

**GRAIN CAPTURING TECHNIQUES FOR FRA BASED ON NEAR FIELD  
COMMUNICATION AND GEOGRAPHIC INFORMATION SYSTEM**

**BY**

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requirements for the award of the degree in Masters of Engineering in Information  
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## DECLARATION

I, the undersigned, declare that this has not previously been submitted in candidature for any degree. The dissertation is the result of my own work and investigations, except where otherwise stated. Other sources are acknowledged by given explicit references. A complete list of references is appended.

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## **DEDICATION**

I dedicate this research to my loving Parents Philip and Maureen Mwansa for their never-ending support during my entire study at the University of Zambia, my loving husband Mpange Kachingwe for the untiring support and always a shoulder to lean on, my sister, my Son and not forgetting all friends and colleagues for their support.

## **ABBREVIATIONS**

API	Application programming interface
FISP	Farmer Input Support Program
FRA	Food Reserve Agency
GIS	geographical information system
MA	Marketing Assistant
NFC	Near Field Communication
NRC	National Registration Card
OOSDM	Object Oriented System Development Methodology
PHL	Post-Harvest Loss
PMC	Provincial Marketing Coordinator
PRCN	Produce Receipt Certification Note
QR CODE	Quick Response Code
SDO	Satellite Depot Officer
SDS	Satellite Depot Supervisor
SMS	Short Message System
UN	United Nations

## **ABSTRACT**

The management of Zambia's national strategic food reserve is done by the Food Reserve Agency (FRA), which also ensures that the country's food market is well facilitated. The FRA also ensures that there is a reliable supply of agricultural commodities to meet local shortfalls during food emergencies caused by floods, drought or any other natural disasters. A satellite depot is a marketing center established by the Food Reserve Agency in outlying or rural areas for the purpose of receiving crops from farmers.

In this study we are proposing a model for automatic grain capture at the satellite depot using cloud technologies, quick response (QR) code and near field communication (NFC) technology. The objectives were to (1) determine and map all the business processes at the FRA satellite depot, (2) design a model for real time data capturing based on the business process established in the first objective using NFC, barcode technology and Geographic information system technologies and finally (3) develop a prototype based on model in the second objective.

A detailed study of the current business processes at the satellite depot regarding FRA activities in capturing the farmer details, processing and capturing of grain bags was successfully carried out to meet objective number (1). To address objective number (2), we used the business processes in (1) to come up with a model for automatic grain bag capturing. The automation and security features of our model are based on three technologies. These are cloud computing and GIS; QR coding of bags of grain and inventory based on NFC technologies.

A mobile application running on android devices and a web-based inventory management system based on the model in (2) have been developed to address objective number (3). The initial results show that we are able to automate the capturing of grain bags based on QR code from the satellite depot and see the results in real time from the FRA head office. The system provided low cost and highly efficient solution for grain capturing at the satellite depot.

**Keywords—Satellite Depot, NFC, QR CODE, GIS, FRA**

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## CHAPTER ONE

### INTRODUCTION TO THE RESEARCH

#### 1.1 Introduction

This chapter gives a brief overview of the research study. The ultimate objective and drive of carrying out the research is covered. The main guidelines are scope, problem statements, the actual objectives, the methodology adopted and the research contributions. It concludes with the organization of the thesis and a further brief outlook of the chapter.

#### 1.2 Background

With the many dangers to the world's climate and weather patterns, production of food is being hit negatively. The irony of this fact is that the world's population keeps growing and the little that is produced indeed needs to be secured. Regardless of the alluded problem, sadly, besides the natural hindrance to food production, the little that gets produced has significant quantities of it lost due to a number of factors [1] .

Postharvest loss (PHL) is *the degradation in both quantity and quality of a food production from harvest to consumption* [1]. This entails the entire process of reduction in quantity and loss of quality in the produce between the points of harvest to finally the consumption experienced even on present day. Agriculture sustains about 80% of Zambia's population, which in turn promotes economic growth and a significant decrease in poverty levels as indicated by the United Nations (UN) [2]. To properly manage the country's National Strategic Food Reserve on the agricultural activities and practices, an organisation called Food Reserve Agency (FRA) was established. The FRA manages the storage facilities that house food reserves in form of grains including white maize and paddy rice. The FRA purchases these products from small scale farmers through satellite depots. A satellite depot is a marketing centre established in outlying or rural areas for the purpose of receiving crop from farmers [3]. At these storage facilities, loss of grain is not a strange occurrence. Some of the causes identified for the PHLs were theft and poor monitoring [1]. To clear out human error in manual counting and tracking of bags of grain

an automated inventory management system it is thought fit to implement system to handle most of these activities.

### **1.3 Significance of the study**

Food security is an important element for a country's economic development. The FRA plays a very important role in the storage and management of our food reserves and therefore it is important to involve the use of ICTs in the inventory management system. The ability to effectively use ICTs has the potential to improve grain capturing, providing the FRA with an efficient option to capture bags of maize just by a click of a button once an automated system has been implemented. Such systems have a number of advantages such as decreased recording errors, reduction of labor costs and overall productivity growth.

### **1.4 Scope**

This study sought to highlight the challenges faced by the Food Reserve Agency at the satellite depots regarding grain capturing through business process mapping and modelling. A mobile application based on Near Field Communication (NFC) and Quick Response (QR) code was modelled to communicate with a web-based inventory management system that would capture bags of grain in real time to the cloud database. Literature review of NFC and QR code technologies and its application in tagging and inventory management was conducted to determine the most efficient way to implement the system. The results of this study were a system prototype based on the models.

### **1.5 Problem Statement**

The FRA manages the storage facilities that house food reserves in form of bags of grains but experiences a lot of losses every year because of theft and manual counting of these bags of grain. The proposed study seeks to develop an effective and convenient option of identifying, tracking and managing storage bags in order to reduce errors and theft.

## **1.6 Aim**

The aim of this study is to develop a technique for the capturing of grain at the satellite depot for the web-based grain inventory management system based on Near Field Communication, Quick Response Code, Geographic Information System technology, a cloud database and a mobile application which will aid the Food Reserve Agency in the capturing, tracking and to improve on security and minimize pilferage.

## **1.7 Objectives**

This research will be guided by the following objectives:

1. Determine and map all the business processes at the FRA satellite depot.
2. Design a model for real time data capturing based on the business process in (1) using NFC, barcode technology and GIS technologies.
3. Develop a prototype based on model in (2) using NFC, QR code and GIS.

## **1.8 Research questions**

The following are the research questions:

1. What are some of the major business processes at the FRA satellite depots during the grain purchases?
2. How can we design a cloud-based inventory management system for the FRA satellite depots that fits into their business processes?
3. Is it possible to develop a prototype based on the model in (2) using NFC, QR Code, GIS and mobile application?

## **1.9 Research contributions**

An automated grain capturing system prototype was developed and implemented to replace the current manual based processes. The mobile application was developed using PhoneGap/Cordova. This is a hybrid application with an android platform currently added. The tools used are html and JavaScript, with android studio used as the development platform. The web application was developed using mainly Hypertext Preprocessor (PHP) and MySQL for the database and was deployed at the satellite depot. The results have been published in both the International Journal of Innovative Research

in Science, Engineering and Technology and in the American Journal of Engineering and Applied Sciences.

### **1.10 Organization of dissertation**

This dissertation includes five chapters, each of which with a specific area of concern. Chapter 1 introduced the overall contents of the entire research works to be documented. It outlines the problem statement, aims and motivation and closes with an overview of the entire thesis.

Chapter 2 digs deep into the background theory and related works. Further, it gives a detailed account of near field communication and quick response codes, geographic information systems, cloud computing technologies and the actual mobile application and web inventory management systems. It closes with related works regarding object tracking, monitoring and inventory management.

Chapter 3 will cover the research methodology. This will basically be the methods used to conduct the baseline study and system implementation plans.

Chapter 4 gives the research findings of the baseline study and the actual implementation of system.

Chapter 5 will outline the closing notes on the aspects of the entire research.

### **1.11 Summary**

Chapter one introduced what the entire research will cover. The major drive to carrying out this research being reducing the challenges in the area of national food security. The development of automated systems both mobile and web applications was proposed as a first step at the inventory management. A clear guidance on the contents of the preceding chapters in this thesis was equally given.



## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter discusses the reviewed literature and related works associated to this research. Firstly an introduction to Zambia's Food Reserve Agency and its functions as a national strategic food reserve then Near Field Communication and Quick Response Code technologies and how these technologies can be used in food security. This will be followed by a review of GIS and cloud technology. At the end of this chapter a review of related works which are using NFC and QR Code are looked at.

#### 2.2 Zambia's Food Reserve Agency And Food Security.

Food security as defined by the United Nations Committee on World Food Security *is the condition in which all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life* [4].

Food availability: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).

Food access: Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).

Utilization: Utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security.

Stability: To be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food

insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

A country's economic growth is only sustainable if it has food security. *The Zambian Ministry of Agriculture has various systems that helps farmers earn a living such as the Farmer Input Support Program (FISP)* [5]. The organization in Zambia which is in charge of managing the country's National Strategic Food Reserve is known as the Food Reserve Agency (FRA). Established in 1995 by an Act of Parliament CAP 225 of the laws of Zambia. In 1996 the Food Reserve Agency (FRA) replaced the operation of the National Agricultural Marketing Board (NAMBOARD) and Zambia Cooperative Federation (ZCF). The Government amended the FRA Act in the year 2005 and conferred upon the Agency the additional mandate of crop marketing. FRA was created because of the assorted social and economic reforms that the Zambian Government embarked upon since 1991 geared towards making a market destined national economic system. This led to the agriculture sector to include the marketing of agriculture produce and this saw the Government reducing its participation. The Governments responsibility within the agricultural sector is currently restricted to:

1. Ensuring the maintenance of food security reserves;
2. Providing overall market support;
3. Providing relevant market information; and
4. Providing agricultural credit facilities to small-scale farmers

### **2.2.1 Food Reserve & Marketing Department**

The Food Reserve and Marketing department is in charge of managing the national strategic food reserves. The department is composed of four units which are named Standards and Quality, Market Information, Operations and Monitoring and Evaluation.

*The agricultural marketing policy of the Government of the Republic of Zambia is reflected in the FRA Act.* This Act contains provisions, which aim at making the required conditions to encourage the non-public sector to develop efficient agricultural production and marketing systems, while curtailing the direct intervention and control by

Government agencies and establishments. The FRA, therefore, is the implementing body of the Food Reserve Act.

### 2.2.2 Storage

Zambia currently has 458 units of storage facilities whose storage capacity is 2 million metric tonnes (MT) of which only 1.1 million MT is serviceable.

Though as a nation we seem to have sufficient storage capacity (2 million MT), the apparent shift in the agricultural production patterns from the Southern to Northern Zambia, due to change in weather patterns, has not matched the distribution and location of existing storage facilities.

Table 2.1 : Existing FRA storage facilities [6]

Location	Quantity	Capacity
Kapiri Mposhi	2	5,630mt each
Serenje	1	4, 980mt
Kalomo	1	19,370mt
Chambishi	3	15,470mt
Chisamba	2	980 mt
Mbala	1	5,630mt each
Petauke	1	4, 980mt
Mfumbwe	1	4, 980mt

### 2.3 NEAR FIELD COMMUNICATION

This technology involves a short range wireless communication mechanism that is used to exchange data and energy based on the Radio frequency identification (RFID) standards and protocols, with NFC based on largely interaction unlike RFID [7]. There is an interrelationship of many aspects and stakeholders to make this communication successful [8] [9] [10] . The touch or tap to communicate mechanism is employed to make two NFC powered devices communicate [11] [12]. For more recent devices, even bringing them to within a few centimetres, information can be read or written [9] . It is also noted

that NFC operates at a high frequency of 13.56MHz [13]. Due to the need of standardising their smart cards Mifare (Philips) and FliCa (Sony) [14], developed the NFC technology to basically help in electronic authentication and authorization. In our everyday life, NFC enhances the mode of linking virtual information to physical objects that are used for various activities to identify, track and even connected to other network setups [15]. NFC devices utilize reverse technology and are backward compatible with other RFID powered devices, setting up a mode for users to handle contactless financial transactions, access digital content, and connect compatible wireless devices [16] [17]. With close proximity being a way in which NFC powered devices communicate, the other technologies of Bluetooth or WLAN connections can be supplemented while still retaining the aspect of contactless connections but with a special advantage of having not the need to configure the devices manually [17] [18].

The technology of NFC employs devices to either be in passive or active mode [19]. NFC Passive mode devices work in such a way that communication can take place without a need of a power source [20]. However, passive mode devices cannot process any information received from other sources, exchange information nor connect to fellow passive devices [21]. This can be experienced among small transmitters and tags, where the major use is for advertisements i.e. beaming text, signs and symbols on walls [22]. The other class of active devices are powered to exchange information or data, communicate with each other and even connecting with passive devices. This class of NFC devices is used mainly in mobile payments, interactive advertising, ticketing mechanism in transits and so on. A very good example of Active NFC powered devices is a smartphone.

### **2.3.1 Comparison of tag based identification technologies**

Perhaps the most prominent advantage of having 2D barcodes, is their ability to store significant amount of data even with little storage capacity and equally being favourably less costly compared to the RFID/NFC tag. Hence, the 2D technology being preferred for visual decoding. However, resources such as good optics, high processing power, complex algorithms, and different methods of data representation are needed to decode

2D barcodes [23]. Figure 2.1 shows the comparisons of NFC technology with other wireless technologies.

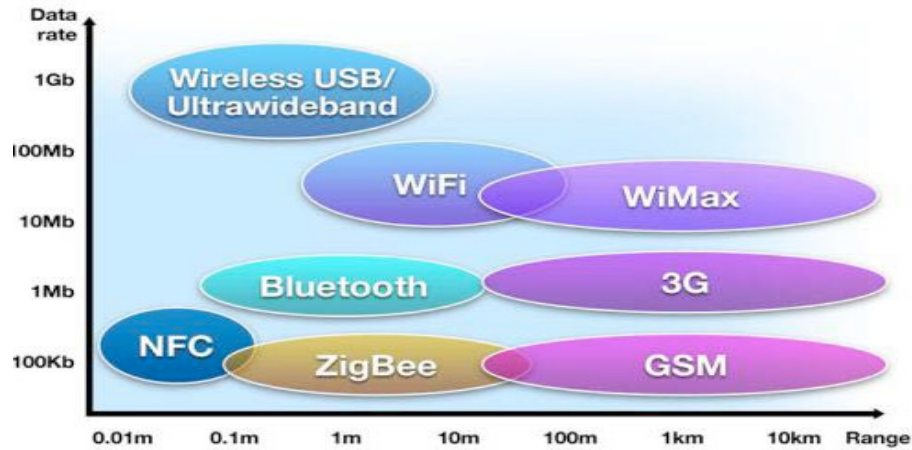


Figure 2.1: Distance and data rate difference of NFC with other existing wireless technologies [24]

Table 2.2 describes the strengths and weaknesses of different types of automatic tag based identification technologies.

Table 2.2: Strengths and weakness of tag-based identification technologies [25]

TYPE	STRENGTH	WEAKNESSES
<b>2D Visual tag</b>	Uses Electronic article surveillance (EAS) to track inventory, Huge data storage capacity, low cost and ideal for visual decoding, printable.	No ability for reusability, low decoding speed.
<b>RF tag</b>	Can read or write data as long as it is within frequency range with fast speed, has reusability capability and high data storage capacity	Costly and not printable.
<b>Near field communication (NFC) tag</b>	Read and write data with considerable speed Could be reused , Huge data storage capacity and low energy consumption.	Costly and not printable.

A wide range of different wireless technologies are in existence, some in direct competition with one another, others designed for specific applications. Wireless technologies can be evaluated by a variety of different metrics (see Appendix A1).

### 2.3.2 NFC modes

Near Field Communication technology has been propelled by the growing need for users' reliance on hand held devices i.e. smartphones to handle they day to day business with ease [26]. NFC technology continues to receive positive feedback from users due to its simplicity and flexible setting in infrastructure surrounding it across the whole world [27]. The three main operating modes of NFC are as follows:

- (1) *Card emulation mode*: This takes after the native contactless smart card mechanism where the NFC device acts as an external reader [26]. This ensures a contactless communication API for making payments and ticketing on transits by NFC devices, but still maintain the existing infrastructure. The NFC powered device can emulate several smart card chips (ISO 14443), while retaining more than a single form of identification.
- (2) *Reader / writer mode*: This is where NFC powered devices are capable of reading NFC Forum-mandated tag types, like ones fused on an NFC encoded poster [26]. This mode is based on the RF interface, designed to meet the ISO 14443 and FeliCa schemes. To resolve multiple detection of tags, an anti-collision algorithm is used to focus to select only one tag (approximately at a 106 Kbps rate of data transfer). This works such that the tag type (ISO/IEC 14443 A/B or FeliCa) is set to communicate appropriately. Third party applications can be used to assume the write capabilities of this mode like the famous Tag Writer.
- (3) *Peer to peer mode*: This is where two NFC powered devices exchange data (approximately 424Kbps) as though they have been networked [26]. The two devices initialise the data block size and other communication parameters before data exchange and works similarly with the Bluetooth or WIFI way. This mode is standardized on the ISO/IEC 18092 standard.

Table 2.3 illustrates the advantages and the future prospects of the NFC modes.

Table 2.3: NFC modes [28]

	Card emulation mode	Reader / writer mode	Peer to peer mode
Positives	<ol style="list-style-type: none"> <li>1. No physical object required.</li> <li>2. Strong access constraints.</li> </ol>	<ol style="list-style-type: none"> <li>1. Utilises mobility.</li> <li>2. Less physical effort</li> <li>3. Very flexible to changing scenarios</li> <li>4. Implementation not difficult.</li> </ol>	<ol style="list-style-type: none"> <li>1. Data exchange is easy to permit between devices</li> <li>2. Device pairing is quick and easy</li> </ol>
Future prospects	<ol style="list-style-type: none"> <li>1. Incorporating identification cards (national and drivers licenses) and finger prints.</li> <li>2. Growing the storage area for critical information, returning the users' privacy needs and access controls on the information.</li> </ol>	With adaptability capabilities, all possible scenarios can be incorporated, where NFC tag reads can be done even on NFC enabled smartphones.	<ol style="list-style-type: none"> <li>1. Strong security measures on data exchange.</li> <li>2. Grapevine exchange</li> </ol>

### 2.3.3 NFC standards and NFC forum

To bring about sanity and global standardisation of handling the NFC technology, various organisations have been formed. The core idea is to match operation and the data exchange mechanisms. The leading organisations are as follows:

- 1) *International Standards Organization (ISO) or European Telecommunications Standards Institute (ETSI)*: Gives guidelines on Interface, protocols and application methods for other NFC standards developed by two subcommittees i.e. SC6 (Subcommittee 6) and SC 17 (Subcommittee 17). The former looks at NFCIP-1 and NFCIP-2 on their Interface, protocols and test methods, while the

latter mainly on RF interface, activation and protocols and standard for Vicinity Cards [24].

- 2) *European Association for Standardizing Information and Communication Systems (ECMA)*: This is a private owned organisation with valid guidance on RF field/signal interface, initialization/anti-collision, transport protocols, and supports all modes of NFC. They also standardise on the operating mode selection (ISO 14443, 15693 or NFCIP-1). They also use ECMA-356: NFCIP-1 – RF for interface Test Methods and single device detection and the transmission protocol to ensure interoperability on the RF interface for ECMA-340 devices. [18].
- 3) *The NFC forum*: Privately ran non-profit making entity, consisting of many working groups, formed 2004 [17]. These organisations collaborate to provide a framework for application development, deployment guidelines and securing the associated transactions. They also go an extra mile to educate NFC users and enterprises across the world. They also work on enforcing and certifying NFC capabilities against the set specifications. They mainly work around Protocols, Data Exchange Formats, tag and record types and Reference Application Technical Specifications, with initial works starting around 2006 [24].

With developments in this sector, the three largely used forms of NFC technology include: Low-Frequency (LF), High-Frequency (HF) 13.56MHz and Ultra-High Frequency (UHF) 860-960 MHz [29] [30].

#### **2.3.4 How NFC works**

NFC technology stems from the RFID technology [8] and as such NFC chip utilizes a wireless link, where once activated by another chip, data transfer takes place within some reasonable centimeters apart [31]. To enable this data transfer, no special pairing code is required as these chips are powered by very low amounts of power (passively, using even less), making it more effective than other types of wireless communication [31]. This identification is readily done by NFC powered cards or devices, within a short-range communication platform and the associated compatibilities [32]. In a single communication setup, one device is required to act as a transmitter, whereas the other



accepting to receive the signal. NFC supports many devices as the technology appreciates interoperability features and returns the passive or active device architecture. Passive NFC enabled devices need no power source of their own to function as seen among tags and other small transmitters to exchange information. The major drawback is that these cannot process any information sent from other sources nor forming a connection with others. These are widely used on interactive signs on walls and other advertisements initiatives [33].

