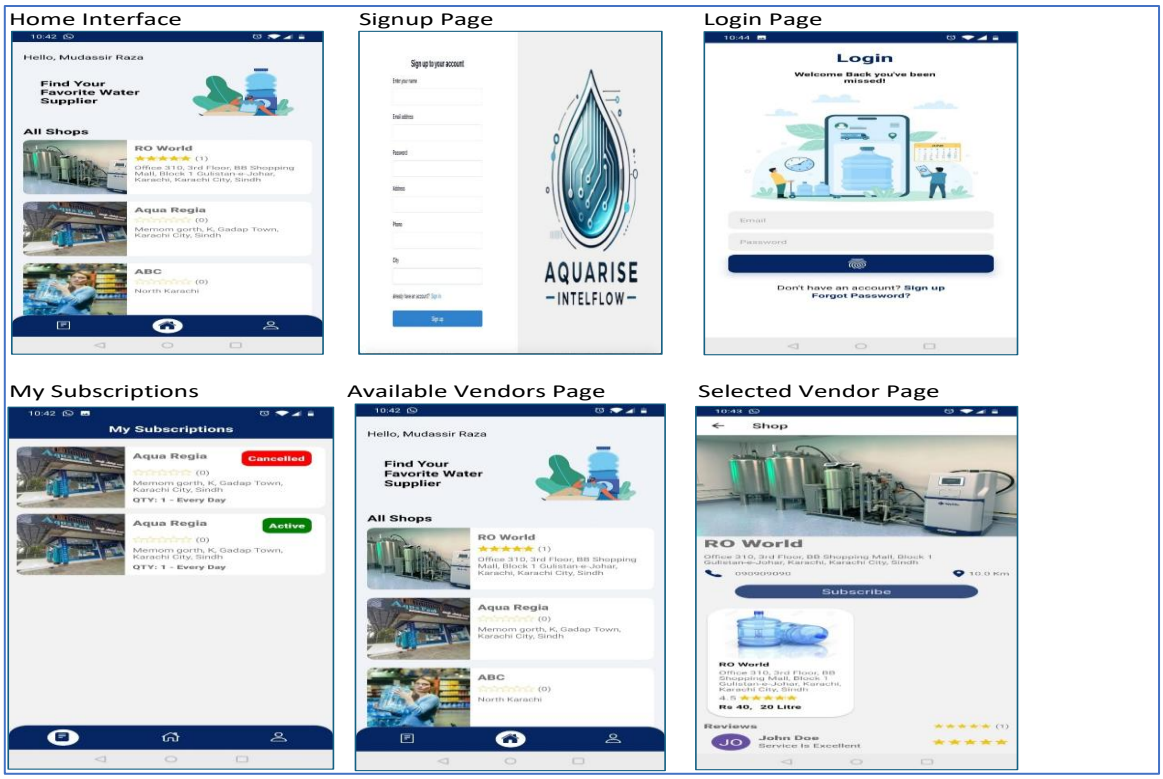

Figure 2. An image of Aquarise interfaces

5. Evaluation and State-of-the-Art Comparison

The evaluation strategy for Aquarise Intelflow has two folds. i.e., comparison with state-of-the-art existing applications and evaluation in real real-world testing environment. We compare our work with four state-of-the-art market solutions, such as PaniWala, AquaLife, WaterOnDemand, and Dejablue water. These applications are selected on the basis of a detailed literature review (Section II). Comparison indicators are derived from the critical analysis of existing solutions, and an answer metric is developed to note the indicator response. Table 2 presents the details of this comparison. Results show that Aquarise Intelflow improved the overall framework of water distribution systems by providing a reliable and rich set of features to enhance user interaction.

Table 2: A state-of-the-art comparison

Features Indicator	Aquarise Intelflow	Pani Wala	Aqua Life	WaterOn Demand	Dejablue Water
On-Demand Delivery	Yes	Yes	Yes	Yes	Yes
Automated Billing & Payments	Yes	No	No	No	No
Subscription Management	Yes	No	No	No	No
Vendor Dashboard	Yes	No	No	No	No
Automated Notifications	Yes	No	No	No	No
Water Drink Can Data	Yes	No	No	No	No
Customer Interaction	Improved (Transparent, Data-Driven)	Basic (Manual Order)	Basic (Manual Order)	Basic (Manual Order)	Basic (Manual Order)
Order Management Automation	Yes	No	No	No	No
Vendor Efficiency	High (Automated Operations)	Low (Manual Order Handling)	Low (Manual Order Handling)	Low (Manual Order Handling)	Low (Manual Order Handling)
Flexibility in Delivery	High (Customizable)	Low (Manual Ordering)	Low (Manual Ordering)	Low (Manual Ordering)	Low (Manual Ordering)

To further evaluate Aquarise Intelflow, we employed it in a controlled testing environment. A team of independent users is deployed to carry out this evaluation. A subjective feedback form is developed to note the users' feedback. This form is created as per the guidelines given in [20]. Questions are related to the overall design, usefulness, and ease of the workflow. It also acquires the users' opinion about the most desirable feature. More than 80% users like the design and business flow. No user has recorded their negative remarks regarding the ease and usefulness of the application. Aquarise Intelflow design and choice of vendors are the most desirable features; users also recommended more enhancements in their most likeable features. This positive feedback from users made us believe that Aquarise Intelflow has the potential to successfully grab the market.

