

# Improving a Coffee Cooperative Operations Using Online Traceability Systems

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**Abstract.** Coffee plays a significant role for many smallholder farmers as their source of income. Global practices in the coffee business need quality assurance, and safety across its supply chain, which could be facilitated through traceability systems. Tracking coffee from the producer to the consumer could encourage eco-friendly farming practices and empower consumers with insights to make ethical purchasing choices. Therefore, traceability systems support coffee business requirements and environmental sustainability across its value chain. Wonosalam coffee cooperative, a group of coffee farmers and producers in Indonesia, has started providing simple traceability reports to comply with customer requirements. The report is manually hand-written on the coffee package directly. To better manage the growing coffee business complexity and provide a proper report to customers, this study proposes to develop a mobile phone-based traceability with a QR code system. This application is developed using a User-Centered-Design approach to ensure its suitability to coffee cooperative member requirements. The application has passed the user test with a high user satisfaction level, based on the System Usability Scale. This traceability system application is then extended with quality control and assurance features that enable coffee cooperative members to monitor and improve their business seamlessly.

## 1 Introduction

Traceability refers to the capability to track food products, food-producing animals, or consumable substances throughout their lifecycle, including sourcing, production, processing, and distribution. It serves as a vital mechanism for addressing potential risks associated with food products. When risks are identified by authorities, consumers, or businesses, traceability enables them to pinpoint the source of the issue, facilitating swift withdrawal or isolation of the problematic product. This process not only helps in managing

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risks effectively but also supports businesses in recalling unsafe products to protect public health and maintain consumer trust [1].

Product authenticity is important in agri-food products as it influences consumers' purchase decisions and willingness to pay. It gives consumers great confidence in the quality and safety of the product [2]. Traceability has become a priority for many countries to improve transparency and safety of food and drug products. The European Union (EU) is an organization that issues regulations related to the traceability of food and medicines. Regulation No. 931/2011 discusses the management of documentation of product traceability starting from the origin of the product, when the product is harvested, management, processing, and when the product is distributed [3]. Not only the EU, the United States Food and Drug Administration (FDA) has also issued regulations regarding traceability in food products that have been formalized since 2023. The regulation was published in the International Association for Food Protection (IAFP) webinar with the title Food Traceability Final Rule: Requirements for Additional Traceability Records for Certain Foods (FSMA Section 204) on September 18, 2023, [4].

Coffee is one of the most important agricultural commodities in the world, both in terms of economics and value. Indonesia is the third largest coffee producer in the world. Indonesia's coffee production is continuously increasing since 2018 and reaches approximately 800.000 tons in 2022 [5] [6], as can be seen on Table 1.

**Table 1.** Indonesia's coffee production in 2018 – 2022 (per 1000 Tons)

	2018	2019	2020	2021	2022
Smallholder Plantation	727,9	742,5	757,3	780,9	790
Industrial Plantation	28,1	10	4,9	5,3	4,8
Total Production	756	752,5	762,2	786,2	794,8

