Using the Cloud Architecture to Automate the Farmer Input Support Programme (Fisp) Inventory System

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Abstract

Inventory processes in the agriculture sector of most developing countries Zambia inclusive still remain manual based. This has resulted in lengthy business processes and inconsistent data processing leading to tedious and complicated processes in the sector. A baseline study was carried out to make us understand the problem in the distribution and management of Farmer Input Support Programme (FISP). The results from the study showed that warehouses were not linked to any computer system and had no computers. The results also show that 61.76% of record keeping was done on spreadsheets and relayed on manual systems to capture data. About 68% of the systems lacked proper monitoring and tracking mechanisms leading to stock theft. The study also revealed that 56% of thefts occurred at warehouses, 35% during transportation and 9% at satellite depots. The study also aimed at automating the inventory processes based on the results from the baseline study. A model was developed and used to come up with a prototype to integrate and automate business processes using barcode technology. The developed system showed improved processes in the FISP inventory system.

Keywords: Barcode technology; FISP; Inventory System.

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1. Introduction

Most developing and third world countries have had challenges in attaining sufficient levels of food security yet most of these countries depend on agriculture for survival. These countries, Zambia inclusive are in this situation mainly due to lack effective systems in place. According to a United Nations (UN) report, majority of Zambian population depends on agriculture related activities for their survival. Reference [1] in 2002 the Zambian Government introduced the FSIP with the aim of addressing the decline in crop production in the country by helping small scale farmers with farm inputs. Reference [2] in Zambia FISP, under the Ministry of Agriculture operates its processes manually. Record keeping is done on spreadsheets and rely on manual systems to capture data. This manual system has led to lengthy business processes and inconsistent data processing resulting in delays of input distribution. These lengthy processes and lack of proper monitoring and tracking mechanisms in the system has also led to rampant stock theft which occurs at various points in the supply chain. In this study, we propose a prototype software that will automate the inventory processes in FISP in order to improve accountability and traceability in the system. The development of the prototype was based on the business processes of FSIP. These processes were identified by means of a survey with stake holders of FISP. Secondly, a baseline study was conducted to help in gaining an appreciation of the challenges in the distribution and management of FISP.

2. Literature review

This research will look at implementing these technologies in the Supply chain management (SCM) of the input distribution in Zambia. SCM can be said to be the management of material and information flow in a supply chain to provide the highest degree of customer satisfaction at the lowest possible cost. SCM looks at a business as one continuous process. Functions such as forecasting, purchasing, manufacturing, distribution and sales and marketing are incorporated in a continuous flow of business processes. Many organization have invested heavily in auto-ID so that their SCM can bring about accountability and reduce on stock pilferage and wastage [3,4,5]. The auto-ID has helped in product traceability in the SCM. Under the European Union law traceability is said to be the ability to track any food, feed, food-producing animal or substance that will be used for consumption, through all stages of production, processing, storage and distribution. Olsen and Borit came up with a definition of traceability stating that it's "The ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications" [6]. Zambia has had a fair share of theft incidences with regards to inputs recorded in the past due to poor methods of traceability and accountability [7, 8]. Information Communication Technology (ICT) is an absolute necessity for taking part in today's global economy and as such the role of ICT in the emerging global market cannot be over emphasized. ICT has also been credited with the potential to integrate world economies thus demolishing the barriers created by time and distance. It equally makes easier the trade in goods and services and encourages investment as well as the creation of new sectors of enterprise, new revenue streams and ultimately new jobs. The appropriate use of ICT can indeed play a very important role in advancing economic growth and reducing poverty [9]. It accelerates economic growth at country level when deployed in accordance with the specific needs and capacities of one country [10]. The most popular and commonly used automatic identification (auto-ID) or Automatic Identification & Data Capture (AIDC) technologies in use today are the Barcoding and the Radio

