2022-01-27

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Hindawi

https://doi.org/10.1155/2022/6041197

Hindawi
Mobile Information Systems
Volume 2022, Article ID 6041197, 11 pages
https://doi.org/10.1155/2022/6041197

Research Article

Design a Services Architecture for Mobile-Based Agro-Goods Transport and Commerce System

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Received 29 October 2021; Accepted 4 January 2022; Published 27 January 2022

Academic Editor: Peter Brida

Despite massive mobile phones adoption globally, Agriculture Supply Chain (ASC) in Tanzania is challenged by the low adoption of m-commerce integrated to m-payment and m-transport services as key information enablers for efficiently linking farmers to buyers. With such an inefficient and ineffective information gap, middlemen have become information custodians by decreasing farmers' bargaining power in the market. In addressing the challenge, this study uses stakeholders to validate core services needed and proposes service architecture for Agro-Goods Transport and Commerce (AgroTC) system using installable and build-in mobile phone applications (internet web, mobile apps, and USSD). The proposed method appreciates a user-centric approach for system development. A scenario of the potato supply chain in Tanzania was considered where 2309 respondents were interviewed from farmers, buyers, and transport service providers from a predetermined sample size ($n = 384$) having a 95% confidence level. Data were collected using mobile phones configured with Open Data Kit (ODK) technology and analyzed using the R Studio tool with Pandas libraries. The results indicated that buyers were not interested in disease and land management information. Collectively, farmers (74%) and buyers (60%) highly demand m-commerce services as a virtual platform for linking them. Only farmers showed concern about disease management information. Furthermore, 35% of the farmers and 57% of the buyers need m-transport, whereas 35% of the farmers and 69% of the buyers need m-payment service Deleted. It was revealed that the remaining percentages lack knowledge on mobile phone features to perform online businesses. All transport service providers pointed to the challenge of existing middlemen in reaching customers and required technological change in managing transport systems. The proposed mobile-based AgroTC architecture provides a foundation business approach in Tanzania and many developing countries. System developers and innovators can use the proposed architecture design to design prototypes using the preferred language to meet ASC stakeholders' needs and expectations.

1. Introduction

Electronic commerce (e-commerce) is defined as a platform initiated to support the selling and purchasing of goods, services, and knowledge via the Internet web. E-commerce technology has recently advanced to mobile commerce (m-commerce) through massive available mobile devices, such as smartphones, laptops, and tablets [1]. DeletedMobile devices allow users to perform e-commerce processes ubiquitously.Evidently, the global population is approximately 7.8 billion people having 3.8 billion smartphone users [1]. Apart from ubiquitous advantages, portability and massive access among mobile phone users, there are other influencing factors associated with global migration from e-commerce to m-commerce. Some noted factors include increasing demand for efficiency among users, such as cost reduction, reduced merchant liabilities, high transaction security, effectiveness in terms of time-saving, high Internet service penetration rate as well as reduced Internet subscription charges, the Internet of Things (IoT) technologies, such as point of sales (PoS) and smartphones, and artificial intelligence (AI). Despite the COVID-19 pandemic, worldwide e-commerce sales continued to grow. Latin America leads with a growth rate of 36.7% globally compared to the Middle East and Africa with 19.8% as the least in 2021 [2]. The data signifies the importance of enhancing e-commerce activities among the global population.

The evolution of e-commerce and m-commerce has impacted many sectors in developed and developing countries. Specifically, the agriculture supply chain (ASC) sector has evidenced many e-commerce and m-commerce platforms initiated to support selling and purchasing agricultural goods (agro-goods), also, in transport, loading, unloads, tracking, and tracing agro-goods [3]. Like many developing countries' economies, Tanzania largely depends on agriculture, accounting for 12% of GDP. The country's population is estimated at 61.7 million people, with 61% of the entire workforce employed in agriculture, 80% of which are smallholder farmers [1]. One critical challenge facing Tanzanian farmers in the agriculture supply chain (ASC) context is limited access to market information to reach buyers and transporters. Existing e-commerce and m-commerce platforms in Tanzania [1, 4–6] focus on linking farmers to the buyers but fail to address how agro-goods are delivered to buyers. Therefore, modeling agro-goods transportation is context-specific and requires consideration of policy involvement, high-cost infrastructure requirements, and user readiness to adopt the technologies.

Despite the challenge, mobile phone usage in rural and urban areas creates massive opportunities for adopting m-commerce in Tanzania. Tanzania Communication Regulatory Authority (TCRA) statistical report of December 2020 revealed that Tanzania has a high penetration of mobile phone services with 32 million mobile money subscribers, 51.2 million mobile network subscribers, and 28.4 million Internet users [7]. Such Internet penetration widens opportunities for e-commerce and m-commerce implementation and usage to interlink at least 50% of the country's population. Smart mobile devices, such as smartphones and intelligent PoS, have embedded Global Positioning System (GPS) and accelerometer sensors [8], which are critical features to support transport services. The application of Information and Communication Technology (ICT) to achieve safer, efficient, and effective transportation services is called Intelligent Transport System (ITS). Therefore, using smart mobile devices complements the need for ITS infrastructure in terms of Road Side Unit (RSU) and On-Board Units (OBU).

This study acknowledges the lack of knowledge and the presence of complexities in handling transport information, high technological infrastructure requirements, and the cost of implementations which are the main setbacks to the existing system. The challenges raise the critical research question on how the existing scarce resource infrastructure is utilized efficiently and effectively to integrate transportation of agro-goods e-commerce platforms. In this view, the study aims to address the challenge and develop a web and mobile-supported e-commerce system that offers selling, purchasing, and transport of agro-goods with a K^{th} price sealed bid approach. The K^{th} price sealed bid makes fair judgments among competing buyers and transporters [9]. K is the highest-ranked buyer and lowest-ranked transporter. The platform utilizes available Tanzania's Road Network casing potato supply chain. Potato (scientific name: *Solanum tuberosum*) emerged to be fourth popular after maize, wheat, and rice [10]. Studies show that there has been an increased demand for potatoes such that 70% of the total potato produced is consumed in urban areas by French fry processors [11–13]. The study also aims to address the challenges by evaluating the MAGITS framework [1] and addressing transportation challenges identified in [14].

