MAGITS: A Mobile-based Information Sharing Framework for Integrating Intelligent Transport System in Agro-Goods e-Commerce in Developing Countries

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***Abstract*—The technological advancement in Intelligent Transport Systems and mobile phones enable massive collaborating devices to collect, process, and share information to support the sales and transportation of agricultural goods (agro-goods) from farmer to market within the Agriculture Supply Chain. Mobile devices, especially smartphones and intelligent Point of Sale (PoS), provide multiple features such as Global Positioning System (GPS) and accelerometer to complement infrastructure requirements. Despite the opportunity, the development and deployment of the innovative platforms integrating Agro-goods transport services with e-commerce and e-payment systems are still challenging in developing countries. Some noted challenges include the high cost of infrastructure, implementation complexities, technology, and policy issues. Therefore, this paper proposes a framework for integrating ITS services in agro-goods e-commerce, taking advantage of mobile device functionalities and their massive usage in developing countries. The framework components identified and discussed are Stakeholders and roles, User Services, Mobile Operations, Computing environment with Machine Learning support, Service goals and Information view, and Enabling Factors. A Design Science Research (DSR) method is applied to produce a framework as an artifact using a six-step model. Also, a case study of potato sales and transportation from the Njombe region to Dar es Salaam city in Tanzania is presented. The framework constructs the ability to improve information quality shared among stakeholders; provide a cost-effective and efficient approach for buying, selling, payment, and transportation of Agriculture goods.**

Keywords—Intelligent transport system; stakeholders; mobile phone; agro-goods; information sharing; agriculture supply chain; machine learning

I. Introduction

The availability and sharing of quality information are of paramount importance to stakeholders involved in the whole process of transportation of agricultural goods (agro-goods) from farms to the markets or buyer locations. Traditional Transport Management Information System (TTMIS) can offer such solution but has a limitation in achieving maximum efficiency such as the ability for users to access the location of the Transporter instantly, driving behavior of the driver, timely access to weather condition in the position of agro-goods, traffic congestion status with alternative routing in cities and precision in the estimation of the delivery time.

The Intelligent Transport System (ITS) introduction offers vast opportunities that address the limitations observed in TTMIS. ITS mainly utilizes Information and Communication Technologies and sensors to ensure cleaner, efficient and safer road transportation of freights and Passengers [1]– [3]. The ITS allows Information Systems to make decisions that will benefit stakeholders intelligently. However, the requirements for development and deployment vary from one country to another due to different factors such as geographical structure, the way transport infrastructure is planned, the availability of technologies, social and economic differences.

The adoption and use of ITS have increased tremendously, since its inception in Japan and later in the USA and Europe over three decades [4]. The importance of ITS cannot be undermined. The global ITS market counted to 26.68 billion USD in 2019, and it is predicted to reach a 5.8% annual growth rate from 2020 to 2027[5]; but, the COVID-19 pandemic affected the market growth predictions. Significant factors influencing such change include the growing number of road vehicles, lack of traffic data, increasing demand for real-time information exchange in logistics, and advancements in big data, Artificial Intelligence (AI), blockchain, and the Internet of Things (IoT).

The developments and impacts of ITS have been realized high in developed countries [6], especially in transportation services, such as autonomous vehicles and applications to smart cities. There is little focus on Freight Intelligent Transport Systems (FITS) when viewing local contexts in developing countries. Some of the main challenges associated with FITS are the lack of transparency in data sharing to keep a competitive advantage against business rivals [7], [8]. Even though the adoption of blockchain technology promises to address this challenge as explained by [7], [8], high implementation cost and complexity of the nature of freights in terms of handling requirement parameters such as size, weight, type (hazardous vs. non-hazardous, perishable vs. non-perishable, etc.).

ITS technologies for handling freight transportation include ubiquitous computing, IoT, wireless sensor networks, RFID, GPS, GPRS, GIS, artificial intelligence, and mobile phones. The increasingly mobile phone usage is crediting ITS development. A recent report reveals that out of 7.8 billion of the total world population, 4.88 billion mobile phone users worldwide, having 3.8 billion are Smartphone users. Sub-Saharan Africa recorded 34% smartphone connection in 2017. It is estimated to reach 67% by 2025 [9]. Some of the fueling factors are lower cost of Internet, cheaper devices, and increasing realization of the service provided by smartphones over the regular phone. This increased penetration of mobile phones, especially smartphones as sensors, has changed the way businesses and services are conducted globally. The ubiquity, power, and versatility of smartphone platforms have become valuable data generators in commerce, transport [2], financial services, agriculture [9], and infotainment.

Despite the advantage offered by mobile phone users globally, there is little focus on applying Mobile phone services integrated with ITS and e-commerce platforms the Agriculture Supply Chain (ASC) to improve transport efficiency of agricultural goods between stakeholders. In developing countries like Tanzania, the application of ITS is at its infancy with limited ITS infrastructure, operational standards, and governing policies. Evidently, there are existing e-commerce platforms linking farmers to markets. For example, Tanzania Mercantile Exchange Market (https://www.tmx.co.tz), which is government-owned platform; mkilimo (http://mkilimo.esrf.or.tz), which uses USSD code; tigo kilimo using USSD, SMS and voice; WeFarm (https://about.wefarm.com/platform) focusing on livestock, and Connected-farmer, which aims to improve agri-business efficiency of smallholder farmers. Although the platforms efficiently operate in Tanzania, many available systems lack integration with transport services. Therefore, users still have limitations in terms of the ability to search, acquire, and manage transport information of agro-goods as.

The contribution of this paper is to propose a mobile phone-based framework integrating intelligent transport systems and e-commerce as a practical approach to assist stakeholders in sharing information during the planning and execution of agro-good sales and transportation. The framework uses mobile phones as a multifunctional tool for solving the challenge of scarce technical resources to facilitate information sharing. Also, the paper identifies and analyzes the stakeholders and needs based on their roles in the system. The study further addresses the technological challenges in the limited access and use of transport information for farmers identified in [10]; and removing missing information to link farmers and other stakeholders, information barriers caused by intermediaries in ASC, identified in [9], [11]. The framework will not cover the internal warehousing operations with assumptions to be handled by Enterprise Resource Planning (ERP).