Frequency Identification (RFID) technologies. AIDC technologies has become so vital in the management of supply chain and make tagging and tracking of products, produce and material a necessity to any business. Tagging can be anything from piece of steak we buy from a supermarket to a cargo container on a plane. These systems become more complex and costly according to size. Today Barcode technology has become a universal application which is used in almost every business globally. This technology has streamlined identification and data collection. Reference [11] stated that Its use was prompted by the need to eliminate human error during the data capturing. AIDC has greatly overcome the weaknesses with manual systems and overall barcodes have improved the efficiency of operations in the process of inventory control as they has revolutionized in the tracking of product details and help with the management of acceptable stock levels in warehouses. Barcodes are used in offices and commercial establishments, hospitals and warehouses, hotels, government agencies and all organizations where it is required to maintain an inventory of products and services. Barcodes have accurate information with a faster rate of transaction and this has been proven with its wide use across the globe [12]. The retrieval process has been made faster because items to be barcoded have all their significant details about them captured and stored in the host computer or server. Coding of information is done with a special barcoding language and just requires a scanner to decode the information and bring it into human readable format. These languages used by barcodes are quite simple as they are made up of symbols which are a sequence of bars which are of different sizes that is length, height and unequal spacing which is seen as a white shading. The sequence or bars hold vital information about products and stores it according to allocated characters. This information stored is vital because it used in inventory tracking as every time a barcode is scanned information about the item is extracted from the host server or database. Barcodes are the ubiquitous business standards used for the visual capture of information in supply chain management, healthcare and business in general [12]. It can be said to an optical machine-readable representation of data relating to the object to which it is attached. Barcode scanners are simple devices comprising a light source, a photo diode and a simple decoder or a complex CCD which is a camera based scanner [13]. Barcodes are classified into two categories that is the One-Dimensional (1D) Barcode and the Two-Dimensional Barcode [14]. One dimensional or 1D barcodes represent data systematically by varying sizes of spaces (width) in between the parallel lines in the barcode [13]. This representation is also called linear barcodes. 2D barcodes are a systematic representation of data using two-dimensional symbols and shapes. Similar to linear 1D barcode, they have more capacity to represent or store more data per unit area. The newer and commonly used 2D barcodes today include types such as the QR code and PDF417 code types [16]. This code was developed by Densa-Wave, a Toyota subsidiary and was originally used for tracking inventory. QR codes are mainly used in advertisement, marketing and business cards [17,12]. These codes have fast readability, flexible in size and high fault tolerance. Though the QR codes cannot be read with a laser scanner but it is able to support four different modes of data namely numeric, alphanumeric, byte/binary and kanji.

There are two (2) types of QR code in use today [18,19,20]:

- Static QR codes-This is most commonly used type of QR code to disseminate information to the public. Often displayed in advertising material such as billboards and posters, newspapers and magazines.
- Dynamic QR codes (also referred to as unique QR codes) has more functionality than the static QR

codes. Owners of the code can edit it any time and can target some group of individuals for personalized marketing.

There are four types of barcode reading technology in use today each using different technology for reading and decoding a bar code. The four categories of the barcodes are:-

The pen type, the Laser scanners, CCD readers and the camera based readers.

i. PEN TYPE READERS.

A barcode is read once the tip of the pen/wand is dragged across entire barcode strips in a steady and even movement across.

ii. LASER SCANNERS

Laser scanners operate on the same principle as pen type readers except that they use a laser beam as a source of light. Like in a pen type reader, a photo diode is used to measure the intensity of the light reflected back from the barcode. The light emitted by the reader is tuned to a specific frequency and the photo diode is designed to detect only this same frequency light. The two type of readers can be acquired with different resolutions to enable them to read barcodes of different sizes.

iii. CCD READERS.

Charge Coupled Device or CCD readers uses hundreds of tiny light sensors lined up in an array of rows in the head of the reader. Each of the sensors works like a single photo diode that measures the intensity of the light immediately in front of it

iv. CAMERA BASED READERS

This is the fourth and newest barcode reader technology currently available in camera based readers

Structure of Barcode

A barcode is split into sections which form a complete strip and each part has its own function. This has been split in four sections namely-

1. Quiet Zone: There is a minimum space required for a bar code to be read/scanned and this space always proceeds the start Character symbol of a bar code. This zone has to be free of any print and has to be of the same colour and shade as of the background of the symbol of the barcode. The Clear area (quiet zone) should be ten times the width of the narrowest element.