The contribution of this paper is threefold:

(i) Providing analysis of the current ICT usage in the Potato commodity supply chain in Tanzania
(ii) Establishing the stakeholders' needs for the use of mobile phones in sales and transportation of potato agro-goods
(iii) Proposing mobile-based system architecture for sharing transport and commerce information among stakeholders.

The rest of the paper is organized as follows. Section 2 focuses on related works. Section 3 discusses the methodology used, while Section 4 entails the results and discussion. The proposed system will be presented in Section 5 followed by the conclusion and future work presented in Section 6.

2. Related Works

Studies have demonstrated the importance of information sharing between farmers and buyers using mobile commerce in developing countries [14–17]. Mobile phones' ubiquitous nature, portability, and affordability compared to desktop computers and laptops are noted factors for widespread adoption. The m-commerce platforms utilize the web, Unstructured Supplementary Service Data (USSD), SMS, mobile apps, interactive voice response (IVR), and voice calls to facilitate exchanging information among stakeholders. Typical examples include Kudu [14], Mercantile Exchange, M-Kilimo, Connected-farmer [1], Esoko [4], First Mile Project [5], M-Farm [18], KACE [6, 19], and Twiga Foods [20]. These existing systems use the web and mobile features to provide advice on price, location, and product information related to farmers and buyers; however, there is a gap in agro-goods transportation information sharing among farmers and buyers [1, 6, 14]. This study addresses the lack of transport functionalities in mobile commerce as an important part when fulfilling order delivery to buyers from farmers.

Limited efforts have been made toward transport inclusion in the ASC using mobile phones. The report [21] emphasizes the role of mobile technology in data visibility, improving efficiency in agricultural transportation, and enhancing access to agricultural markets. The report outlines the importance of mobile phones in collecting location, speed, and route data to achieve intelligent logistics, tracking and tracing the agricultural products from farm to shops, and managing suppliers' networks. In the same direction, [1] proposed an m-commerce-based framework for the potato supply chain by saving time, removing traveling costs in searching for markets, simplifying agro-goods information availability, and creating possible solutions agro-goods traceability. Also, a detailed study on traceability is found in [22]. In the effort to transport inclusion in agro-goods e-commerce, [1] posits the importance of integrating Intelligent Transport System in agro-goods e-commerce while focusing on the potato supply chain in Tanzania. The use of the mobile phone as the sensor in Intelligent Transport System (ITS) has been discussed in [8]. The study [2] insisted on the importance of logistics in delivering the right agro-goods at the correct quantity, place, time, and cost.

A study for evolving an electronic marketplace in Uganda [14] reveals the lack of transport information critically hinders the business model. As a proposed solution, [1, 5] see that using aggregation information from geographically dispersed smallholder farmers and locating them to single shared transport located in the near road is one efficient way to increase participation in the market. The approach lowers transportation costs incurred by smallholder farmers to meet Full-Truck-Load (FTL) requirements. The GPS coordinated maps, road network data, time, and network route optimization algorithm [3], such as Dijkstra's algorithm [23], to determine the shortest path from reported smallholder farmers to the nearest collecting vehicle located in an identified road-side virtual-collection point.

The advancements in computing technology, such as High-Performance Computing (HPC), Internet of Things (IoT), cloud computing, artificial intelligence (AI), and big data generated from agro-goods e-commerce platforms make it possible to predict and optimize the demand and supply. For example, in [17], the study demonstrates using cloud computing to develop an intelligent agro e-marketplace architecture for the crowd data warehouse to indicate the right product linking farmers to buyers. Reference [1] posits that machine learning (ML) techniques for optimization and prediction use variables, such as products, locations, price, and quantities, to develop different important patterns to support decision-making, while [14] sees the importance of ML in future predictive performance. Under the IoT architecture, [24] designed and implemented the real-time traceability monitoring system for the agro-goods supply chain using Near-Field Communication (NFC) technology. The four layers, namely, physical, data, service, and application layers, were presented to achieve data collection, storage, analysis, and virtualization in intelligent management and traceability of the agriculture supply chain (ASC). Conclusively, the study confirms that IoT in ASC traceability improves the quality of people's livelihood and standardizes agro-goods markets' operational processes.

The m-commerce virtually gathers both farmers and sellers using mobile phones. In case many buyers seek one product simultaneously, the auction approach is inevitable to achieve fair competition. In the literature by [9], three types of auctions were noted. The first is the English auction, where the price of products is raised until one bidder remains. The Dutch auction is when the auctioneers' desirable price and the bidder win from the willingness to pay the final price. In realizing the need for auctioning in agro-goods e-commerce, [9] further proposed smartphone-supported e-auction and data flow architecture with the registration process, products description and bid setup, bidding, and evaluation. A case study of Location-Based Service (LBS) using GPS to auction for freight transport was presented in the study [25].

Additionally, a study [26] used a mathematical approach to link farmers and retailers efficiently using an auction approach in intermediaries. The results show that farmers' profits improve with less market share among intermediaries. In the Kudu project [14], buyers are able to register and bid for the type of product, quantity, and price using mobile phone web, SMS, calls, and Unstructured Supplementary Service Data (USSD).

