Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 253 (2025) 2116–2126

Procedia Computer Science

www.elsevier.com/locate/procedia

6th International Conference on Industry 4.0 and Smart Manufacturing

Optimizing Coffee Supply Chain Transparency and Traceability through Mobile Application

Mizna Rehman[a], Antonella Petrillo[a]*, Ilaria Baffo[b], Gianfranco Iovine[b] and Fabio De Felice[a]

[a]*University of Naples Parthenope, Isola C4 Centro Direzionale, Napoli (NA), 80143, Italia*
[a]*University of Tuscia, Loc. Riello snc, VI, Viterbo, 01100, Italia*

Abstract

In an era where consumers increasingly demand transparency and sustainability in food production, this study introduces a mobile application tailored for the coffee supply chain. The goal of the study is to enhance the entire coffee production process by integrating technologies such as blockchain, RFID, and barcodes to improve transparency, traceability, and operational efficiency. The application tracks and records data from farm inspection to export, covering coffee variety, environmental conditions, and supplier actions. It manages logistics with real-time updates on quantities, destinations, and delivery times, which supports better decision-making and fosters consumer trust through verifiable information. By improving coordination, reducing fraud, and optimizing quality control, the app aims to cut costs by up to 20%, reduce inventory carrying costs by 15-25%, and boost crop productivity by up to 15%. Furthermore, it supports precision agriculture, aligns with Just-In-Time principles, and promotes sustainability while ensuring compliance with ISO 9001 and ISO 14001 standards.

Keywords: Coffee supply chain; Mobile application; Supply chain management; Decision-making

1. Introduction

The coffee supply chain is complex, involving multiple stages from cultivation to retail, each influencing the quality, cost, and sustainability of the final product. Traditional management practices often lack transparency and traceability, leading to inefficiencies, fraud, and unsustainable practices [1]. These issues are worsened by climate change, fluctuating market prices, and the COVID-19 pandemic, which disrupted global supply chains. The European coffee

* Corresponding author. Tel.: +00390815476747;
E-mail address: antonella.petrillo@uniparthenope.it

1877-0509 © 2025 The Authors. Published by Elsevier B.V.

10.1016/j.procs.2025.01.272

market, which accounted for 33% of global consumption in 2020, is a significant player, with consumption projected to reach 3.6 million tons by 2024 and revenues expected to exceed USD 50 billion [2]. Despite growth driven by demand for specialty and ethically sourced coffee, the pandemic shifted consumption patterns and disrupted production and logistics. Lockdowns and restrictions in coffee-producing countries led to labour shortages, cafe closures, and increased home-brewed coffee consumption, boosting retail sales and e-commerce. Online coffee sales surged by 45% in 2020 emphasised the critical role of e-commerce in maintaining supply chain continuity [2]. Information technology is pivotal in enhancing the coffee supply chain's efficiency and transparency. Technologies like blockchain, RFID, and barcodes improve traceability, providing verifiable data at each stage from cultivation to consumption. For instance, blockchain creates an immutable ledger that enhances trust and reduces fraud, while RFID and barcodes enable real-time tracking, ensuring quality control [3,4]. In 2020, the European Union imported about 3.4 million tons of green coffee beans, with Germany and Italy being the largest importers, accounting for 38% and 14% of imports, respectively. Italy's coffee industry, featuring major players like Lavazza and Illy, leverages advanced technologies for efficient supply chain management. E-commerce giants like Amazon and Alibaba have entered the coffee market, facilitated direct-to-consumer sales and supported smaller brands through data analytics to optimize operations. Key industry players, including Nestlé, Starbucks, and JDE Peet's, use technologies like blockchain for traceability and IoT for quality monitoring and process optimization [5]. This research aims to improve coffee supply chain management by developing a mobile application integrating blockchain, RFID, and barcodes to enhance visibility and accountability. The app will track and record data from farm inspection to processing and exporting, aiding decision-making in transportation, inventory, and purchasing while promoting sustainable practices. It captures detailed data on coffee variety, climate conditions, and supplier actions, managing shipment and processing details to increase efficiency, reduce waste, minimize environmental impact, and support fair trade. The manuscript is structured as follows: Section 2 reviews relevant studies; Section 3 outlines the methodology; Section 4 details the mobile application development process; Section 5 discusses technology integration implications. Finally, Section 6 concludes with recommendations for stakeholders.

2. Literature Review

The integration of advanced technologies like blockchain, RFID, barcodes, and mobile applications addresses inefficiencies and enhances sustainability in the coffee supply chain. The complexity of coffee supply chains varies by nation, as discussed by Ibrahim and Zailani [6], Grabs [7], Fakkhong and Yamsa-ard [8], and Plengplang and Khutrakun [9]. E-SCM integrates enterprises and partners, enabling shared processes, objectives, and information that enhance supply chain performance [10]. The CSCMP defines supply chain management as the coordination of planning, sourcing, logistics, and integration of supply and demand across companies [11]. Internet technologies have evolved SCM into E-SCM, facilitating real-time data sharing and automation with suppliers and customers [12].