2. Start Code: This marks the star of the barcode. In this zone special characters are used to signify the start of data to a scanner/reader. These Start characters are mainly stripped off and not transmitted to the

host.

3. Check Digit: This zone (check digit zone) is not always present as it is just a mathematical sum that is used to verify the accuracy of the elements found in the barcode. This check sum is an extra digit that is added at the end of a barcode so that a scanner can be sure of the accuracy of the data read from the barcode. The check sum digit is mainly stripped off and not transmitted to the host.

4. Stop Code: This zone marks the end point of the barcode. The characters in this zone signify the end point of data to be read/scanned. And typically these characters are not transmitted to the host. [13] Figure 3 below shows the structure of a barcode [15]
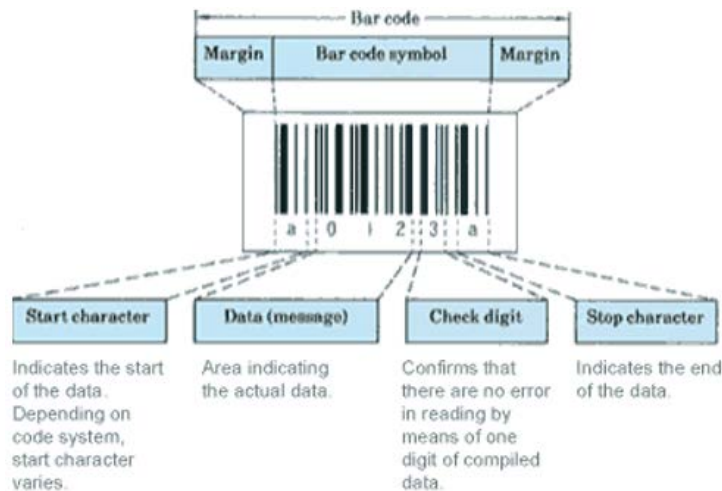
Figure 1: Structure of Barcode [15]

3. Related works

Barcode technology is the most widely used auto ID application in inventory systems today. This technology is used not only in inventory systems but also in Health, security, livestock and food traceability(Agriculture), supply chain management and library services to mention but a few. In China the wheat supply chain has seen the use of barcode (2D) and Radio Frequency Identification incorporated in flour production in form of traceability encoding, small package identification using a QR Code and Package bin identification by RFID [16].

Online Registration New Student Intake System (ORNSIS) barcode system was developed in Malaysia to help with the registration process in Higher education in that country. The purpose of ORNSIS was to stream line the process of student registration using barcode technology making the process more reliable by reducing human error. [11] In food traceability the Chinese government undertook a study on pork traceability in order to meet production supervision and safety and giving customers the right to know what they are buying. Ear tags were used on pigs which had a 2D image embedded on the tag and used for scanning [17].

In health services in Hong Kong, a bar code assisted medication administration was used without the support of computerized prescribing on the dispensing processes and its user methods and the effects were assessed. Afterwards a ward at the hospital had a standalone system implemented and it was observed that dispensing times increased and potential dispensing errors (PDE's) reduced. It was also observed that staff moral had increased [18].

4. Methodology

4.1 Baseline Study

A baseline study was conducted in order to understand the challenges faced by the FSIP programe in the input management and distribution. Qualitative and quantitative analysis approach was employed in this study. This approach was selected as it allowed detailed data collection for the research study. Three (3) sites in two provinces were selected to be used as pilot sites in the survey. These are Chongwe in Lusaka province for its high crop production levels in the province, Lusaka also in Lusaka province for its central locality to the FSIP administration and Mumbwa in Central province also for its high crop productivity in province. A structured questionnaire was administered to a sample size of 35 respondents. The respondents included management and warehouse staff. In addition oral interviews were conducted with staff to gain the qualitative part of the survey**.**