6. Conclusions and Future Direction

A research-intensive framework based on qualitative and quantitative approaches is proposed, i.e., Aquarise Intelflow. Existing manual and automated water distribution systems are critically analyzed to identify the real-world issues and build the foundation of the proposed solution. Aquarise Intelflow, a smart technology-based water delivery and distribution framework with a rich set of features, is implemented to address the inefficiencies of local market solutions. It is equipped with on-demand market features such as delivery plan subscriptions, request/process orders with interactive tracking, and payment methods. Aquarise Intelflow is evaluated in a controlled testing environment with a dedicated team of testers. Results show the positive performance of the given solution to improve customers' acceptance and satisfaction. In the future, we are planning to add a more advanced set of features to make it users' ultimate preference. Moreover, a cloud-based water distribution system is also one of the potential future research directions.

7. References

[1] Acemoglu, D., & Restrepo, P. "Automation and new tasks: How technology displaces and reinstates labor," *Journal of Economic Perspectives*, vol. 33, no. 2, p. 3-30, 2019.

[2] Ngai, E. W. T., Cheng, T. C. E., & Lee, C. M. Y. "Development of a web-based system for supporting sales in a mineral water manufacturing firm: A case study," *International Journal of Production Economics*, vol. 83, no. 2, p. 153-167, 2003.

[3] Melkamu, M., & Atsegeba, B. D. "Increase Effectiveness of Distribution System in Bottled Mineral Water Industry Through Reducing Major Challenges," *Journal of Innovations in Business and Industry*, vol. 3, no. 2, p. 92-102, 2025.

[4] Watebly. (Pani Wala App). Watebly: Water delivery app. [Online] Available: https://www.watebly.com. [Accessed: 24 February 2025].

[5] Aqualife. (AqLife Water). Aqualife: Clean water solutions. [Online] Available: https://www.aqualifetx.com. [Accessed: 24 February 2025].

[6] Trina Marketing. (Triana). Water on demand. [Online] Available: https://www.trinamarketing.com. [Accessed: 24 February 2025]

[7] DejaBlue. (Dejablue). DejaBlue: Premium bottled water. [Online] Available: https://www.dejablue.pk. [Accessed: 24 February 2025]

[8] Habib, M. S. (2021). Qualitative and Quantitative Research Approaches. Unicaf University.

[9] Bhangu, S., Provost, F., & Caduff, C. "Introduction to qualitative research methods–Part I," *Perspectives in Clinical Research*, vol. 14, no. 1, p. 39-42, 2023.

[10] Bacon-Shone, J. H. (2013). Introduction to Quantitative Research Methods. Graduate School, The University of Hong Kong.

[11] Khan, F. Q., Rasheed, S., Alsheshtawi, M., Ahmed, T. M., & Jan, S. "A Comparative Analysis of RAD and Agile Technique for Management of Computing Graduation Projects," Comput. Mater. Contin, vol. 64, no. 2, p. 777-796, 2020.

[12] Shiffman, R. N., Liaw, Y., Brandt, C. A., & Corb, G. J. "Computer-based guideline implementation systems: a systematic review of functionality and effectiveness," *Journal of the American Medical Informatics Association*, vol. 6, no. 2, p. 104-114, 1999.

[13] Wasson, C. S. (2015). System Engineering Analysis, Design, and Development: Concepts, Principles, and Practices. John Wiley & Sons.

[14] Reactive Native, "Reactive Native – Learn once write anywhere," [Online] Available: https://reactnative.dev/. [Accessed: 26 Feb 2025].

[15] Shah, H., & Soomro, "T. R. Node.js challenges in implementation," *Global Journal of Computer Science and Technology*, vol. 17, no. 2, p. 73-83, 2017.

[16] Chougale, P., Yadav, V., Gaikwad, A., & Vidyapeeth, B. "Firebase-overview and usage," *International Research Journal of Modernization in Engineering Technology and Science*, vol. 3, no. 12, p. 1178-1183, 2021.

[17] Le, T. "Comparing State Management Between Redux and Zustand In React," 2023.

[18] Chauhan, A. "A review on various aspects of MongoDB databases," *International Journal of Engineering Research & Technology (IJERT)*, vol. 8, no. 05, p. 90-92, 2019.

[19] Expo: Open-source platform for universal React applications. [Online] Available https://expo.dev. [Accessed: Retrieved: February 28, 2025].

[20] Brace, I., "Questionnaire design: How to plan, structure and write survey material for effective market research," Kogan Page Publishers, 2018.

[21] Arshad, U., Khan, G., Alarfaj, F.K., Halim, Z. and Anwar, S., "Q-ensemble learning for customer churn prediction with blockchain-enabled data transparency," *Annals of Operations Research*, vol. 353, no. 2, p.607-633, 2025.

[22] Elahi, E., Anwar, S., Al-kfairy, M., Rodrigues, J.J., Ngueilbaye, A., Halim, Z. and Waqas, M., "Graph attention-based neural collaborative filtering for item-specific recommendation system using knowledge graph," *Expert Systems with Applications*, vol. 266, p.126133, 2025.

[23] Shah, B., Junaid, M., Rustam, H., Habib, M. and Anwar, S., "AI-Driven Fog-Edge Computing for IoMT Systems: Architecture and Use Cases," *In Proceedings of the AAAI Symposium Series,* vol. 6, no. 1, p. 42-48, August 2025.