Research on blockchain for food traceability has grown, though much of it focuses on technological aspects, often overlooking human factors [13]. Studies on food traceability systems by Saberi et al. [14], Chen et al. [15], and Duan et al. [16] explore user perspectives on benefits, challenges and solutions. Traceability in supply chains has been explored through blockchain and RFID in China [17], applications or distributed storage in agricultural commodity markets and others [18],[19]. Bager et al. developed a framework to enhance traceability in coffee supply chains, highlighting barriers and opportunities for technology adoption. He emphasized the potential of blockchain and e-commerce in agro-food supply chains, but real-world validation is still needed [20]. Studies such as Behnke and Janssen [21], Yadav et al. [22], and Saurabh and Dey [23] included consumer perspectives to identify obstacles to technology adoption. Khan et al. demonstrated that RFID and barcodes improve supply chain efficiency, accessibility, responsiveness and reduce costs, automating data collection and inventory monitoring [24]. In coffee supply chains, these technologies ensure compliance with standards and regulations. Blockchain and RFID can improve the livelihoods of smallholder farmers, reduce poverty in coffee-producing regions, and support sustainable agricultural practices, thereby mitigating environmental impact and promoting biodiversity [25]. Starbucks launched one of the first widely used coffee applications in 2011, allowing customers to order and pick up coffee in stores, a feature that gained popularity during COVID-19 for contactless pickup. However, the need to download multiple apps for different coffee chains poses challenges due to storage limitations and user learning curves [26]. Liu et al. [27] found that over 60% of users are frustrated by mandatory app installations for ordering, with nearly 80% abandoning transactions as a result. Mobile applications also help improve crop yield and quality by providing updates on weather, pest outbreaks and best practices, supporting data collection and sharing [28]. Consumers increasingly appreciate the quality and precision in coffee preparation, from bean selection to extraction methods, driving innovation and setting high standards in the industry. Furthermore, ingredient specifications have gained popularity, with customers being more aware of the origin, roast degree, and taste profiles of coffee beans used in their favourite beverages [29]. This demand for transparency has stimulated the growth of specialty coffee shops and micro-roasters that emphasize sustainability and ethical sourcing. Mobile devices and applications are essential for logistics professionals in managing supply chains, enhancing supplier relationships, and improving customer service. Future research should develop integrated frameworks using blockchain, RFID, and mobile technologies for end-to-end traceability in coffee supply chains, addressing challenges like data privacy, standardized data exchange protocols and interoperability [30]. Future research should explore these challenges while examining the socio-economic impacts of technology adoption across different stakeholder groups in the coffee supply chain A centralized coffee app can unify access to various supply chain points, enhancing user engagement and providing insights into customer preferences, thereby supporting stakeholders in refining their offerings. Research on coffee industry sustainability reveals key gaps, including limited focus on smallholder farmers, technology scalability, accessibility, and the social and economic dimensions of the supply chain. Systematic reviews are crucial for guiding decision-making and promoting sustainable practices. This study addresses the gap by unifying blockchain, RFID, and mobile technologies in a single app to enhance traceability, transparency, and efficiency, focusing on smallholder integration and sustainable supply chain management.

3. Methodology

The dynamics within the coffee SCM encompass not only the physical movement of beans but also intricate economic, social, and environmental interactions. Factors such as trade relationships, sustainability practices, market fluctuations and consumer preferences influence every stage of the coffee supply chain. The digital era has transformed the coffee supply chain, enhancing sales through digital payments, online ordering, and beverage customization. The proposed mobile app aims to streamline this experience by providing a unified platform for purchasing, distributing, and selling coffee [31]. Users can browse and order from a marketplace, utilizing expedited payment options that eliminate the need for cash or credit transactions at pickup. The app focuses on customization to specific coffee preferences and allows users in warehousing, logistics, and manufacturing to select convenient collection sites, improving efficiency [32]. Its adaptability enhances convenience, accessibility, and supply chain performance, reducing costs, fuel use, environmental impact, and waste. This platform bridges the gap between technology and the coffee industry, appealing to major manufacturers and consumers alike, enhancing transparency, customer loyalty, and revenue growth for participating businesses. The objectives for designing this app are outlined as follows:

- To support small and medium-sized businesses in optimizing their inventory management.
- To oversee delivery times and track orders effectively.
- To build a user-friendly platform for seamless supply chain management for industries.
- To provide manufacturers with insights into alternative suppliers in the marketplace.
- To incentivize timely delivery of components by suppliers through a rewards system.
- To create a cost-effective marketing platform aimed at boosting the growth of local enterprises.

Figure 1 illustrates the design of an online data monitoring system via mobile application. It begins with the "Supplier association," who inputs data on certification activities, seed types, and fertilizer usage. Next, the "farmers" records real-time harvesting details, including varieties, humidity, and temperature. The process splits into two paths, the "Logistics Module," which tracks data shipment details and exporter ID, Importer ID, transportations and the "Plant Module," which manages processing times, batch quantities, and moisture levels, Fan speed, temperatures, roasting details. Both data streams converge at the "Data Aggregator represented as Data acquisition Unit," where information is compiled and analyzed. Finally, the data is accessible to the "Customer" through the mobile application, providing comprehensive monitoring and insights. This block diagram emphasizes the seamless integration and collaborative efforts in tracking and managing data from the field to the mobile app.