4.2 Software Design methodologies

The architecture of the inventory system will be a 3 tier cloud computing client- server model. The application will be run on a desktop, laptop or mobile device like a tablet 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 layer. This layer provides customers with services over a network and has the ability to scale up and down according to user requirement. Reference [19] These virtualized pool of computing resources manage a variety of workload from back end operations to user application interaction. Reference [20] Cloud computing has enabled resource sharing in terms of scalable infrastructures, middleware and application development platforms to increase value addition in service delivery. Reference [21] Service in the cloud is offered in a number of service categories such as SaaS (Software as a service), PaaS(Platform as a service)and IaaS (infrastructure as a service) [22]. Figure.2 below depicts some of the cloud references architecture.
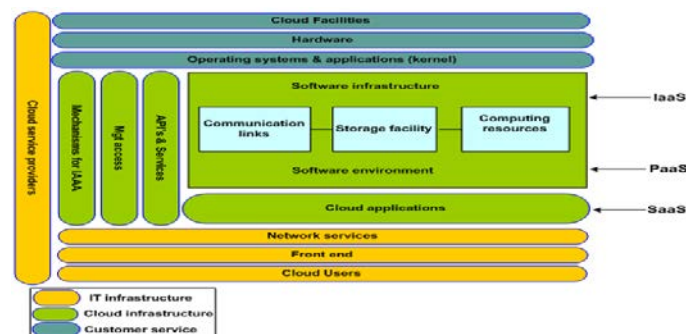

Figure 2: Cloud reference architecture

4.3 Business Process Mapping

The system under development is a cloud computing architecture comprising the user interface on the client side while the business logic and the database on the cloud. Figure.3 shows the context architectural diagram for the system. This system will be accessed by either through the World Wide Web (www) or a direct link on the network depending on user's location for them to perform their desired functions. Five primary actors have been identified as potential system users for the proposed system.
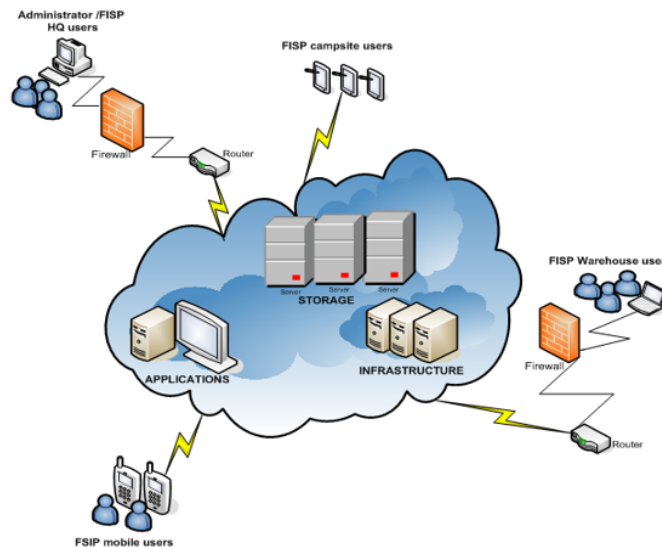
Figure 3: Architectural diagram of the proposed FISP inventory system
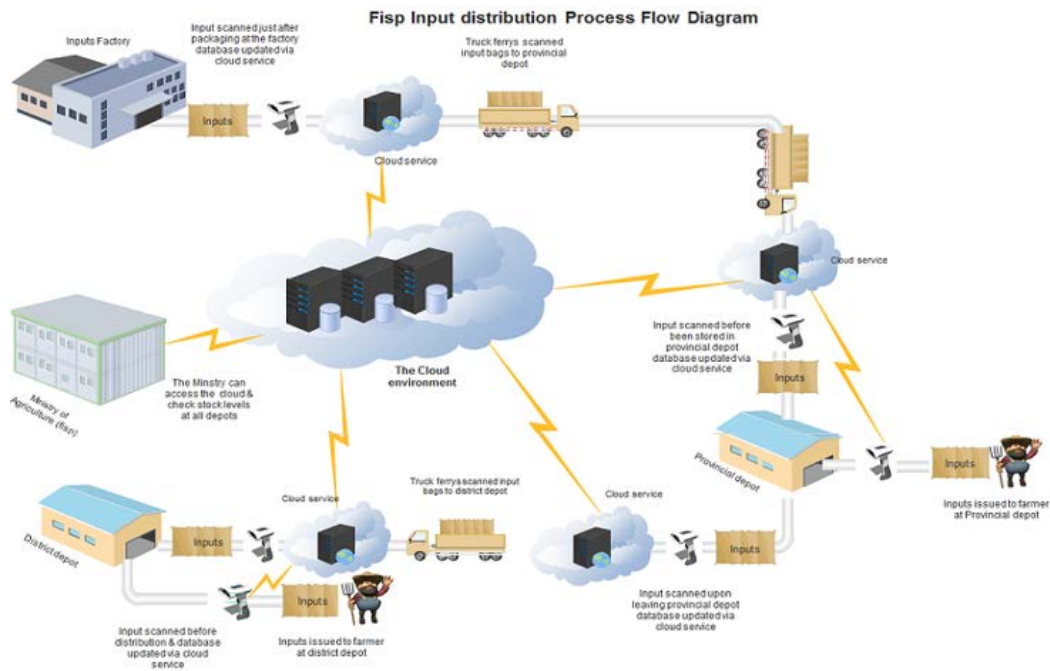
Figure 4: Proposed FISP process flow