On the other hand, active devices are able to handle sending and receiving data, and communicate across with passive devices. The most common implementation of this mode is with smartphones, transit ticketing and handling payment terminals [33]

### **(1) NFC tag reading**

The first step is enabling NFC mode on the smartphone's settings to power up NFC decoding and encoding. This calls the device's system detection area to decode the payload. This tag dispatch system then analyses a tag and classify the associated data. This process is demonstrated in Figure 2.2. Where the smartphone starts the NFC function and tag is detection. Next, the tag dispatch system will automatically create intent of encapsulating the NFC tag information and concludes with receiving the acquired information via the information acquisition system.

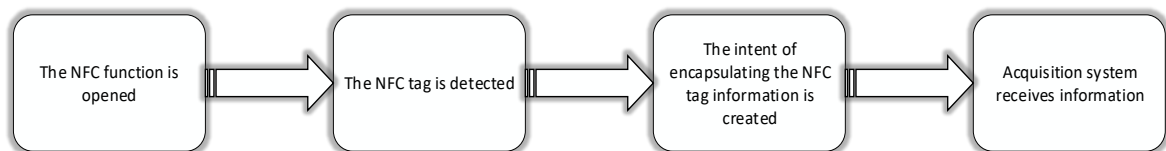


Figure 2.2: Information acquisition system reading an NFC tag flow with a smart phone

## **(2) NFC tag writing**

- i. Select an encoding type: This will determine the kind of data that a tag will hold like contact, URI, Plain text, Short Message Service (SMS), Email, Telephone or Bluetooth [34].
- ii. Define a bookmark to hold the data [34].
- iii. Actual creation of the data [34].
- iv. Choose the encoding options, such as locking the tag, data rewrite on other tags and confirmation of data overwrites [34].
- v. Tap the tag to encode it by placing the device until encoding is complete (usually takes a few seconds) [34].

These steps follow four technical processes as object initialisation, chip connection, reading allocated sector and data lengths and finally writing that data with the specified start sector.

### **2.3.5 Examples of different types of NFC tags**



Figure 2.3: NFC tag

Figure 2.3 depicts a sample NFC tag. This particular tag can store data due to its small amount of memory, an antenna and can be programmed. This type doesn't have its own power source and as such, relies on powering from another device via magnetic induction. This allows customization of data read or write, with an initial state of being programmed into blank NFC tags. These tags come with security features where data can be written

and set to be read-only and even encryption to only allow reading by set devices. Due to their small size, they can be easily incorporated on several devices that help with the day to day activities.

### **NFC enabled digital tattoos**

This is a semi-permanent skin art of digital nature which can be read by NFC-enabled smartphones. The skin tattoo works like the other NFC tags, where at close proximity data can be exchanged with the device [35]. As in Figure 2.4, NFC enabled digital tattoos are stuck onto a user's arm, and they use very little power especially during data exchange.



Figure 2.4: NFC enabled digital tattoo

With every of these tattoos imbued with an identification code, once in contact with an NFC-enabled device, the exchange is promptly initiated and allow synchronisation of the code. Hence each time the tattoo comes within a detectable range of the phone the code is verified and the phone locks itself. This tattoo is adhered to a user's skin using a high-quality adhesive, which is so mild on the user's skin. With a life span of up to five days, these tattoos are designed to guide against withering brought by day to day activities. The internals of the tattoo are built using semiconductors that provide the flexibility [36] to bend in accordance to the user's skin. When a new tattoo is stuck, the device has to be synced once again to allow communication. To provide a customised way of syncing every time, a special scheme is devised to allow backup and restore processes. This mechanism works well to protect the phone in events of theft or erosion of the current tattoo.

NFC-enabled device locking and unlocking technology has even proven to be faster and more accurate than biometric systems like fingerprint or retina scanners. Another drawback is that these other systems require hardware architecture inbuilt onto the device and noticeably costly. With kicks and development with these digital tattoos, one can only predict how communication between a user and their device being simpler and more efficient.

### **Motorola Skip™ - wearable accessory to unlock your phone based on NFC**

The Motorola Skip™ is a suitable example [37] that depicts the concept of locking and unlocking smartphones using NFC. It was first tested as an add-on accessory for the Moto X [38]. This technology combines the Skip™ clip and Skip™ dots components, making it a hybrid. With both components having NFC tags embedded onto them, the entire process of NFC already alluded is returned.

As shown in Figure 2.5, the Skip™ clip bears a strip of fabric, which comes with magnet closures at the tips to firmly hold on clothes worn by a user [39]. It fits well without denting the appearance of the clothes and can easily be unlocked once the phone is placed within specified proximity. On the other hand, the Skip™ dots are not too different from the digital tattoos alluded, with only flexibility of been placed or fixed on surfaces like desks, dashboards and the like. They work effectively and can keep the phone unlocked once placed on them.



Figure 2.5: Motorola NFC tag [40]

This mechanism provides ease of working as the day to day activities might require phones being unlocked and hence the need not to manually do it when required. The phone is always on the move and with the flexibility of being placed almost anywhere, these dots come in very handy.

### **2.3.6 Advantages of electronic tags**

The NFC technology has taken the world of technology by storm due to its several advantages including automated identification, the tags being small yet accommodating essential data and contactless data exchange with a favourably high-speed rate [41]. The following are the other common advantages:

1. These tags can be reused, providing the capability of writing new data at high speed.
2. NFC requires no manual configuration provided the devices in question are NFC enabled. They can also be configured to connect/enable Bluetooth or Wi-Fi automatically.
3. The NFC-enabled smartphones not only work as NFC readers but can also be used to write data on and store.
4. They support backward technology set by RFID platforms as tags and/or contactless smart cards.
5. They require little power for functionality and the communication setup is easy as it only requires two devices i.e. one where data is stored and the other to read it.
6. They can be used to process payments and transit ticketing to the public with the needed security constraints implemented.

### **2.3.7 Disadvantages of electronic tags**

1. Besides limited storage space, these tag chips produce electronic rays and radiation which can cause cancer and tumour.
2. Short read range
3. Limited tag features

### **2.3.8 NFC security**

Encryption and decryption capabilities of data stored on NFC applications comes as one security measure that this technology bears [42]. Once sensitivity is applied NFC devices can also read NFC tags, even with less power energy present on them. The power is that, some NFC data might include URL links or even other programs that may guide where to get the source of a particular data set. As earlier stated, inheriting the architecture of RFID, NFC data transfer can be exchanged at a maximum of 424kbit/s rate, requiring an initiating device with a Radio Frequency that powers the exchange to reach the receiving device [42]. Further, the active NFC device should have its own power to trigger the IC for generating the outgoing signal, which requires that the passive device doesn't necessarily need to have its IC embedded with power. This form makes the NFC tags to come in varieties of cards, stickers and mere tags. The other forms of NFC operations can also help explain the security aspect that each bear depending on the type of data that needs to be exchanged. Once an NFC powered device nears the active space or proximity, it has power to initiate a phone call, launch a URL, or can even send an SMS. This comes handy as any security alerts can be programmed to safeguard the user at the time.

### **Security concerns with NFC technology**

Much as NFC is making our every day to day activities easier, there are some new users that fall prey to various aspects of social engineering from unscrupulous individual. The most common case is on the payment models where users might want to make payments using NFC and without proper measures to safeguard this information, they end up having their card/bank information stolen. This causes a huge security breach and even compromising on the users' personal information. The following are some of the classes of these acts:

#### **Eavesdropping**

This is where a criminal intercept or listens in to a transaction or conversation without being noticed [42]. The idea is not to get every detail but gather enough information to use against the victim. There are gadgets that these people use to achieve this interception, as they try to breach the exchange parameters. To curb this, NFC technology allows close proximity to exchange data between devices and also the usage of secure channels. With

secure channels comes the aspect of decrypting data and allowing the receiving device to decrypt it in an end to end channel. This keeps the criminal out of reach.

### **Data Corruption and Manipulation**

The criminal might also try and alter the form of data by way of either corrupting it or making it unreadable [42]. With secure channels again, data can be protected to guard against tampering with it before reaching the intended terminal. This entails that, there has to be a constant check/listen to data being exchanged to block any foreign gadgets or bad data from attacking it.

### **Interception Attacks**

This is an advanced attack where unauthorised gadgets or objects are fused in in between the sender and receiver such that data reaches in a distorted form to the receiver [42]. To combat this, NFC devices are set to be in an active-passive pairing. This helps dictate that one device just sends data while the other receives in that communication cycle, unlike both devices exchanging roles in an uncontrolled or monitored manner.

### **Theft**

This is more physical. Much as the software aspect can be guarded, sometimes protecting NFC devices from being stolen tends to be difficult [42]. Once stolen, these criminals can use the devices just like the owner would, even making purchases. The users are strongly encouraged to guard their devices diligently and also enable passwords.

While there is a debate of which technology is safer between NFC and credit cards; NFC comes slightly above as it requires a fellow device to read its contents unlike cards where the owner's information is readily seen. With passwords enforced on NFC powered devices, this technology will prove safer and more efficient than the cards. The explained secure channels and encryption constraints present on NFC just adds more advantages of using this technology instead.

## **2.4 Quick response (QR) code**

### **QR codes and how they work**

With the growing presence of QR codes in supermarket shelves, magazines and other places, this technology begs to be adhered to. Quick response code (QR code) is a two-dimensional barcode that is mobile phone readable that can contain small sets of data and was developed in 1994 by Denso Wave Corporation [38] [39] [40]ISO/IEC. It was initially developed as a way to track vehicles as they were assembled and to scan components at high speeds and now has been adopted into various industries and innovative applications [41]. QR code is established as an ISO standard, it has been defined in the Information technology — Automatic identification and data capture techniques — QR code 2005 bar code symbology specification [40]. It is free to use (open standard and public patent) and the technology is open since its specification is disclosed and the patent right owned by Denso Wave is not exercised [38]. QR codes are capable of much higher capacities of information storage compared to their traditional bar code predecessors [38].

The original one-dimensional barcodes used on most consumer product can be mechanically scanned [43]. The mechanism is such that a bouncing narrow beam of light is focused on the code and interpreted using the reflection of light off of the white gaps separated by some lines. In terms of comparing the 1D barcodes against the QR codes, the disparity is that the latter can hold about 100 times more data [40]. In terms of encoding information, QR codes reads from left to right then top to bottom [44]. With the power of matrix barcodes, these can more data and encode several types of data due to the said different directions they take when encoding. The block formed by black and white squares is basically read by the sensors present on smartphones, the transfer to the system processor for interpretation [45]. On the other hand, the three large squares help to align the reading as targets, while the smaller square around the left corner help to normalise the angle and size of the shot [46]. These usually contain formatting information, while the other part contains the actual data, which then is converted into binary code and scanned to detect any errors before the final information display. The



interpretation can then form the primary modes as byte/binary, numeric, Kanji and alphanumeric.

With developments in the technology of QR codes, the amount of data that they can contain has increased from 21 \* 21 pixels by 4 characters of data to about 177 pixels square and can hold up to 1852 characters. As shown in Figure 2.6, the main characteristic of a QR code compared with a traditional bar code is that it contains information in both the vertical and horizontal directions, while a bar code contains data in one direction only. For this reason, QR code holds a considerably greater volume of information [47].



Figure 2.6: QR code compared with a Bar code [48]

In addition, QR code can encode several types of data including symbols, control codes, binary data, and multimedia data. The typical barcode only holds a maximum of 20 digits, while the maximum data capacities of a QR code are 7,089 characters for numeric data, 4,296 characters for alphanumeric data, 2,953 bytes for binary data, and 1,817 characters for Japanese Kanji and Kana data [49]. It can encode a website URL, a YouTube video URL or any social media links, geo-coordinates, email addresses, email message, a PayPal Buy Now Button link, and so on.

Table 2.4 illustrates some of the differences between barcode technologies and NFC technologies.

Table 2.4: Comparison between barcode and NFC [50]

Attribute/feature	Barcode	NFC
Technology	Optical(laser)	RF (radio frequency)
Environment condition	Sensitive to environment, dirt scratches and temperature	Customized to resist environmental stress and severe processes
Read/write	Cannot be updated	New information can be over written
Price	Cheap	Expensive
Identification	Most barcodes only identify the item (UPC code) but not uniquely	Can identify each item/asset tagged
Read range	Several inches up to several feet	Up to 10cm
Data storage	Barcode is the representative of numbers that cannot store any data	Can store data up to 168 bytes of data.
Type of tracking	Require manual tracking and therefore susceptible to human error	can be automatically tracked removing human error.
Integrability	Not integrable	Integrable with sensors

QR code is faster to read than other two-dimensional code, because it contains three large square patterns in the corners that are used for position detection [49], as shown in Figure 2.7 which depicts the structure of QR code.



Figure 2.7: Structure of QR Code [51]

The patterns are used to detect the size, the angle and the outer shape of the symbol. When a reader scans a symbol, it first detects these patterns [52]. Once the position patterns have been detected the scanner can rapidly read the inside-code in all directions. The inside code consists of several small blocks where the information is encoded. The decoding speed of the QR Code can be 20 times faster than that of other 2D symbols [53].

The elements contained in a QR code are the following:

- I. **Position Pattern.** Three big squares in the corners used for detecting the position, the size and the angle of the QR Code [49].
- II. **Alignment Pattern.** A pattern used for correcting the distortion of the QR Code. These distortions could occur for example when attaching the codes onto a curved surface [49].
- III. **Timing Pattern.** It consists in white and black modules arranged alternately and placed between two position patterns. It is used to determine the central coordinate of each cell in the QR Code [49].
- IV. **Quiet Zone.** A margin space that makes easier to detect the QR Code. At least four cells are required for the quiet zone [49].
- V. **Data Area.** The area in the QR Code that contains the data (for example a URL) encoded in binary numbers. The data area also includes Reed-Solomon codes to provide error correction functionalities [49].

Away from the automotive industry, QR codes have taken use in almost everything, from shipping and logistics, inventory tracking and online ticketing. They can also be used to link information on websites and offer customers with reminders when new stuff is posted and for event adverts. They are used on business cards to bear Google Map directions, call the company website or even contacting the company's helpline. To achieve this, steady focus when taking a shot, appropriate QR application to interpret and data connection to the website/server is needed.

Like any other technology, QR codes are also a subject of attack. With the freedom of generating QR codes, these can also be used to transmit malicious code known as "attagging" [54]. Programmers can write some malware and easily imbed them on the QR code, even over tags that are legit. Depending on the intentions of these malware, they can even go as far capturing the users' contacts, passwords, camera access and other private data on the smartphone. The phone's functionality can be altered to even be used as a bot net to send unauthorised texts or even phone calls.

#### **2.4.1 How it works**

To use a QR code, one would need a smartphone, iPod, netbook or similar device with a camera, a QR code reader application must be installed, and, in most cases, Internet access, either through a wireless network or through a data phone plan [55]. The user would scan the code and gain access to a variety of information, from textual information and URLs, to contact information that can initiate a text message or phone call. Although QR codes were first developed in the 1990s, they have only more recently appeared in public spaces such as on posters, flyers, newspapers, and magazines. The content on the QR code cannot be changed once generated. Once scanned the QR code will direct you to the content in which it was generated for.

There are many different types of barcodes (see Appendix A2). Each of these barcodes have different special characteristics [53].

### **2.4.2 QR code structure and the software tool for processing QR codes**

Each QR code is structured by dark (logical '1') and light (logical '0') modules. The modules are evenly distributed in a square net of fields, where the size of the field is the size of a single module. By the standard ISO/IEC 18004 *one module should be sized 4\*4 px (pixels) with the print resolution of 300 dpi (dots per inch)*. This size ensures readability by the majority of optical devices.

ZXing (pronounced “zebra crossing”) is an open source multi-format 1D/2D barcode image processing library implemented in java, with ports to other languages [47]. Functions for QR code generation from this library are used for generating QR code image, which is further sent to direct printing to each product / semi product packaging. QR code can be directly printed by applying toner powder to the laser printer to the packaging material or by using specialized lasers (for example marking lasers of the producer TRUMPF) for engraving the QR codes in the packaging material [56]

### **2.4.3 QR generator**

QR codes can be created for free using any number of web-based forms [57]. Creating QR code is as simple as copying and pasting or writing the desired information into a text box and hitting ‘generate’. We can choose what the content of the QR code will be -URL, text, phone number or SMS by selecting the appropriate check. We can also choose the size of the code. Usually there is some kind of menu where we can do this. After all this the generated code appears in a special place of the screen. With the right -click of the mouse on the image of the QR code, we can save it in the computer. After that, this image can be printed, emailed, posted online or otherwise [58].

### **2.4.4 Some day to day uses of QR codes**

Like introduced, we now look at the common uses of QR codes in everyday business activities.

1. QR on business cards: Common business cards contain basic contact information (name, title, phone number, address and email), but with the incorporation of QR codes, so much more can be stored [59]. QR codes help put links to company website, social media accounts and other professional profiles like LinkedIn. This

initiate comes in handy for customers amidst their busy schedule, as such one scan can save all the said information instantly on phone contacts or even on notepads depending on the configurations done.

2. QR with print advertisements: Unlike showing just recent promotions on sales and specials, the company can save so much time and space on adverts by using QRC codes [59]. Where flyers containing prints of shrunk information on small pages, links to website for more information can be useful as achieved by QRC codes. This means that on the advert posters, include only few information and leave the rest to be handled by QRC codes to link customers to website where they can see videos and even online purchase links. The business can also track how many customers are visiting their sites, providing a platform for customer relationship enterprise systems.
3. QR with stationery and invoices: Running a smooth business involves reducing on mistakes especially on anything printed to be shared with customers [59]. QR codes imbedded on business stationary and invoices help reduce this by linking this to essential information like contact numbers, return labels and even user guides.
4. QR on events: QR codes on events can virtualise event versions on event materials to allow viral market at a speed of light on attendees [59]. They can find location directions, e-ticket, handouts, google maps and other information useful to the invited guests.
5. QR with inventory: Inventory tracking is key for any business. QR codes and other 2D barcodes provide tools for manufacturing and inventory control as they provide more information than just names and price of a product [59]. These can even store information such as part numbers, expiry dates, serial numbers and other inventory check data points. QR codes also serve as fall back systems when barcode systems exceed their limit of operations especially when they have been over used.

QR codes come in to cut costs as smartphones can easily scan them to read data unlike a company using too much money on massive scanners for storing inventory transactions

effectively. Even in warehouses and other storage facilities, many companies prefer using QR codes which can easily be scanned by smartphones with the ease of convenience. Unlike industrial scanners, smartphones need no power connection all the time and even cut on very close proximity to perform the inventory management operation tasks. With more data storage capacity and ease to scan using smartphones, QR codes are increasingly becoming everyone's choice.

## **2.5 GEOGRAPHIC INFORMATION SYSTEM**

A Geographic Information System (GIS) is a computer software that has the ability of gathering, keeping, analysing and providing a view of geographically generated information and spatial data [60]. GIS also includes the procedures, the operating personnel and relation information that form input into the entire system [61]. The presentation of this information is in maps and other graphic displays to help with analysis and manipulation [62]. To produce this data in this presentation, a GIS mapping software is used.

### **2.5.1 GIS mapping software**

With the capability of this software, it becomes easier to map gathered information into a more structured manner essential for decision making [63]. The spatial data can be visualised and help make informed strategic decisions and even help feed into the existing decision support systems in an organisation [64]. The representation can be categorised into areas, lines, points or raster images [65]. An example is how a city's map can be represented in terms roads as lines, actual data as lines, boundaries as areas and aerial snaps or scanned maps being stored as raster images.

To identify features in a specified region of a map, GIS has spatial indices that help generate this. GIS will work such that the locations can be quickly mapped against the radius of a point, include the streets and some other features that are present in a specified locality [64]. Another set of software called Maptitude helps to generate a stable relational database which forms a critical part of the GIS ecosystem [64]. Data management becomes easier with Maptitude as associated data can be freely joined to or separated

from geographic layers and schemas. This brings about the ease to keep data in an accurate form and easy to manipulate, with the incorporation of stable geoprocessing for spatial queries, polygon overlay and other location-based analytics [66]. This processing further helps to migrate data between relational tables and geographic databases. The Maptitude fixed-format binary table comes powered to support unlimited character field widths with about 32,767 fields and 1 billion records.

### 2.5.2 Key uses of GIS

GIS's Geospatial data can be analysed to determine disparities among location features, to include the density aspect, the feature changes, the happenings and the developments or changes that occur in a specified locality [67]. The following are some of the usage areas:

1. **Feature Mapping:** Real-world features can be mapped with their spatial location to help visualise the associated spatial relationships among them. As seen in Figure 2.8 for frac sand, the visual patterns show the status of every mining activity.

