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# Securing Grain in Transit for the Food Reserve Agency Based On the Cloud Model

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***Abstract*- Despite the fact that Zambia is undergoing rapid development, it still faces food security challenges. Zambian government through FRA ensures national food security and provides market access for rural based small holder farmers by maintaining a sustainable national strategic food reserve. Unfortunately despite the government of Zambia through FRA ensuring national food security almost every year huge quantities of grain are lost due to many factors such as spoilage, infestations, theft and spillage during transporting, this is as reported by the auditor general's office. As a result of the challenges identified, there is therefore need for better management of the grain during transportation through automation of the process. As the world is trending into new technologies and implementations it is a necessary goal to trend up in agriculture as well. In this paper we proposed a solution that seeks to minimize on the theft at FRA that occurs during grain transportation from a particular depot to the storage facilities. Research proposed the use of geographical position system (GPS) to monitor and track the location of the vehicle in transit using a mobile and web applications. Vital information about the vehicle carrying grain e.g. location will be gathered by the GPS fitted in the vehicle and will be transmitted to the server in the cloud, this information will be made available to the authorized users using the web application anytime, and anywhere provided there is internet connectivity.**

**Keywords— FRA; Food Security; GPS; GSM; Cloud Computing; Tracking.**

## I. INTRODUCTION

Food is a fundamental human need [26] and as such food security is cardinal in any country. The Food and Agriculture Organization (FAO) defines food security as a condition whereby all people at all times have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life [22]. However, in Zambia government through FRA ensures national food security and provides market access for rural based small holder farmers by maintaining a sustainable national strategic food reserve [11]. The FRA also acts as a macro-economic stabilizer for food grown in the country, such as maize which is the nation's staple crop. Unfortunately despite the government of Zambia through FRA ensuring national food security, almost every year huge quantities of food are lost due to many factors such as spoilage, infestations, theft and spillage during transporting [3] [24] in [26].it has also been noted that FRA faces challenges in efficient management of inventory, this is according to the audit [30] that was carried out between 2006 and 2009 by the Auditor General to review the performance of FRA. According to the audit report, during the period of 2006-2009 the Agency experienced maize shortages of 115, 516 × 50kg bags valued at ZMK4, 274, 092, 000 (old currency) at various depots. These losses were due to theft and grain spoilage at the warehouse depots [30].Most of these challenges are as a result of poor monitoring and a poor inventory management approach which is largely manual and paper based [26]. The report further stated that FRA faces challenges to effectively monitor and inspect its storage facilities. Further, the report stated that organized crime was another factor leading to shortages, usually at the time of dispatch. A baseline study carried out by [12] further adds that FRA had challenges such as manual report generation, no connectivity to remote warehouses, inability to track stock on demand, theft, spoilage of stock due to lack of environmental monitoring. According to [27], many difficulties exist that have to be overcome to attain food security. These include climate change, water scarcity, energy requirements and reducing the huge amount of food losses. Efforts to raise farmer's income and improve food security consequently reducing hunger especially in the world's poorest countries should give priority to the issue of crop losses [23]. It is hardly possible to ensure food security in the absence of efficient delivery, control and tracking mechanisms across the supply chain. As a result of the challenges identified, there is therefore need for better management of the grain transportation through automation of the process. As the world is trending into new technologies and implementations it is a necessary goal to trend up in agriculture also [25] .Therefore there is need to have a precise, and appropriate technique of tracking of the grain bags. This shall be done in order to reduce theft of the grain and ensure management and monitoring of the grain that is being transported from one location to another in a credible and efficient manner. Hence, we are proposing a model based on Cloud and GPS technologies in the development of a secure tracking system for the FRA.