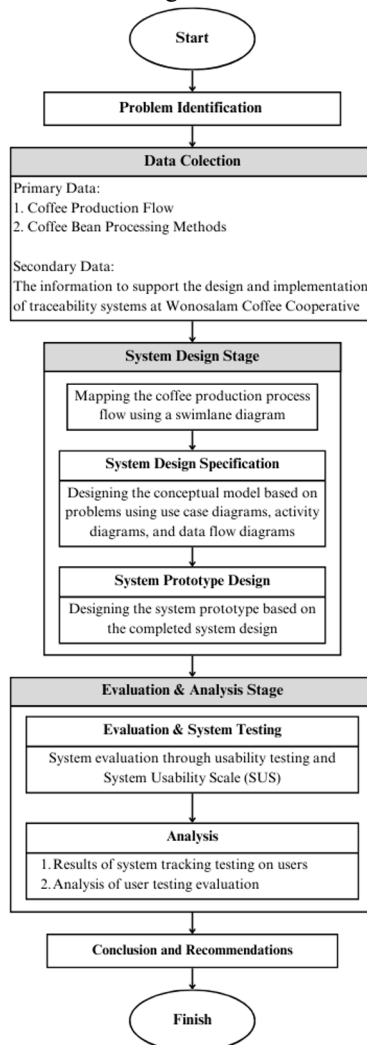
Coffee production in Indonesia is mainly produced by smallholder plantations which include individual or family-owned businesses and coffee cooperatives. Wonosalam Coffee Cooperative is a group of coffee farmers and producers that resides in the area around Anjasmoro mountain, Jombang, East Java. As Wonosalam Coffee has started to export its products overseas, it needs to comply with several requirements, one of which is to provide traceability information. The information includes the origin of the coffee mountain or plantation, the altitude of planting, more specific geographical locations such as subdistricts, districts, and provinces, as well as details on the type of coffee, variety, processing, moisture content, processor, net weight, and year of production. Wonosalam Coffee Cooperative has managed to meet this requirement by writing down all information on paper and then manually transferring the information using permanent markers on the coffee package. However, as the number of cooperative members, customers, and production volume increase, a manual traceability system becomes a complicated task that could lead to inaccurate information. Therefore, to improve the efficiency and reliability of the coffee traceability system, this research aims to develop an automated traceability system. The proposed traceability system utilizes mobile phone-based applications to manage (i.e. input, edit, revise) the data. This application produces QR codes printed on the coffee package, then customers can scan it to get detailed information via its website using a computer and/or a mobile phone. As a result, the traceability process becomes faster, more transparent, and more accurate. While this study aims to develop an automated traceability system (application) for Wonosalam Coffee Cooperative, this application can be utilized for other Coffee Cooperatives or Industries to comply with overseas customer requirements.

To develop the automated traceability system, the User-Centered Design (UCD) approach is utilized to ensure these requirements are met, they are: (1) easy-to-use applications, as the users are coffee farmers and producers who have limited technology digital literacy, (2)

suitability to the needs of Wonosalam coffee cooperative members (coffee farmers and producers) and its customers. UCD approach focuses on the mental state, environmental conditions, and user experience so that it can provide products, systems, or services that are usable, accessible, and satisfying for the people who will use them. [7]. After the design is complete, the automated traceability system is tested using the System Usability Scale (SUS). A similar study to develop a traceability system for a medium-sized coffee producer is reported in [8]. However, this research uses a Computer-Based Information System (CBIS) as it has a different focus which is the utilization of computer technology and information systems in managing data and business operations.

## 2 Method

This research uses a User-Centered Design (UCD) approach, starting with identifying the current condition of the Wonosalam coffee cooperative, collecting data needed for the design process, designing a suitable solution, and evaluating the resulting solution to ensure its suitability for user needs, as can be seen at Fig. 1..



**Fig. 1.** Flowchart of the Research Methodology

### 3 Result and Discussion

#### 3.1 Required Data

Before designing a traceability system for Wonosalam Coffee Cooperative, relevant and detailed data is needed. The first step is to understand the flow of coffee production in the cooperative. This understanding is important for mapping the flow of information to be designed using activity diagrams, to describe the process systematically. In addition, understanding the production flow will help identify the type of data required as input as well as the data to be displayed in the information system. The data includes the stages of production, the parties involved, and important information that needs to be provided to ensure effective product traceability.