The rest of this paper compasses the case study as presented in Section II and related work in Section III. Section IV discusses the methodology used in this study, followed by a proposed framework as articulated in Section V. The illustration and evaluation of the framework are described in Sections VI and VII, respectively. Jointly, the conclusion and recommendation are given in Section VII.

II. Case Study

A. Background

In Tanzania, agriculture is the backbone and the leading contributor of the national economy accounting for 28.2% of the GDP in 2018[12]. The total population estimates at 58 million [13], but [14] estimates at 61 million in 2021. About 65% of the entire labor force lives in rural areas and depends on agriculture for daily living. It is also estimated that 80% of the concentrated rural farmers are smallholder farmers. The survey report by [15] indicated that Tanzania produced 68,000 tons of Irish potato in 2019; the production increased by 59% to reach 108,000 tons in 2020. Recent studies show an increased demand for potato consumption in urban areas to process French fries, also known as chips [16], [17].

Road transportation is the primary means for delivering potatoes to the consumers. It is estimated that 75% of the total freights are transported through an estimated 86,472 km road network [18]. In the current practice, the transportation of Potato agro-goods flows from rural to urban. This study focuses on the effective and efficient use of the limited available resource on Potato agro-goods transportation from the Njombe region to the Dar es Salaam region. The selections of the areas rely on the fact that Njombe is the leading producer, and Dar es Salaam is the primary consumer of Irish potato.

In the Njombe region, as a rural area, the study is based on two districts of Makete and Wanging’ombe. Wherein Dar es Salaam, as the urban area, the study concentrated in Ilala, Ubungo, and Kinondoni districts because of the availability of concentrated major potato marketplaces where potatoes from Njombe are delivered. Potatoes will be transported from Njombe rural road network through the highway to Dar es Salaam City with urban roads.

The sales, purchases, and transportation of agro-goods from farmers (in Njombe) to buyers (in Dar es Salaam) require seamless information sharing between stakeholders. Mobile phone technologies and functionalities provide a unique chance to simplify the processes. For example, the Tanzania Communications Regulatory Authority (TCRA) quarterly subscription report [19] recorded 51.2 million mobile network subscribers, 32 million mobile money subscribers, and 28.4 million internet subscribers by December 2020. Such information reveals the stimulating environment for mobile phone use in accessing services. In addition, mobile phones require sharing information with other devices such as vehicle tracking systems, intelligent cameras, etc., to build IoTs. Tanzania has a machine-to-machine (M2M)/IoT management guideline to create a better environment for exchanging information [20]. The guidelines are vital in using mobile phones to develop an Intelligent Transport System to facilitate agro-goods sales, purchase, and transport.

B. Challenges

In the ASC, the enabling environment and features provided by mobile phones assure services such as seamless linking of farmers to buyers or markets, the provisioning of inputs for farming, and the formal and informal exchange of agricultural information and recommendations [21], [9], [22], [10]. Many existing ICT initiatives focus on market, pest and disease, weather, soil, financial, insurance, and technical advisory information [11]. Despite usefulness, the existing solutions lack transport integration as the fundamental aspect to ensure the movement of agro-goods from one point to another within ASC stakeholders. The transport integration challenges have also been expressed in the paper [10]. The road transportation of agro-goods is currently inefficient due to a lack of information sharing among agro-goods stakeholders. Since Tanzania is characterized by smallholder farmers, lack of information provides middlemen the opportunity to set prices for farmers [23], blocking the market's bargaining power. Also, transporters on their business face a similar challenge of middlemen while linking with buyers. In particular, tracing what, when, why, where, how, and who has transported agro-goods is a severe challenge [11]. Smallholder farmers have to wait for a long time for the transporters to collect small agro-goods from other sources to meet truckload requirements. Hence, delivery time becomes uncertain, and transport charges are becoming higher due to a lack of information sourcing. Besides, data on transport and agro-goods that eventually illustrate the actual demand for goods is inadequate.

III. Related Works

A. Mobile Phone Usage in Agriculture Supply Chain

In developing countries, mobile phones have contributed to agriculture and rural development by providing access to information, knowledge, services, and market [24], [25], [26]. The mobile phone penetration has further streamlined agro-goods supply and demand. It reduces post-harvest loss through real-time information exchange between agriculture stakeholders, makes delivery more efficient, and forces closer links between farmers and consumers. In Malaysia, the study by [7] proposed five linking participants and their roles engaging in the physical flow of the pepper agri-food supply chain. At each stage connecting the participants, the third-party logistics (3PL) provider ensures an exchange of agri-food information. Tanzania largely depends on the movement of agricultural goods from rural to urban and involves several stakeholders or Actors. A study by [27] presented a typical chain from Producer, Collection Distribution, Marketing, and Consumption as modified in Fig. 1. A clear description of the Transport Service Client (appear as Transport user) and Transport Service Provider is found in the paper [28]. In the process of developing a framework for accessing market information for farmers, the recommendation for improving ICT connectivity, electrifying rural areas, and increasing awareness of ICT issues were provided [27]. The author posits that minimizing communication costs will motivate rural farmers to purchase mobile phones as an effective tool for accessing marketing information. A survey performed in the Iringa region –Tanzania revealed that mobile phones are not strongly impacting the yields; the agriculture stakeholders positively perceive mobile phone use in agricultural tasks such as accessing information about fertilizer transportation [9]. Hence, call for policy intervention on promoting the use of the mobile phone. While mobile phones, especially smartphones, have become more popular and affordable among agriculture stakeholders in Tanzania [10], [19], their ability to access and disseminate information has positively impacted efficiency, reduced transaction costs, and increased income among ASC stakeholders.