The proposed FISP process flow is depicted in figure. 4 above. Inputs such as fertilizer will be sourced from Government appointed suppliers. Inputs will be packed in bags that are pre-printed with barcodes which will be captured and stored in a database. Bags received from the supplier will be scanned and data sent to the database before transportation for onward distribution. Once the truck gets to the provincial warehouse, bags will be scanned again before being loaded into the warehouse. The database is once again updated and data is used to compare stock that left the factory and what reached the provincial depot. At the provincial depot some registered farmers who are closer to this site can be issued with inputs at this point. Issued bags are scanned and stock levels updated in the database. Farmers that receive are marked as received and the database is updated to avoid unfair distribution experienced with the manual systems. For onward transportation to district warehouses, bags will be scanned as they are taken out of the provincial depot onto trucks. The database is updated on stock levels and inputs issued out. Once input reach the district depot, bags are scanned before being stored away at district level and again the database is updated on stock levels. When registered farmers start receiving inputs, bags are scanned and database is updated. At this point farmers that receive are marked as collected. A farmer as a zone member will apply for inputs and pay the necessary contribution required. Once the farmer's application has been approved by the District Agriculture Coordinator (DACO), the warehouse manager will be notified of the development. In turn he or she will notify the depot clerk of the applicants to issue inputs to. A famer who at this point should already be registered in the FSIP database will be notified about the input collection date.