## II. TRACKING TECHNOLOGIES

It is nearly impossible to ensure food security in the absence of efficient delivery, control and tracking mechanisms across a given supply chain. [2] Notes that a Tracking system refers to the ability of tracking the path of a particular unit or a batch of products from upstream to downstream along a supply chain. According to [7] Tracking allows the base station to continuously track the vehicle without any interference of the driver or the method of continuously collecting the co-ordinates of moving vehicle that is getting from GPS receiver. On the other hand [21] adds that a Vehicle Tracking System is a device that is fitted in a vehicle, to enable the vehicle owner to identify the vehicle's location. Currently, there are several tracking solutions of different [29] forms, some operate in client-server architecture while some others work in standalone mode. Most of the client-server solutions are designed to provide tracking only. While a client-server system is a better solution when considering cost, a standalone solution will give better performance in terms of speed of response. However in Vehicle Tracking System for tracking the vehicle any tracking device is required. Now a days, three navigation systems are available and people use those for tracking any object. The GNSS (Global Navigation Satellite System) consists of three main satellite navigation systems. They are GPS (Global Positioning System), GLONASS and Galileo [31].

TABLE 1 [31]
GNSS LOCATION TRACKING TECHNOLOGIES

| **Parameters** | **GPS** | **GLONASS** | **Galileo** |
|---|---|---|---|
| Satellites per complete constellation | 32(Block III) | 24 | 27+3 spares |
| Orbital Planes | 6 | 3 | 3 |
| Plane Inclination | 55 deg | 64.8 deg | 56 deg |
| Radius of Orbit | 26650 km | 14100 km | 23222 km |
| Period required for complete cycle | 12 hrs | 11 hrs 15 min | 11 hrs 15 min |
| Civil Data Rate of Satellite | 50 bps, up to 100 sps | 50 bps | 50 bps, up to 100 sps |
| Accuracy | 5-20 m | 50-70 m | Claimed 1 m |
| Operation Bands of Satellite | L1,L2,L5 | L1,L2,L3,L5 | E1,E5,E6 |

Table 1 shows the three GNSS technologies from which it can be seen that GLONASS and Galileo provide more precise location than GPS but they are costly. GPS (Global Positioning System) is highly available GNSS technology. With regards to the proposed system, GPS is the best technology considering its availability and receiver cost. In our proposed system we decide to use GPS.

## III. GLOBAL POSITIONING SYSTEM (GPS)

According to [29] GPS is a navigation technology providing accurate location and information. Preserved by the U.S, GPS is a space-based satellite system, granting contact to anyone owning a GPS supported receiver. Global Positioning System (GPS) technology has provided an essential tool for management of agricultural and natural resources. [6]Adds that The Global Positioning System (GPS) is a satellite-based navigation system consists of a network of 24 satellites located in the orbit. The system provides essential information to military, civil and commercial users around the world and which is freely accessible to anyone with a GPS receiver. GPS works in any weather circumstances at anywhere in the world. [19] Also notes that The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites, GPS satellites rotate twice a day around the earth in a specific orbit. These satellites transmit signal information to earth. This signal information is received by the GPS receiver in order to measure the user's correct position. The GPS receiver compares the time a satellite transmits the signal with the time the signal is received. The time difference calculated enables us to know the distance of the satellite. By measuring the distance of few more satellites, the user's position can be verified and displayed on the unit's electronic map. GPS is a satellite and ground based radio navigation and locational system that enables the user to determine very accurate locations on the surface of the Earth. Remote sensing technologies are used to gather information about the surface of the earth from a distant platform, usually a satellite or airborne sensor. Most remotely sensed data used for mapping and spatial analysis is collected as reflected electromagnetic radiation which is processed into a digital image that can be overlaid with other spatial data.

In our proposed system GPS will be the main module, as the vehicle location will be tracked using GPS technology. This is so that it could get the exact location of respective vehicles carrying grain in transit from the source to the destination.