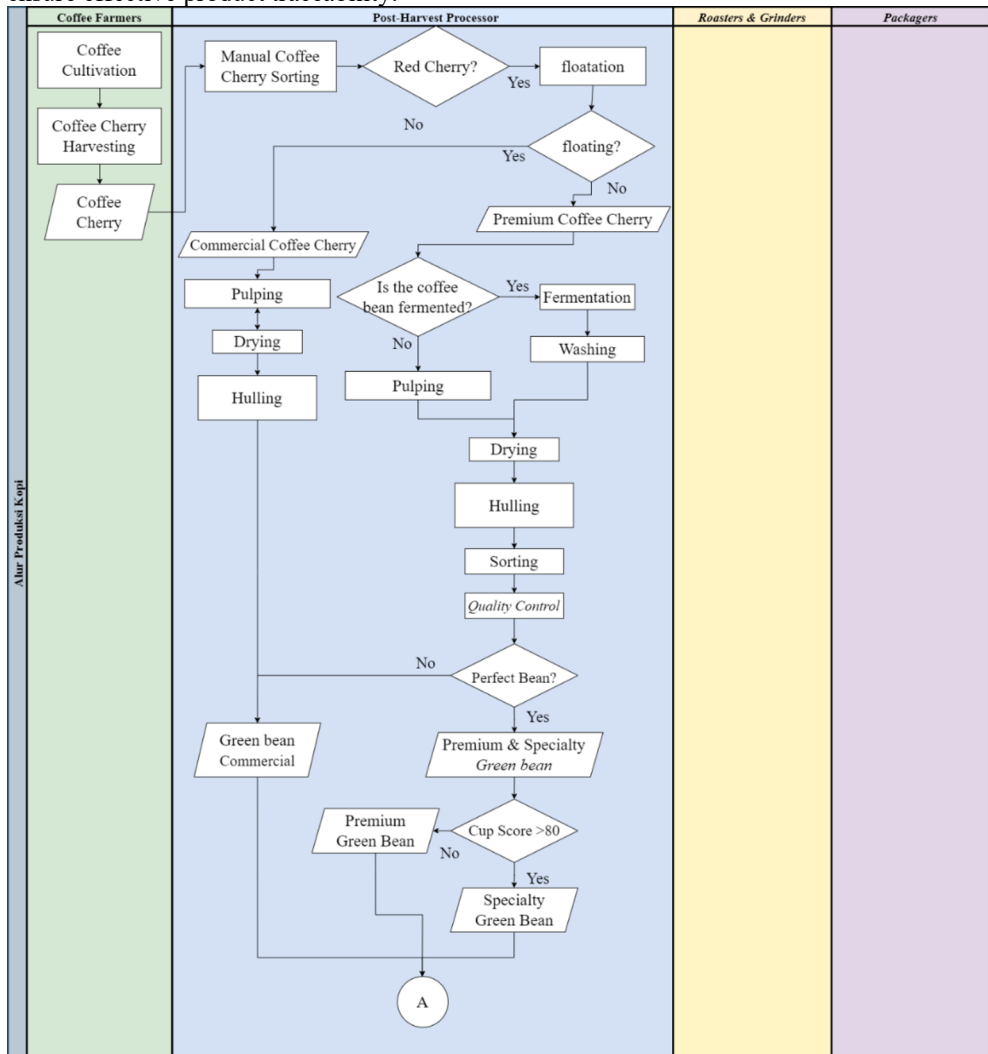


Fig. 2. Wonosalam Coffee Cooperative Production Flow

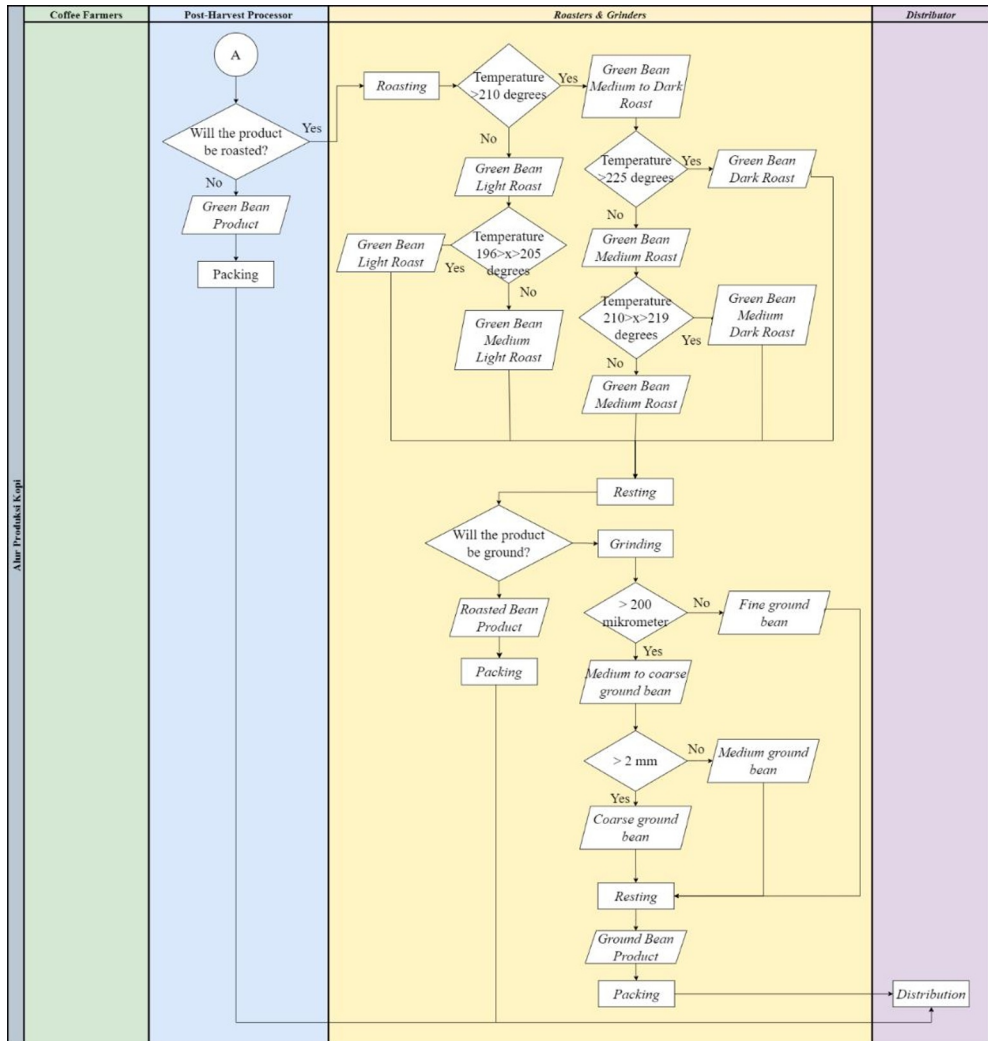


Fig. 3. Wonosalam Coffee Cooperative Production Flow (continued)

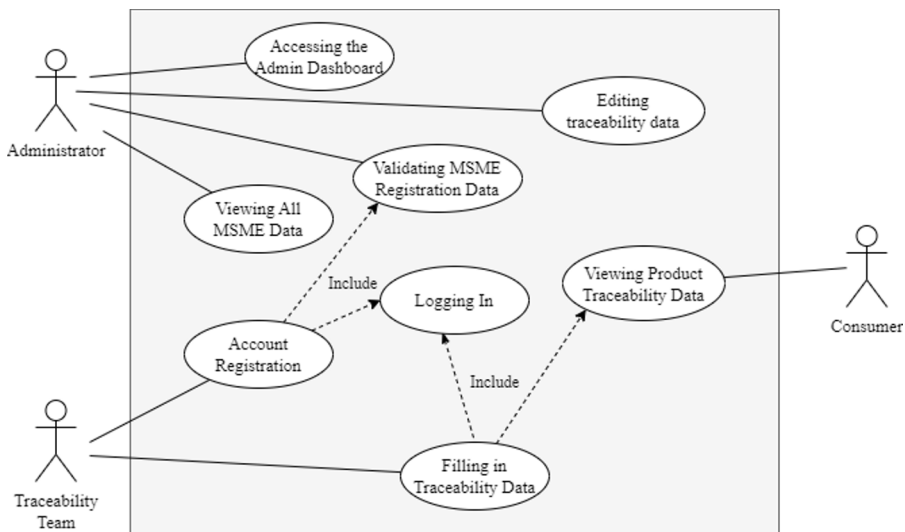
The coffee production process at Wonosalam Coffee Cooperative involves four main operators. Coffee farmers, post-harvest processors, roasters - grinders, and distributors. (Figure 2), and (Figure 3), show the production flow of Wonosalam coffee cooperative. The process starts with the production of coffee cherries (i.e. planting and harvesting) by coffee farmers, then it is followed by post-harvest processing by processors that produce green beans. This post-harvest stage is very important as it determines the flavor, aroma, and quality of the coffee. In general, there are three levels of coffee quality, namely: commercial, premium, or specialty grades. If the product is sold as green bean, it is directly packaged and distributed. The process continues to the roasting stage when it needs to produce a roasted bean. Products that are not sold as roasted beans go through the grinding process and the output is called ground beans. Data input on the application is designed to follow production flow and refer to guidelines from ISO 9000:2015. The information that is displayed in the Table 2 is the result of various considerations, such as traceability regulations, emerging trends, and discussions with Wonosalam coffee cooperatives leader.