B. Mobile Phone and Freight Intelligent Transport System

Before digging further, it is an excellent reminder to note that agricultural goods (Agro-goods) are agricultural yields for commercial purposes whose source details have come from the farmer and can be perishable or non-perishable. Transportation of perishable goods differs from non-perishable in handling during transport and monitoring parameters such as temperature and humidity, and delivery time. In such a situation, accessing real-time information impacts the value of agro-goods in transport. Mobile phones, especially smartphones, have been the best approach because they provide multiple functionalities using installed sensors to deliver the required information while also interacting with users using mobile applications.

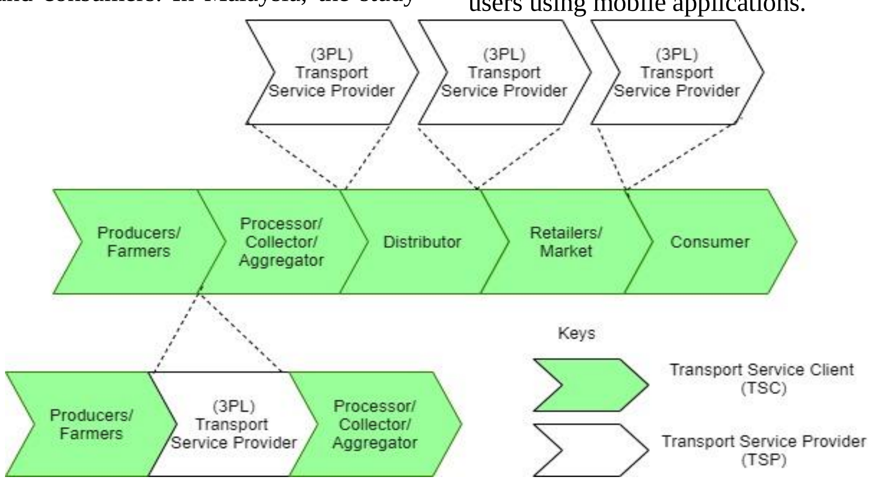

Fig. 1. Information Sharing between TSC and TSP in the Agro-goods Supply Chain (Modified from [7], [27]).

The argument is also supported by [29], posit that smartphone sensors such as Magnetometer, GPS, and accelerometer are critical in developing mobile applications in the Intelligent Transport System environment to capture the compass, location, and speed. Previous studies have complemented GPS-based traffic information exchange between vehicles and infrastructure specifically for road transport performance using GPS and other Intelligent Transport System sensors. In [30], a study demonstrated using GPS data collected from freight trucks for dynamic route planning and visualization using various traffic information such as travel time, route planning, and other congestion indices from the FITS-based application. The vehicle identification, location, and timestamp of record were captured. The study used the floating phone to observe long path trips. A web was developed to fit in more complex logistic business applications and scientific research usage.

In [31], a study identified low information utilization and flow, lack of timely and effective feedback of data, long time, low efficiency, high cost, inadequate security monitoring, and difficulties to meet product quality, food safety, and the market needs are the main challenges to the agricultural goods cold chain transport. The approach to employing an Intelligent Transport System based solution is proposed. The solution combines consumer and driver in the transportation of agricultural goods by designing a mobile phone-based system integrated with RFID and GPS for real-time information sharing to monitor the flow of perishable agricultural products. The author also designed an alarm for temperature and humidity during transportation as key quality variables for perishable agro-goods. A mobile payment Module to facilitate electronic commerce was developed using a two-dimension code to scan the code to transfer payment on goods delivery. With such an approach, tracing the reverse logistics chain is possible as all vendors are captured through the system during the forward chain.

Chapter six of the book [32], contributed by Charalambos A. Marentakis, provides a detailed view of telematics for transportation and agri-food product distribution. In the study, the author gives an ICT tool to offer monitoring and interaction capabilities between vehicle drivers and freight stakeholders from planning to monitoring and reporting need to ensure just-in-time (JIT) delivery, quality preservation, and efficiency. The author posits that the requirements for freight transportation vary depending on the nature of the operation. The author further added that e-commerce, e-business, and enterprise resource planning (ERP) directly influence the transport of agri-food in terms of performance and ability to handle large amounts of data generated through position sensing such as GPS and other sophisticated Information Systems applied in the transportation of agri-food. The author identified some of the requirements such as vehicle location, state of transported goods, including its temperature and humidity, time of arrival and time of departure for loading and unloading points, distance driven, length of the personal break, refueling stations, freight weight, transportation costs as well as vehicle, driver and trailer information. Advanced portable devices such as mobile phones provide features and functionalities for instant data capturing, such as barcode scanning, SMS, proof-of-delivery, and reconciliation. Also, their ubiquities offer movable information-sharing services among participating stakeholders. The author proposed architecture for telematics applications integrating stakeholders, freight with their particular requirements, position sensing, tachograph operation (speed, stop, and idle), and shared transportation information portal. The author introduces Shipper, Customers, Recipients, Forwarders, Carrier, Vehicle Owners, and Fleet Owners as the users and stakeholders of the system.

A national large and medium agricultural-fresh products management system to monitor the transport of agricultural products considering the number, type, environmental-related temperature and humidity, vehicle speed, routes, locations, and driver information parameters was successfully designed, developed, and tested [33]. The main objective is to minimize the damages of agricultural products caused by transportation flowing from the original point to the destination/sales points/wholesale markets. The system comprises four subsystems focusing on testing environmental-related variables, mainly the temperature and humidity of agriculture products, collecting speed and line of the vehicle, wireless data transmission, and data control center. The study uses GPS for positioning services, GPRS, and the Internet for communication between the vehicle on-board unit (OBU) and the control center. ZigBee wireless network technology was applied for receiving temperature and humidity and communicates to the control center. Although the system met the requirements, the system required enhancement of planning functionalities, optimization functionalities, and emergence assistance services.