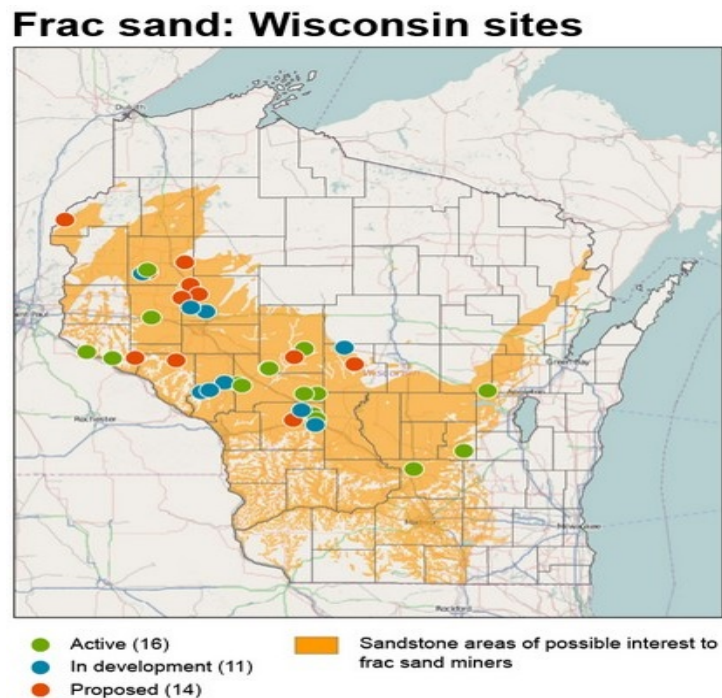


Figure 2.8: Visual Mining activities status for Frac Sand [67]



2. **Quantity Mapping:** As can be seen in Figure 2.9, GIS can also be used to map the volumes or quantities in terms of least and most numbers or presence of structures to compare from place to place. The dots in Figure 2.9 represent density and the colours represent the disparities from most to least in Wisconsin.

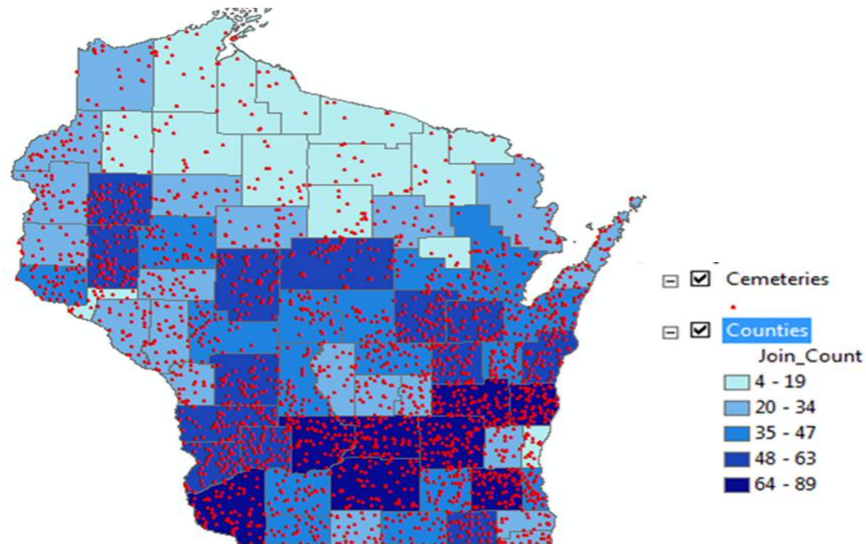


Figure 2.9: Volumes of cemetery locations in Wisconsin [67].

3. **Density Mapping:** These will help map concentrations aggregated by area or total counts. Figure 2.10 shows the population density of Manhattan.

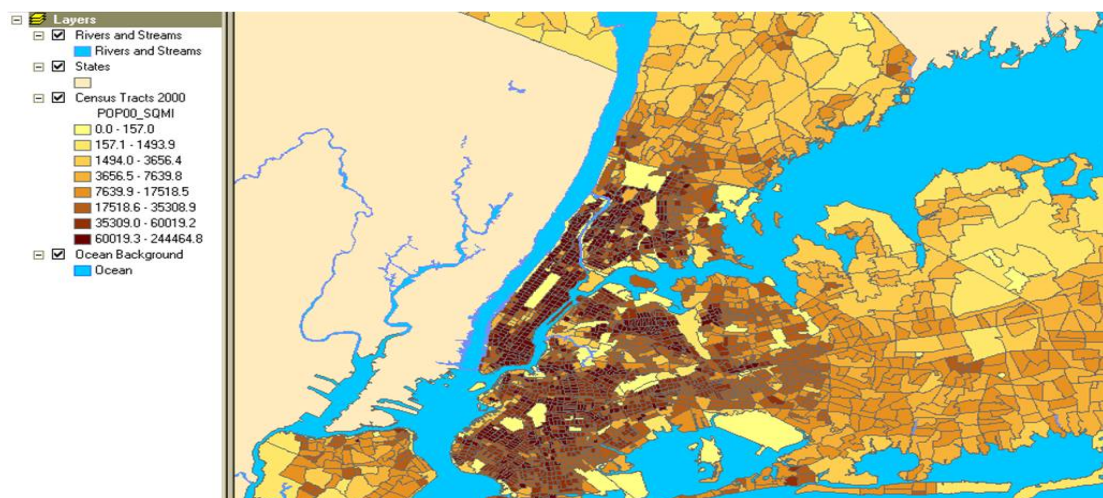


Figure 2.10: Population density of Manhattan in square miles (census tracts [67]).

4. **Inside feature identification:** GIS can also be used to determine the happenings or features located inside a given locality. With a given Area of Interest (AOI), certain characteristics can be used to determine the inside composition. These visuals can also help use some traits to determine potential costs of property damage. Figure 2.11 shows flood event and the tax parcels.



Figure 2.11: Flood event, tax parcels and floodway [67].

5. **Locating nearby places:** Geoprocessing tools like BUFFER can be used to navigate what is happening (feature or event) within specified distances. Figure 2.12 shows a map of drive times in the CBD in the City of Madison, WI. Streets act as a network and a defined criterion can be the speed limit and how easy a driver can get to a place with a time factor.

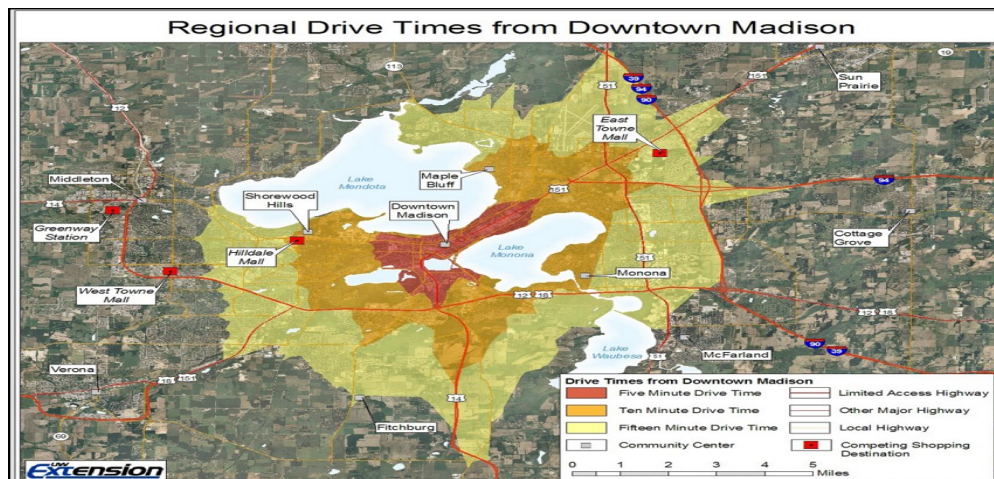


Figure 2.12: Drive times in the City of Madison, WI [67].



**6. Mapping change:** Change in a specified area can be tracked to forecast on future conditions, devise control plans and also project the results of an action or guideline. Figure 2.13 shows changes in residential developments (land use) from 1951 to 1999 in Barnstable, MA.

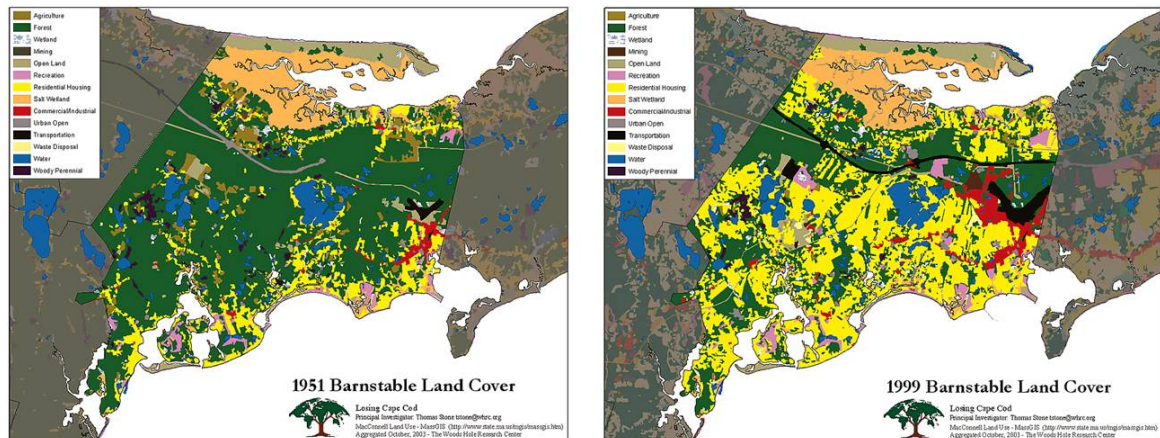


Figure 2.13: Residential developments of Barnstable, MA [67] [68].

### 2.5.3 GIS Data Capture

GIS data formats include applications for both hardware and software systems. These include cartographic data, photographic data, digital data, or data in spreadsheets. GIS will overlay and combine these different types of data formats into one single map. The processing of putting this data on GIS is referred to as data capture.

**Cartographic data:** Already processed maps to include information such as hills, roads, valleys and rivers [69]. This can further include survey data and provision to map this directly into a GIS.

**Photographic data:** Once photos are generated, interpreting them in terms of assessing the aerial photographs and the feature layout forms a major part of GIS [69].

**Digital data:** This includes computer data collected by satellites to show land use, location of catchment areas, town and forests can also be incorporated into GIS [69]. Remote sensing can be used to provide imagery and all the said data collected from satellites, drone or even balloons.

**Table Data or spreadsheet form:** These include population demographics i.e. income, ethnicity age, Internet browsing preferences and traceable payments [69].

GIS file formats can either be raster or vector. Raster formats are grids of cells or pixels which are ideal for storing data that varies like satellite imagery. On the other side, vector formats are polygons that use node points and lines which are for storing data with firm frontiers like streets or counties [69].

## 2.6 Related works

This section looks at some related works in the use of Near Field Communication and Quick Response Codes in our everyday lives.

### 1. Touchin: an NFC supported attendance system in a university environment

NFC simplifies the attendance registry process by simply touching an attendance poster or the lecturer's NFC based mobile device in the class. This system called the TouchIn system is a web-based attendance system utilizing NFC technology. As can be seen in Figure 2.14, the TouchIn system comprises of two main units which are the reader unit and the web server unit:

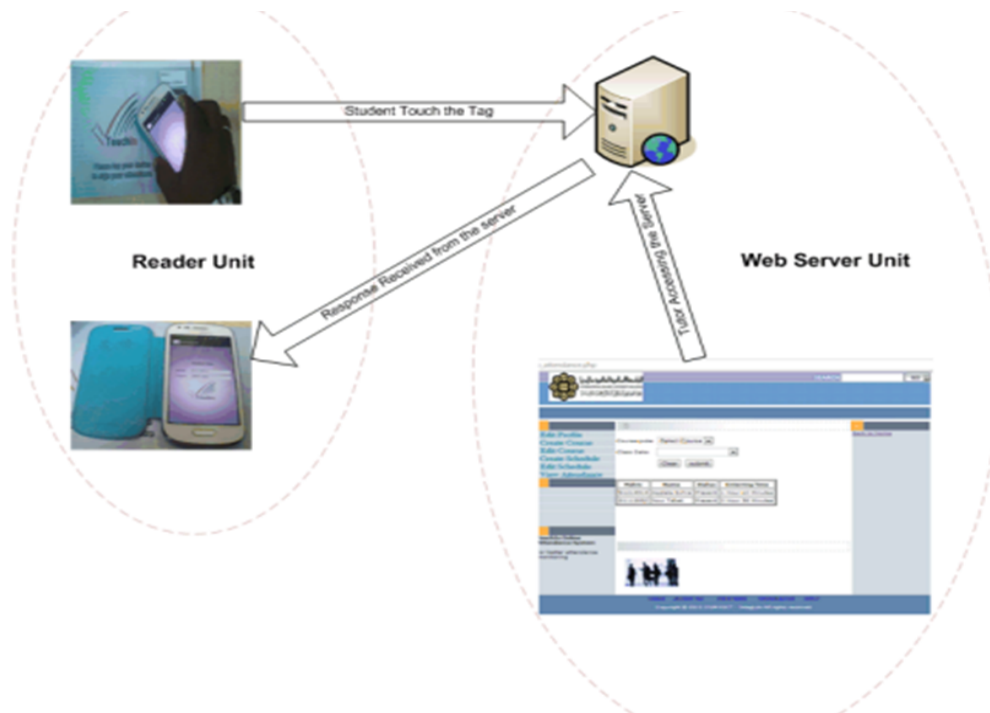


Figure 2.14: TouchIn system overview [70]

The students simply use their NFC enable mobile phones and touch the poster each time they entire the classroom. The student OD is retrieved from the file stored in the mobile device and is sent to the server. This method saves time from the traditional tedious method of signing in the student register which was even prone to cheating by some students [70].

## 2. Electronic data capture in health care- nfc an easy way for self reported health status information.

NFC is an easy way for self-reporting of health status information. As traditional paper-based questionnaires are time- and cost-consuming and may be affected by low patient compliance, the Electronic Data Capture system allows patient monitoring and electronic data acquisition directly from the patient's home. It enables real time representation and analysis of patient data and thus allows direct medical intervention by physicians. This system consists of a smart poster and a mobile application.

As depicted in Figure 2.15, the smart poster enables the patient to give answers to 12 questions, the poster contains images in the front and NFC tags glued to the back. A physician dashboard has been implemented through which physicians can extract relevant information about their patients in order for the information to be available anytime and anywhere, a web portal has been implemented. It is through this dashboard that patients' records can be added, deleted or edited [71] .

1. Touch the "start" icon to launch the application installed on the phone.
2. Touch one of the twelve questions.
3. Touch again on the rating scale to answer the question.
3. (Step two and three is repeated twelve times)
4. Touch on the "senden" [send] tag and confirm it with a second touch to send the data to the physician.

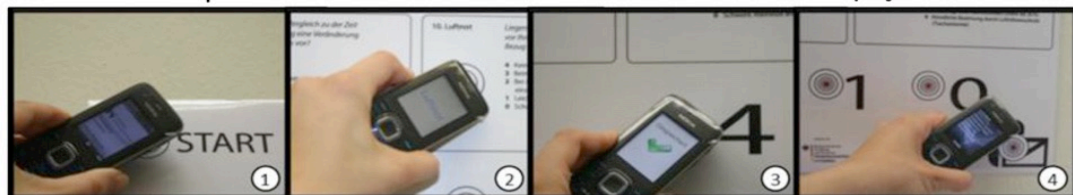


Figure 2.15: the smart poster being used with the mobile application [71]

### **3. NFC mobile credit card: the next frontier of mobile payment?**

In this research it was seen that mobile credit card (MCC) which only needs you to wave your smartphone at an NFC reader to make a payment was implemented. The mobile device and the NFC-enabled point-of-sale system communicate with each other to process a payment. When a contactless payment is initiated (by a customer holding or tapping a mobile device to the payments terminal), the NFC technology goes to work. The NFC-enabled reader and the smartphone pass encrypted information back and forth to each other to complete the payment. This all takes just seconds. Speed, in fact, is one of the coolest parts of NFC payments. They take a fraction of the time of magnetic stripe and chip card transactions—and are leagues faster than cash. [72].

### **4. A crop trait information acquisition system with multitag-based identification technologies for breeding precision management.**

The crop trait information acquisition system for breeding precision management is an effective way for improving the breeding information management level. The wide application of mobile phones provides convenience for real-time and on-field management. Smartphones use NFC and QRC technology to allow the linking of plants and traceability information. RFID-based identification technology and computerized data recording system is economically feasible. The system was devised to ensure (a) correct identification of each crop material and plot, (b) quick query and positioning for information collection, (c) correct combination of crop phenotypic data and images, and (d) reliable recording of periodic crop trait data with dependable transmission to the main Server [73].

### **5. A mobile learning support system for ubiquitous learning environments**

Smartphones and 2D barcode tags were used to acquire Learning materials from websites. The Mobile Learning Support System (MLSS) utilizes Geographical Positioning

Technology and 2D barcodes by letting the users install the MLSS application onto their mobile phones, the users can then simply scan the tag attached to the corresponding object to display related multimedia materials on the screen of mobile phones. The GPS aspect is used to detect the user's location and identify which 2D barcode tags are nearby. The system was designed to provide three functions: (1) database connection function, (2) content learning function, and (3) tags searching function. The system consists of two remote databases on Internet, which one was used to record students' information and other was being used to keep multimedia materials. The content learning function enables students to learn teaching materials on mobile devices, and control the learning paces themselves. When students use mobile devices that have installed the MLSS to scan 2D barcode tags, the content learning function will decode the internal information of tags. Then, this function will require the database connection function to download corresponding teaching materials according to that internal information [74].

## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1 Introduction**

This chapter outlines the methodology that was used to achieve the research needs. The system development tools, the process flow diagrams, how relationships among data sets are and the key actors onto the system.

#### **3.2 Business process mapping**

Business process mapping is a way to visualize what a business does by considering roles, responsibilities and standards [75]. Business process modeling (BPM) takes this one step further by providing a visual way to understand, analyze, and improve upon a current method of working [75].

##### **3.2.1 The current FRA satellite depot business processes**

The current business processes that were described in the interviews with the satellite depot supervisors are described in this section. The following is the current system that is being used at the satellite depot. Firstly, who should deliver crops to FRA?

1. A small-scale farmer in possession of a national registration card (NRC).
2. He/she should belong to a group such as a cooperative or farmers association and should be registered with the government through the cooperative society.

Where will FRA Purchase its Produce from?

FRA is operating in 1,231 satellite depots as of the year 2013[1], FRA is operating on 15 satellite depots on average in each district [76]. No form of transport assistance is being provided to farmers to ferry crop to satellite depot. FRA is, however, transporting received crops from designated satellite depot to main depot for safe storage FRA is running 74 main depots across the country.

Criteria for selection of satellite depots:

1. At least marketable surplus of 5,000 x 50Kg of maize
2. Suitable storage infrastructure and accessible throughout the year
3. Secure locations



4. Community participation encouraged in terms of provision of security of crops through neighbourhood watch groups
5. Community to contribute logs or raised platforms where sheds are not available in order to secure crop
6. FRA operations should not disrupt private sector operations

### 3.2.2 Study Setting

This study was carried out in Lusaka Province at a number of satellite depots which included: Chongwe and Mwembeshi.

### 3.3 System Automation

The following procedures below illustrate how the system was automated. Qualitative data was used to evaluate the current business processes that happen at the satellite depot. The methodology that was used for the analysis, design and development of the software prototype system is the Object-Oriented Systems Development Methodology (OOSDM).

#### 3.3.1 System Architecture

Figure 3.1 illustrates the system architecture which comprises of 3 parts , namely the cloud storage [77] , the grain inventory management system mobile application [78] and the farmer registration and printing system.