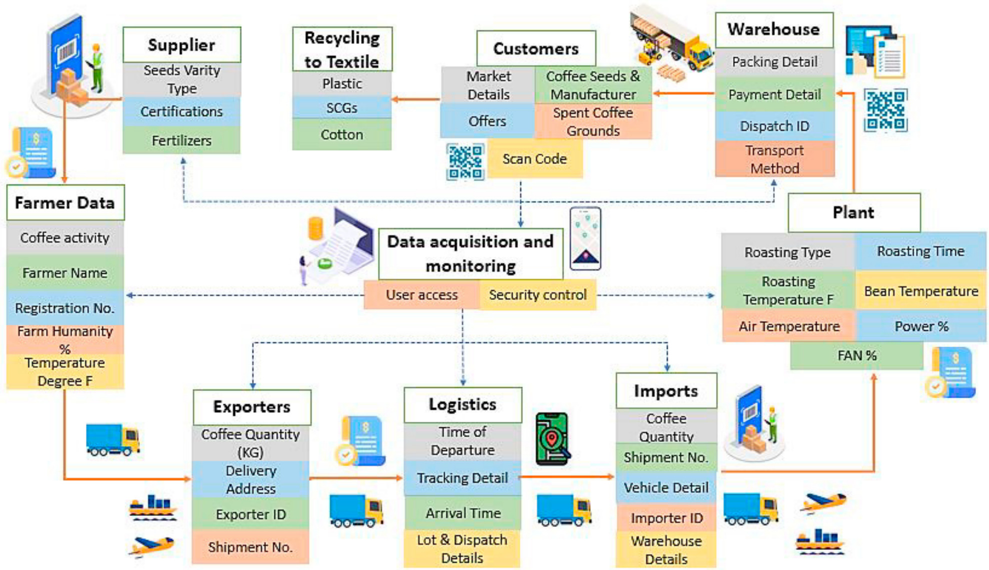

Fig. 1. Block Diagram for online data monitoring system

4. Steps to Develop a Mobile Application for the Coffee Supply Chain

The development of a mobile application for the coffee supply chain follows a systematic six-step approach. First, requirements definition and architecture design establish the foundation by selecting suitable technologies and features to meet supply chain needs, such as Android and iOS platforms, Java or Dart for programming, and Node.js/Express for backend performance and scalability. Second, UI/UX design focuses on creating an intuitive user experience through wireframing, prototyping, and iterative improvements. Third, backend development sets up a secure, scalable database with RESTful APIs for real-time data interaction and authentication, utilizing technologies like MySQL and JWT. Fourth, frontend development integrates UI with backend services, ensuring data validation and error handling for a seamless interface. Fifth, comprehensive testing, including unit, integration, and user acceptance testing, ensures functionality and reliability. Lastly, deployment involves configuring cloud infrastructure, publishing the app, and implementing maintenance plans to sustain performance and user satisfaction.

4.1. Step 1: Define Requirements and Architecture

The first step in developing a mobile application for the coffee supply chain is to define the requirements and architecture comprehensively, as illustrated in Figure 2. This step establishes the foundational framework, ensuring the application aligns with stakeholder needs for efficiency and transparency. Key activities include selecting cross-platform technologies, such as Flutter for the frontend, to maximize market reach and accessibility. Backend development involves Node.js/Express for server-side logic and secure API integration. Integrating RFID, QR codes, and GPS enables real-time tracking, enhancing the application's functionality for a highly efficient, transparent, and sustainable coffee supply chain management system.

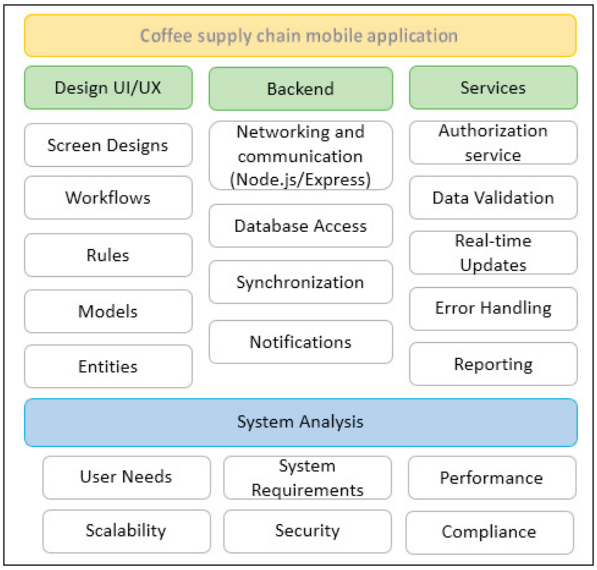

Fig. 2. System design for integrated mobile application development for coffee supply chain

4.1.1. Technical Specifications for Platform design of Android and iOS

The application is developed for both Android and iOS using Flutter, allowing a single codebase for streamlined cross-platform deployment. Node.js with Express powers the backend, offering scalability, performance, and support for RESTful APIs and real-time features essential for supply chain operations. The backend handles user authentication, data storage, and real-time processing through secure API endpoints. PostgreSQL serves as the database for its ACID (atomicity, consistency, isolation, and durability) transactions, complex queries, and data integrity, suited for structured data like user details, transactions, logs, sensors data and inventory. RFID, QR code scanning, and GPS are integrated for comprehensive tracking of coffee beans, products, and shipments.

4.1.2. Features and Functionalities

The app uses JWT (JSON Web Tokens) for secure authentication and implements role-based access control to ensure only authorized users (e.g., Farmers, Suppliers, Processors, Shippers, Customers) access specific features. It employs RESTful APIs for real-time data updates and notifications, with dashboards and alerts for monitoring key metrics. Data visualization libraries like D3.js are used for interactive reports, and analytics tools provide data trends.

4.2. Step 2: Design UI/UX

The second step involves designing the user interface (UI) and user experience (UX) to ensure an intuitive and user-friendly application for all coffee supply chain stakeholders. Figma is used for wireframing and prototyping, followed by usability testing with stakeholders to gather feedback and improving designs. Comprehensive testing includes unit, integration, and user acceptance tests to ensure functionality and performance.