3. Methodology

3.1. Study Area and Sample Size. The case study conducted in Tanzania focused on potato agro-goods transportation from the Njombe region to the Dar es Salaam. In the Njombe region, as a rural area, researchers focused on two districts of Makete and Wanging'ombe. In Dar es Salaam as the urban area, the researchers concentrated in Ilala, Ubungo, and Kinondoni districts because of the availability of concentrated major potato marketplaces arriving from Njombe region. The study area is shown in Figure 1. A study from [1] presented the case study scenario and its associated challenges. The selection of the regions relied on the fact that Njombe region is among the leading producer and Dar es Salaam city is the dominant consumer of Irish potatoes. The study limited to road transportation since 75% of the total freights are transported through the roads.

The study considers potato agro-goods transport from rural to urban as the forward chain. Potatoes are transported from the rural roads, through highways to urban roads from Njombe region to Dar es Salaam city as shown in Figure 2.

The study focuses on four main stakeholders, namely, farmers, collection center managers (collectors), buyers (French fryers), transport service providers (TSP), or transporters [1]. The TSP will act as distributor in this case. Since a sample population is unknown, the probabilistic sampling approach is used to estimate the sample population. A 95% confidence level is used with ± 5% error. The sample size is determined using the following formula:

$$n = \frac{\left(Z_{(\propto/2)}\right)^2}{4e^2} = \frac{(1.96)^2}{4 * 0.05^2} \approx 384\,\text{samples}, \tag{1}$$

where n is sample size, $\propto/2$: is (1-confidence level)/2. Required for calculating the z score, z is the numerical score showing the relationship between the mean value and standard deviation from the mean. For 95% confidence interval, z value is ± 1.96 and e is error margin for the unknown population which is ± 5%

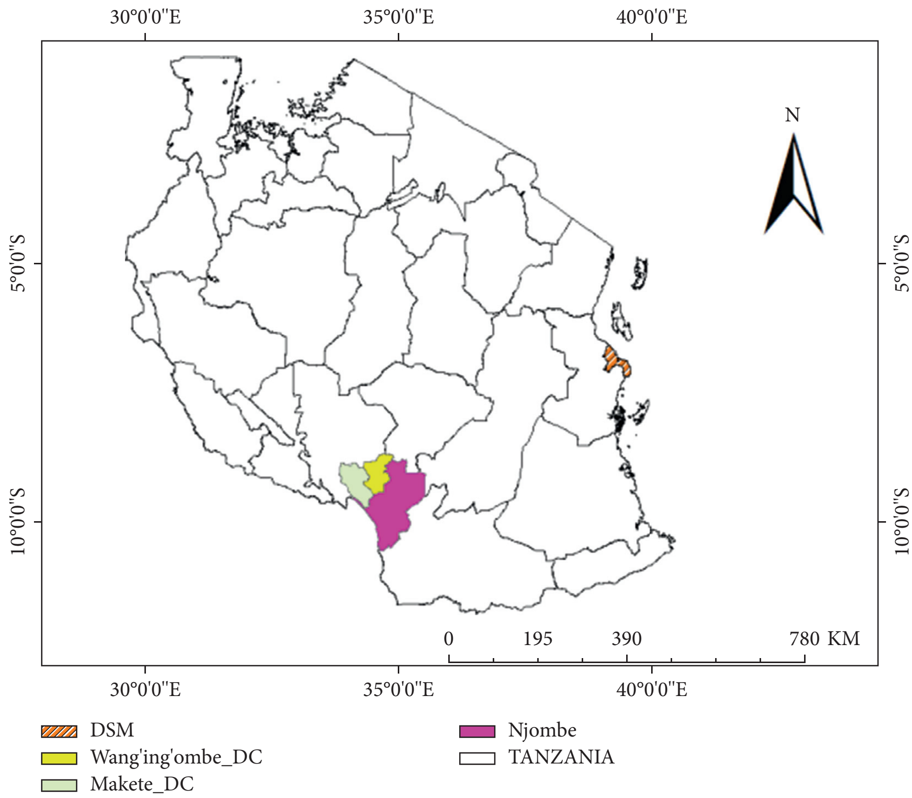

Figure 1: Study areas in Tanzania, Eastern Africa.

Table 1 presents a combination of stratified and cluster sampling techniques from the population for each stakeholder used in this study.

3.2. Methods, Tools, and Techniques. Literature review, observation from site visits, and survey using questionnaires were used in this study. The methodology is structured using the following phases.

3.2.1. Phase I: Review of Related Works, Observation, and Questionnaire Formulation. A literature review was conducted to get detailed domain knowledge in ASC, focusing on e-commerce, e-marketplace, and e-logistics edging on web and mobile devices technologies. The summary is provided in Section 2 of this paper. To gain insight into the actual scenario of a case study [1], the observation approach was conducted to equip the team with a detailed understanding of the real situation on the ground, that is, natural setting or as-is scenario.

The researchers could not find evidence of the existing ICT system that links farmers and buyers. Hence, a survey using structured questionnaires was developed to gather information. The questionnaires contained five (5) questions as follows:

(1) What are the demographic characteristics of farmers and buyers involved in the potato supply chain?

(2) What is the preferred type of produced potato and how is it packaged, sold, and highly consumed in Dar es Salaam?

(3) Which type of mobile phone do farmers and buyers possess?

(4) What are farmers' and buyers' perceptions on mobile money service and the challenges faced when coordinating transport services?

(5) What are the users' needs for the new system?