The use case diagram in Figure.5 below shows some of the functionality of the proposed prototype that users can perform based on the findings from the research conducted. Access will be granted according to levels and functional needs in order to maximize security within the system. This will allow multiple users to perform different functions without compromising data integrity of the system.
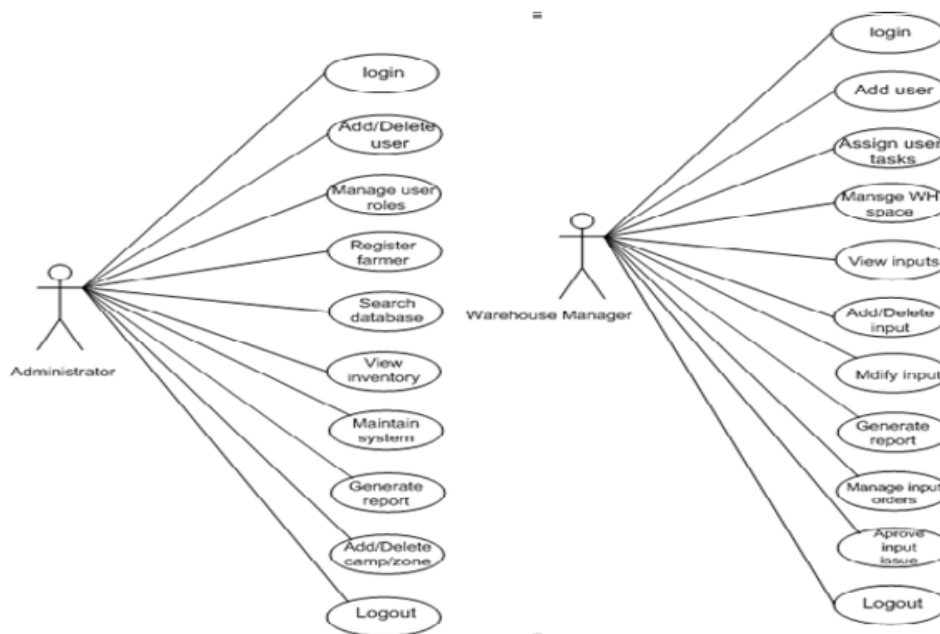
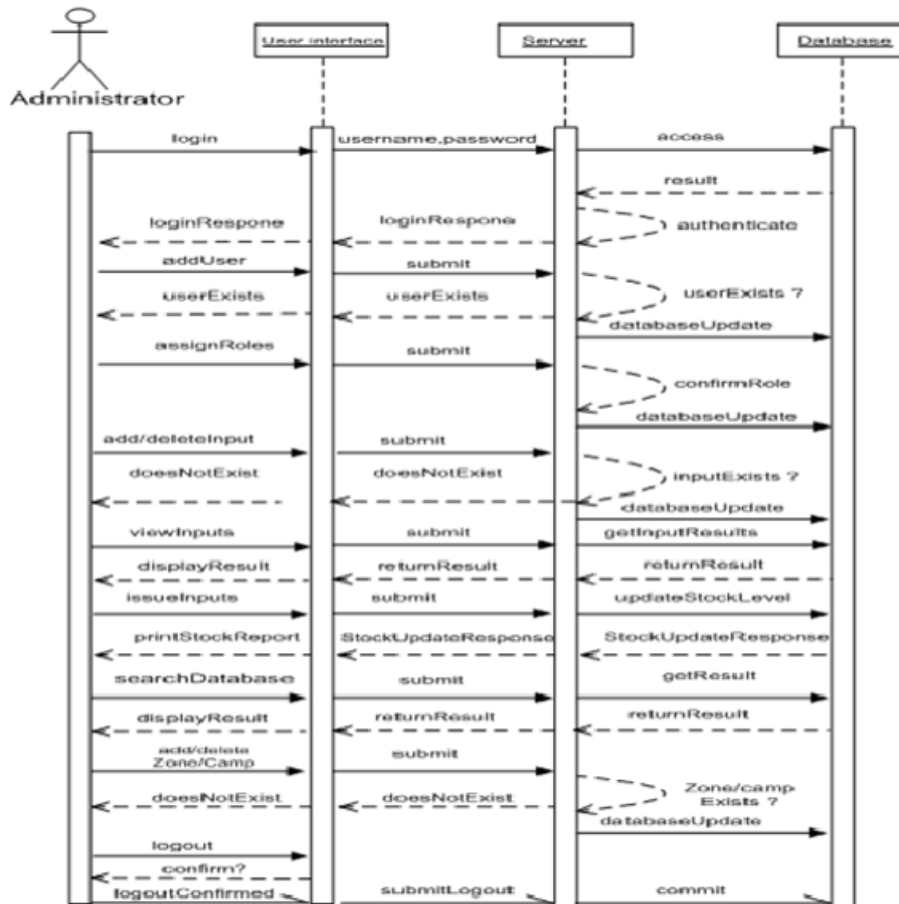**Figure 5:** System Use case diagram

Figure 6: Sequence diagram showing administrator

Figure. 6 above shows the flow of business processes involving the administrator such as logging into the system. Adding of users and assigning them roles. Adding and deleting of inputs, searching the database and the logout process.