## IV. CLOUD COMPUTING

Cloud computing is a computing paradigm in which real-time scalable resources such as files, data, programs, hardware, can be shared via the Internet to users [33]. Cloud computing is assumed to be the solution that overcomes the problem of processing large amounts of data [34]. By using cloud computing the cost of implementing software solutions and storage of data is reduced considerably. Cloud solutions have desirable features such as high scalability, agility, high availability and reliability and multi-sharing [34]. Clouds offer different service models, the service models include; software, platform and infrastructure as service [33]. In the Infrastructure as a service (IaaS) service model, providers offer physical or virtual machines with the capability to fulfill customer needs to implement software solutions on them [34]. In the Platform as a service (PaaS) service model, software applications such as an operating system, a programming language, a web server, are already installed [34]. PaaS facilitates the implementation and testing of software solutions and provides the needed resources for an application to run. Finally, the Software as a service (SaaS) service model is described as a pay-per-use service where the providers offer clients a fully configured hardware and software solution [19]. The advantage of SaaS is that clients don't have to worry about any maintenance, hardware or software [33]. Cloud computing has been implemented in various spheres such as healthcare [10], education [18], smart grids [1], etc. Recent

publications have demonstrated the benefits of cloud computing for intelligent transportation systems [20]. The architecture of the proposed system shall be a 3 tier cloud computing client- server model were the application will be run on a laptop or mobile device from which the client will interact with the system. Unlike a 2 tier, 3 tier will have a business layer which is added to the model and act as an intermediary between the presentation and data layers.

## V. RELATED WORKS

The research domain is not presently very popular, but there are a few of such systems in the literature which were thoroughly reviewed to define the scope and requirement of this work. Their special features were also studied, [28] Notes that the Rapid growth of technology and infrastructure has made our lives easier, the researchers proposed the Design and Implementation of Real Time Vehicle Tracking System model, for the vehicle tracking unit with the help of GPS receivers and GSM modem, GPS for tracking and GSM for SMS's and google earth maps.

According to [16] the researchers propose a security system that would help prevent Vehicle theft, Design and Implementation of Vehicle Tracking System Using GPS, Automatic Vehicle Location system using GPS for positioning information and GSM/GPRS or information transmission. Tracking vehicle using GPS, GSM/GPRS and a web based application by displaying the location of the vehicle on the map, this was to curb vehicle theft.

[13] proposed a GPS based Advanced Vehicle Tracking and Vehicle Control System vehicle tracking system that employs a GPS module and a GSM modem to find the location of a vehicle, the focus was also on the control system of locking and unlocking the vehicle door remotely.

Real-Time GPS/GPRS Based Vehicle Tracking System, in this paper a vehicle tracking system based on GPS and GPRS is proposed [4]. The location of the vehicle was retrieved using embedded GPS sensor. Technologies used for Vehicle Tracking, GPRS, GPS, GSM, Data Coding.

An efficient vehicle tracking system was designed and implemented for tracking the movement of any equipped vehicle from any location at any time this is according to [13] .The proposed system made good use of a popular technology that combines a Smartphone application with a microcontroller. Design and Implementation Of Vehicle Tracking System Using GPS system using GPS/GSM/GPRS Technology and smartphone application and uses GPS and GSM/GPRS to track the vehicle and Google Maps. In a related study [8] proposed paper on vehicle tracking system based on GPS and GPRS, the location of the vehicle in this system is retrieved using embedded GPS sensor. A modified coding method is used to encode and compress location data before it is sent to offer cost effective usage of network traffic. The privacy of the transmitted data is guaranteed using a simple security mechanism. The encoded and encrypted location data is then sent to a tracking server using GPRS technology. The authorized user can then track a vehicle using a secure web interface [8]. A number of papers has been published on the development of vehicle tracking system using GPS and GSM Modem which include these [9] [17] [5].