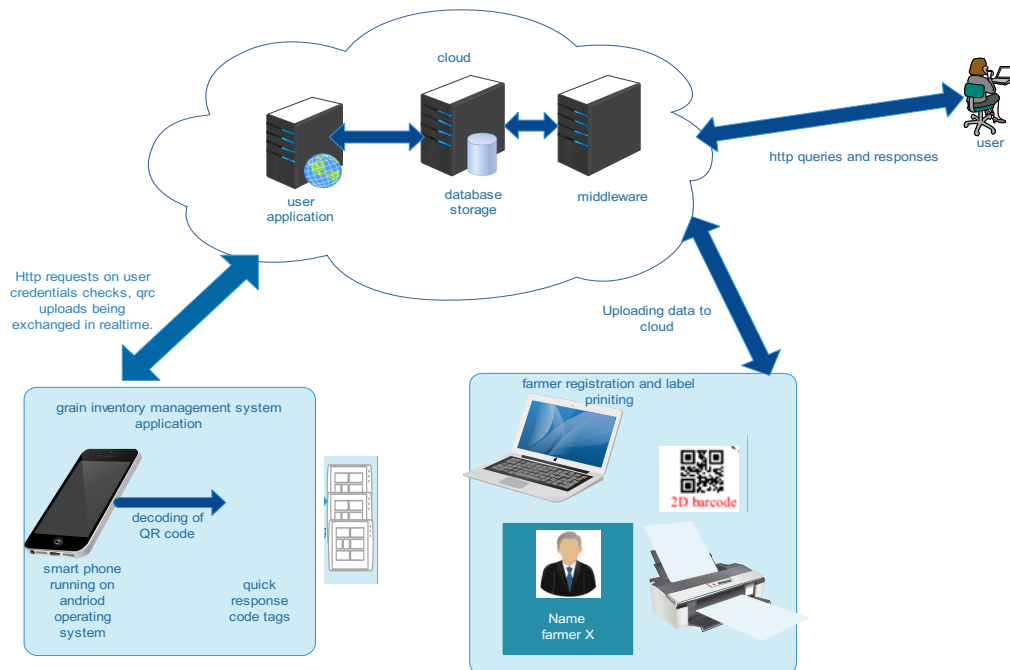


Figure 3.1: System architecture

### 3.3.2 Systems middleware architecture

The systems NFC middleware architecture is shown in Figure 3.2.

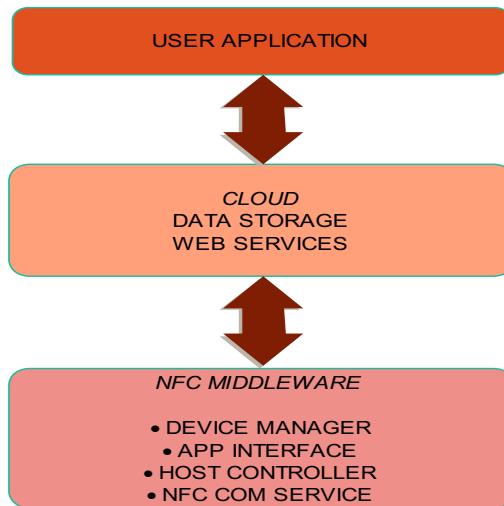


Figure 3.2: Systems NFC middleware architecture

As shown in figure 3.2, the systems NFC middleware architecture consists of the user application, the cloud which comprises of data storage and web services and the NFC middleware which consist of the device manager which is used to manage the hardware devices installed, the application interface specifies how software components should interact, host controller and the NFC COM service.

### 3.3.3 System Requirements Specification

A requirement is a service, feature or function that the user proposes that the system should execute or output. These requirements are broken into Functional and non-functional requirements. In the functional requirements are the things that the system will perform or output as actual elements of the system collective features whilst the non-functional requirements would be those good to have things should as a good user interface, interoperability with different system platforms, strong implementation of security features. The non-functional requirements are those good to have things which are not the baseline of the system to given its core desired output.

The MoSCoW prioritization technique which is depicted in Figure 3.3, is primarily a technique used to prioritize requirements that should be part of would-be built system. In

essence, this is the determinant in what should become part of the system that should be built. The general rule in the Atern methodology is not more than 60% of the requirements must be Must Haves. As such, we will address these core part of the system carrying three fifth of the system in order to demonstrate the elements of the system [79].

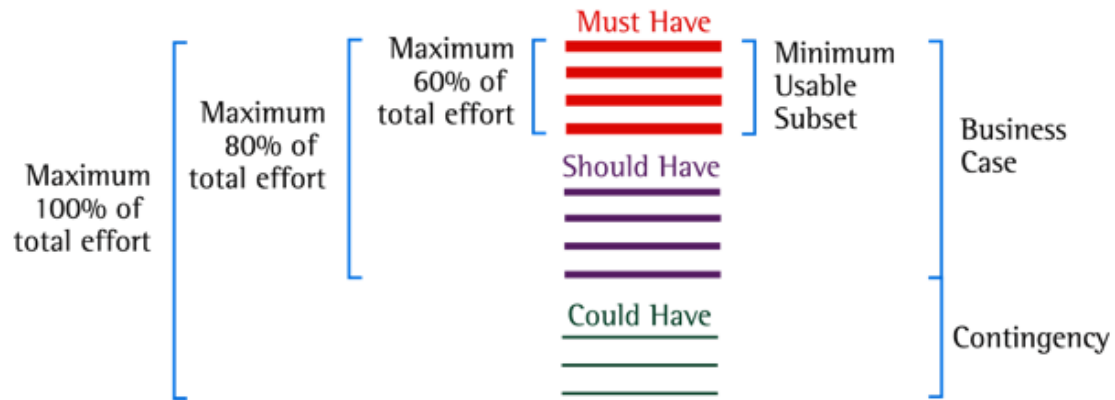


Figure 3.3: MoSCoW Prioritization [79]

The Must Haves are the Minimum Usable Subset of requirements which the project assures to deliver. The Must Haves are important in that they will command the following:

1. Will be delivered without a targeted date
2. It would be pointless to give a delivery date without including the Must Haves
3. The system would not be regarded as legal in the absence of Must Haves
4. The Business Case would be void without the inclusion of the Must Haves.

The second line in prioritizing the functional requirements will be the Should Haves, which usually are important but not vital. In other words, they may be painful to leave out but the solution will still be good enough for functionality. The last two are Should Haves and Could Haves but generally are desirable but less important and requirements the project has agreed not to include in the delivery of the product respectively.

### 3.3.3.1 Functional Requirements

The features in Appendix A3 specify what exactly the system needs to perform to satisfy a business need [80].

### **3.3.3.2 Non-Functional Requirements**

As shown in Appendix A4, a non-functional requirement which is a collection of quality attributes ensures the supply of an operable and manageable system which provides anticipated functionality reliably, uninterrupted or with relatively acceptable time of interruption amidst unusual circumstances [81] .

### **3.3.4 System Modeling and Design**

The system was designed with Object-oriented design (OOD) which is the process of using an object-oriented methodology to design a computing system or application [82]. This technique enabled the implementation of a software solution based on the concepts of objects.

#### **a.) Use cases**

A use case diagram summarizes the details of your system's users (also known as actors) and their interactions with the system [83]. To build one, you'll use a set of specialized symbols and connectors. An effective use case diagram can help your team discuss and represent:

1. Scenarios in which your system or application interacts with people, organizations, or external systems
2. Goals that your system or application helps those entities (known as actors) achieve
3. The scope of your system

Table 3.1 summarizes the details of the prototype system's actors with descriptions of their interactions with the system:

Table 3.1: Use cases

<b>Actor</b>	<b>Description</b>
NFC reader/ writer	Responsible for writing information onto tags and reading the tag information and posting it onto the server
QRC scanner	Responsible for scanning information from the QR code and uploading it onto the server
NFC middleware	This sits between the NFC hardware and the backend database. it is responsible for managing devices, collecting and integrating data, structuring data, filtering data and tag ID association.
Provincial marketing coordinator	At province level, this position requires making strategies and incentives that will attract farmers to bring conduct business with the agency. This bears many privileges on the system. From adding provinces and all the tasks under up until viewing reports.
Satellite depot supervisor	To handle all the logistics at a depot. This includes adding staff and all the tasks from depot up to handling scanned grains.
Administrator	Responsible for the administration of the entire system and has access to the entire system
Staff	Has limited access to the system functionalities.

Figure 3.4 shows a diagrammatic representation of the actors for the QR code reader which is on the mobile application:

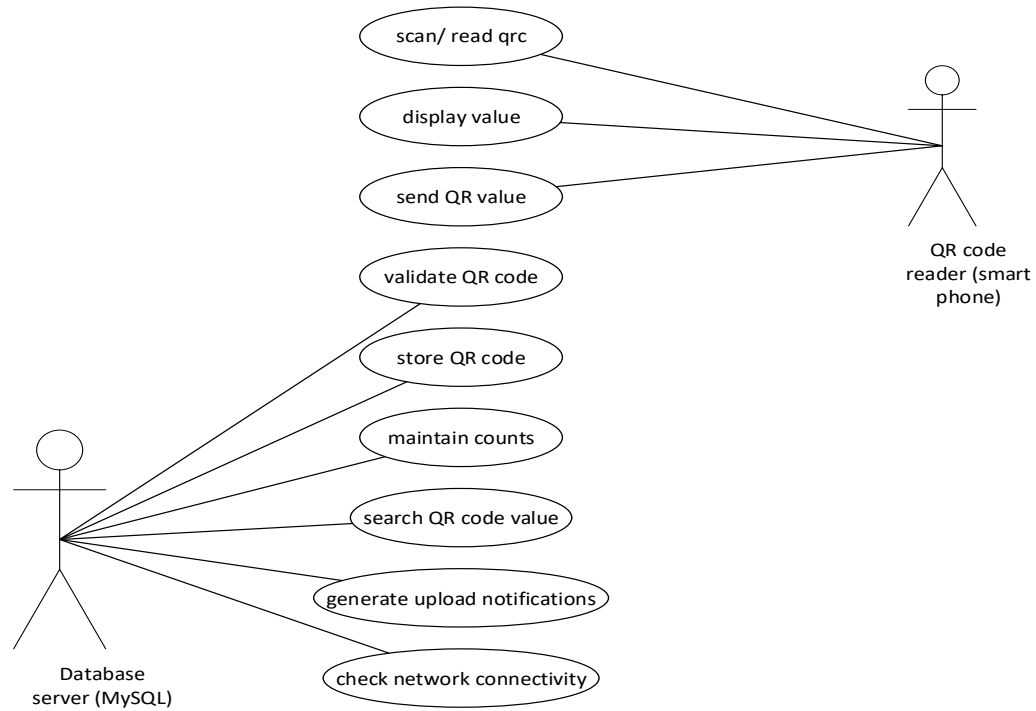


Figure 3.4: QR Code Reader

Table 3.2 describes the QR code reader and the use cases.

Table 3.2: QR code reader use case description

Use case	Description
Scan / read QR code	The main task of invoking the phone camera to initiate scanning the QR code. Once focus is attained, the reading process starts.
Display value	Once value has been read, a value is displayed to the user.
Send QR code value	The application now communicates with the server via a URL to send the displayed value.
Validate QR code	Once the value is received on the server, it has to be validated by way of checking if such a value indeed exists to avoid saving foreign values.
Store QR code	Once validation is successful, the received QR code value is now saved onto the database.
Maintain counts	To avoid adding the same QR code value more than once, a count is maintained and help with the validation process. Since the saving of values is for checking how many grain bugs have be counted for inventory, only one instance of a grain bag should be counted.
Search QR code value	This will provide the ease of canvassing through the system to identify a specific QR code value. This helps when some bags have been isolated and a user wants to know if they have captured already.
Generate upload notifications	Once scan and upload process is successful, a dialog notification pops up to alert the user. Similarly, if there was an error, a user is prompted.
Check network connectivity	For the application to have a successful communication with the server for upload purposes and logging in, the phone's network connectivity is checked. A phone needs to have internet access to make the upload process successful.

Figure 3.5 shows the use cases for NFC reader/ writer and the NFC middleware

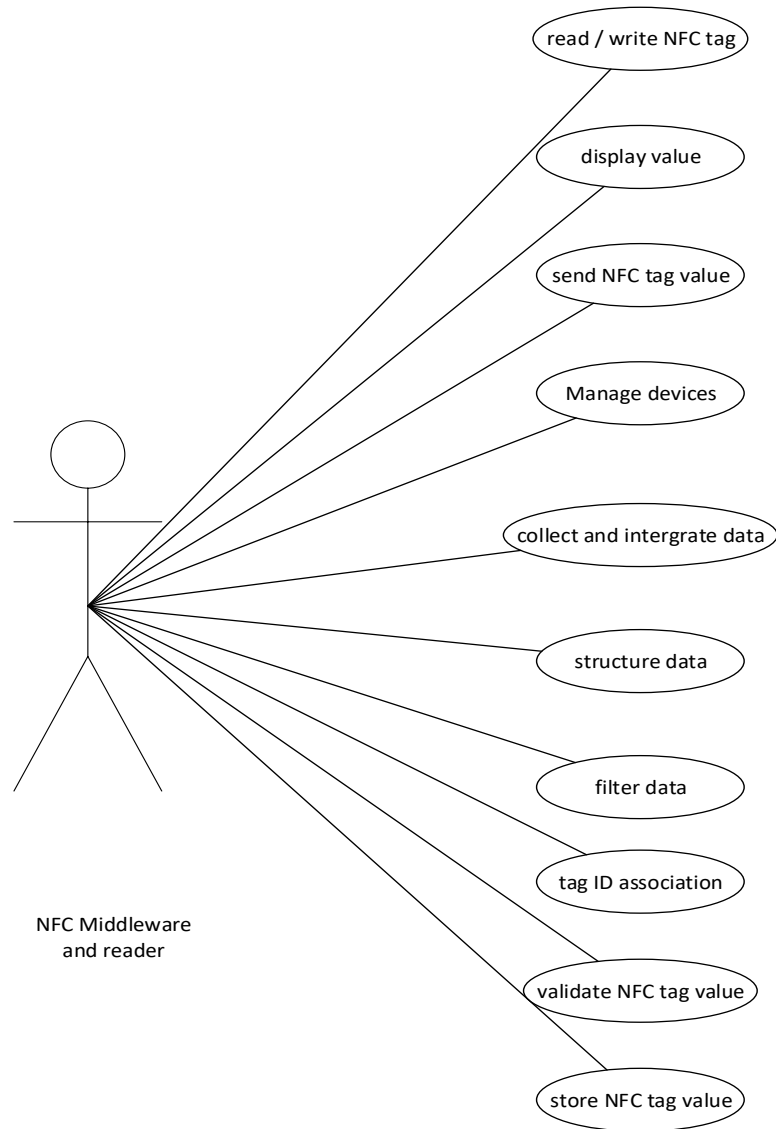


Figure 3.5: NFC reader and middleware

### Table Use case descriptions

The process of NFC tagging precedes the QR code process explained above. This process was designed to check through the values generated as QR codes, to provide input to the NFC tags. This was to avoid generating new scanned grain values. Table 3.3 below describes the use cases in detail.



Table 3.3: Use case description

Use case	Description
Read/ write NFC tag	When a QR Code is read, the value remains on the buffer and NFC write will pick it up to write to an NFC tag. The application invokes the NFC write function. Once written, the application can also read this value.
Display value	At reading process, once the Near field or tapping was accurate, a read value is returned.
Send NFC tag value	Similarly, the displayed valued is sent to the server for storing and validation.
Manage devices	NFC requires that the phone has this capability, and the NFC mode has to be activated to process this. The application will alert the user to activate this from the phone's settings if it identifies that it is off.
Collect and integrate data	Once the application communicates with the Near field surroundings, the read data is put in a form that is comprehensive.
Structure data	Since NFC stores data in several states, the application has to bring out the information set to be viewed by the user. Some values require that the user only views the value but imbedded values like URL can't be viewed just normally.
Filter data	The application is designed to only post the QR code value stored on the tag, so the data is cleaned on the tag to have this equivalence.
Tag ID association	Every tag needs to have an ID or unique identifier. The value and ID are put together to have the continued association, every time this process is done.
Validate NFC tag value	This is done at the web application level, where checks of availability of received value exists on the server's database.
Store NFC tag value	At success, the received NFC value is stored on the server database.

Table 3.4 details the descriptions of each use case identified in the use case diagram in Figure 3.6.

Table 3.4: Web system management overview Use Case descriptions

Use case	Description
Manage users	This will involve managing how users are added onto the system. Once a user is added the privileged user will have the ability to edit, search and even delete a user.
Manage user groups	To control user access levels, this area will handle what every class of users can perform on the system
Manage provinces	To control the tree of locations, all the provinces where they will be activity shall be added.
Manage districts	All districts will be added to be linked to the provinces.
Manage camps	Camps will be linked to the districts, and when adding a particular district has to be selected.
Manage blocks	Blocks will fall under camps, when adding them, a camp where they belong has to be associated.
Manage depots	At the bottom of the location tree, sits the actual satellite depots. With the association obeyed. Adding a depot to a block will allow generating through up to knowing the process it falls under.
Manage farmers	Farmer details will be managed under this section. Manipulating their details is done under this module.
Manage grains	With the association to the farmer, all the grains brought forward will be controlled under this section.
Manage scanned grains	All the values scanned either using QR code readers or NFC tagging process, will be managed under this module.
Manage user profiles	Users can change passwords and view their system details and make necessary changes.
Manage reports	All the system reports will be managed here. This will range from a list of farmers by a criterion, the grains available by farmer and the scanned grains will be some of the reports generated.

Figure 3.6 shows the web system management and the various users involved in the website management.

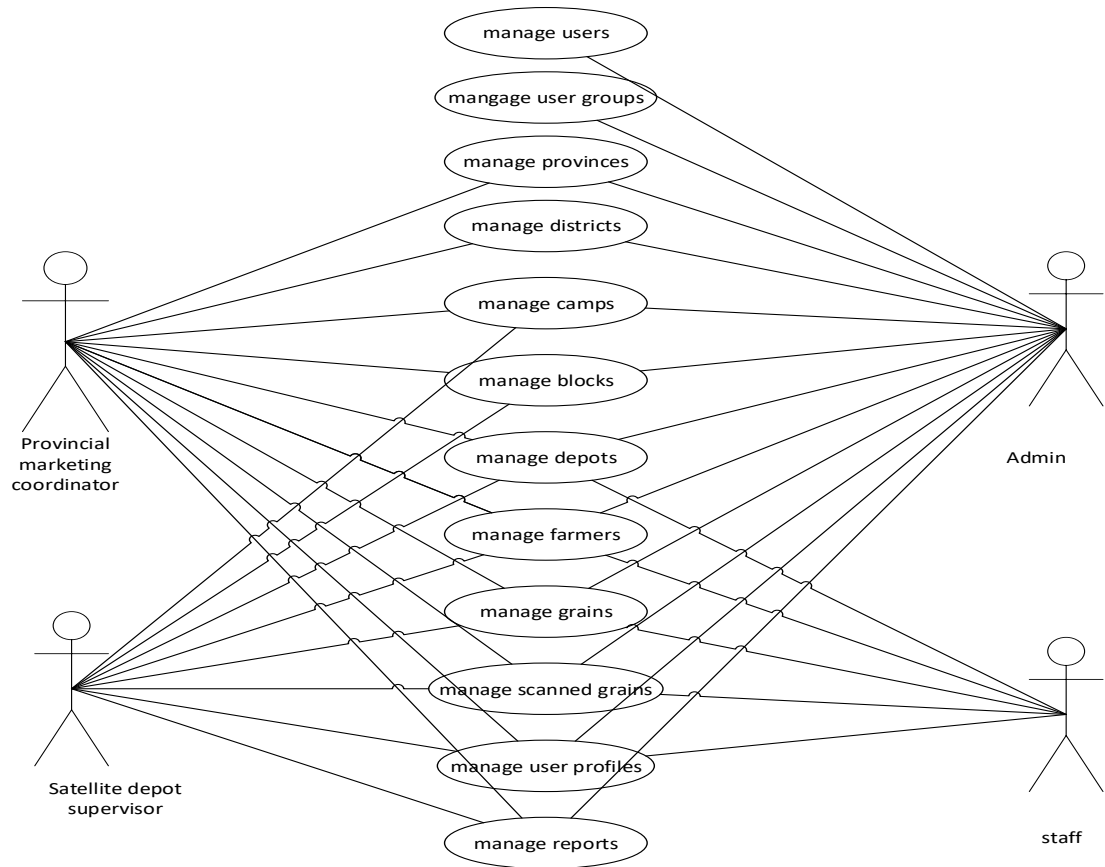


Figure 3.6: Web system management overview

## b). Key system functionality Use Case Diagrams details

Figure 3.7 is a diagrammatic representation of the management of users and user groups.