C. Existing Freight based Intelligent Transport System Frameworks

While looking for the possibility of the plan and manage co-model freight transport without a centralized system, [28] hypothesize that all transport services providers can publish their information on the Internet in a standardized format. The aim is to allow efficient sharing of accurate information between transport service providers and transport users. To achieve that, the authors argue on the efficient integration of all transport services and users in the transport chain and the lower cost of new connections and accessing the Internet. The ARKTRANS (Norwegian framework architecture for multimodal ITS) methodology to introduce abstraction levels ranging from transport policy, overall concept, logical aspect, and communication aspect together with Rapid Unified Process (RUP) were used. The RUP is used for an architecture-based iterative software development process. The four stakeholders identified were Transport Service Provider, Transport user, Road Network Manager, and Transport Regulator. The identified attributes were based on cost, status, from-to addresses, cargo details, and the reference document to show the Transport User and Transport Service Provider agreement.

In [34], freight brokering system architecture integrates web services and agents combining freight owners and transport services providers using web services integration gateway (WSIG) in JADE, two-layered architecture WS2 JADE RESTful web services were proposed. Users can register and post their products and offers in the public directory through the virtual platform process. Potential customers can then browse, search and manually inspect the posted products that suit their needs. The available information contains real-time information on transportation and goods. Through employed intelligent services, the system included the provision of transport needs such as optimal transport routes focusing on requirements of the customers and the availability of free transport. The system can also negotiate with transport providers and customers to efficiently choose among the many delivery segments. Each element is covered, and no vehicles travel without cargo on the schedule. The study proposed the Customers, Transporters, and Brokers. Also include Payment, Statistics, and Email-notification service providers.

Also, a step-by-step approach to ITS system architecture for developing countries from scratch while considering limited resources in the countries established in [34]. The author emphasized adopting a framework from developed countries where affordability, compatibility and integration, geopolitics, and technical capabilities are the main identified criteria for building the ITS framework. It is proposed that the list of ITS user services be derived from existing services from developed countries; however, user services may differ in every country depending on the user's needs. Therefore, for countries like Tanzania, broad coverage of mobile networks and the massive availability of users amplify the effort toward implementing such services. The author further proposed to create a common data model, establishing the communication standard, using available communication technologies, and promoting standardization.

IV. Methodology

The road to the described above is complex and requires extensive multidisciplinary knowledge. Therefore, different documented approaches presented by [4], [35]– [40] were reviewed to establish an appropriate method for the desired framework. As a result, this study adopted Design Science Research. The selection of the Design Science Research Model (DSRM) [40], as inspired by [41], is based on its appreciation to produce new knowledge and seeking for innovations in solving problems. The six steps identified in DSRM are 1) problem identification and motivation, 2) defining the solution's objective, 3) creating the artifact, 4) demonstration, 5) evaluation, and 6) communication.

STEP1: The study used an observation approach, domain knowledge acquired, challenges identified from the case study, the need to use Intelligent Transport System in ASC, and literature reviews. Detailed information is available in sections I, II, and III.

STEP2: Through literature review, different solutions were proposed. For the case study presented in this paper, the objective is to develop a new framework using the mobile phone as a multifunctional tool for developing and managing stakeholders' information sharing systems. Also, the FREIGHTWISE Reference model [39] was extended to identify and analyze the stakeholders based on the roles and type of exchanged information while interacting in the ASC in developing countries. Sections II, III, and V describe more details.

STEP3: The artifact was developed as the main artifact of this study to foster innovation in the new products. The artifact, in this case, means the solution for the challenges, as detailed in Section V.

STEP4: The proposed framework was demonstrated using a scenario context mapping the existing potato agro-goods supply chain from Njombe rural, as the producers of potato, and Dar es Salaam, as main buyers. Section VI provides a detailed demonstration. A descriptive approach using case and scenario was used to illustrate the proposed framework [42], [41].

STEP5: The proposed framework evaluated in section VII. A total 12 experts used to provide opinion based on constructed framework (the artifact) based on challenges presented in the case study. The aim is to gain views on how it addresses the challenges.

STEP6: This paper is communicated to the audience the output of the study.

V. MAGITS Framework

A proposed framework, MAGITS, is presented in this section. The MAGITS is abbreviated from a Mobile-based Agro-goods Intelligent Transport System. The framework integrates M-commerce, M-payment, and Intelligent Transport System. The following are primary objectives of the framework:

1) To address the existing gap of information sharing among stakeholders,

2) To simplifying the current complexity in the transportation of agricultural goods, consider differences in stakeholders' requirements in rural as well as urban transit,

3) To reduce the highly technological infrastructure demands through efficient utilization of mobile phones and additional functionalities such as GPS to share information among stakeholders.

4) To reduce the transport and intermediaries costs associated with routing through sharing of agro-goods information and easily deployable, readily available,

5) To achieve common language and standard information exchange patterns.

The MAGITS framework extends the Freightwise Framework (FWF) components [43]. The MAGITS framework, shown in Fig. 2, has seven components. These components are Main Services, Computing Center, Enabling factors, key performance goals (KPG), Mobile Operations, Operating environment, Stakeholders and their roles, and Information view. The enabling factors comprise the ITS Infrastructure, Policy, Management, Operating environment, Finance, communication viewpoints, and External services. In addition to the stated objectives, the MAGITS framework also uses mobile phone technologies to address the limitation of an on-board support, which was not part of the FWF Reference Model as stipulated in [28], [44], [43].