### *A. FRA Current Business Process Process-Stock Receipt Business Process Transaction*

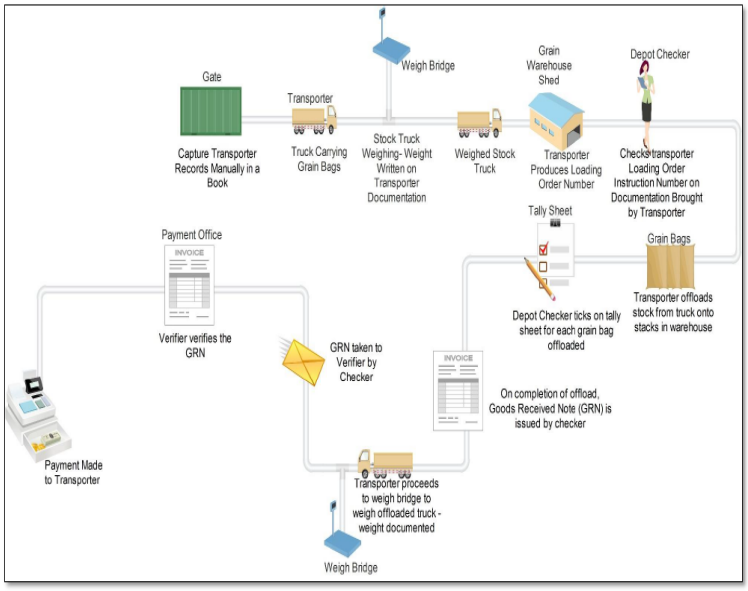


Figure 1 FRA stock receipt business process [26]

In a stock receipt business process transaction, FRA buys stock from small scale farmers. FRA then delivers the stock to FRA warehouse depots for storage [26].

## VI. PROPOSED MODEL ARCHITECTURE

We propose a model that seeks to address some of the gaps in the reviewed literature, in a paper presented by Cynthia and Jackson [26], Mulima and Jackson [12], both authors brought out the need for curbing theft of grain in the FRA circulation but there focus was automating other FRA business processes, therefore our proposed paper seeks to address monitoring vehicles responsible for transferring of grain in the FRA circulation in order to curb grain theft.

Tracking of grain in transit from the source to the destination using Global Positioning System shall enable monitoring of grain when it is not stationary at the warehouses. This is so as to aid in deterring thefts along the way if the inventory is being transported from one depot to another within FRA circulation. In the proposed model the vehicle under tracking shall be fitted with a tracking device that contains GPS, GSM modem and GPRS functionality. This device will be used to transmit data directly to the tracking server and database in the cloud. The tracking device will continuously request to the GPS satellite for its location information and at the same time GPS satellite will provide the location information to tracking device installed in vehicle that's in transit. The tracking device will send the location information back to the server through GPRS and continuously update the database. Monitoring and tracking server shall be housed in the cloud. The GSM/GPRS module shall be responsible of establishing connections between a tracking device in the vehicle on transit and a remote tracking server in the cloud for transmitting the vehicle's location information, using TCP/IP connection through the GSM/GPRS network.

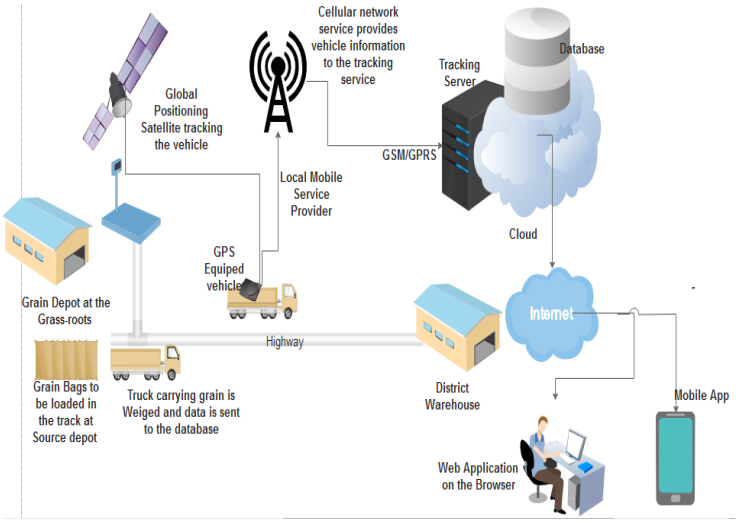


Figure 2 Proposed System Model

A web interface has also been proposed as it will be directly connected to the database which will allow the system admin at FRA to view vehicle location using google maps and other tracking related issues, the mobile application will also be another platform that will be used to track the vehicles using google maps.