**Table 2.** List of information

Information to be Displayed on the System
Origin Information
Mountain
Subdistrict
Regency
Province
Elevation
Variety
Coffee Type
Post-Harvest Process
Moisture level
Processor
Roast Level
Roast Date
Grind Size
Production Date
Best Before

### 3.2 Use Case Diagram

Use case diagrams represent interactions between actors in the application by providing an overview of how the system is used. In this system, there are three main actors, namely the administrator, traceability team (coffee producers), and consumers. Wonosalam coffee cooperative secretary becomes the administrator of this traceability system. The traceability team is run by coffee cooperative members, while consumers receive output in the form of QR codes that can be scanned to the designated website.



**Fig. 4.** Use Case Diagram

(Figure 4) . shows the draft use case diagram for this application, which includes the functions, limitations, and objectives of each actor in the system to be designed. Administrators have access to an application dashboard that is used to validate accounts that register on the application. After the account is successfully registered, the Administrator can access the account profile data and product. In addition, the Administrator also has the authority to adjust the types of information for consumers as needed. The task of Traceability Team is to record all information regarding the whole coffee production process. Meanwhile, consumers get a QR code based on the product that they order and receive traceability information that has been documented by the Traceability Team.

### 3.3 Activity Diagram

This diagram (Figure 5) shows the activities of each user of the traceability application (i.e. Administrator, Traceability Teams, and Consumer) when using it from start to finish. First, the Administrator manages the traceability application. The administrator, who is one of the managers of Wonosalam coffee cooperative, can verify individuals who are eligible to be the application users. Next, administrators can edit or make changes to traceability information as needed as they can get access to any data in the application. Second, the Traceability Team, a member of Wonosalam Coffee Cooperative (farmer or producer), should register before using this application. The Traceability Team is responsible for filling all required information (coffee types, coffee form, elevation, variety, Post-Harvest Process, Moisture level, etc). When the final product is reached, the application generates a QR code that can be printed or attached to the coffee packaging. Third, the consumer is the coffee buyer (in the form of green beans, roasted beans, or ground coffee). Consumers find the QR code attached to coffee packaging. They can scan the code and see the detailed history of the coffee.