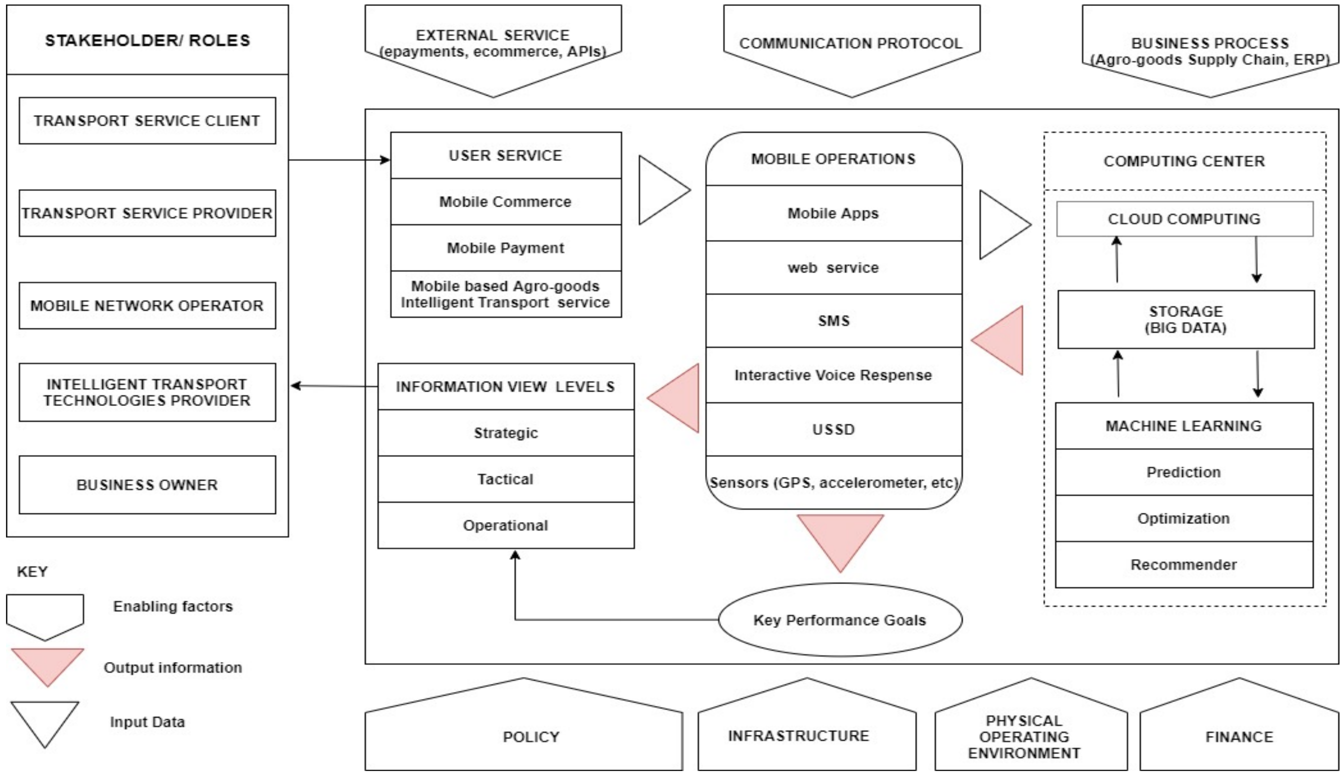

Fig. 2. A View of a Proposed MAGITS Framework.

A. Core Components of the Framework

1) User services: The core of the MAGITS framework is the services the stakeholders benefit from accessing and using the Systems developed under the framework. The MAGITS integrates three primary services, Mobile Commerce (M-Commerce), Mobile payment (M-Payment), and Mobile-based Agro-goods Transport Service, as central functions of the system. These services will use an auction-based approach to ensure fairness in the business operation. Based on [46], Researchers propose a most applicable first-price sealed bid as it creates privacy among competing bidders. The services are described in Table 1.

TABLE I. USER SERVICES

No	User Service	Description of service as per framework
1	M-commerce	Sell and buy agro-goods and services using mobile devices such as mobile phone or tablets
2	M-payment	Electronic money transaction for sell and buy of agro-goods or services using mobile devices
3	M-intelligent transport	Using mobile phone to hire and provide intelligent transport services for moving agro-goods between stakeholders in the Agriculture supply chain

2) Computing center: This framework component is responsible for capturing, analyzing, processing, storing, and sharing processed information between stakeholders. It ensures the security of information using technologies such as blockchain. The machine learning technology for optimizing and predicting services, big data, and cloud computing technologies provides the environment for accessing and using the platform as a service by reducing the high cost of procuring and maintaining the MAGITS hosting equipment. It also provides a secure mechanism for electronic data interchange (EDI) with external services components using Application Programmer Interface (API) and other decided tunneling approaches.

3) Mobile operations: Mobile phones, especially Smartphones, offer important integrated features such as GPS for location identification and WiFi and Bluetooth for wireless communication. These features are critical to ITS services due to the ubiquitous nature of mobile phones and enable stakeholders to access ITS services. For instance, the ITS-enabled sensors installed as the Onboard Unit (OBU) in vehicles wirelessly communicate with mobile phones to share information such as speed, fuel consumption data, mileage, and instant location information. The integration of such information from different ITS components resulting in improving timely delivery, accurate information about clients and providers of transport services, demand and supply optimization, prediction of loss and profit from transport business, tracking and tracing of cargo and vehicles, information of agro-goods to be delivered to the destination, and transportation costs. Mobile phone-based information systems hosted in computer centers are accessed online through Unstructured Supplementary Service Data (USSD), web, Interactive Voice Response (IVR), and mobile apps to provide a unique environment to support such information lifecycle.

4) Stakeholders and their roles: These are institutional entities or persons responsible for operating, managing, using, or maintaining one or more framework services. Each stakeholder in the framework has a role to perform. Some stakeholders have more than one role. For example, a Customer can possess the role of TSC when in need of a transport service to deliver agro-goods to the destination. Table 2 describes the roles of each stakeholder, information to supply and lead to a demand from other stakeholders.