### A. *Proposed Tracking flow chart*

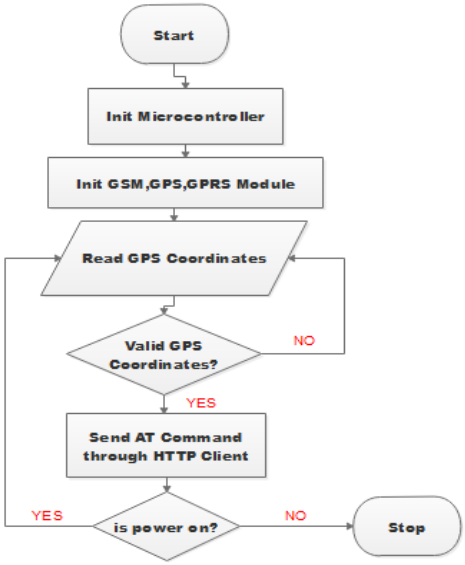


Figure 3 Proposed Tracking Flow Chart

The flow chart depicts the proposed working of the tracking module. The application shall make use of the Arduino microcontroller that shall be fitted with a GPS, GSM and GPRS module. The microcontroller will communicate with the GSM using AT commands, AT commands are merely instructions that are used to control a modem whose abbreviations stand for ATtention. Then an HTTP client will be programmed through the microcontroller that shall utilize a parameterized URL to send GPS data and other related information to the remote server in the cloud using the underlying GPRS data network. Then the application shall be used to display real-time GPS data as received in form of a binding on the satellite map.

### B. *Preliminary Results*

As part of the main project below is a web application for FRA that is mainly concerned with mapping of the depots, farms and generating reports as well as managing detailed information for small scale farmers. The application is being housed in the cloud.