3.2.2. Phase II: Data Collection and Analysis. For data collection, primary quantitative data were collected in 35 days using interviews from January to April 2020 targeting on learning challenges of transportation during the rainy season. Before the interview, each interviewee learned the importance of core services (m-commerce, m-payment, and m-transport) as enablers to their individual economic development and society at a broad scope. The researchers aimed to equip interviewees with maximum choices and allow free user participation in establishing the need. The Open Data Kit (ODK) was used to prepare and deploy the questionnaires using an android-based smartphone. The collected data is stored and accessed using Google sheets [27]. Since the data was collected using a smartphone, each interviewer was required to visit the appropriate farms, collection centers, and French fryers (potato chips sellers) locations. The aim is to capture the GPS coordinate at each point [28]. For transporters, the GPS coordinate will be captured on demand due to the dynamic nature of moving vehicles. GPS coordinates are essential for Location-Based Services (LBS) such as routing, distance, pick-up, and

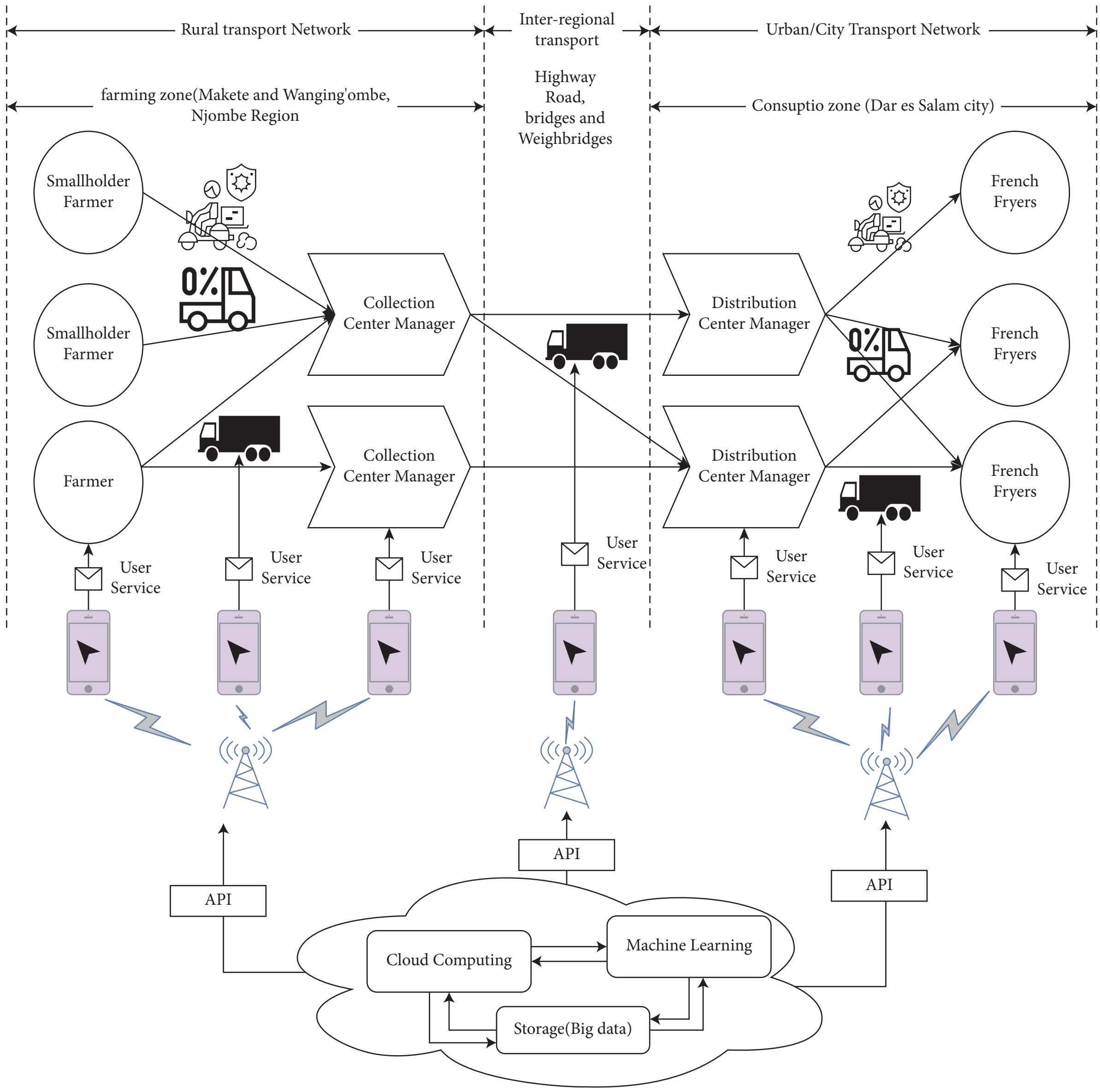

Figure 2: Mobile supported potato supply chain in Tanzania (adopted from [1]).

Table 1: Population sample.

Stakeholder (user)<	Geographical area	Sample size
Farmers	Njombe	1142
Buyers (French fryers)	Dar es Salaam	1117
Transporters (TSP)	Dar es Salaam and Njombe	50
Total		2309

delivery points. Quantitative data were analyzed using the R Studio software.

4. Results and Discussions

This section presents the findings obtained from data analysis. Demographically, the results mainly focus on the gender and age of respondents. From the sample size ($n = 384$) initially set, however, 2309 managed responded to the questionnaires due to the simplified mobile-phone-based approach used in data collection from the paper-based process. It was observed that the type of potato grown varies from year to year. This approach is vital in disease control among farmers, the marketing strategy invested by potato seed suppliers, and the market demand. The government frequently authorizes to interfere with the packaging to protect farmers. For example, the government has restricted eight tin bags because of unrealistic measurements.

In the study, four potato names were identified per farmers' preferences. The local names available are International Potato Center (CIP), Obama [13], Tigo-Tengeru, and Cherekea [10]. Farmers also commented on CIP to tolerate market need due to lasting ability in the ground up to eight months, while Obama needs harvest on time so it can accept the market challenges delays than other species.