5) Information view: Focusing on stakeholders' needs for the MAGITS, the three categories of information flows are Electronic document information flow, payment information flow, and agro-goods information flow. The information flows between partners participating in the services and their processes. Understanding the information flow is critically important in completing the movement of goods from F to C, as defined in Table 2. Through the integration of information flow, the business processes and the depiction of the main objective of the design of any system are realized. It is the responsibility of stakeholders to feed timely and accurate information to the system to achieve actual results and efficient management and as part of sustainability strategy. The framework identified three levels of information: operational, tactical, and strategic. These levels of information assist stakeholders in deciding for their business.

TABLE II. STAKEHOLDER-ROLES AND INFORMATION REQUIREMENTS

Stakeholder	**Roles**	**Information supply parameters**	**Information demand parameters**
Farmers (F) or Producers (P)	Agro-goods producers, sellers, and supply chain initiators	Product Information(Farm-gate Selling Price, Location data, Time of harvest, etc	TSP, TSC, MNO, C
Customer (C)	The purchaser of agro-goods and requires goods to be transported to the desired location	Product information such as quantity in demand, type, delivery location, expected delivery time, Purchasing price, business permits, payment method, etc	F, MNO, RNM, TR, TSC and TSP
Transport Service Client (TSC)	Requires transport service from TSP to move agro-goods from F to C as shown in Fig. 1	Customer's information, product information such as location, quantity, type, payment method and expected delivery time, etc	F, MNO, RNM, TR, TSC and TSP
Transport Service provider (TSP)	Owner of commercial vehicle purpose(Individual/Company) and lease transport service to TSC or direct to C delivery of goods from F to C based on agreed terms	Carriage information such as type, quantity, and transport licensing. Also, vehicle location, current loading information such as FTL or LTL, routing information nearest to the loading point	ITTP, RNM, TR, TSC, MNO, P and C
Road Network Managers (RNM)	Plan, manage and maintain the road network	Route information, road toll charge, and payment models	ITTP, TSC, TSP, P, and C
Transport Regulators (TR)	Road rules enforcement and regulations checker	Law parameters, road charges, and payment approaches	ITTP, RNM, TSC, TSP, P and C
Mobile Network Operators (MNO)	Mobile network provision and mobile-based payment services	Internet charges, connection, and payment approaches	ITTP, RNM, TR, TSC, TSP, P and C
Intelligent Transport Technology Providers (ITTP)	Intelligent Transport System technology and service providers	Location (GPS), weather and communication, Application Programmer Interface (API), OBUs, RSUs, etc	MNO, RNM, TR, TSP
Business Owner/System owner	A framework manager. A person or entity who legally owns the system. Responsible for setting the environment for other stakeholders to interact. Responsible for day to day internal management of a system	All information	All information

6) Key performance goals: The Key Performance Goals (KPGs) are the overall outputs of the framework. These KPGs directly affect the sustainability of the framework. The key goals of this framework are improving efficiency, increasing safety, reducing carbon emission, and introducing intelligence in agro-goods transport through the collection, store, model (prediction and optimization), and analyzing operational transportation data to improve future transportation investment planning. The lower the KPG rating, the shorter lifetime of a framework. Likewise, the higher the KPG ratings, the longer the sustainability of the framework. The KPGs are achieved due to stakeholder's satisfaction level with the system and services. Performance Indicators (KPIs) are applied to the MAGITS framework to measure its performance, including but not limited to a percentage of uptime of e-commerce per time, percentage of detected overloaded vehicles, average delivery time per trip, number of the shortest routes compared to available routes, rate of carbon emission, improved transport safety, number/amount of electronic toll collection and e-payments per vehicles/time, average transport cost or profit per trip, average loading/unloading time of agro-goods, number of pickup and delivery points per same truck, average available time of tracking and tracing services per vehicle, number of prediction modeling services, number of goods delivered/loss during transportation, and average available time of information among stakeholders.

7) Enabling factors

a) Policy and Governance: Policies dictate the direction of the business. Therefore, policies in place must harness the integration of Intelligent Transport System with e-commerce and e-payment services to promote the development and deployment of the framework. The policies include how data will be shared between participating stakeholders at lower cost and timely, enabling the usage of services to impact the individual and national economies, strengthening sharing of business information by reducing unnecessary barriers from competing rivals. In addition, the presence of policy support validates the business. It assures participants of recognizing data generated from the system, i.e., electronic payments, contracts, and other e-documents, as legal evidence for business contracts.

b) Communication Viewpoint: The two communication types, namely short-range and long-range communication, are identified for this framework, as studied by [47]. The short-range communication protocol, commonly known as a Dedicated Short-Range Communication (DSRC) by IEEE, is a highly reliable, fast network acquisition, high interoperability, and low latency. They are, therefore, suitable to be applied for vehicular data exchange between the Vehicle-to-Infrastructure (V2I), especially roadside units (RSUs) and antennas, Vehicle-to-Vehicle (V2V), and Vehicle's OBUs to loaded cargo using wireless technologies such as ZigBee.

The long-range communication protocol is Cellular-Vehicle-to-Everything (C-V2X) PC5 technology, the cellular-based communication protocol. The detailed study by [48] pointed out two applicable communication protocols for ITS are 802.11p-based, which contain ITS-G5. The 5G technology offers adaptive application-focused, increased speed, reduced latency (i.e., from 20 milliseconds to approximately one millisecond), and more service-oriented with 99.999 percent reliability. Still, many developing countries such as Tanzania still require more time to overtake the dominancy of 3G and 4G in cellular long-range communication technologies.

c) Business Processes: The primary business processes are planning, execution and completion. For instance, in FREIGHTWISE[28][43], the planning phase is complete when the Transport Execution plan(TEP) is marked ready for execution. When proof of delivery has been issued, the execution phase is completed. In most cases, the business processes are integrated into the operating business's ERP. The Oasis Universal Business Language (UBL) – 2.3 [49]and ISO TC204 work groups[50] have established the standard documents that facilitate the development of systems related to freight transportation. It is easier for system developers to adopt such agreed design documents as baseline designs to conform to such recognized international standards. The UBL uses the XML standard for exchanging business data.