1. **Login, Registration and Dashboard Screen:** The login and registration screen ensure secure user authentication and registration with role-specific access, requiring details like name, email, password, and role, utilizing OAuth 2.0 for secure login, JWT tokens for session management, and Node.js/Express for API-based processes. The dashboard offers role-specific widgets, notifications, and real-time updates. It uses the D3.js library for visualizing key metrics and alerts, with RESTful APIs for backend integration and real-time data fetching (Figure 3).

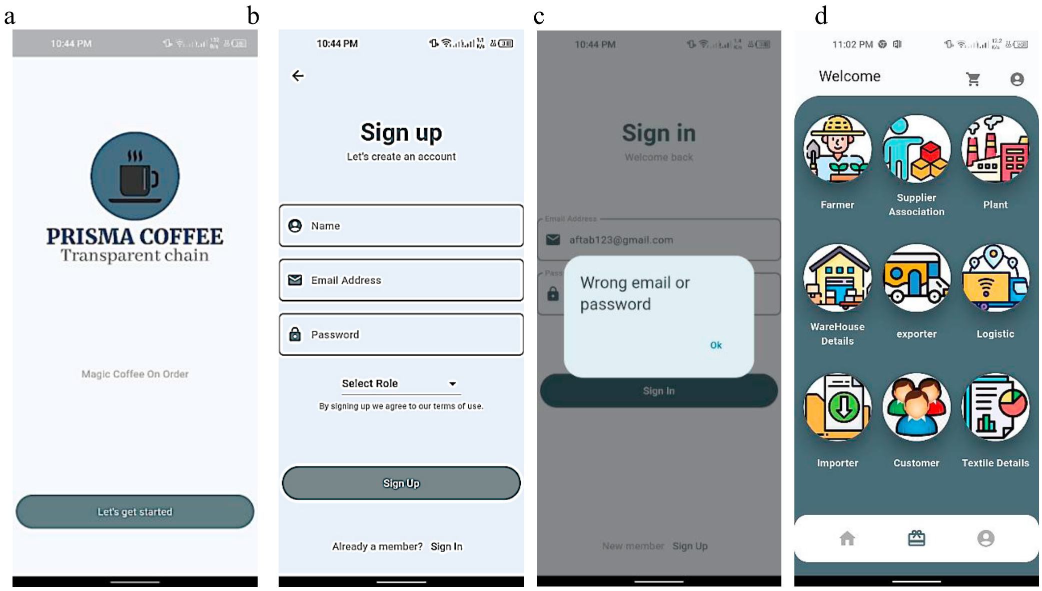

Fig. 3. (a) Welcome screen; (b) Registration screen; (c) User authentication; (d) Main dashboard screen

2. **Supplier association, Farmer, Processing and Logistics Screens**: These screens work together to enhance data management and traceability in the coffee supply chain. The Supplier Association screen gathers data on raw materials exchanged with farmers, including coffee seeds, fertilizers, certifications, and inspection details, using sensors and IoT for real-time alerts on deviations. This data is stored in PostgreSQL for traceability updates (Figures 4a). The Farmer screen enables harvesters to log coffee bean collection and quality control information, such as quantity, farmer details, humidity, and temperature checks, with photo uploads and timestamps to track progress and trigger quality control workflows, updating inventory records accordingly (Figures 4b). The Processing and Logistics screens aid factory workers, administrators, and shippers in managing sorting, roasting, packaging, and shipment tracking. Processing screens capture information on size, color, quality checks, batch numbers, processing dates, and packaging, syncing with production management systems for transparent records. Logistics screens monitor deliveries via GPS, transport methods, dispatch IDs, and packaging stages with QR code scanning (Figure 4d).

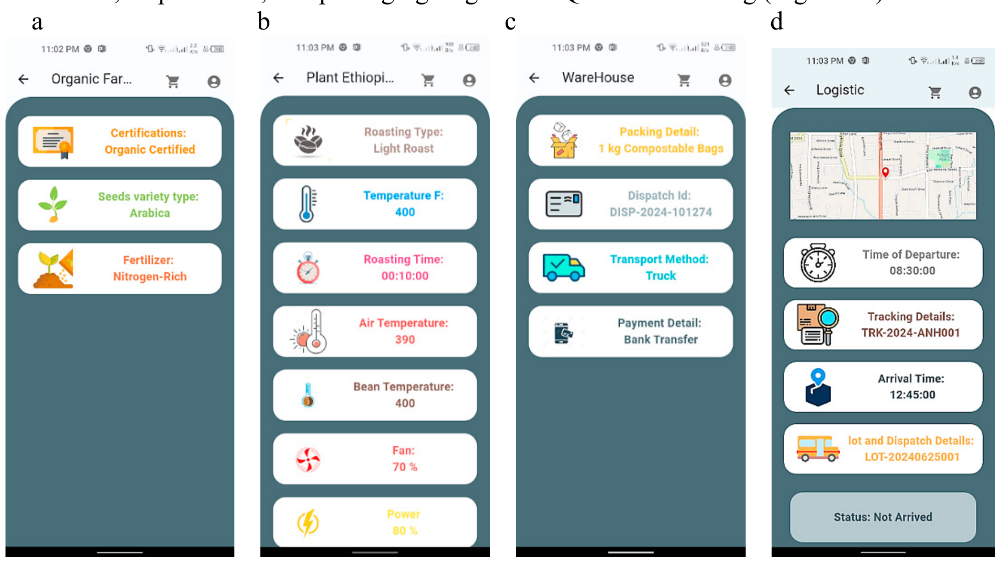

Fig. 4. (a) Coffee farming details; (b) Sensor-based quality checks; (c) Warehouse tracking systems; (d) Logistics with GPS tracking;

3. **Shippers and Customers Screens**: Shipper screens facilitate the management and tracking of shipments, including imports and exports (Figure. 5a,5b). They capture data on quantities, invoices, importer IDs, addresses, shipment numbers, and dispatch details, enabling shipment management, invoice generation, and real-time integration of shipment data with inventory and customer orders. Customer screens allow users to register, log in, submit materials for recycling, track coffee origin and processing, and monitor order status. They connect customers with management systems and recycling centers, provide real-time updates on recycling status, and support the transfer of spent coffee grounds to the textile industry as raw material (Figure. 5c, 5d).