Figure.7 below shows the Entity relationship diagram for the prototype. The relationships between the different tables can be seen in the diagram.
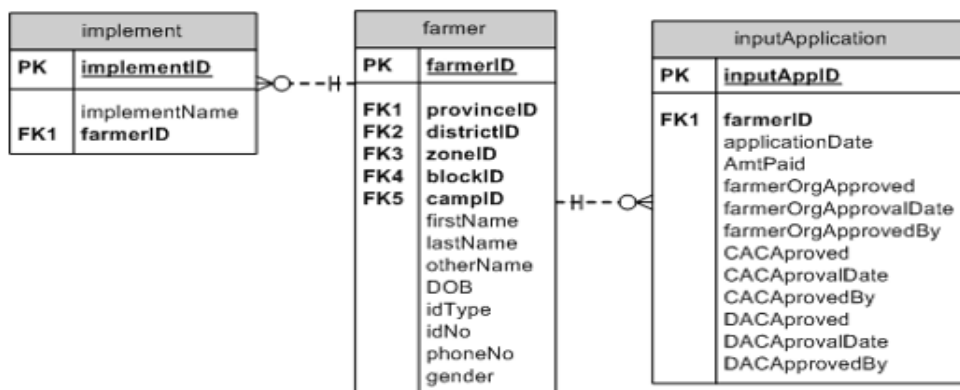

Figure 7: Entity relationship diagram depicting some entities of the proposed prototype

5. Results

The main purpose of the survey was to determine whether the automation of inventory processes can be adopted in the current setting of FISP to improve accountability and monitoring. Suffice to mention the need for ICT skills in order to use the system. The research focused on accountability and monitoring in supply chain of input distribution.
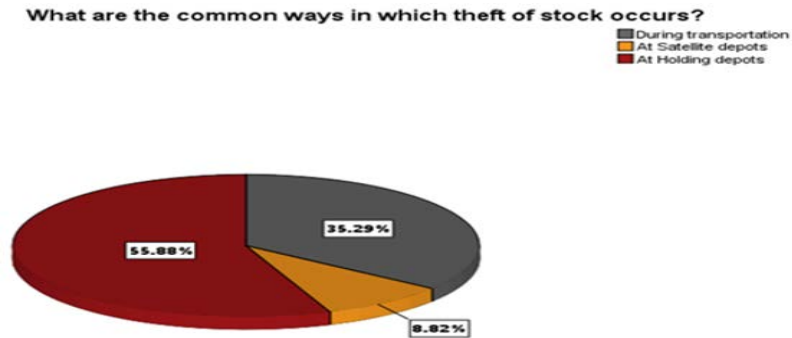
5.1 Theft Occurrence

Figure 8: Theft occurrences

Figure. 8 above shows the various variances of stock theft. The survey revealed that 56% of thefts occurred at warehouses, 35% during transportation and 9% at satellite deports.