d) Finance: In-depth consideration of the investment cost, revenues, and expenditure must be made during the system's design, deployment, and operationalization. The factors such as payback period, minimizing expenses while increasing revenue, service charges such as internet-service-subscription charges, cost of equipment, labor charges, etc., are essential at every stage of the system lifecycle.

e) Infrastructure: In this context, infrastructure contains all physical assets that support the transportation of agro-goods to the consumer. These include roads, OBU, RSU, cameras, sensors, vehicles, agro-goods, Mobile phones, weighbridges, and road toll gates.

f) Physical Operating environment: The quality of products and services depends on the operating environment. It involves handling mechanisms in handling agro-goods physical flow to preserve expected quality. The forward physical flow of goods channels from Farmer as Producer/Seller to Collection Center Manager, Distribution Center Manager, and Consumer. Transport Service Provider is involved at each stage to pick up and deliver agro-goods successfully. Each stakeholder in the chain is responsible for preserving the quality of the product and feeding the system with accurate data such as GPS locations to meet the other stakeholders' expectations.

B. High-Level Layered MAGITS Framework Architecture

All information will be accessed centrally from the Computing Center using a client-server architecture. The idea is to achieve controlled data flow and reduce the data storage size in the stakeholders' smartphones or tablets and allow coordinated and controlled integration of information whenever needed by stakeholders or other systems. The general concept of the MAGITS framework considers the use of micro-service architecture using a lightweight approach like application programming interface (API) to communicate different designed services in solving the management of information as the goods move from one point to another. The advantages of using microservice architecture over typical monolithic architecture. The designed architecture has proven scalable, adaptable, and easy to maintain in the microservice approach, as shown in Fig. 3.

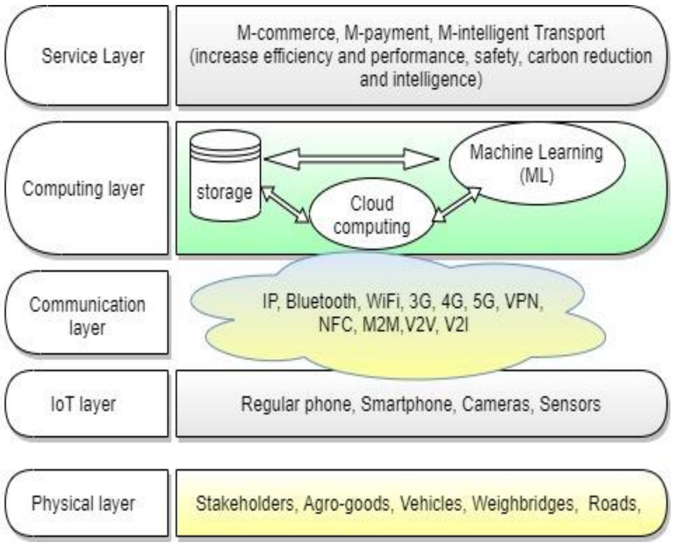

Fig. 3. High-Level Layered MAGITS Framework Architecture have been Defined by [45].

VI. Illustration of the Framework

As described in the methodology, this section illustrates the proposed framework using a descriptive scenario by combining the sales, purchases, payments, and transportations of potatoes in Tanzania. The Transport Service Clients (TSC) and Transport Service Providers (TSP) were selected for this evaluation phase. Fig. 4 illustrates the applicability of the framework. In the process, all stakeholders interact with each other using mobile phone services.

The mobile phone with GPS and mobile app services, such as Android and IOS, qualifies to be installed as vehicle OBU specifically for location serves as an input to the system. Each stakeholder will register in the system. Except for TSP whose locations are changing during transportation, all other stakeholders will register their GPS location. It is crucial in calculating the distance as the parameter for the vehicles. The majority of farmers are smallholders who can afford regular phones. The straightforward approach is for the collection center to register all the farmers located near their collection center using a Smartphone to capture the GPS coordinates of farms and other important information for later use. The essential criteria are that Collection Centers and Distribution Centers must directly connect to the main road to access all transporters. The framework also allows mobile phone information sharing from geographically dispersed smallholder farmers to aggregate potato agro-goods to meet the full truckload (FTL) concept.

The approach is essential for cost-sharing, providing access to markets, and increasing farmers' bargaining power in the markets. From Fig. 4, farmers as an initiator of the chain, feed information including quantity and price about potatoes using the mobile phone.

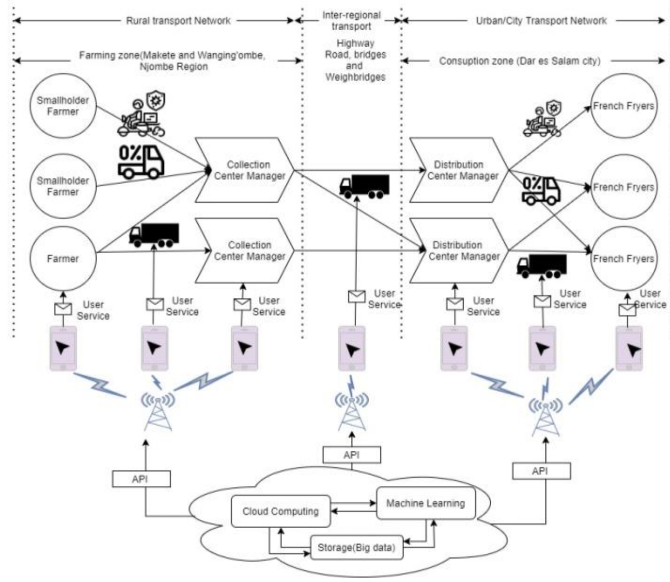

Fig. 4. Information Sharing Scenario of Potato Mobile-based Agro-goods Intelligent Transport System.