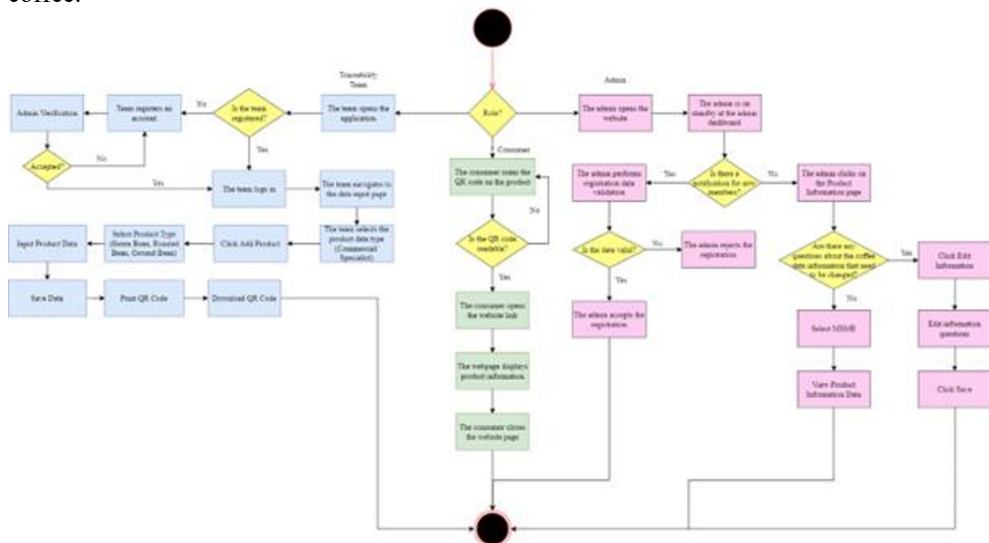
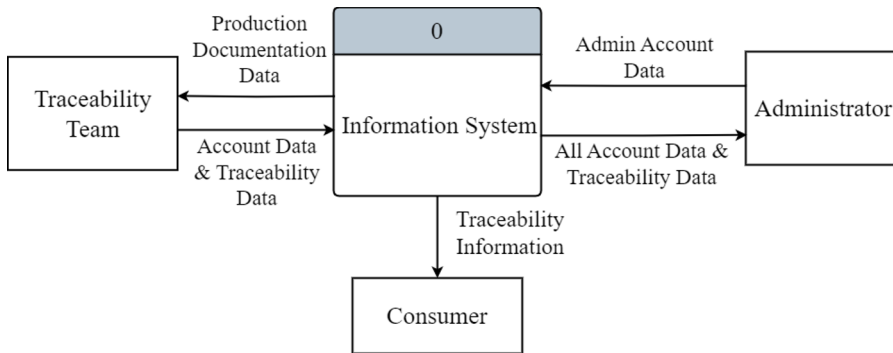


Fig. 5. Activity Diagram

### 3.4 Data Flow Diagram

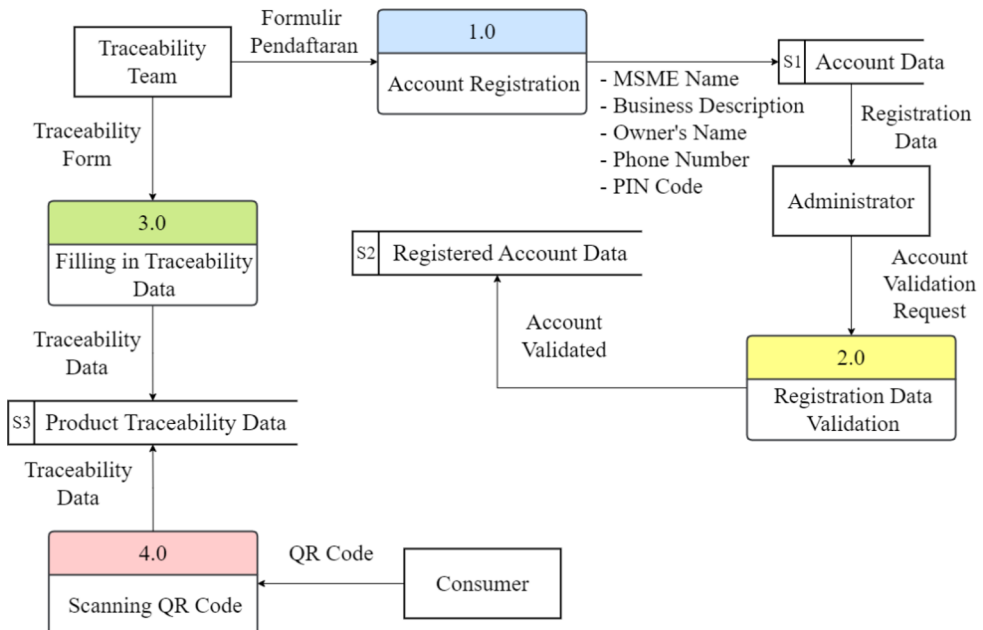
Data Flow Diagram (DFD) is a tool used to describe the workflow or steps in a process with a focus on data flow and transformation. DFD consists of three main elements, namely external entities (actors involved in the application), processes that occur in the system, and

input and output data stored in the application. In this research, the DFD will be presented at three levels: level 0, level 1, and level 2, which describe the flow of data in the traceability application at Wonosalam Coffee Cooperative.