5.2 Prototype Development

The prototype has been developed as a web based platform using PHP, MySQL, NetBeans and Apache web server as developmental tools incorporating Barcode technology to generate barcodes for tagging inputs and recipient farmers. Figure.9 below shows the login screen for the prototype.
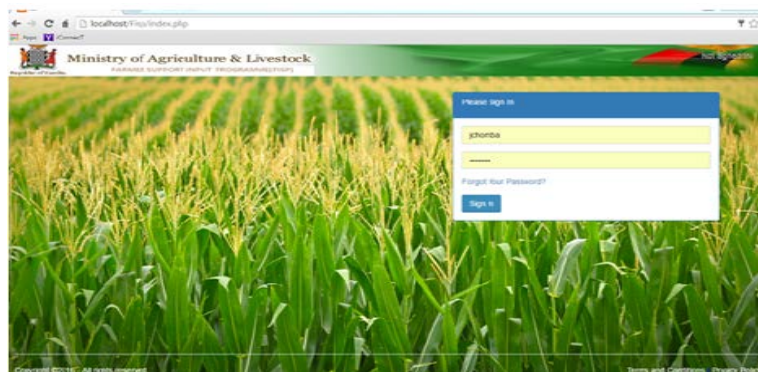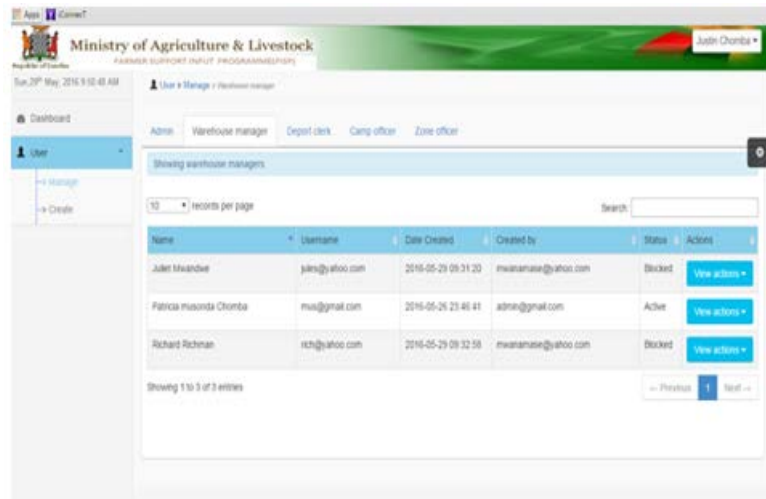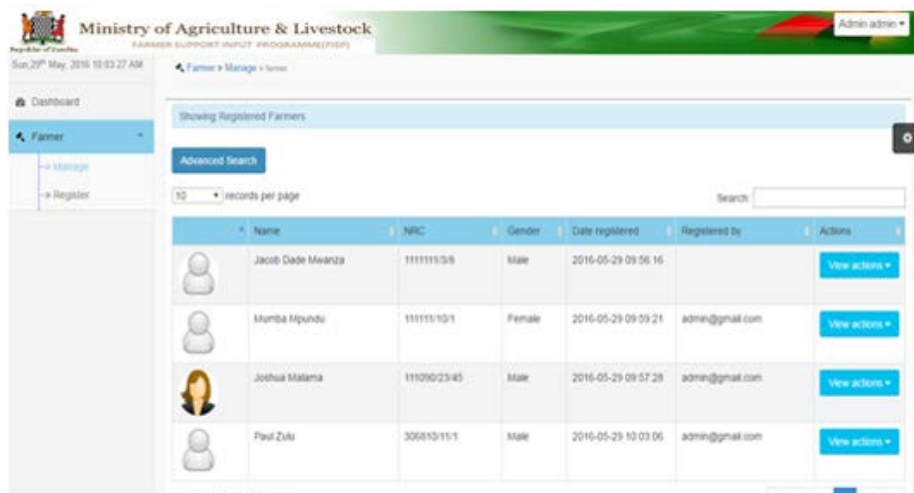

Figure 9: Prototype login page

Figure 10: User created in the Prototype

Figure 10 above shows some of users that have been created in the system while Figure 11 below shows some farmers that have been created in the system.

Figure 11: Farmers created

6. Discussions and Conclusion

The baseline study results showed that warehouses were not linked to any computer system and had no computers. As seen from fig.7 results show that 67.65% of record keeping is done on spreadsheets and relays on manual systems to capture data. About 68% of the systems lacked proper monitoring and tracking mechanisms leading to stock theft. Figure.8 Illustrates results from the survey which revealed that 56% of thefts occurred at warehouses, 35% during transportation and 9% at satellite deports.

In conclusion, a prototype has been developed that will improve accountability and traceability in FISP input distribution from farmer input application to input issuance. This prototype has been implemented using PHP,

MySQL, NetBeans and Apache web server as developmental tools incorporating Barcode technology to generate barcodes for tagging inputs and recipient farmers.

This study involves automating the inventory processes in FISP by integrating barcode technologies in the FISP Inventory Management System. Other Government support programs can greatly benefit by taking the route of inventory automation as poor accountability has been the greatest revenue loss in government institutions.

7. Future Works

This study saw some processes being implemented though some functionality has not yet been fully achieved. In the future, it is hoped that the prototype will incorporate some of the functions below:

- Global positioning satellite (GPS)

- IP Cameras in warehouse that can be monitored from any part of the globe

- Humidity and temperature monitoring systems

- Development of a comprehensive inventory management system

Acknowledgement

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