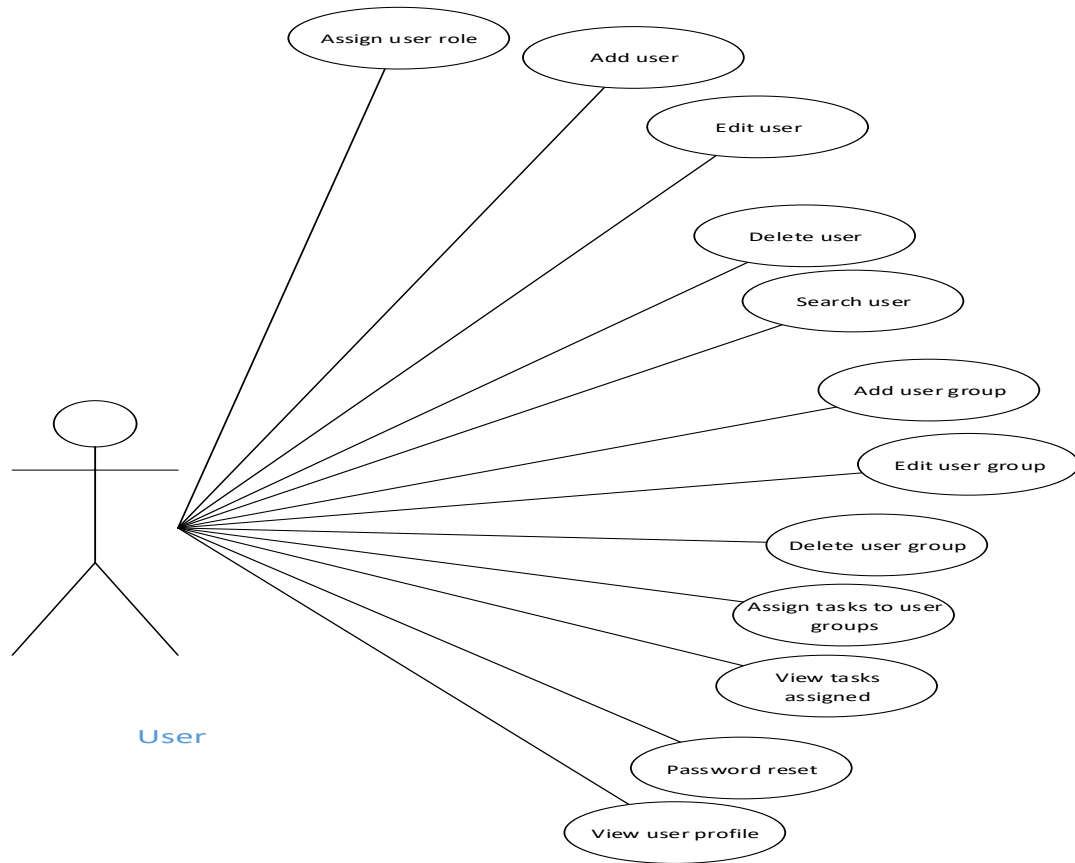


Figure 3.7: Manage users and user groups

Appendix A5, details the descriptions of each Use Case identified in the Use Case diagram in Figure 3.7 for manage users and user groups.

Figure 3.8 shows the management of the satellite depots.

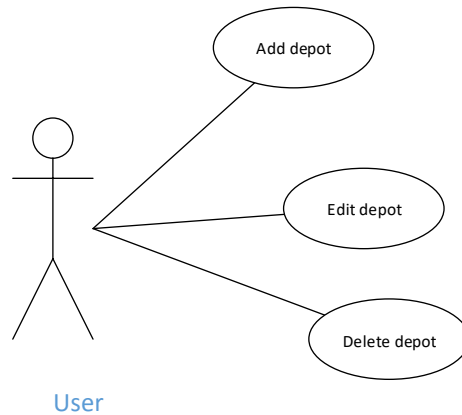


Figure 3.8: Manage Depots

Table 3.5 details the descriptions of each Use Case identified in the Use Case diagram in Figures 3.8 for manage depots and use case descriptions.

Table 3.5: Manage Depots Use Case descriptions

Use case	Description
Add depot	Once all the other geographical boundaries have been added i.e. from province to block, a depot will be added. This is critical as all the farmers trade at a depot level.
Edit depot	All depot details can further be edited once added.
Delete depot	A depot that isn't needed anymore or was wrongly captured can be removed. Likewise, only unassigned depots can be deleted as the system checks through before allowing the deletion.

Figure 3.9 shows manage farmer.

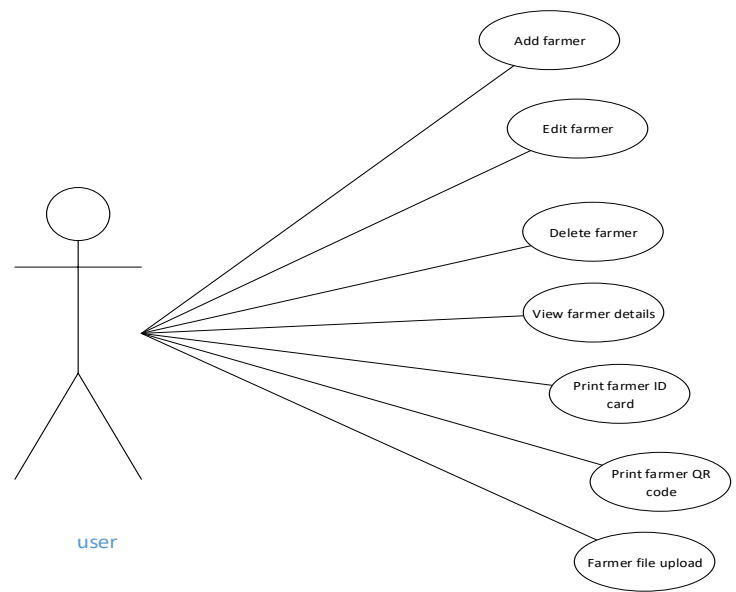


Figure 3.9: Manage farmer

Table 3.6 details the descriptions of each Use Case identified in the Use Case diagram in Figures 3.9 for manage farmer.

Table 3.6: Manage farmer Use Case descriptions

Use case	Description
Add farmer	As farmers come to bring merchandise at the depots, if their details have never been captured, they are added onto to the system.
Edit famer	All farmer details onto the system can be edited to include new information or any other corrections.
Delete farmer	Farmers that have violated rules and regulations set, can be deleted from the system.
View farmer details	A report to view farmers according to a chosen criterion.
Print farmer ID card	For identification purposes, the system will print farmer ID cards to be used by the farmers as they come to trade.
Print farmer QR code	Every farmer is assigned a unique QR code, and this can be printed to be stack onto every merchandise that they bring.
Farmer file upload	Any supporting documents about a farmer can be uploaded and associated to them.

Figure 3.10 shows the Manage Grains description.

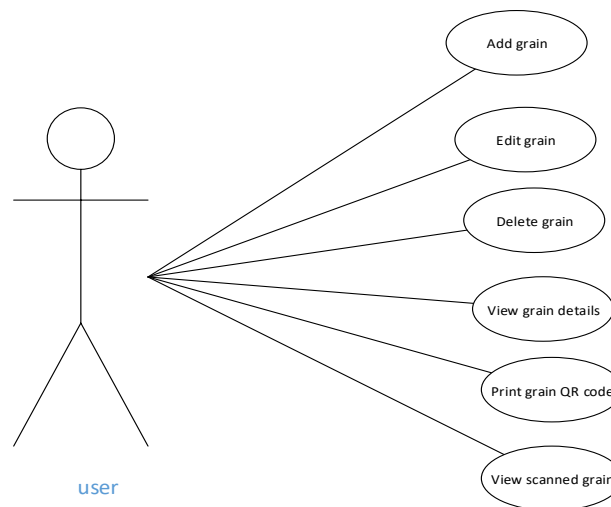


Figure 3.10: Manage Grains.

Table 3.7 details the descriptions of each Use Case identified in the Use Case diagram in Figures 3.10 for manage grains.

Table 3.7: Manage Grains Use Case descriptions

Use case	Description
Add grain	A grain bag will be added onto to the system whenever a farmer brings them. This means that a farmer's grain bags can be tracked by this association when adding them.
Edit grain	Editing details where necessary, maybe when a grain bag was wrongly captured under a different farmer, such corrections can be done.
Delete grain	Only wrongly captured grains will be deleted from the system. Adding the same grain bag more than once will also provide a basis for deletion.
View grain details	A report showing the added grains will be available. This can be by farmer or location (district, camp, depot etc.), and other set criteria according to a user's preference.
Print grain QR code	To identify grain bags, a QR code image will be stack on every sack. This will provide input for the mobile application to scan for inventory checks.
View scanned grain	This will be a report of some sort, where a basket of all scanned grains will be viewed. The values will be for both saved via the QR code scanning and NFC processing.

#### **b.) Sequence diagrams**

These are diagrams that depict process operations and how entities interact. The collaboration on how objects interact to achieve a task are outlined [84]. Since Sequence Diagrams are time focus, they visually the interaction at every intersection (vertical and horizontal dimensions axis) to show message exchange and signify when they are to be sent. They show in brief the collaborations from a use case or an operation where the user and system can interact. The path(s) that a particular operation undertakes, and when what



object is invoked to demonstrate a certain outcome is shown [84]. The diagram is set to show interaction starting from the top and end at the bottom, moving from left to right. Sequence diagrams are essential as they demonstrate visually and validations many runtime scenarios. These can further help forecast how the system will be operating and identify tasks that a class may have to in the design modelling of a new system [85].

### Login (web and mobile application)

Figure 3.11 shows the sequence diagram for logging into the system. The user keys in the password and username on the User manager form, then that information is sent to the database server. The database checks availability of user account and if the password supplied matches. Where it matches, a session is created and the user is redirected to a page that will show all that they are privileged to perform. On the other hand, mismatching username and/or password, alerts the user of unsuccessful login.

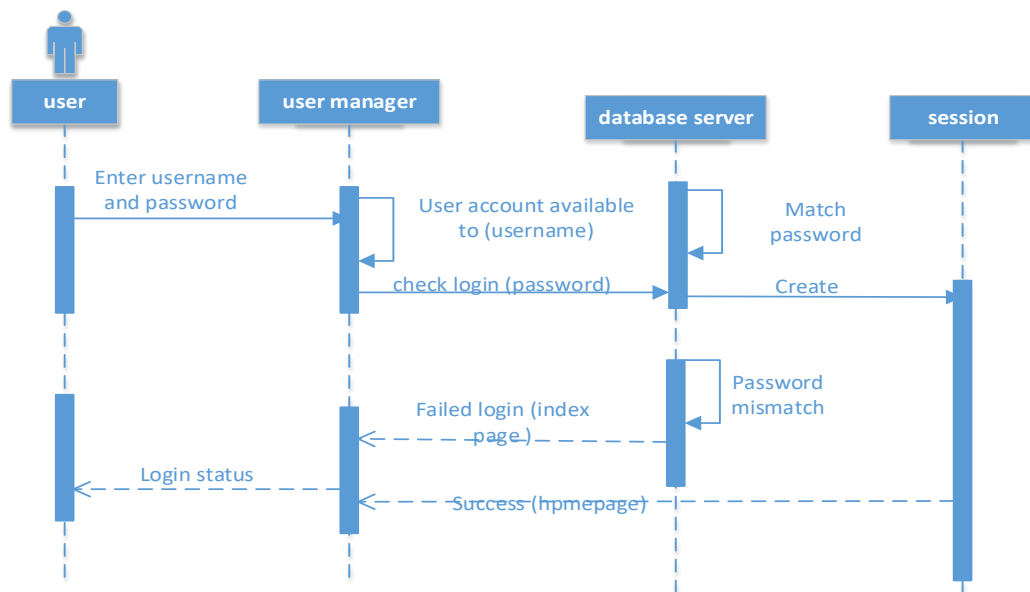


Figure 3.11: Sequence diagram for login

## Scan QR code

Figure 3.12 shows the sequence diagram for the process of reading QR code and posting values into the system. The user starts up the application on the mobile phone. On button press, the QR code service calls the phone's camera to start scanning through the image. Once detected and read properly, the value is displayed and then sent to the server database for storage through a URL link. The web server checks through for QR code availability (validation checks) before saving. Then final the user is alerted of the upload status.

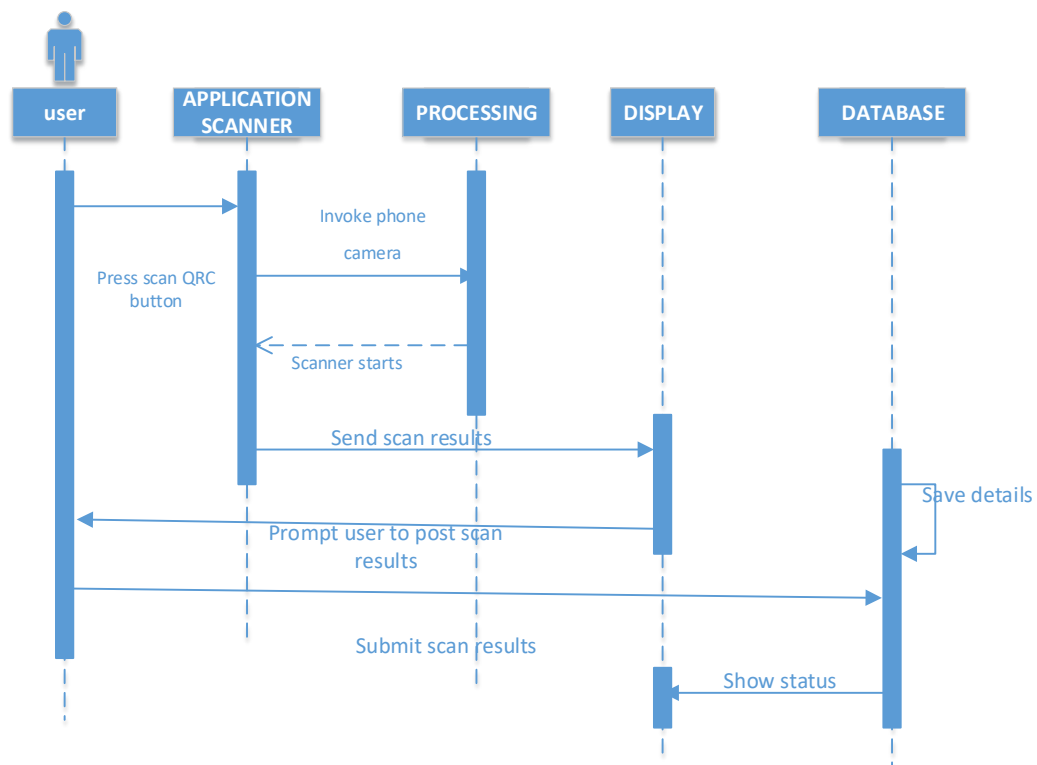


Figure 3.12: Sequence diagram for the process of reading QR code and posting value

### NFC write, read and post

Figure 3.13 shows the sequence diagram for NFC processing and posting value. This gets input from the QR code scanner, where once a value is scanned/put on the form for upload, it gets that same value and writes it on an NFC tag. The reading process is just the same, where once a tag with NFC enabled on the smartphone's settings, a value is returned and sent to the server for storage using a URL link as explained on QR code scanning process.

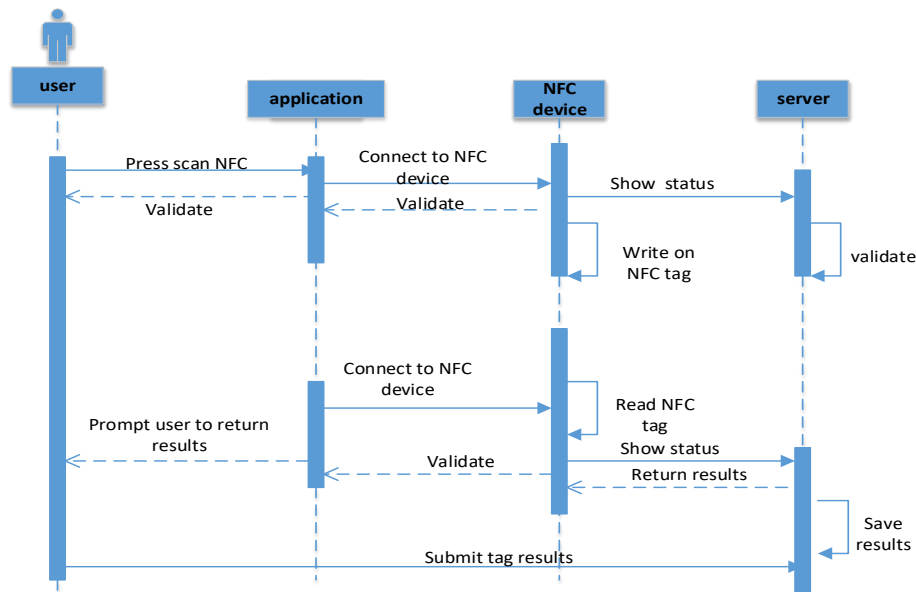


Figure 3.13: NFC read and write sequence diagram

### Adding new user

Figure 3.14 shows the sequence diagram for adding new user. The new user form is used to capture all the details required for creating a new user. There is a validation of checking if National Registration Card right on the form using an Ajax call. Once these details are checked and satisfies the requirements, they are saved and a new user is created with password and username given. The next stage is assigning user privileges onto the system by associating that account to a user group.

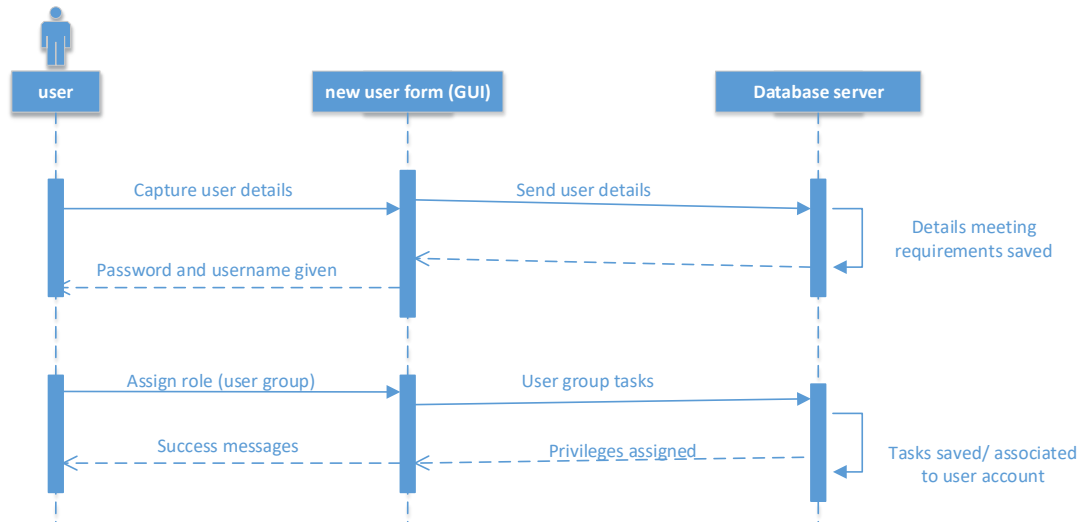


Figure 3.14: Sequence diagram for adding a new user

### Adding new farmer

Figure 3.15 shows the sequence diagram for Adding new farmer. Just like with creating a new user, a new farmer form captures the required details and a new farmer recorded saved and created is associated to a depot for tracking purposes. A QR code is also generated to be printed on the Identity card.

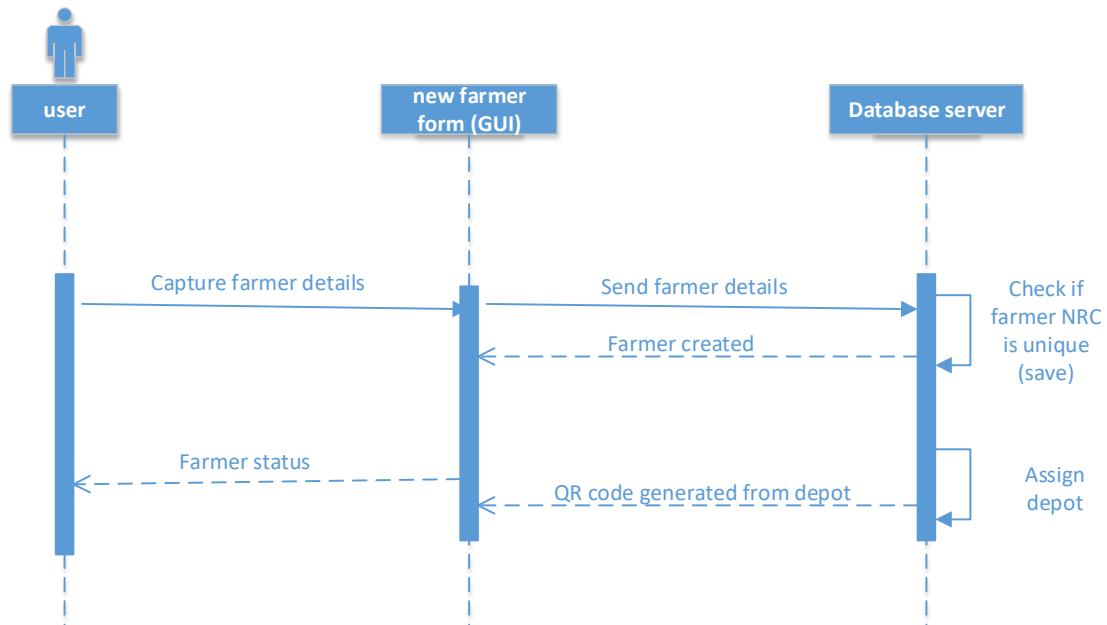


Figure 3.15: sequence diagram for adding a new farmer

### Adding new grain bag

Figure 3.16 shows the sequence diagram for Adding new grain bags. A user captures the grain bag details associated to a farmer on the form and the database server saves the information. A QR code is generated in readiness for stacking onto it for future inventory checks.