Since the location information was previously captured, the Collection Center will automatically receive notifications about farmers ready to sell using the mobile phone. The Collection Center Manager will confirm the request and advertise to French fryers (Fried Irish potato chips sellers) and other buyers. All buyers will confirm the order through a mobile payment system, where the system will send feedback to the collection center and farmer. The system will automatically publish the successful order to transporters showing parameters such as quantity, pickup location, and delivery location. For a specifically given time interval, each transport will make a sealed bid for the service by manually filling the cost and expected delivery time.

The system will evaluate submitted offers and send a notification to the buyer to confirm the payment. Using the same payment system for paying transport costs, all parties will receive confirmation about the confirmation of the order. At each payment stage, the system will hold the amount until the buyer confirms the receipt of the potatoes consignment. The system keeps the amount on each payment while generating a secret code and sending it to the buyer's phone. The code will be entered into the mobile phone upon receipt of the order.

The application of Machine Learning (ML) in the proposed framework adds unique achievement to MAGITS. The applications of ML, namely optimization, prediction, and rating, are identified. For instance, each time stakeholders use the system will provide feedback about the service. The combination of rating, questions, comments, demographics, technographic, behavior, and geographic features will be processed using ML recommender modeling techniques to create patterns for decision-making purposes. These patterns aim to improve the system's services, logic, and decision-making. The model, using ML, will use GPS coordinates from smallholder farmers and the location of the nearest road; it is possible to optimize the nearest collection center accessible to the road and share transport to the buyer or markets. The massive data generated from the use of the framework plays a critical role in predicting the demand and supply of potatoes in Tanzania.

VII. Evaluation of the Framework

A total of 12 experts were interviewed to provide expert opinions on the proposed framework, as shown in Table 3. One challenge encountered was the possibility of identifying an interviewee with all the required skills to evaluate the method.

All interviewees were given the paper using the walkthrough approach and establish views on the acceptability of the framework using the challenges as identified in Table 4. The comments were then discussed through a convened online meeting to agree or disagree with the proposed framework. From the discussion, all experts agree on the proposed framework approach to solve the identified challenges and suggest the need for developing web and mobile applications to integrate the proposed service for higher impact to the community, especially marginalized smallholder farmers. Experts also commended the simplicity of the ASC process using a system developed from the framework and suggested more research on the users' acceptability approach. Finally, the experts comment that many more researchers will benchmark this study.

All experts concluded that the framework works best in the presence of smartphones than regular phones.

TABLE III. Experts Background

Expert	Area of expertise	Experience in the industry (in years)
1	Agriculture	25
2	Electronic Business	13
3	Information Communication Technology	18
4	Information Communication Technology	12
5	Agri-business	18
6	Agricultural products Transportation	30
7	Information Communication Technology	16
8	Freight Intelligent Transport Systems	4
9	Agri-business	22
10	Smart Cities	5
11	Agriculture Extension Services	16
12	Internet Service Provision	20

TABLE IV. Evaluate Challenges

Challenge	How framework addresses the challenge?
Stakeholders' involvement	The framework considered all participants involved in the sales, purchase, and transportation of agro-goods.
Context-awareness coverage	Since agro-goods are produced in rural areas then transported to urban areas, the framework has incorporated the environment. The framework has also considered minimum enabling factors required during the design, deployment, and operations.
Resources scarcity	The additional use of mobile phone sensors acting as OBU and Point of Sales (PoS) minimizes the demands for deploying many devices where each performs a single task
Real-time information sharing capability	It is possible for stakeholders accessing and sharing sales, purchases, and payment information in real-time through installed mobile phones. Tracking and tracing of agro-goods loaded vehicles anywhere at any time.
Service demands	The Machine Learning integration in this framework is essential for travel route optimization, sharing of transport and transport cost for smallholder farmers, predicting agro-goods demand, and supply factoring location and time. The framework achieves the KPG indicated in this paper.

VIII. Conclusion and Future Work

This study provides a unique guide for ASC practitioners linking technology to agro-goods business. It addresses the need for both Information Systems developers during the designers, government authorities in deliver service while seeking income generation, and business managers during investments and operations using limited resources. It also serves as a benchmark for further researchers focusing on developing new products supporting communities based on e-commerce and transportation using mobile phones to monitor and manage the supply chain.

The developed framework for integrating ITS in agro-goods e-commerce in developing countries is inevitable due to the high dependence on agriculture for economic and social survival. The requirements for the framework differ from one place to another, but the proposed framework unifies the high-level needs for successful and sustainable systems. A framework enables the design, implementation, deployment, and ITS in the Agriculture Supply chain in many developing countries from limited available infrastructure, especially mobile phones. For instance, it is possible to obtain traffic and weather information about particular route agro-goods transportation using data collected from other mobile phones located on in-transit vehicles using mobile phone sensors. On the TSP side, there are information limitation challenges that may arise when using the mobile phone as an OBU sensor, such as fuel consumption and break information will not be captured. Nevertheless, some recent vehicle OBU can transmit such data to mobile phones wirelessly using short-range communication such as Bluetooth and WiFi. Further research is required to use mobile phones when installed as OBU, such as power consumption, availability due to changes in environment, and durability.

In terms of Internet service, there is a need for harmonization between different MNOs (defined in Table 2). Therefore, the study establishes a service-focused internet subscription to achieve maximum service availability despite the vehicle in transit changes MNOs. One limitation of the proposed framework is the inability to handle multi-products in the same truck; therefore, the study recommends investigating and suggesting an appropriate ML modeling approach for managing more than one product within a single truck based on type, size, and weight. There is no evidence of Tanzania's framework to researchers' best knowledge. Still, researchers believe that implementing the framework will solve transport challenges of limited-resource many e-commerce platforms globally. This framework also provides the foundation for further research in big data in the transportation of agro-goods in developing countries.

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