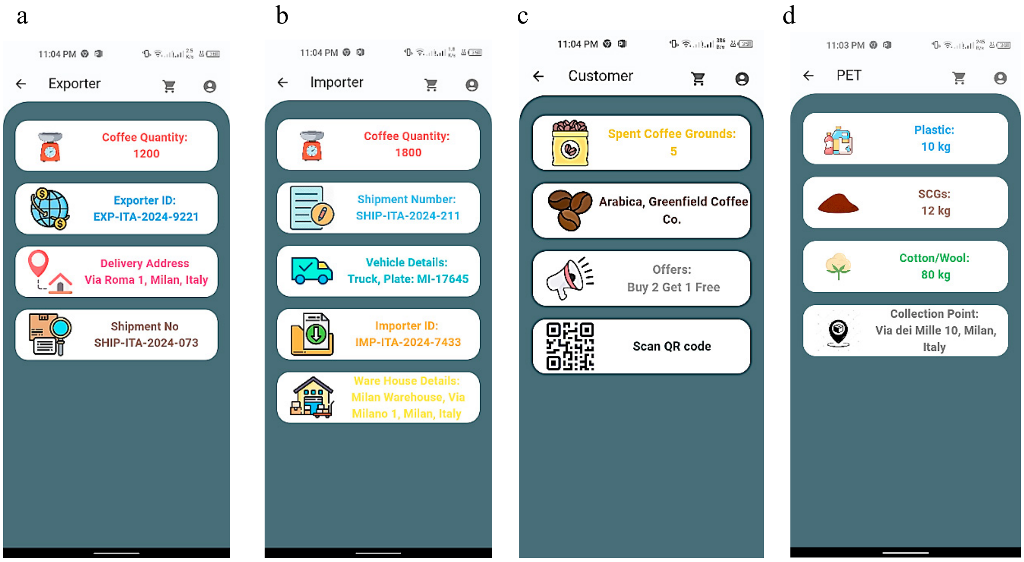

Fig. 5. (a) Exports with inventory orders; (b) Overseas shipments; (c) Updates on coffee origin; (d) Sustainability initiatives to support textile

4.3. Step 3: Backend Development

Backend development for the mobile application involves setting up a robust PostgreSQL database to manage diverse data structures, creating RESTful APIs for CRUD (Create, Read, Update, and Delete) operations on entities like users, farmers, and shipments, and ensuring secure authentication and real-time updates. PostgreSQL's flexibility and scalability support complex data interactions, while RESTful APIs enable data synchronization and notifications through Node.js. In the Middleware layer following actions are performed to increase security.

- **Authentication**: JWT (JSON Web Tokens) are used for secure user authentication with tokens applied to protected routes.
- **Authorization**: Role-based access control restricts API endpoint access based on user roles.
- **Validation**: Zod library is utilized to validate incoming data, ensuring integrity and preventing malicious inputs

Real-time data synchronization and notifications, such as inspection alerts and shipment updates are managed via APIs, with automated testing and deployment facilitated by GitHub Actions, and the backend is deployed on Google Cloud. Docker is employed for containerization and Kubernetes for orchestration, laying a solid foundation for integrated data management and connectivity.

4.4. Step 4: Frontend Development

Frontend development focuses on creating user interface (UI) screens and connecting it with backend services to ensure smooth functionality across all supply chain roles with data validation and error handling mechanisms. Authors used the Flutter framework, which enables cross-platform development with Dart, the UI screens are implemented as separate widgets, including login, registration, and dashboards. The HTTP library in Flutter is used to manage API requests at backend, Services or providers are created to manage API requests and responses. While WebSocket integration facilitates real-time updates by using REST APIs for initial data and WebSocket for ongoing changes, with `axios` or `fetch` and `web_socket_channel` to handle real-time calls. Data validation is handled through Flutter's built-in validation library, ensuring accurate input fields, and error handling mechanisms are in place to address network, data, and server issues, providing users with appropriate error messages such as invalid data or you do not have rights to access this screen.

4.5. Step 5: Testing

Testing, the fifth step in the development process includes unit testing to verify the functionality of individual components, integration testing to ensure seamless interaction between frontend and backend, and user acceptance testing (UAT) to validate the application with real users from each role. Each testing level identifies and resolves issues, ensuring a robust and seamless user experience.

4.6. Step 6: Deployment

Deployment is the final phase in developing the mobile application. It involves setting up Google Cloud services for backend scalability and reliability, publishing the app to app stores for user access, and implementing monitoring and maintenance for ongoing updates and user satisfaction. This approach ensures the application operates efficiently in real-world conditions and adapts to user needs. Table 1 provides a structured blueprint for the app’s development, guiding the systematic integration of technological solutions across all supply chain roles.