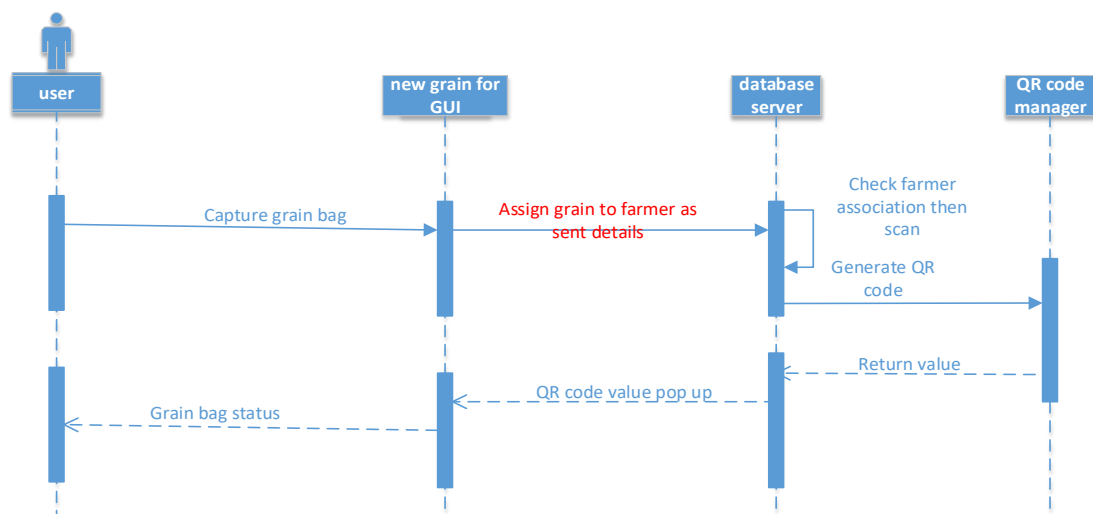


Figure 3.16: sequence diagram for Adding new grain bag

### Adding new depot

Figure 3.17 shows the sequence diagram for adding a new depot to the system. Depot sit on the bottom of the geographical locations, and right on the data capture form, the depot details are associated to a block. At success, the user receives back the Depot ID in the form of a pop-up window.

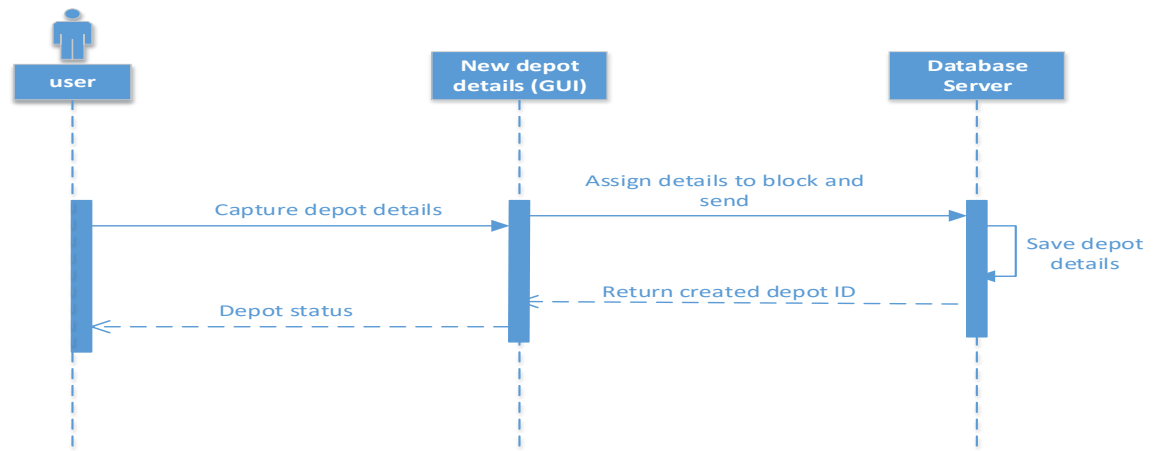


Figure 3.17: sequence diagram for Adding new depot

### View scanned grains

Figure 3.18 shows the sequence diagram for viewing scanned grains. Once a user clicks on the scanned grains menu link, the details set are pulled from the database and returns all values.

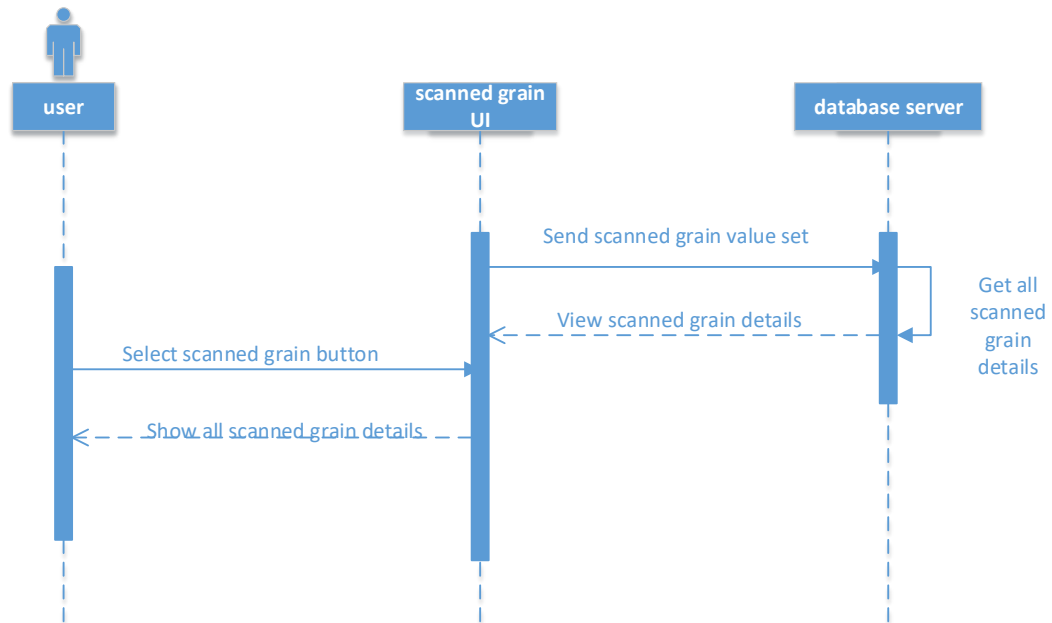


Figure 3.18: Sequence diagram for Viewing scanned grains

### Generate grains report

Figure 3.19 shows the sequence diagram for generating a grains report. A user first selects the search criteria and the format in which the reports should be viewed. The search values are checked against on the database and all the matching values are viewed back in the format selected.

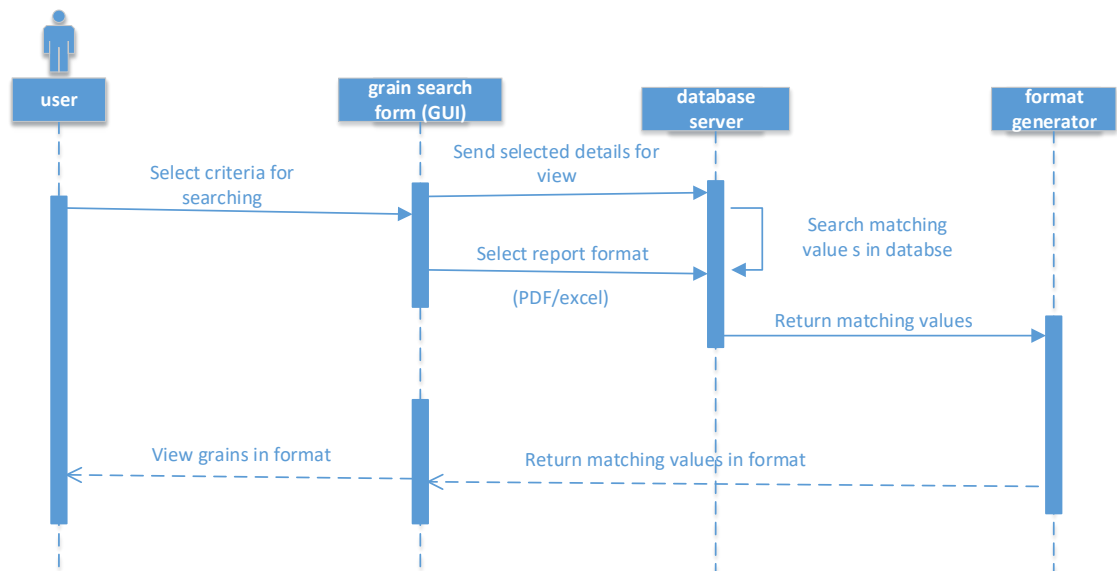


Figure3.19: sequence diagram for Generating grains report

### c.) Class diagram

Class diagrams are a type of structure diagram because they describe what must be present in the system being modeled. They clearly map out the structure of a particular system by modeling its classes, attributes, operations, and relationships between objects [86].

Figure 3.20 depicts the system class diagram. The class shape itself consists of a rectangle with three rows. The top row contains the name of the class, the middle row contains the attributes of the class, and the bottom section expresses the methods or operations that the class may use. Classes and subclasses are grouped together to show the static relationship between each object.

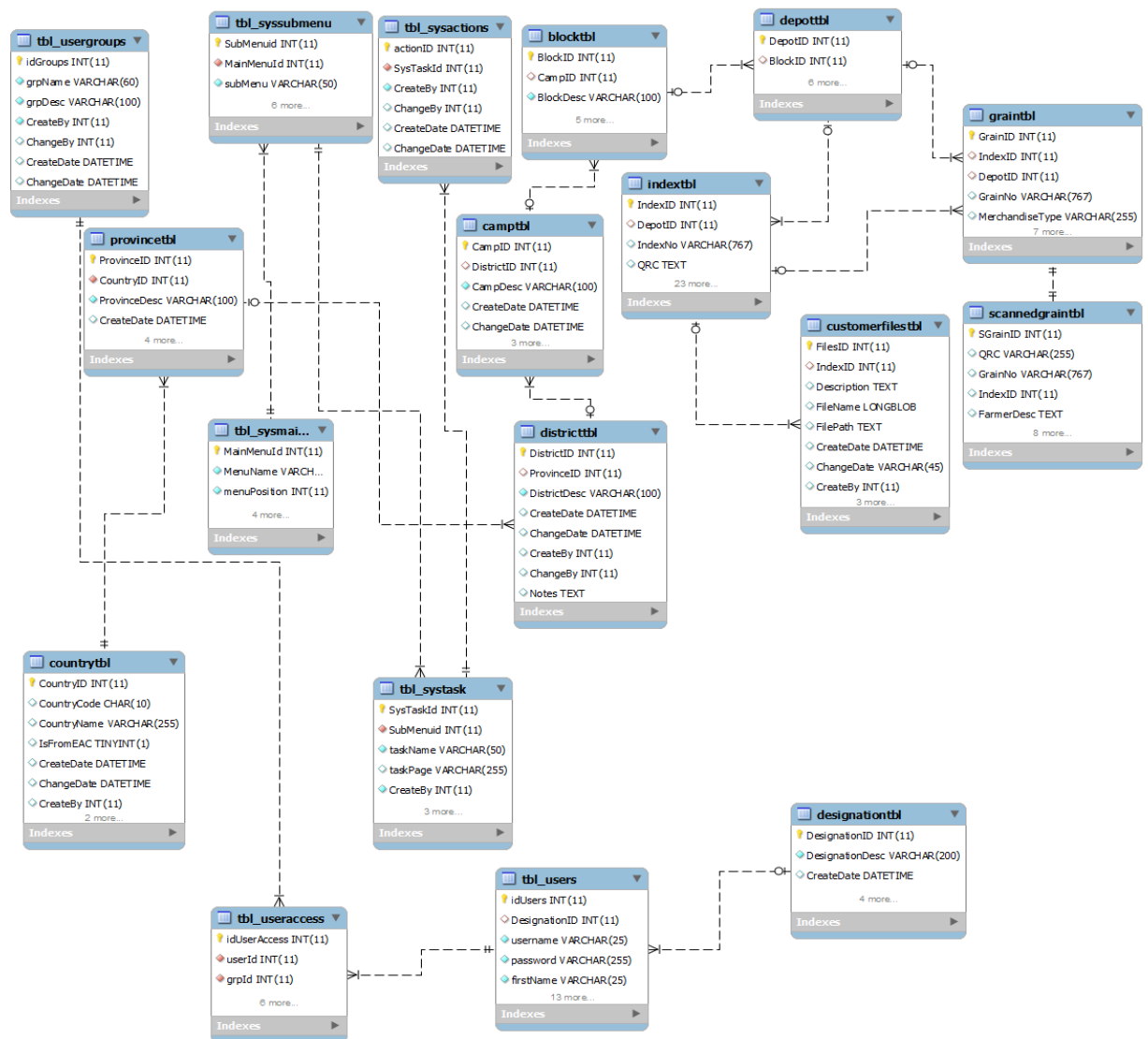


Figure 3.20: System class diagram



#### d.) Entity relationship diagram

Figure 3.21 below shows the entity relationship diagram model which shows the entity sets stored in the database. It illustrates the logical structure of the database.

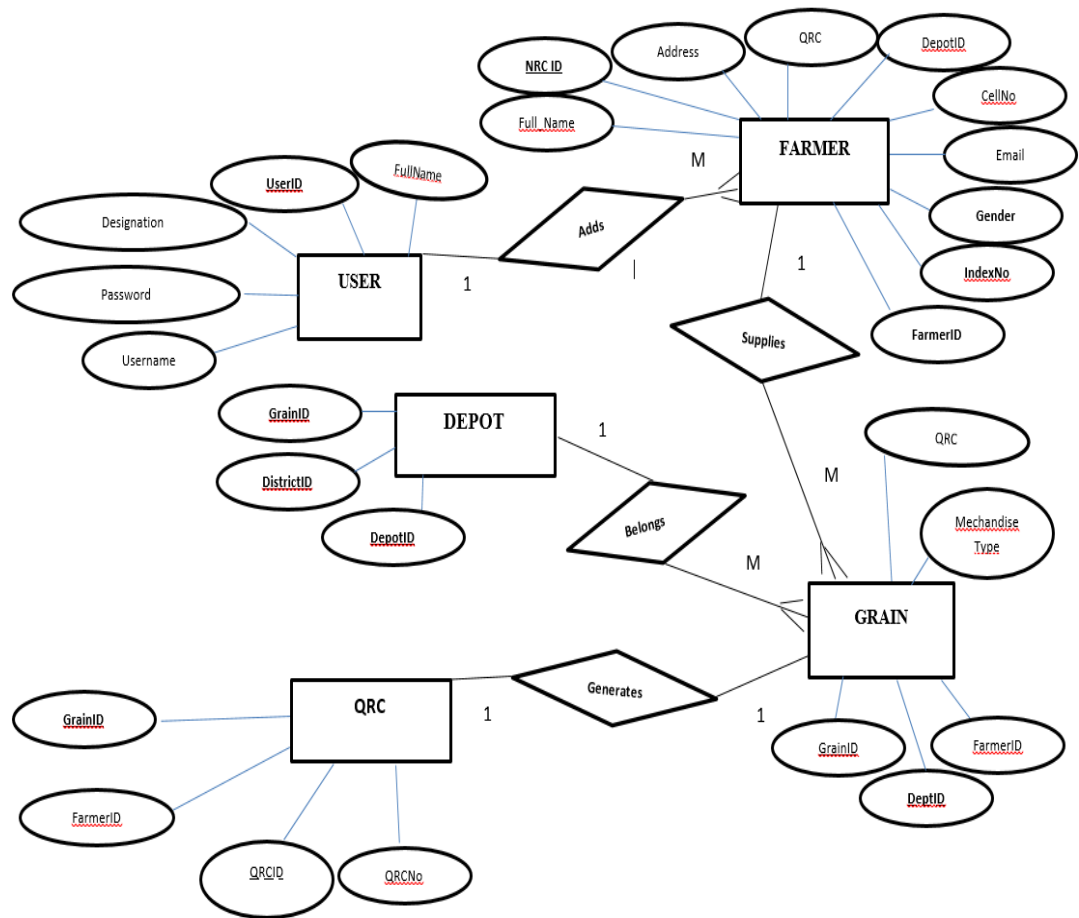


Figure 3.21: Entity relationship diagram

The main tables are the farmer, depot, user and QR code. The relationship is such that before the any other table is fed with data, the user table has to be populated. The user table then provides information on which users can access the system to add the Depot details. The farmer details are then captured to provide details on capturing grain details to finally give input to the actual grain table for the scanned bags of grain.

As shown in Table 3.8, the main relationship tables are interrelated to offer strong constraints and data integrity.

Table 3.8: Relational database schema

No	Entity	Attribute
1.	User	Fullname, userID, Designation, Password, Username.
2.	Depot	GrainID, DistrictID, DepotID
3.	QRC	GrainID, FarmerID, QRCID, QRCNo
4.	Farmer	NrcID, Address, QRC, DepotID, Cellno, Email, Gender, Indexno, FarmerID
5.	Grain	QRC, Merchandise Type, FarmerID, DepotID, GrainID

#### e.) Data dictionary

A data dictionary is defined as a well collected centralized repository of descriptive information about data including the meaning, inter data relationships, usage and the origin of format [87]. In terms of databases, it is a set of well gathered tables with metadata, including the attribute constraints and allowable data sets or values. The tables are found in appendix B showing the entire system's data dictionary breakdown.

#### 3.3.5 System Implementation

The system comes with two systems (web and mobile) which communicate together to perform some tasks especially for inventory checks. The two applications can be implemented as follows:

- **Web application:** This can either be hosted locally (offline) or online via internet access. For the offline installation, we require a server or one computer to be improved as a server in cases where the company considers the cost of procuring a server. Any of the two needs WAMP server, a text editor and a MySQL third party software like MySQL-workbench or navicat and a browser installed. The WAMP server will create a local server to manage the php files, MySQL database and the actual Web server software i.e. Apache. The php files will have to be installed on a www folder created by WAMP server, and using any of the suggested MySQL software, a new database should be created and import the database file (or running it) that is given as part of the project files. Once WAMP is fully installed and put online, the other computers (terminals) within the

organization can access the application via a web browser pointing to the server's IP address and the name of the application for example "<http://192.168.43.211/graininventory/>". Additionally, the organization will need intranet to access the application. This means that, on the server or on that one computer the application can be accessed without intranet as it both holds the database and the files on a one to one basis.

On the other hand, the application can be hosted remotely to be accessed via internet on the various cloud platforms available [88]. Once a host space is procured, the database and php files can be uploaded to that service and with internet access, the application can be accessed from anywhere with just using a browser.

- **Mobile application:** This is a hybrid application developed with JavaScript, HTML and necessary plugins, and Android platform activated. To access this application, we need Android Studio software to generate APK executable files to be installed on the smartphones. Once an APK file is transferred to an Android smartphone, it just needs running, and the application is installed. At success, it generates a shortcut icon for access like any other application on the phone. The main index file has to be edited to point to where the Web application (under all the URLs sections) is sitting to allow the communication between them.

### 3.4 Summary

This chapter covered the research methods that were used. The tools used and the sample selection targeted was outlined. It further covers the design process involved from the user requirements and system functionality, the design diagrams and how the user interacts with the system to how the actual data sits on the database and the relationship that exists between entities and attributes. From the business process flow outline to how the system will be implemented to answer those needs sums up this chapter's focus.

## **CHAPTER FOUR**

### **RESULTS**

#### **4.1 Introduction**

In this chapter, we present the results that were derived from the business process mapping and the business process modelling. We also present results from the implementation of the system prototype using screenshots of the system mobile application and website.

##### **4.1.1 The current satellite depot business processes**

Figure 4.1 depicts the current Food Reserve Agency satellite depot business processes. Farmers with bags of grain transport them to the satellite depot in their own bags. The farmer arrives at the satellite depot and registers the quantity of bags with the security guard. Once this process is done the farmer gives the Satellite Depot Officer (SDO) an ID (National Registration Card) then it gets verified, afterwards the bags of grain are then opened and put on a sieve for cleaning, once the grain has been cleaned it is transferred to standard FRA bags, the bags are then weighed, each standard bag should weigh 50kg), at this point the total number of bags supplied by a particular farmer is determined. The SDO at this point produces a Produce Receipt and Certification Note (PRCN). The PRCN issued should be marked on each bag supplied by the farmer before stitching. This number is written on the side of the bag using permanent markers provided. Marking on the sides preserves the writings from abrasion and makes it visible on the stack. The bags are then stitched, it is done manually through the use of bailing twine and locally made needles. The bags are then stacked onto wooden platforms or slabs. The stacking is done in a compact and countable pattern. At the end of the day, the satellite depot should be left in good order. Stocks should be reconciled by comparing the book value and the physical count. All documentation is paper based and formats are provided in the appropriate sections of this chapter.