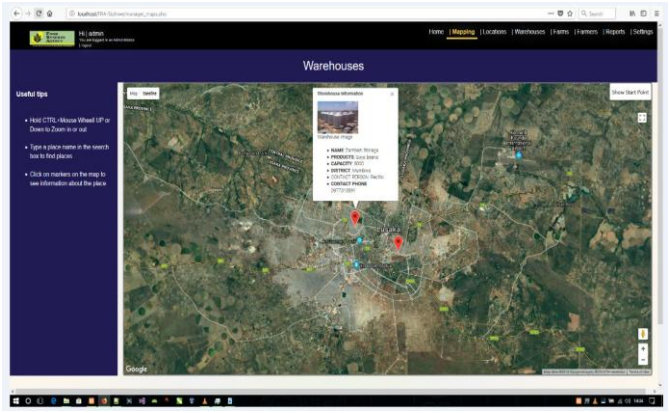


Figure 4 storage facilities mapping

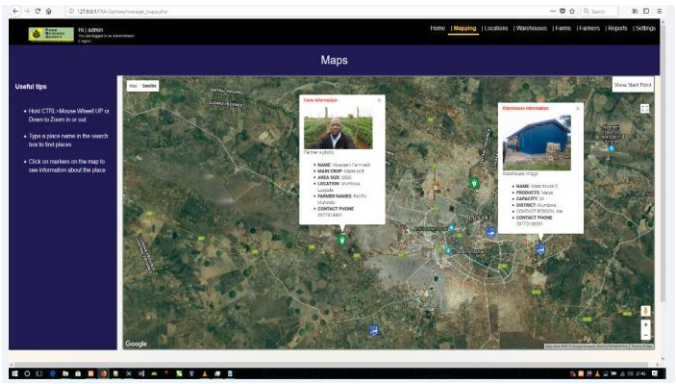


Figure 5 farm mapping

## VII. CONCLUSION AND FUTURE WORKS

In this paper we have proposed a cloud model for tracking vehicle carrying grain in transit that could be used by FRA to curb on theft that occurs during grain transportation from one depot to another until the storage facilities within the FRA circulation. The model offers a novel approach that incorporates both security from theft of grain in transit within the circulation as well as monitoring the vehicle transferring the grain. The model is based on the Cloud, GPS, GSM/GPRS, web and mobile applications. The model shall provide real time tracking and location of the vehicle in transit within the circulation. For the future works, we shall develop a software prototype to test the model and thereafter obtain pragmatic data regarding the performance of the system. As part of the future works we also propose a tele-cut off (weight of the truck) this Is to further enhance the security of the grain by weighing the truck carrying the grain through sensors, in case of the weight of the truck changing one of the solutions is to send an alert to the authorities through sensors and track the location.

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## REFERENCES

[1] X, Fang, S. Misra, L. G and J. D, "Managing Smart Grid Information in the Cloud: Opportunities, Mo- del, and Applications," IEEE Network, vol. 6, no. 4, pp. 32-38, 2012.

[2] G. Weihua, Z. Yuwei and Z. Tingting, "On RFID Application in the Tracking and Tracing Systemof Agricultural Product Logistics," 2010.

[3] K. V, Post-harvest Losses and Strategies to Reduce Them, 2014.

[4] L. ,. SeokJu, "Design and implementaion of vehicle tracking system using GPS/GSM/GPRS Technology and Smartphone Application," in IEEE World Forum on Internet of Things (WF-IoT), Seoul, South Korea, 2014.

[5] C. Sagar, K. Prasad, K. Santosh, R. Vinod and S. Prof, "GPS-GSM Based Advanced Tracking System," International Journal Of Engineering And Computer Science, vol. 3, no. 11, pp. 9248-9251, 2014.

[6] R.Ramani, S.Valarmathy, D. N.SuthanthiraVanitha, S.Selvaraju, M.Thiruppathi and R.Thangam, "Vehicle Tracking and Locking System Based on GSM and GPS," I.J. Intelligent Systems and Applications, pp. 86-93, 2013.

[7] S. Pooja, "Vehicle Tracking System Using GPS," International Journal of Science and Research (IJSR), vol. 2, no. 9, pp. 128-130, 2013.

[8] H. Pham, D. Micheal and C. Nguyen, "Development of Vehicle Trac□ing System using GPS and GSM Modem," in IEEE Conference on Open Systems(ICOS), Sarawak Malaya, 2013.

[9] F. P, N. A, S. R and B. A, "Design and development of GPS/GSM based vehicle tracking and alert system for commercial inter-city buses," in IEEE 4th International Conference on Adaptive Science & Technology (ICAST), 2012.

[10] M. T. Nkosi, "Cloud Computing for Enhanced Mobile Health Applications," in IEEE Second International Confer- ence on Cloud Computing Technology and Science (Cloud-Com), Indianapolis , 2010.

[11] M. Nicole, S. T and J. Robert, Zambian Smallholder Behavioral Responses To Food Reserve Agency Activities, Lusaka, 2011.

[12] C. Mulima and P. Jackson, "A Remote Sensor Network using Android Things and Cloud Computing for the Food Reserve Agency in Zambia," (IJACSA) International Journal of Advanced Computer Science and Applications, vol. 8, no. 11, pp. 411-418, 2017.

[13] B. Mohammed, "Real-Time GPS/GPRS Based Vehicle Tracking System," International Journal Of Engineering And Computer Science, vol. 4, no. 8, pp. 13648-13652, 2015.

[14] B. M. K. Mohammed, "Real-Time GPS/GPRS Based Vehicle Tracking System," International Journal Of Engineering And Computer Science, vol. 4, no. 8, pp. 13648-13652, 2015.