4.1. Demographic Characteristics of Farmers and Buyers. The results presented in Table 2 shows that males (98% French fryers and 59% farmers) dominate the buyer-seller interaction than females (2% French fryers and 41% farmers). A significant percentage observed on females participating in the farming activities than French frying business. It was noted that only 1% of farmers are aged 18–24 years and 65 years and above. The results imply that 98% of the farmers lies between 25 and 64 years old, with 35–44 years occupying 35% of the workforce. In the French fries business, 70% are between 25 and 34, followed by 35 to 44, covering 17% of the population engaged in the industry. On education level, 37 farmers did not attend formal education compared to all buyers who have received formal education. The majority of farmers and buyers possess primary and secondary education. It was revealed that 18% of the farmers had received vocational education, while buyers had only 1%. Three farmers were found to have university education weighed against 22 buyers.

4.2. Potato Packaging, Consumption, and Price Information. It was observed that farmers used the 20-liter plastic cylindrical-shaped tin as a measurement tool to fill potatoes in the bags. The two bags used can fill 5-tin and 8-tin bags. Among the potato breed, farmers were selected; 60% grow International Potato Center (CIP), 38% grow Obama, and 2% grow Tigo-Tengeru. The results resembled respondents' data obtained from the demand side of the French fryers where 56%, 33%, 11%, and 1% prefer CIP, Obama, Tigo-Tengeru, and Cherekea, respectively. Potato prices vary depending on seasonal availability and market trends. While all costs and prices were collected and analyzed in Tanzania Shillings (TZS), it was revealed that the farmers' price per 5-tin potato bag ranges between TZS 20,000 to TZS 35000 in the high availability and 40,000 in the low availability. In the Dar es Salaam market, the buying price ranges from TZS 35,000 to TZS 40,000 in the high season and up to TZS 55,000 in the low season. French fryers were interviewed to gain consumption bags per day; the result entails that 65% consume only one bag, and 30% were those who consume two sacks, while the remaining 5% consume three bags per day.

4.3. Availability and Usage of Mobile Services among Stakeholders. In understanding the importance of ICT service, respondents were interviewed to respond to mobile phone usage and Mobile Network Operation (MNOs) services. The majority of farmers (95.3%) and French fryers (99.7%) possess mobile phones as a communication tool and information sharing. 65.6% of French fryers own smartphones of those possessing mobile phones, while 34.2% own feature phones. It was also indicated that 39.7% and 60.3% of the farmers own smartphones and feature phones. All respondents acknowledged using mobile money service almost daily. However, very few use mobile money services to pay farmers in purchasing agro-goods. Many respondents (84.1% buyers and 85.5% farmers) use cash payment methods over online payment systems such as mobile money and banks.

4.4. Surveys on Transportation Aspect Related to Time and Costs. While 100% of respondents (TSP) pointed to the challenge of existing middlemen in reaching customers, 83% agreed that mobile phone technologies would timely links with transport service clients, minimize transportation delays (increases mobility), and lower transportation costs without middlemen. Few TSP (17% respondents) lack knowledge on the importance of technology, and no respondent (0%) disagreed. While accessing the potato agro-goods transport cost, it was found that prices depend on the farm's location to the pick-up point and buyers' locations. The majority of farmers (54.8%) responded to pay TZS 1000 per bag, and 28.8% of respondents pay TZS 2000 per bag, while the rest pay between TZS 2500 and TZS 5000 per bag for transportation from harvest point to farm gate, collection center, or market.

4.5. Core Service Needs among Buyers and Farmers. The study [21] posits that using intelligent mobile-based information systems in the agriculture supply chain minimized carbon dioxide (CO2) emission from vehicles and reduced post-harvest losses (PHL). The m-payment, m-commerce, and m-transport are critically important business services when linking farmers to buyers. A clear description for each service and information sharing requirement to different stakeholders is covered in [1]. Users voted (using yes/no options) against predefined needs established from the case study using observation and literature review.

The results of the analysis linking farmers and buyers are presented in Figure 3. From the analysis, it was found that only farmers showed great concern about disease management information. It was also found that 35% of farmers and 57% of buyers need m-transport, 35% of farmers and 69% of buyers need m-payment information, and 60% of farmers and 74% of buyers need m-commerce services. It was revealed that all remaining percentages depend on word of mouth as the source of information and lacks knowledge on other mobile phone features apart from SMS and voice call functionality to perform online businesses. Such constraints have also been addressed in the study in [29].

5. Proposed Mobile-Based AgroTC System

5.1. System Architecture and Stakeholders Interactions. The core function of the AgroTC system is to facilitate information exchange between transport services providers (TSP) and transport service clients (TSC), who are buyers,

Table 2: Demographic characteristics of farmers and buyers.

Demographic information		Farmers/sellers		Buyers/French fryers	
		Frequency	Percent	Frequency	Percent
Gender	Male	677	59	1098	98
	Female	465	41	19	2
	Total	1142	100	1117	100
Age	18–24	11	1	124	11
	25–34	343	30	782	70
	35–44	401	35	193	17
	45–54	319	28	18	2
	55–64	59	5	0	0
	65–or-above	9	1	0	0
	Total	1142	100	1117	100
Education level	Informal education	37	3	0	0
	Primary education	638	56	513	46
	Secondary education	264	23	576	52
	Vocational education	200	18	6	1
	University education	3	0	22	2
	Total	1142	100	1117	100

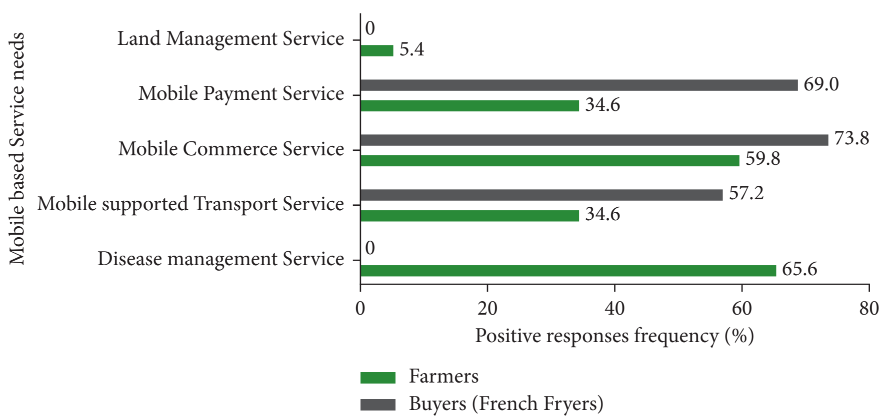

Figure 3: Service needs among farmers and buyers.