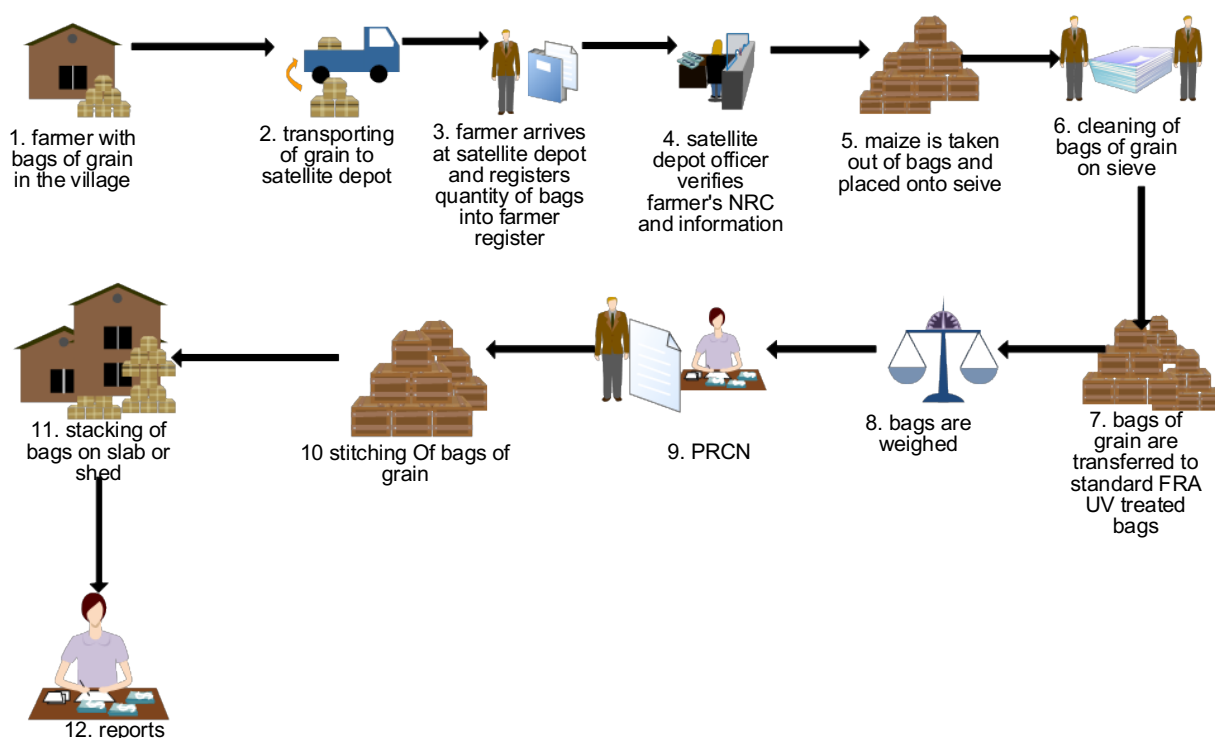


Figure 4.1: Current business processes

#### 4.1.2 Documentation

All satellite depots maintain a visitor's book with the format shown in Table 4.1. This serves as a monitoring tool for both FRA staff and stake holders. Everyone visiting the depot is meant to sign in the document. The visitor's book is properly kept by the SDO

Table 4.1: Visitors' book

Date	Name of Visitor	Institution	Mobile	Purpose	Comment	Signature

#### 4.1.3 Casual workers

Every year from June, FRA identifies and recruits over 6,000 casual workers countrywide during the grain marketing season to perform various roles at its satellite depots. The casual workers weigh, stitch and stack the bags. The following explain the various roles of the workers:

**Scale Operator:** weighing is a critical activity that requires a person who fully understands how to operate the platform scale provided. No underweights are accepted. Any losses that may be incurred will be recovered from the SDO.

**Stitchers:** this role is mostly performed by women.

**Loaders:** Loaders work as a group.

**Stack-Master:** usually group leaders among loaders with a skill of positioning each bag in a countable pattern to form a stack. The acceptable pattern of stacking is 'block type'. A stack-master should therefore understand the block type of stacking which is recommended by FRA.

#### **4.1.4 Receiving the crop**

Farmers supply crops, which meet prescribed standards, at their nearest satellite depot and received by the SDOs.

#### **Farmer register**

The farmer register is the first point of contact with farmers at the satellite depot. A clear register as depicted in Table 4.2 is maintained by security guards. FRA operates on a first come, first serve basis. The farmer register has provision to record when a particular farmer arrived and the quantity of bags they delivered.

Table 4.2: Farmer Register

NO	Date	Farm er Nam e	Locat ion/ Villa ge	NR C No.	Qty Before Screeni ng (Bags)	Farme r Signat ure	Securi ty Guard Signat ure	Qty after weighi ng (bags)	PRC N	SDO Signat ure

### **Grain sieve**

A grain sieve is provided at the satellite depots for the purpose of screening the grain. Farmers are expected to clean their crop from home before delivering at the depot. Farmers who deliver dirty crop are sent to the grain sieve to clean the grain. The grain sieve is also used to check that the crop supplied is free from pests, disease, foreign matter, coloured grain, stones, droppings etc. Any crop identified to contain pests such as weevils and grain borers is not accepted or packed in the FRA bags. The SDOs constantly monitor the screening process to ensure that only crop meeting the prescribed standards is transferred into FRA bags.

### **Quality standards for white maize**

FRA demands good quality Grade ‘A’ maize from farmers meeting the specifications in Table 4.3. The maize is supposed be free from live insects, diseased grain and foreign matter. It is the responsibility of the SDO to ensure that the prescribed quality standards are met.

Table 4.3: Grade A maize [3]

Characteristics	Specification
Colour	White
Moisture content (%max)	12.5
Diseased grain (%max)	2.0
Shrivelled grain (%max)	0.1
Insect damaged grain (%max)	3.0
Discoloured grain (%max)	4.0
Other coloured grain (%max)	2.0
Broken grain (%max)	2.0
Foreign matter (%max)	1.0
Total defectives (%max)	14.1
Aflatoxin content, ppb, maximum	10.0

### **Empty grain bags**

FRA provides labelled empty grain bags for the crop marketing exercise. The bags are ultra violet ray treated and are able to withstand longer period of exposure to sunlight without damage. Foreign bags are not treated and are therefore not used as they can start breaking on the stack, which in turn can make work difficult during handling.

Farmers are allowed to bring their crops to the satellite depot in grain bags of their choice which are given back once the grain is packed into FRA bags. No SDO is allowed to issue bags to farmers in advance or at a point other than the sieve. A record of bags used is kept.

### **The scale**

Portable beam scales are provided for weighing of the crop received from farmers. The basic unit is a 50kg bag for maize and a 40 kg bag for paddy rice.

### **Labelling the bags**

Immediately after weighing and the determination of the total number of bags supplied by a particular farmer, a Produce Receipt and Certification Note (PRCN) is raised and issued. The serial number of the PRCN issued is then marked on each bag supplied by the



farmer before stitching. This number is written on the side of the bag using permanent markers provided by FRA. Marking on the sides of the bag preserves the writings from abrasion and makes it visible on the stack. Labelling of the bags enables the FRA to trace back the supplier and source depot in the event of theft or any queries.

### Stitching

Stitching is the process of sealing or closing up the bag containing a measured quantity of grain. This is done manually through the use of bailing twine and locally made needles. Once bags are weighed and marked with PRCN numbers, they are lined up in tens for stitching. Bailing twine which is used for stitching is cut into 1 meter long pieces which are enough to stitch 1 bag of grain each. Each roll of bailing twine is enough to stitch an average of 1000 bags. Proper stitching is essential in grain handling. Poorly stitched bags lead to grain losses through breakages and spillage. It also leads to falling stacks and difficulties during the transportation as bags do not hold on to each other. The following stitching guide assists to ensure good stitching:

1. Fold inside the top end of the sack (5-10 cm) for increased strength of stitches.
2. Leave space between the grain surface and the stitch line to allow for bag flexibility.  
This will support the bag on the stacking booth at the depot and during transportation.
3. Stitches should be made close to each other in order to seal the bag completely.

### Stacking

Stacking is the arrangement of bags in a compact and countable pattern. This is done on the platform or the selected space inside the shed. There are two patterns of stacking, block and layer types. However, the block type is a recommended pattern for use in all FRA depots. The formula used for counting of grain stacks is depicted in Figure 4.2.

Number of Bags on the Stack	=	Block Unit (5)	x	Height (No. of Layers)	x	No. of Blocks in Length	x	No. of Blocks in Width
<i>A stack which is; 12 layers high, 9 blocks in length and 6 blocks in width:</i>								
Number of Bags on the Stack	=	5	x	12	x	9	x	6
	=	3,240 bags						

Figure 4.2: formula for counting stacks

Wooden platforms and concrete slabs provide temporal storage facilities for the crop in satellite depots. These are also referred to as outdoor storage facilities.

### Stack card

All stacks are supposed to have stack cards pasted on their visible side. Stack cards provide key information on the crop stored such as type of commodity, year of purchase, last date of fumigation, condition and quantity as seen in the sample stack card shown in Figure 4.3.


 <b>STACK CARD</b> TO BE UPDATED EVERY DAY AT CLOSE OF BUSINESS					
DISTRICT					
DEPOT					
WAREHOUSE MANAGER					
COMMODITY					
UNIT OF MEASURE					
STACK NUMBER					
YEAR CROP PURCHASE					
DATE OF LAST FUMIGATION					
CROP CONDITION					
DATE	OPENING STOCK	RECEIPTS	DISPATCHES	CLOSING BALANCE	REMARK

Figure 4.3: stack card

### Dispatching stocks

When purchases are made and reported, stocks are moved to the main or nearest holding depot for safe storage. This process starts on accumulation of 600 by 50kg bags at the satellite depot. This activity is performed simultaneously with the purchasing exercise. Movement of stock from satellite depots is done by FRA registered transporters. When stock accumulates at the satellite depot, the SDO requests for transfers through the Marketing Assistant (MA) upon submission of weekly reports. Timely transfer of stock protects against theft, effects of weather and enhances accountability.

Participating transporters are instructed to move stocks from satellite depots through a document called Loading Order (LO), accompanied by the transporter manifest. These are issued by the Provincial Marketing Coordinator (PMC) through the MA. Transporter

manifest is simply, a list of vehicles and details of the drivers that will be used to collect assigned stock from the depot. These two documents should be confirmed with the MA or the regional office before any vehicle is loaded at the satellite depot.

### **Crop purchases**

These are reference documents issued to the farmer for supply of the crop at the depot. They also include other documents maintained for stock accountability at the satellite depot at any given time.

### **Product Receipt And Certification Note**

The Product Receipt and Certification Note (PRCN), is the first document raised and issued to the farmer for supply of the crop at the satellite depot. A PRCN is raised immediately after weighing and determination of the total number of bags supplied by a particular farmer at the satellite depot. To complete a PRCN one SDO assumes the role of certifying quality and quantity and writes on part B a. The other is assigned the role of a buyer and writes on part C after verifying quantity delivered. PRCN has a maximum and minimum number of bags recorded. All bags brought are labelled with a PRCN number.

Figure 4.4 depicts a PRCN. The 1<sup>st</sup> PRCN copy is given to the farmer, whilst the 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> copies are arranged in order of serial numbers and attached respectively to the 1<sup>st</sup> 2<sup>nd</sup> and 3<sup>rd</sup> copies of the weekly receipt summary.

**FOOD RESERVE AGENCY**  
Plot No. 7419, Manda Road, Light Industrial Area  
P.O. Box 14024, Lusaka, Zambia  
Tel: (260-211) 286097, 286106 & 286113  
Fax: (260-211) 286096  
E-mail: fra@fra.org.zm

**PRODUCE RECEIPT & CERTIFICATION NOTE**  
Please Tick Applicable Box PRCN No. 1058501  
Cash ☐ Bank Transfer ☐

**Part A: Supplier's Details**  
Name: \_\_\_\_\_ National Registration Card No.: \_\_\_\_\_  
Cooperative Name: \_\_\_\_\_ Farmer's Code: \_\_\_\_\_  
Bank Name: \_\_\_\_\_ Branch: \_\_\_\_\_  
Bank Account Name: \_\_\_\_\_ Bank Account No.: \_\_\_\_\_  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_ Mobile Phone No.: \_\_\_\_\_

**Part B: Quality Certification**  
Product Description e.g. Maize, Rice, Cassava etc. \_\_\_\_\_  
Number of bag inspected (Figure) \_\_\_\_\_ (Words) \_\_\_\_\_  
Weight per (Kgs) (Figure) \_\_\_\_\_ (Words) \_\_\_\_\_  
Quality of Grain: \_\_\_\_\_ Date: \_\_\_\_\_  
Name of Inspector: \_\_\_\_\_ Signature: \_\_\_\_\_  
**Part C: Satellite Depot Buyer**  
Satellite Depot Name: \_\_\_\_\_ District Main Depot Name: \_\_\_\_\_  
Number of bags Received (Figure) \_\_\_\_\_ (Words) \_\_\_\_\_  
Crop Value (ZMK) (Figure) \_\_\_\_\_ (Words) \_\_\_\_\_  
Depot Clerk/buyer's Name: \_\_\_\_\_ National Registration Card No.: \_\_\_\_\_  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Quality Inspector's Stamp**

**DISTRIBUTION:** 1st Copy (white) Receiving Depot, 2nd Copy (Pink) Transporter, 3rd Copy (Yellow) FRA Accounts, 4th Copy (Green) Bank Copy

Figure 4.4: Product receipt and certification note

### Purchases ledger

A stock ledger as depicted in Figure 4.5, is a daily monitoring tool that records the accumulation of stock at the satellite depot.

Date	Farmer Name	NRC No.	PRCN No.	Amount (K)	Qty In (Bags)	Cumulative Total (Bags)
21/07/17	OPENING SOCK					0
22/07/17	PETER MULENGA	306514/34/1	350001	9,775	115	115
23/07/17	GEORGE SHUMA	555432/54/1	350002	8,670	102	217
24/07/17	LANDO LUNGU	345248/23/1	350003	3,825	45	262

Figure 4.5: Purchases ledger entries

### Weekly receipt summary

As seen in Figure 4.6, the weekly receipt summary presents a summary of purchases made during the week and / or any additional stocks received at the depot.





**FOOD RESERVE AGENCY**

P.O. Box 34954  
Plot No. 7419  
Manda Road  
Lusaka  
Tel: 2532997 / 253135 / 253196  
Fax: 2532996

**WEEKLY STOCK REPORT**

Warehouse Manager:.....  
Depot Name:.....  
District:..... Week ending:.....

(x) (b) (Quantity in Bags) (c)

**No. 282101**

PRODUCT	UNIT	OPENNING BALANCE	ADD RECEIPTS			LESS ISSUES			BOOK STOCK	PHYSICAL STOCK	VARIANCE
			GRN	PRCN	Total	GIN	IDT/IPT	Total			
Good White Maize											
Insect Damanged Maize											
Discoloured Maize											
Rotten Maize											
<b>Total Maize</b>											
Good Rice											
Undergrade Rice											
<b>Total Rice</b>											
Empty Grain Bags											

Comments:.....

Prepared by:..... Checked by:.....  
Signature:..... Signature:.....  
Date:..... Date:.....

**Official Stamp**

Figure 4.7: Weekly stock report

### Closing business for the day

After closing business at the satellite depot, the SDO sends the crop purchase figures for the day to the MA and the data entry clerk. These figures are communicated by short message system (SMS) on mobile phones. In areas that may have challenges with mobile network, community members usually have identified spots that most mobile phones pick up communication network.

### 4.2 Proposed business process

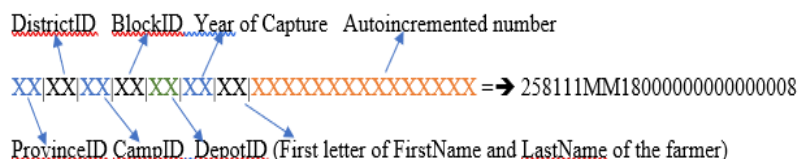
As seen in Figure 4.8 maize is sourced from the villages situated in the districts. Small scale farmers bring their harvested maize to a central place in the village (the satellite depot). The maize is initially brought in their own maize bags; at a later stage the farmer is required to then purchase the FRA standard bags at a small fee and transfer the grain once it's cleaned.

The farmer provides an NRC and an e-voucher card to the SDO. If the farmer has not been registered in the database he/she will have to go through the farmer registration

process and a new e-voucher card will be produced for them. After the capturing of the information, the farmer's photo is then taken and attached to his information on the database. An identification card is then printed out. This ID is what the farmer will be using each time he or she wants to sell stock to FRA. The ID will also contain a QR code which when scanned will bring up the farmer's information. The depot officer will scan the ID to verify the farmer details.

Once the ID is scanned the farmer then proceeds to the next stage. In the next stage, the bags of maize are taken out of the bags for cleaning. Cleaning grain means removing all the materials other than the grain.

After the cleaning process the bags of grain are then transferred to FRA standard bags. At this point the bags are put on the weighing scale for weight verification, each standard bag should weigh 50kgs. When the weight is verified the bags of maize are tagged with QR Code. This is done by adding the grain bag into the system and producing a QR Code for it as seen in the example below. The serial number will be 29 digits:



Once the attachment of the tags is done bags are stitched. Then the SDO will use the mobile application to scan the bags. Once the bags are scanned the SDO then uploads the information onto the cloud based database. This is done in real time, this information can be viewed by anyone who has authorization from any location. The system then generates a report or invoice for the farmer. The depot officer then stacks the bags of maize onto the slab or shed for storage.

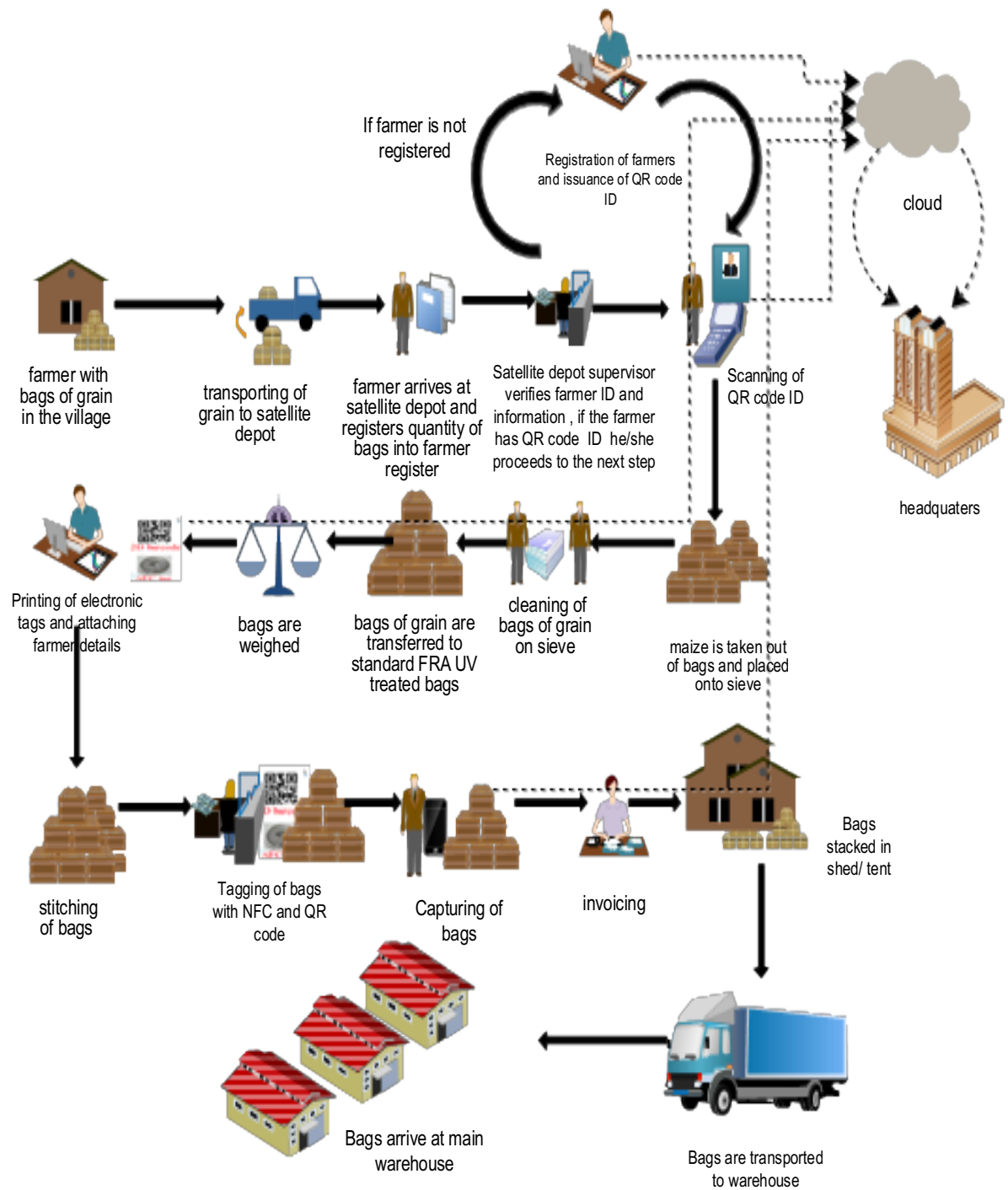


Figure 4.8: Proposed business processes



#### 4.2.1 Testing

Various usage scenarios were tested both on the web and mobile application. Below is Table 4.4 which is consisting of the plan devised.