**Fig. 6.** Data Flow Diagram (Level 0)

DFD level 0 will provide information about what happens to the system and the interactions that happen in its environment. In (Figure 6), the interaction between consumers and applications only occurs in one direction. This is because consumers can only access the application to view product traceability information by scanning the QR code found on the product packaging.

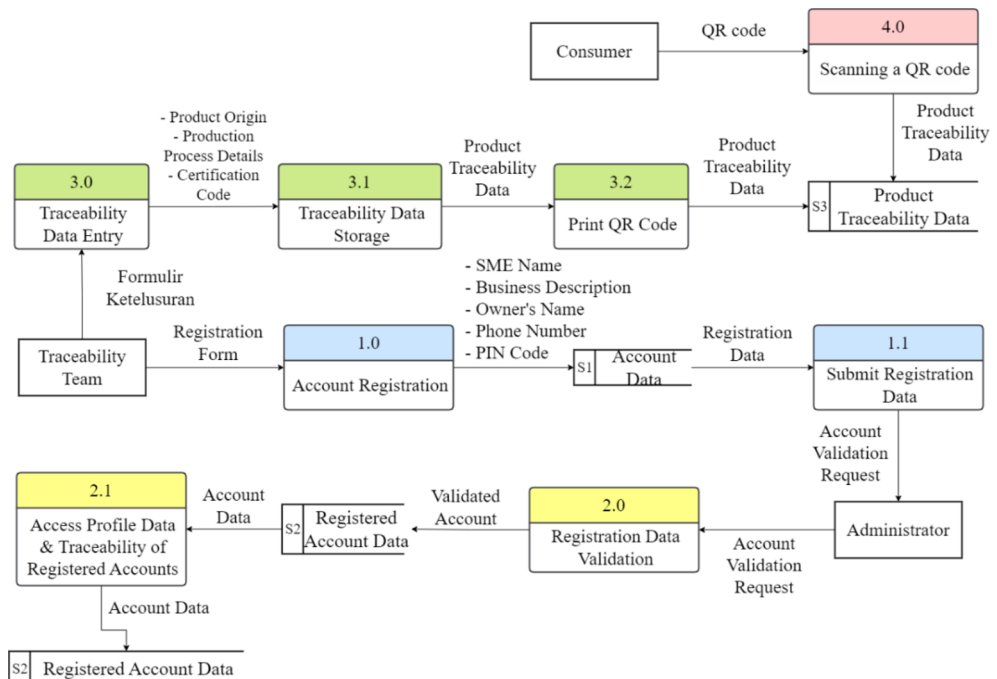


**Fig. 7.** Data Flow Diagram (Level 1)

In DFD level 0, it describes how interactions occur between external entities and the system as a whole. Meanwhile, at DFD level 1, the focus is on interactions between entities to achieve the goals of the system. At this level, there are four main processes in the application as described in (Figure 7).. The first process is the registration of the brand on the application, which allows documentation of the coffee



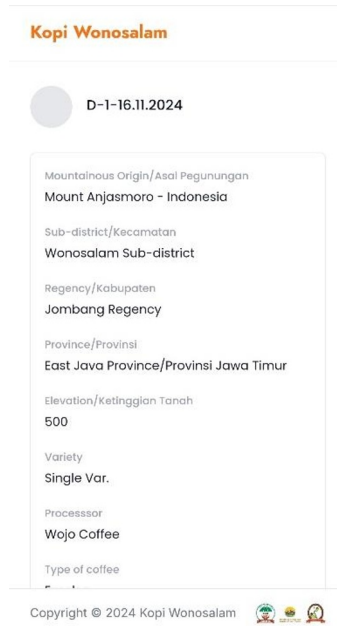
production process carried out by the brand. The second process is the validation of the registering brand by the administrator or core management of the cooperative to ensure that the registered account is a legitimate and registered brand in the cooperative. The third process is filling in coffee production traceability data, which documents the details of the coffee production process. Finally, the fourth process is the scanning of QR codes by consumers to access the cooperative's product traceability information directly. In (Figure 8), DFD level 2 is shown which breaks down the process at DFD level 1 into more detailed subprocesses. At this level, the stages that occur in the application are explained, starting from account registration by the Traceability Team until consumers can access or view coffee production traceability data on Wonosalam Coffee products.