Table.1. Detailed Technical Framework and Benefits of Each Mobile Application Screen for Coffee Supply Chain Management

Screen	Features	Technical Data	Benefits
Login and Registration	User authentication and registration	User details (name, email, password, role)	Secure access control and user management
Dashboard	Overview of supply chain status	Real-time data monitoring	Centralized access to all functionalities
Supplier Association	Data collection for seeds, fertilizers, humidity, temperature	Input fields for various inspection parameters	Accurate and timely farm data collection, improving quality and traceability
Farmer	Harvesting data collection and quality control	Input fields for quantity and quality control checks	Ensures quality control during harvesting
Coffee Factory	Sorting, quality checks, roasting, and packaging	Input fields for sorting, roasting, and packaging details	Streamlined factory operations and quality assurance
Warehouse	Processing data entry for batch numbers, dates, and addresses	Input fields for batch numbers, processing dates, and processor addresses	Enhanced tracking of processing stages and batch management
Shipper	Shipment management, quantities, invoices, importer IDs	Input fields for shipment quantities, invoice numbers, and importer IDs	Efficient and transparent shipment tracking and management
Customer	Registration, order tracking, and recycling material submission	Input fields for registration details and recycling submissions	Enhanced customer experience with real-time order tracking and recycling options
Reports and Analytics	Report generation and visual analytics	Filters for date, batch, location, etc.	Data-driven insights and decision-making

The methodology ensures the mobile application is technically sound and meets the practical needs coffee supply chain. With a user-centric design, it enhances operational efficiency, inventory management, quality control, and transparency. Comprehensive testing and a flexible deployment strategy ensure reliability and scalability.

5. Discussion

The findings from this study highlight that the development of a mobile application for the coffee supply chain enhances operational efficiency and addresses key industry challenges, benefiting stakeholders such as farmers, processors, shippers, and customers. The app significantly improves traceability by providing verifiable data on seeds, fertilizers, humidity, and temperature, thus addressing transparency and counterfeiting issues prevalent in the coffee industry. This reduces fraud and increases trust among consumers. Quality control checks at the harvesting and factory stages further ensure that beans are sorted, roasted, and packaged according to predefined standards, reducing recalls and enhancing brand reputation, consistent with results seen in the broader agricultural sector [33]. Real-time data provided by the app improves coordination among stakeholders, reduces shipment delays, and optimizes routes, potentially lowering operational costs by up to 20%, like findings by the World Economic Forum [34]. Enhanced inventory management mitigates supply shortages and overproduction, reducing carrying costs by approximately 22%, aligning with the results reported by the Council of Supply Chain Management Professionals [35]. For farmers, access to data supports precision agriculture, potentially increasing yield quality and productivity by up to 15%. Processors benefit from improved batch tracking and quality assurance, which helps in reducing waste and maintaining high standards for specialty markets. Shippers achieve better logistics management with real-time tracking, enhancing delivery reliability and aligning with Just-In-Time (JIT) principles, thus reducing costs and increasing turnover rates [36]. Customers gain transparency and confidence in product quality, with features supporting ethical sourcing and recycling [37]. The proposed solution integrates blockchain for traceability, real-time monitoring, and robust data validation, ensuring reliability and scalability. While challenges such as high initial costs and the need for stable internet connectivity, particularly in remote areas, may pose barriers to implementation, the long-term benefits of cost savings, enhanced efficiency, and improved quality make the app a compelling solution. Additionally, the application aligns with industry certifications like ISO 9001 and ISO 14001, emphasizing its commitment to quality management and environmental sustainability, which further strengthens its credibility and market acceptance [38]. Table 2 outlines the app's features, supply chain challenges, benefits, and regulatory compliance, demonstrating its strategic design and potential impact on the coffee supply chain.

Table.2. Analysis of mobile application features in enhancing coffee supply chain efficiency and regulatory compliance

Features of mobile application	Challenges in current coffee supply chain	Benefits of implementing mobile application	Certifications/regulations fulfilled
Dashboard	Overview of supply chain status	Real-time data monitoring	Centralized access to all functionalities
Supplier Association	Data collection for seeds, fertilizers, humidity, temperature	Input fields for various inspection parameters	Accurate and timely farm data collection, improving quality and traceability
Farmer	Harvesting data collection and quality control	Input fields for quantity and quality control checks	Ensures quality control during harvesting
Coffee Factory	Sorting, quality checks, roasting, and packaging	Input fields for sorting, roasting, and packaging details	Streamlined factory operations and quality assurance
Warehouse	Processing data entry for batch numbers, dates, and addresses	Input fields for batch numbers, processing dates, and processor addresses	Enhanced tracking of processing stages and batch management
Shipper	Shipment management, quantities, invoices, importer IDs	Input fields for shipment quantities, invoice numbers, and importer IDs	Efficient and transparent shipment tracking and management
Customer	Registration, order tracking, and recycling material submission	Input fields for registration details and recycling submissions	Enhanced customer experience with real-time order tracking and recycling options
Reports and Analytics	Report generation and visual analytics	Filters for date, batch, location, etc.	Data-driven insights and decision-making

6. Conclusion

This study highlights the critical role of mobile applications in enhancing various phases of the coffee supply chain, emphasizing benefits such as real-time inventory management, blockchain-enabled traceability, IoT integration, and mobile accessibility, all of which improve operational efficiency and sustainability compliance. The proposed application proposed real-time data and analytics to optimize production, streamline logistics, address consumer demands for ethical sourcing, and ensure quality control through remote monitoring of environmental conditions, ultimately reducing waste from farm to consumer. Novelty lies in the integration of advanced technologies targeted specifically for the coffee supply chain, providing a comprehensive solution that addresses both operational and sustainability challenges unique to this sector.However, challenges remain, including interoperability issues among platforms, data security concerns with blockchain, high IoT deployment costs in resource-limited settings, slow adoption by small-scale producers, and difficulties in integrating new technologies into existing infrastructures. Future research should address these challenges by enhancing data standardization for interoperability, improving blockchain scalability for large networks, and developing cost-effective IoT solutions for smallholder farmers. Additionally, exploring the socio-economic impacts on coffee-producing communities and assessing long-term sustainability implications will be essential for shaping future strategies and policies, driving innovation, and promoting sustainability in the global coffee market.