farmers, and collectors. The system also enables all stakeholders participating in the agro-goods supply chain to interact modernly through mobile phones and personal/office computers. The system answers the questions about who purchases, what type of agro-goods, what quantity and price, delivery time distance, and when the order is completed. The core services are mobile commerce (m-commerce), mobile payment (m-payment), and mobile-based intelligent transport (m-intelligent transport). The system adopts the Service Oriented Architecture (SOA) with each service (i.e., m-commerce, m-payment, and m-transport) is loosely coupled and communicates with other systems using Application Programming Interface (API) technology. AgroTC will register and use a close-bid auctioning approach [9] to allow fair competition among buyers and transporters. The computing environment, enabled with machine learning processing, is critically essential in route optimization to achieve the shortest route in distribution agro-goods and propose virtual collection centers to be used by smallholder farmers in aggregating agro-goods for transport sharing purposes. The collected data will assist in providing informed decisions in various social, economic, and technological challenges related to ICT, agro-processing industries, agriculture plantations, and transportation. Figure 4 presents the system architecture of AgroTC as extended from Figure 2.

5.2. Core Services Blocks and Information Flow

5.2.1. Mobile Commerce (m-Commerce) Service. The system creates a seamless environment for linking farmers, transport service providers, and buyers in a virtual way. The approach is vital in ensuring maximum profit by skipping multiple middlemen challenges, increasing smallholder farmers' bargaining power to the market, and reducing transportation costs and time. Since most farmers use featured phones, the collection centers will register farmers and coordinate the ordering process. Farmers will be able to interact with the system using both mobile app and USSD technology. Since many farmers (60.3%) possess feature phones which do not capture GPS coordinates, collector will

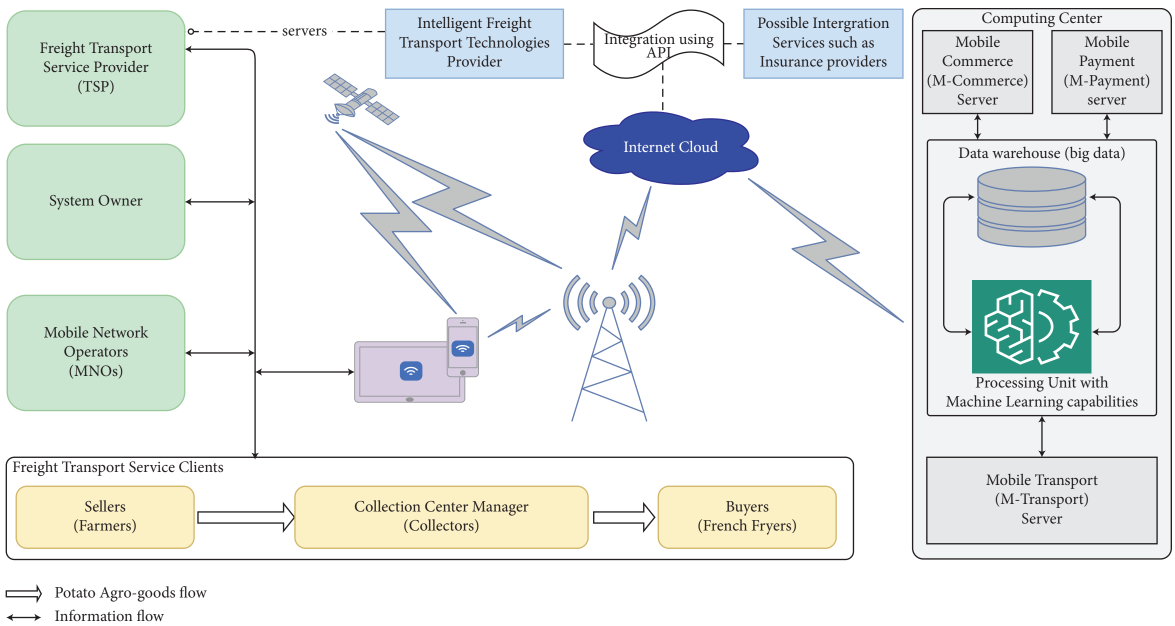

Figure 4: System's architectural view of AgroTC.

register all nonsmartphone owner farmers for later USSD usage.

On harvest, farmers use USSD in feature phone to receive an option for submitting to and receiving information from the AgroTC in a predefined menu by dialing the unique number provided by mobile network operator (MNO) to access such service. The information includes crop type, quantity, and price where the collection center manager (CCM) approves it before publishing it to the AgroTC catalog. Figure 5 provides a sample description of the buyer in the agro-goods bidding process. Farmers, with smartphones, register directly with the role of CCM and register other farmers, including themselves as farmers and CCM. After publishing the details in the catalog, all buyers bid for the submitted product detail under a limited time slot set by system. A common approach is to establish a countdown time from publishing to closing the bid. For example, the bidding may last for six hours before the system blocks new submissions to provide room for processing the bid and awarding the winner. The system then recommends the highest bidder notify the bidder giving a specific time interval to accept. When the declared winner agrees to the offered price through payment, the confirmed order information automatically be published in the m-transport service to be accessed by TSP. The information contains transport requests showing the type of agro-goods, pick-up location, and delivered place.