[15] M. Michael, G. Dilusha, W. Lanka, L. Nadeeka, K. Indika and D. Dileeka, "GIS/GPS/GPRS and Web – based Framework for Fleet Tracking," in National conference on Geoinformatics Applications , Sri Lanka, 2008.

[16] M. Mashood, "GPS based Advanced Vehicle Tracking and Vehicle Control System," Intelligent Systems and Applications, vol. 3, pp. 1-10, 2015.

[17] A. M and D. M, "Remote vehicle tracking system using GSM Modem and Google map," in IEEE Conference on Sustainable Utilization and Development in Engineering and Technology (CSUDET), Selangor, 2013.

[18] A. M, "Cloud Computing for Higher Educa- tion: A Roadmap," in IEEE 16th International Conference on Computer Supported Cooperative Work in Design (CSCWD), wuhan, 2012.

[19] M. ,. Kathi, S. K And R. Geetha, "Wireless Communications Experimental Implementation Of Electronic Voting System For Real Time Applications By Using Rfid,Gsm,Gps And Fingerprint Module," International Journal of Engineering Science Invention Research & Development, vol. 2, no. 1, pp. 8-11, 2015.

[20] P. Jaworski, "Cloud Computing Concept for Intelligent Transportation Systems," in 14th International IEEE Conference on intelligent transportaion systems, Washington DC, 2011.

[21] A. Humaid, K. Veton and A. Hazza, "Real Time Vehicle Tracking Using Arduino Mega," International Journal of Science and Technology, vol. 5, no. 12, 2016.

[22] FAO, "Report of the World Food Summit," FAO, Rome, 1996.

[23] FAO, "Global Hunger declining but still unacceptbaly high: International Hunger Targets Difficult to Reach," FAO, Rome, 2010.

[24] FAO, Global food losses and waste: Extent, Causes and Prevention, 2011.

[25] Dr.N.Suma, S. R. Samson, S.Saranya, G.Shanmugapriya and R.Subhashri, "IOT Based Smart Agriculture Monitoring System," International Journal on Recent and Innovation Trends in Computing and Communication, vol. 5, no. 2, p. 177 – 181, February 2017.

[26] L. M. Cynthia and P. Jackson, "A Wireless Sensor Network Based Grain Inventory Management System for Zambia's Food Reserve Agency," IJIRSET, vol. 5, no. 3, pp. 3519-3526, March 2016.

[27] W.-S. Charlie, J. T and M. W, "The Impact Of Reducing Food Loss In Global Cold Chain," University of Norttingham, Norttingham, 2015.

[28] K. CH. Vinay and K. M. Rama, "Design And Implementation Of Real Time Vehicle Tracking System," International Journal of Computer Science and Mobile Computing, vol. 4, no. 7, p. 55 – 60, 2015.

[29] P. (. BharatiWukkadada and A. F. , "Vehicle Tracking System using GSM and GPS Technologies," IOSR Journal of Computer Engineering (IOSR-JCE), pp. 05-08, 2015.

[30] O. C. Anna, "FRA Audit report," Lusaka, 2009.

[31] D. Amol, N. Amol, P. Yutika, S. Manali and M. Prof, "Vehicle Tracking System using GPS and Android OS," International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), vol. 4, no. 4, pp. 1220-1224, 2015.

[32] S. Ambade and S. S.A, "Design and Implementation Of Vehicle Tracking System Using GPS," Journal of Information Engineering and Applications, vol. 1, no. 3, pp. 1-7, 2011.

[33] A.Shawish and M.Salama, "Cloud Computing:paradigms and technologies," International cooperative collective intelligence:techniques and Applications, pp. 39-67, 2014.

[34] A.A.Tole, "Cloud Computing and Business Intelligence," Database Systems journal, vol. 5, no. 4, pp. 49-58, 2014.