**Fig. 8.** Data Flow Diagram (Level 2)

### 3.5 Prototype & System Design

The design of the traceability system is based on the required data, use case diagram, activity diagram, and data flow diagram. (Figure 9). shows the display for consumer perception, where consumers receive traceability information that is documented by the Traceability Team by scanning the QR code found on the Wonosalam Coffee product packaging.



**Fig. 9.** Product Details - Consumer View

### 3.6 Usability Testing

The test conducted in this study utilizes the System Usability Scale (SUS), which is a questionnaire or a series of ten questions that provide a general view of the subjective assessment of the feasibility of using a system [9]. Ten individual members from Wonosalam Coffee Cooperative are selected to conduct the test. There are several tasks in the application that should be tested by these respondents, they are as follows: (1) Administrator validate accounts that submit account registration requests, (2) Administrator edit questions from the traceability form, and (3) Traceability Team member fills in the traceability data and prints the QR code.

At first, the respondents are given 5 to 10 minutes to explore the traceability application after instal in their owned mobile phones. Then, respondents are given 10 questions (as can be seen on Table 3) and they should choose one answer out of five options based on the Likert scale (1 to 5), they are as follows:

- Strongly Disagree = 1
- Disagree = 2
- Neutral = 3
- Agree = 4
- Strongly Agree = 5

**Table 3.** Questions for System Usability Scale Testing

No	Questions
1	I think I will use the Wonosalam Coffee Application again.
2	I find this application complicated to use.
3	I find this application easy to use.
4	I need assistance from others or a technician when using this application.
5	I feel that the features of this application work as they should.
6	I feel there are many inconsistencies in this application.
7	I believe others will quickly understand how to use this application.

8	I find this application confusing.
9	I feel there are no obstacles in using this application.
10	I need to get used to this application before using it.

The score from each respondent as well as the final results can be seen in Table 4. The score Usability testing is 76.5 which indicates the proposed automated traceability application is feasible to use.

**Table 4.** SUS Test Result Score

No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total	Score SUS
1	3	3	4	3	4	4	3	4	4	2	34	85
2	3	3	3	2	3	3	3	3	3	2	28	70
3	3	3	3	3	3	3	3	3	3	2	29	72,5
4	4	4	3	2	3	4	3	4	3	2	32	80
5	4	4	3	1	3	4	3	4	3	1	30	75
6	4	4	3	1	3	4	3	4	3	1	30	75
7	4	4	3	2	3	4	3	4	3	2	32	80
8	4	4	4	1	3	3	4	4	3	1	31	77,5
9	4	4	3	2	3	3	3	4	3	2	31	77,5
10	4	3	3	2	3	3	3	3	3	2	29	72,5
Average	3,7	3,6	3,2	1,9	3,1	3,5	3,1	3,7	3,1	1,7	30,6	<b>76,5</b>

Even though the score of usability testing shows good acceptance from users (Wonosalam Coffee Cooperative members), there is still a need for assistance during the initial implementation of this application. Therefore, a training or workshop for all Wonosalam Coffee Cooperative members is provided to ensure everyone can benefit of this online traceability application.

## 4 Conclusion

The online traceability system for Wonosalam Coffee Cooperative is proposed to answer the rise of market demand volume. This mobile phone-based traceability system or application is developed utilizing User-Centered Design (UCD) and tested according to System Usability Scale (SUS). These approaches are selected to provide a traceability application that is user-friendly specifically for Wonosalam coffee farmers, coffee producers and customers. The SUS testing score of this application is 76.5 which indicates a good acceptance by Wonosalam coffee cooperative members as it meets their expectations and needs.

Traceability plays a crucial role in promoting environmental sustainability in coffee production worldwide. Understanding the coffee journey, from its source up to the cup, supports the adoption of sustainable practices as well as ensures product quality and safety. A proper traceability system is essential not only for Wonosalam Coffee Cooperatives but also for all coffee industry players in Indonesia to comply with the requirements to gain acceptability, especially from overseas customers to further expand the market.

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