5.2.2. Mobile Payment (m-Payment) Services. Through the AgroTC system, online payments are possible using the Application Programming Interface (API) integrated with the mobile network operators (MNOs) and financial institutions in Tanzania. The payment system performs both aggregation and disbursement of the transaction on behalf of the interacting stakeholders. The system provides payment verification by holding payments between buyer and transport and farmers as the seller. The approach is as follows. The buyer pays for agreed price and transportation cost to the system and receives verification code through mobile phone. On delivery, the buyer enters a verification code to confirm payment to the transport service provider and farmer. The farmer and TSP receive order payment notifications but cannot access the payments until successful delivery, while buyers cannot withdraw the amount after order confirmation. It means the system holds the payment until successful delivery, as expressed in Figure 6. This mechanism assures transaction safety as no payment is withdrawn until the delivery of agro-goods to the buyer. The approaches also build trust among participants and reduce challenges associated with middlemen interaction in each process.

5.2.3. Mobile Transport (m-Transport) Services. TSP receives information from m-transport, which was previously published from m-commerce paid order and request for transport. The TSP then submits their sealed price and delivery time bid, where the top five lowest bidders are offered for buyer's choice. The buyer picks one bidder among recommended and pays for the transport cost. The system administers and assigns roles using a web panel. The approach minimizes loading in the mobile app. Smallholder farmers are always dispersed, and they need optimized collection points to aggregate their agro-goods. The machine learning (ML) method application set accurate GPS positions of collection points. The collectors (collection center managers) promote and build confidence in their participation in economic activities. Transport service providers get information about the location of transport demands and the required quantities to be transported. Transport service clients who, in this case, are collection center managers and

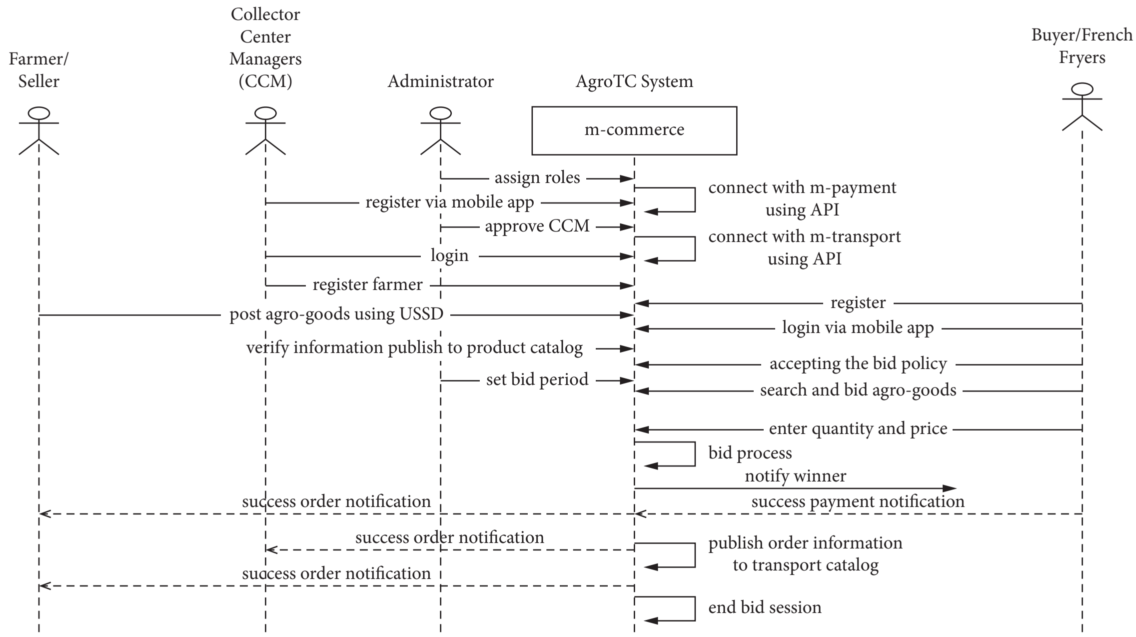

Figure 5: High-level sequence diagram showing the m-commerce process.

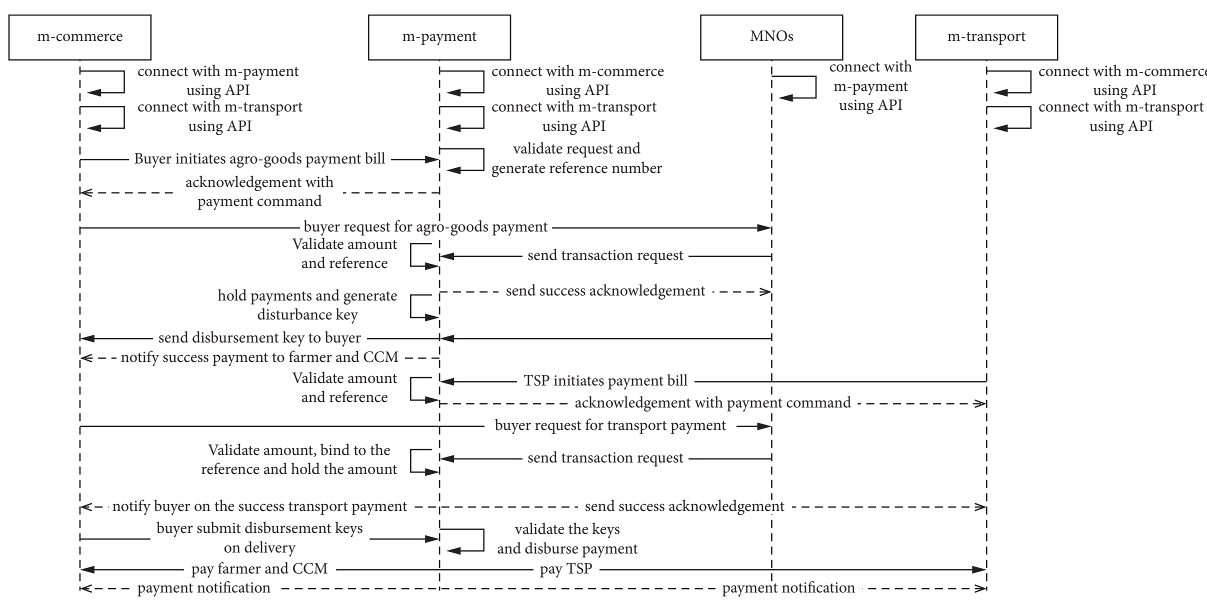

Figure 6: High-level sequence diagram showing the m-payment process.

buyers access more feasible options of the transport they need, and the cost of each transportation needs to deliver agro-goods to the market or food processing locations.