Acknowledgement

We acknowledge financial support under the National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.1, Call for tender No. 104 published on 2.2.2022 by the Italian Ministry of University and Research (MUR), funded by the European Union – NextGenerationEU– Project Title PRISMA Platform (Physical internet RegeneratIve Sustainable MAterials) – CUP I53D23001660006 - Grant Assignment Decree No. 961 adopted on 30/June/2023 by the Italian Ministry of Ministry of University and Research (MUR).

References

[1] Nurgazina, J., Pakdeetrakulwong, U., Moser, T., & Reiner, G. (2021). "Distributed Ledger Technology Applications in Food Supply Chains: A Review of Challenges and Future Research Directions". *Sustainability*, **13, 4206**. https://doi.org/10.3390/SU13084206..

[2] Mordor Intelligence. (2021). "Coffee market Growth, trends, COVID-19 impact, and forecasts" (2022– 2027). https://www.mordorintelligence.com/industry-reports/coffee-market.

[3] Wang, Y., Han, J., & Beynon-Davies, P. (2019). "Understanding blockchain technology for future supply chains: a systematic literature review and research agenda". *Supply Chain Management: An International Journal*. https://doi.org/10.1108/SCM-03-2018-0148

[4] Alfian, G., Syafrudin, M., Farooq, U., Ma'arif, M., Syaekhoni, M., Fitriyani, N., Lee, J., & Rhee, J. (2020). "Improving efficiency of RFID-based traceability system for perishable food by utilizing IoT sensors and machine learning model". *Food Control*, **110, 107016**. https://doi.org/10.1016/j.foodcont.2019.107016.

[5] COFFEE REPORT AND OUTLOOK December 2023. (2024). *International Coffee Organization*. https://icocoffee.org/documents/cy2023-24/Coffee_Report_and_Outlook_December_2023_ICO.pdf

[6] H. W. Ibrahim and S. Zailani. (2010). ''A review on the competitiveness of global supply chain in a coffee industry in Indonesia,'' *Int. Bus. Manage*., vol. **4**, no. **3**, pp. **105–115**.

[7] J. Grabs. (2017). ''The rise of buyer-driven sustainability governance: Emerging trends in the global coffee sector,'' *ZenTra-Center Transnational Stud., Germany, ZenTra Work*. Paper Transnational Stud. **73**.

[8] K. Fakkhong and S. Yamsa-Ard. (2021). ''Value chain and market opportunity of Thai's coffee products to enhance the marketability competitiveness among the ASEAN countries,'' *J. Humanities Social Sci. Thonburi Univ*., vol. **16**, no. **1**, pp. **56–67**. [Online]. Available: https://so03.tcithaijo.org/index.php/trujournal/article/view/252559

[9] P. Plengplang and A. Khutrakun. (2020). ''Supply chain management in social enterprise: Case studies of lapato coffee,'' *Political Sci. Public Admin. J.,* vol. **11**, no. **2**, pp. **1–28**.

[10] R. Valverde and R. G. Saadé. (2015). "The effect of E-supply chain management systems in the North American electronic manufacturing services industry," *J. Theor. Appl. Electron. Commer. Res*., vol. **10**, no**. 1**, pp. **79–98**, doi: 10.4067/S0718-18762015000100007.

[11] "Council of Supply Chain Management Professionals" (2014), *CSCMP's Definition of Supply Chain Management*, Available at: http://cscmp.org/about-us/supply-chain-management-definitions (accessed 30/06/2014)

[12] W. O. Widyarto, M. J. Shofa, and N. Djamal. (2019). "Key performance indicators on supply chain performance measurement in an electronic commerce: A literature review," *Int. J. Eng. Adv. Technol*., vol. **8**, no. **5**, pp. **137–141**. doi: 10.35940/ijeat.E1019.0585C19.

[13] H. Feng, X. Wang, Y. Duan, J. Zhang, and X. Zhang. (2020) ''Applying blockchain technology to improve agri-food traceability: A review of development methods, benefits and challenges,'' *J. Cleaner Prod.,* vol. **260**, Art. no. 121031.

[14] S. Saberi, M. Kouhizadeh, J. Sarkis, and L. Shen. (2019) ''Blockchain technology and its relationships to sustainable supply chain management,'' *Int. J. Prod. Res*., vol. **57**, no**. 7**, pp. **2117–2135**.

[15] S. Chen, X. Liu, J. Yan, G. Hu, and Y. Shi. (2020) ''Processes, benefits, and challenges for adoption of blockchain technologies in food supply chains: A thematic analysis,'' *Inf. Syst. e-Bus. Manage*., vol. **19**, pp. **1–27**.

[16] J. Duan, C. Zhang, Y. Gong, S. Brown, and Z. Li. (2020). ''A content-analysis based literature review in blockchain adoption within food supply chain,'' *Int. J. Environ. Res. Public Health*, vol. **17**, no. **5**, p. **1784**.

[17] F. Tian. (2016). ''An agri-food supply chain traceability system for China based on RFID & blockchain technology,'' in *Proc. 13th Int. Conf. Service Syst. Service Manage*., pp. **1–6**.

[18] J. Jaiyen, S. Pongnumkul, and P. Chaovalit. (2020). ''A proof-of-concept of farmer-to-consumer food traceability on blockchain for local communities,'' in *Proc. Int. Conf. Comput. Sci. Appl. Agricult. (ICOSICA)*, pp. **1–5**.

[19] F. Casino, V. Kanakaris, T. K. Dasaklis, S. Moschuris, S. Stachtiaris, M. Pagoni, and N. P. Rachaniotis. (2021) ''Blockchain-based food supply chain traceability: A case study in the dairy sector,'' *Int. J. Prod. Res*., vol. **59**, no. **19**, pp. **5758–5770**.

[20] S. L. Bager, B. Düdder, F. Henglein, J. M. Hébert, and H. Wu. (2022). ''Event-based supply chain network modeling: Blockchain for good coffee,'' *Frontiers Blockchain*, vol. **5**, p**. 5**, Art. no. 846783.

[21] K. Behnke and M. F. Janssen. (2020). ''Boundary conditions for traceability in food supply chains using blockchain technology,'' *Int. J. Inf. Manage*., vol**. 52**, Art. no. 101969.

[22] V. S. Yadav, A. R. Singh, R. D. Raut, and U. H. Govindarajan. (2020). ''Blockchain technology adoption barriers in the Indian agricultural supply chain: An integrated approach,'' *Resour., Conservation Recycling*, vol. **161, 1428**, 104877.

[23] S. Saurabh and K. Dey. (2021). ''Blockchain technology adoption, architecture, and sustainable agri-food supply chains,'' *J. Cleaner Prod*., vol. **284**, Art. no. 124731.

[24] Khan, Y., Su'ud, M. B. M., Alam, M. M., Ahmad, S. F., Ahmad, A. Y. a. B., & Khan, N. (2022). "Application of Internet of Things (IoT) in sustainable supply chain management". *Sustainability*, **15(1),** 694**.** https://doi.org/10.3390/su15010694.

[25] Kampan, K., Tsusaka, T., & Anal, A. (2022). "Adoption of Blockchain Technology for Enhanced Traceability of Livestock-Based Products". *Sustainability*. https://doi.org/10.3390/su142013148.

[26]. C. V. Lombardi, N. T. Chidiac, and B. C. Record. (2021). "Starbucks coffee corporation's marketing response to the COVID-19 pandemic," *Innovative Marketing*, vol. **17**, no. **2**, pp. 177–188. doi: 10.21511/im.17(2).2021.16.

[27]. Y. Liu, Y. Ma, X. Xiao, T. Xie, and X. Liu. (2023). "LegoDroid: flexible Android app decomposition and instant installation," *Science China Information Sciences*, vol. **66**, no. **4**. doi: 10.1007/s11432-021-3528-7.

[28] Che'Ya, N., Mohidem, N., Roslin, N., Saberioon, M., Tarmidi, M., Shah, J., Ilahi, W., & Man, N. (2022). "Mobile Computing for Pest and Disease Management Using Spectral Signature Analysis: A Review". *Agronomy*. https://doi.org/10.3390/agronomy12040967.

[29] D. Simedru and A. Becze. (2023). "Complex Profiling of Roasted Coffee Based on Origin and Production Scale," *Agriculture*, vol. **13**, no. **6**, p. 1146. doi: 10.3390/agriculture13061146.

[30] Matharu, G. S., Upadhyay, P., & Chaudhary, L. (2014). "The Internet of Things: Challenges & security issues," *2014 International Conference on Emerging Technologies (ICET)*, Islamabad, Pakistan,pp. **54-59**, doi: 10.1109/ICET.2014.7021016.

[31] De Felice, F., & Petrillo, A. (2021). "Green transition: The frontier of the digicircular economy evidenced from a systematic literature review", *Sustainability* (Switzerland), vol. **13**(19),11068.

[32] De Felice, F., & Petrillo, A. (2014). "Proposal of a structured methodology for the measure of intangible criteria and for decision making", *International Journal of Simulation and Process Modelling,* vol. **9**(3), pp. 157-166

[33] Tian, N. F. (2017). "A supply chain traceability system for food safety based on HACCP, blockchain & Internet of Things*". In International Conference on Service Systems and Service Management,* Dalian, 2017, pp. **1-6**, https://doi.org/10.1109/icsssm.2017.7996119

[34] Accelerating digital Transformation for Long term growth - *World Economic Forum*. (n.d.). https://initiatives.weforum.org/digital-transformation/home

[35] Gebbers, R., & Adamchuk, V. I. (2010). "Precision Agriculture and food security". *Science*, **327(5967)**, 828–831. https://doi.org/10.1126/science.1183899/

[36] De Felice, F., Petrillo, A., Autorino, C., (2015). "Development of a framework for sustainable outsourcing: Analytic balanced scorecard method (A-BSC)". *Sustainability (Switzerland)* **7(7)**, 8399-8419*.* https://doi.org/10.3390/su7078399.

[37] Lombardi Netto, A., Salomon, V.A.P., Ortiz-Barrios, M.A., (...), Petrillo, A., De Oliveira, O.J., (2021). "Multiple criteria assessment of sustainability programs in the textile industry". *International Transactions in Operational Research*, **28(3)**, 1550 – 1572. https://doi.org/10.1111/itor.12871.

[38] De Felice, F., Petrillo, A., Zomparelli, F., (2018). "Prospective design of smart manufacturing: An Italian pilot case study". *Manufacturing Letters* **15***,* **81-85**. https://doi.org/10.1016/j.mfglet.2017.12.002.