In general, AgroTC uses the Intelligent Transport System approach to track and trace the movement of goods in vehicles during the transportation time. Machine learning (ML) algorithms, commonly used by Dijkstra to determine the shortest route in the network [30], are employed to optimize the transportation cost of goods from the farm, collection centers to the market, or food processing locations. The intelligent freight transport system providers (in Figure 4) are technology providers responsible for offering

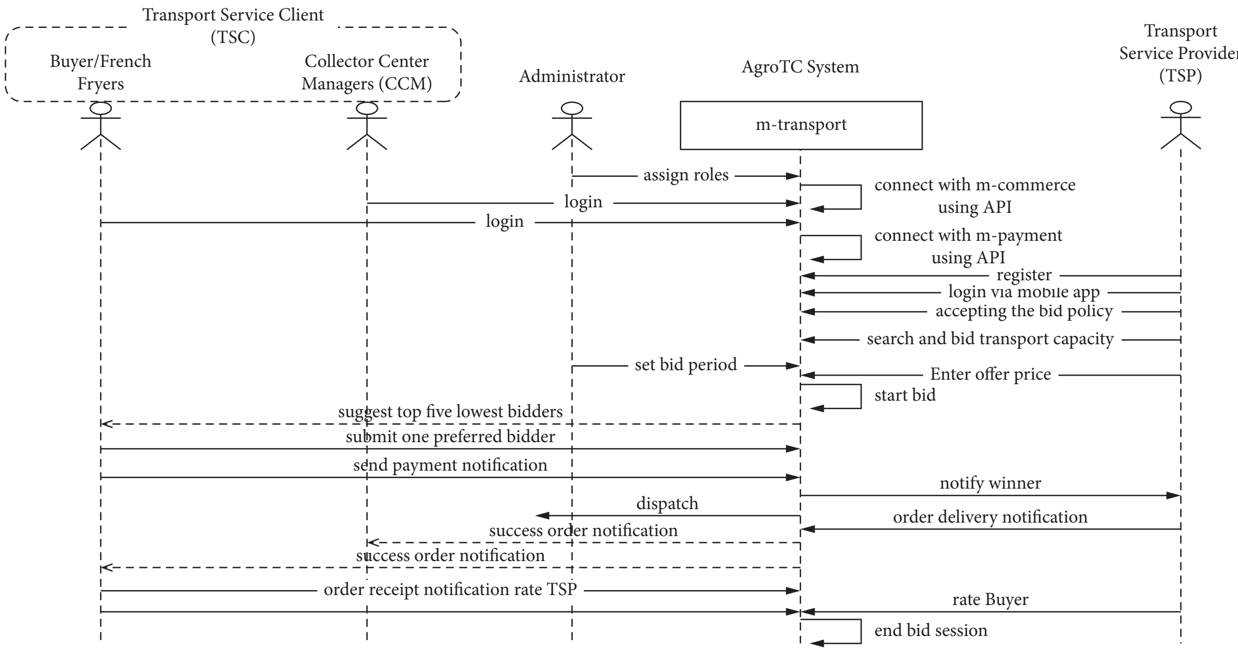

Figure 7: High-level sequence diagram showing the m-transport process.

the state-of-the-art devices to the transport services providers (TSP). These devices can capture and disseminate GPS and other information critical for the identification and management of the vehicle, such as capacity, driver's behavior, weather, location, and speed. Figure 7 shows the sequence diagram for m-transport.

6. Conclusion and Future Works

Many advantages of using AgroTC have been presented throughout this paper. The system bridges the problem of incomplete data in the planning and government decision-making in understanding the agro-good demand and supply in Tanzania. The collections of massive data from reliable sources significantly predict the agro-goods supply chain. Compared to many existing systems, one main contribution is integrating mobile payment systems into mobile payment. The two services (m-payment and m-transport) are essential but lacking in many m-commerce systems in Tanzania. The information provided through the AgroTC will improve farmers' negotiation power when linking to buyers, increase fairness in the ordering system among transporters and buyers, and bridge the existing information gap resulting in less dependent on multiple middlemen. The system operation's results play a decisive role in developing policy briefs to assist the government in migrating from existing manual transportation to Intelligent Transport System (ITS) and smart cities.

This study provides a comprehensive and efficient system linking farmers, buyers, and transporters intelligently. The study focuses mainly on Tanzania, but the system can be adopted in many developing countries with a similar environment, such as transport infrastructure, mobile network coverage, mobile phone users, and affordable phones. Although the requirements for systems are context-specific, the system architecture offers a benchmark that can be adopted in many developing countries due to their similarities in scarce resource environments and devices used. The identified needs and the study approach by utilizing the method of the votes embrace user centered in architecting the system. Moreover, it fosters innovation from predefined services based on experience, expert observations, and existing literature. It sets a benchmark for Programmers, business analysts, and system designers to interact with ASC stakeholders in developing an information-sharing system. Regardless of the programming language used toward the system prototype, the approach will increase efficiency in ASC using ICT.

Data Availability

The primary data used to support the findings of this study are available on request to the corresponding author.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Acknowledgments

The study was supported by the Ministry of Works and Transport of the United Republic of Tanzania.

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