Table 4.4: Test Plan

TEST NO.	DESCRIPTION
1	To test whether a user can log in the system and system validation.
2	To test if an administrator can add a new user, edit, delete, search user records, perform user password reset and Assign user roles.
3	To test if an administrator can add a new user group, edit, delete user group records, assign tasks to user group, View tasks assigned to user group.
4	Add, edit and delete provinces, districts, camps, blocks and depots.
5	Test if farmer details can be added, edited, deleted, view them, print ID and QR code and handle a file upload.
6	Add, edit, delete, and view grain bag details, print grain bag QR code and View scanned grain.
7	Generate reports based on farmer details, grain bags and scanned grains.
8	To test if mobile application can Read and Post QR codes to web server database.
9	To test if mobile application can Write, Read and Post NFC tag codes to web server database.

For the test log see Appendix A6.

## 4.2.2 Screen shots and commentary

### Web Application

Figure 4.9 shows the validated log in form for the website. This is the landing page once the website is opened.

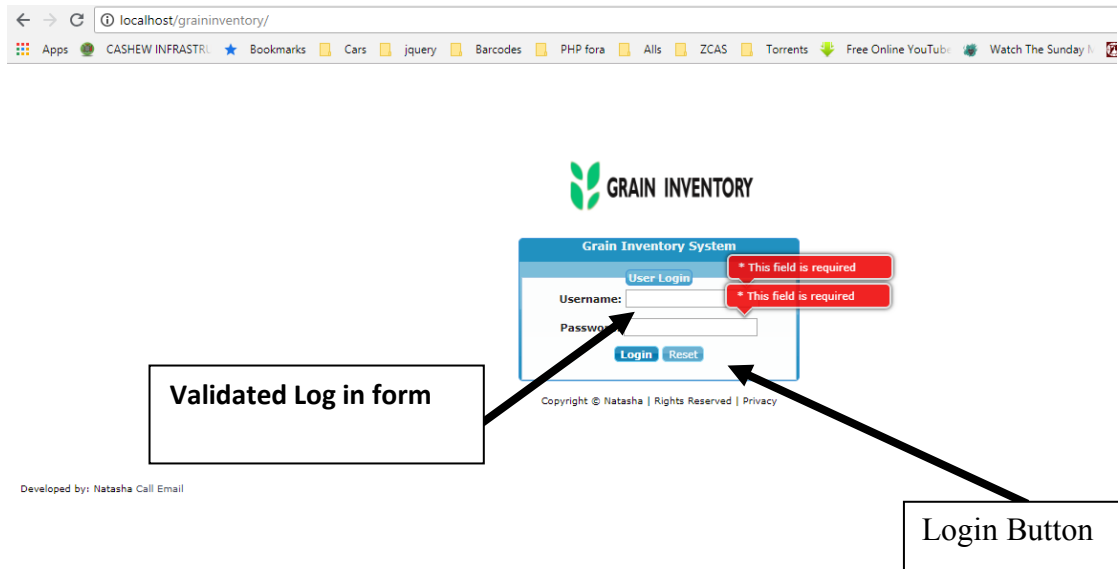


Figure 4.9: Screenshot of the validated Log in form for system log in

Figure 4.10 shows the error message when there is a username and password mismatch. This is one of the security features that guarantees that only authorized users can access the website.

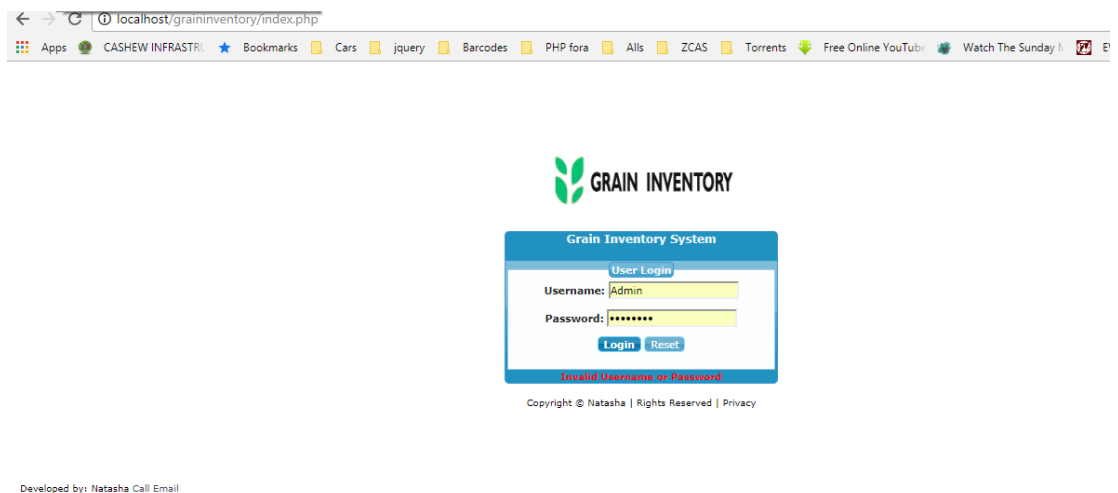


Figure 4.10: Screenshot of username and password mismatch.

Figure 4.11 shows the screenshot of the main page, System menus, that are auto derived depending on the user access levels granted by the system admin.

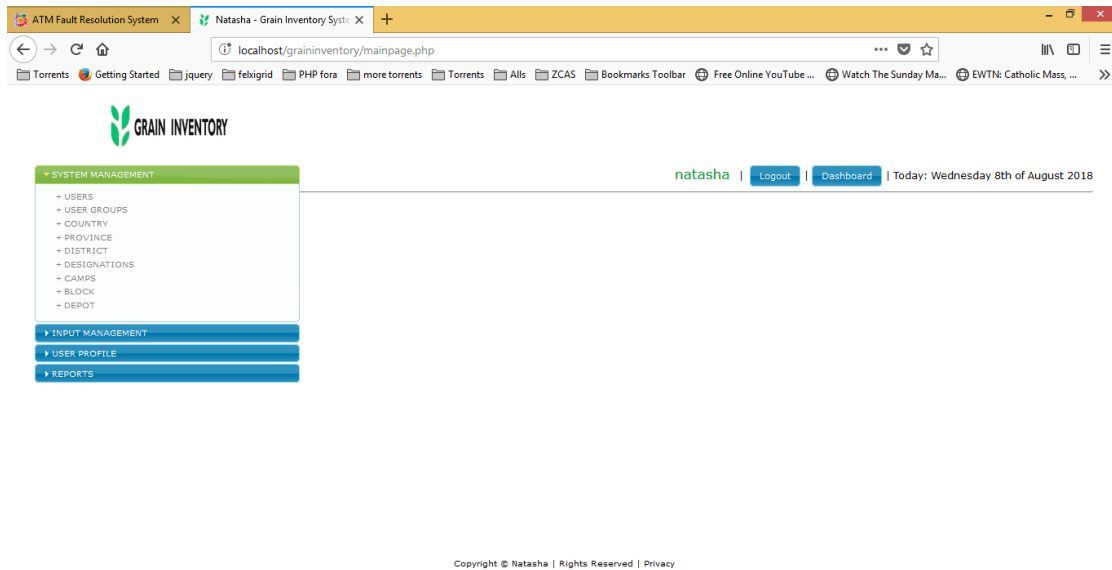


Figure 4.11: Screenshot of Main page on successful login.

Figure 4.12 shows the user management page, System tasks buttons. Depending on the access levels, these privileged based buttons help perform tasks on the system. Under user management we have: Add, Edit, Delete, Reset Password, Assign User Role and View user Role Assigned.

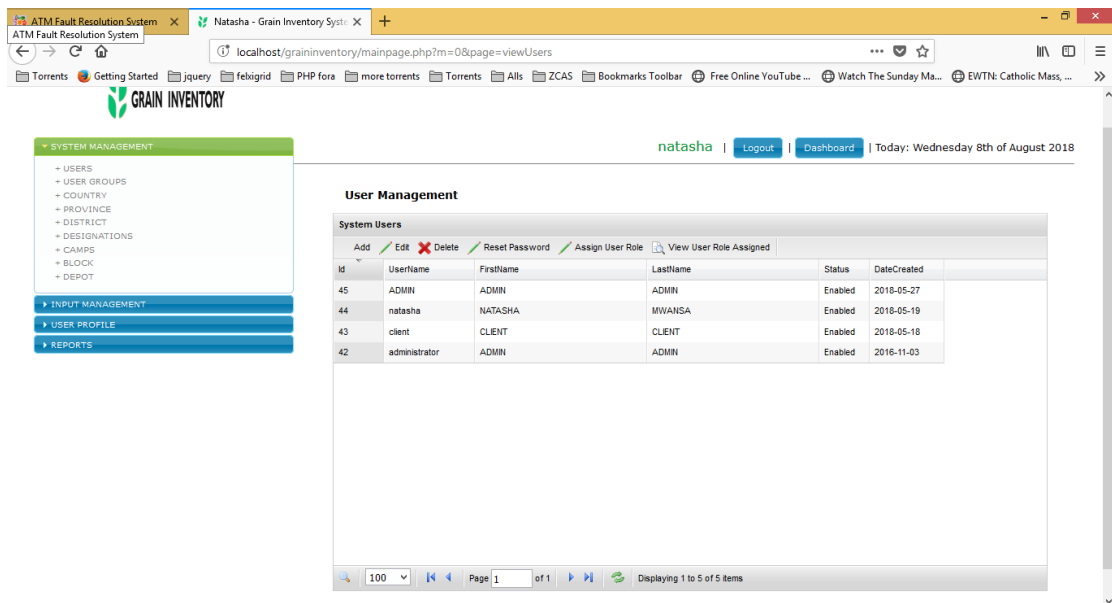


Figure 4.12: Screenshot of sample system users.

Figure 4.13 shows the add user input form, The username should be unique, and an Ajax call is made to check availability. The passwords should also be matching to avoid a user entering a password that they can easily forget.

Figure 4.13: Screenshot of Add user input form.

Figure 4.14 shows the add user group input form, a user group name is given and the two columns show tasks to be granted to that group. The column on the right bears the tasks availability under that module, and upon selecting them to push them to the left column using the arrows, shows how to assign roles.

Figure 4.14: Screenshot of Add user group input form.

All tasks assigned to a selected user group can be view on assigned tasks button click as seen in Figure 4.15:

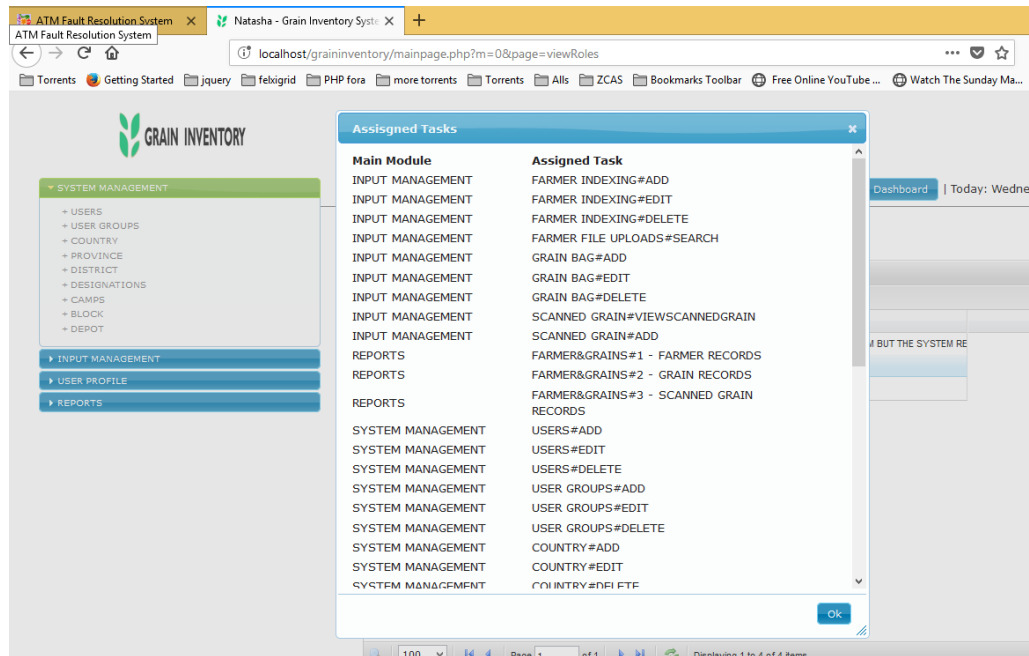


Figure 4.15: Screenshot of User group Assigned tasks/roles.

Figure 4.16 illustrates the Adding depot input form, it sits on the bottom most of the geographical tree. A user has to first add Province, District, Camp, Block then finally Depot. The add depot input forms take the same functionality i.e. Add, Edit and Delete. When adding a Depot, we first pick the block to form the relationship up to the Province. Similarly, up the tree, when adding a Block, we also select the Camp and so on.

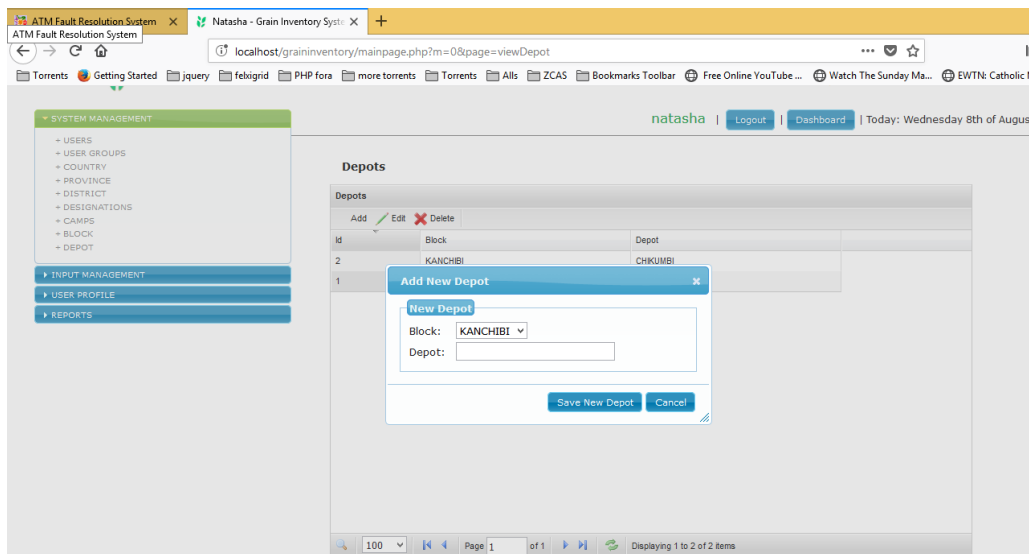


Figure 4.16: Screenshot of Add Depot input form.

Figure 4.17 shows the system sample farmers. Depending on the access levels, these privileged based buttons help perform tasks on the system. Under Farmer management we have: Add, Edit, Delete, More Details, Print ID & Print QRC

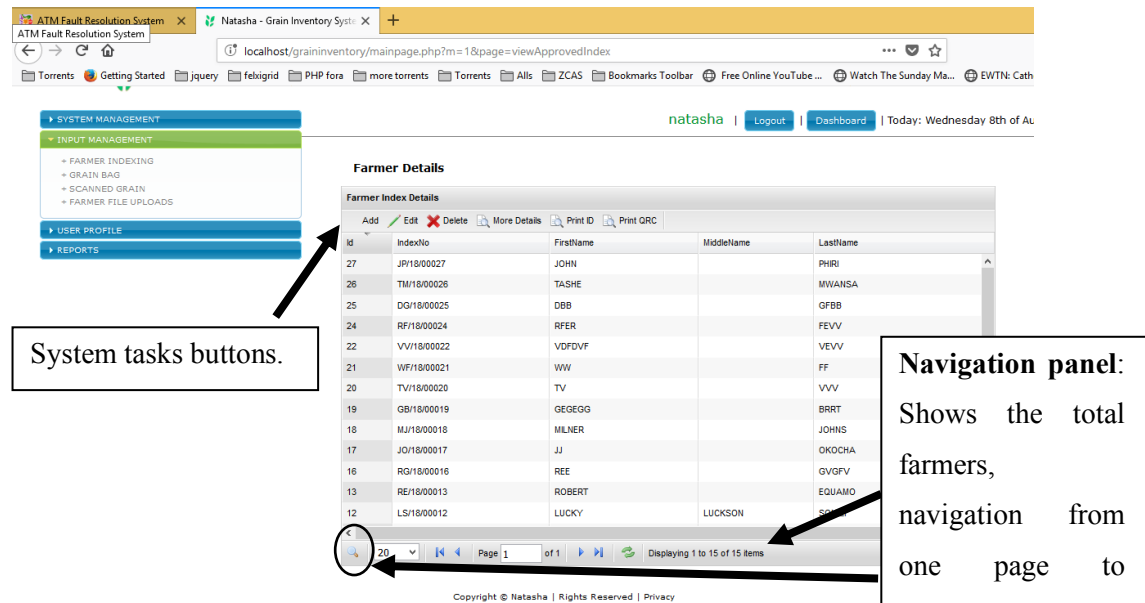


Figure 4.17: Screenshot of system sample Farmers.

Farmer details are captured, and the depot where they belong is selected as seen in figure 4.18. This form also has strong validation checks on required fields and uniqueness of the NRC. When the farmer come to the depot we check through the database and see if their details exist. The search criteria is by index number, full name or NRC.

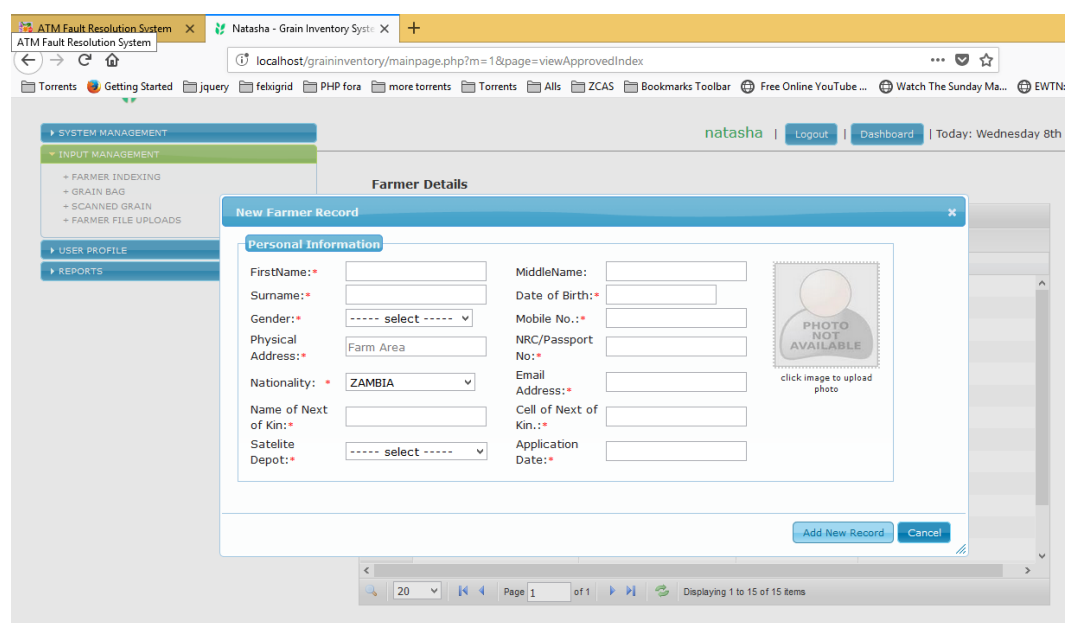


Figure 4.18: Screenshot of Add Farmer Input form.

Figure 4.19 is a report which shows all farmer details captured for a particular farmer.

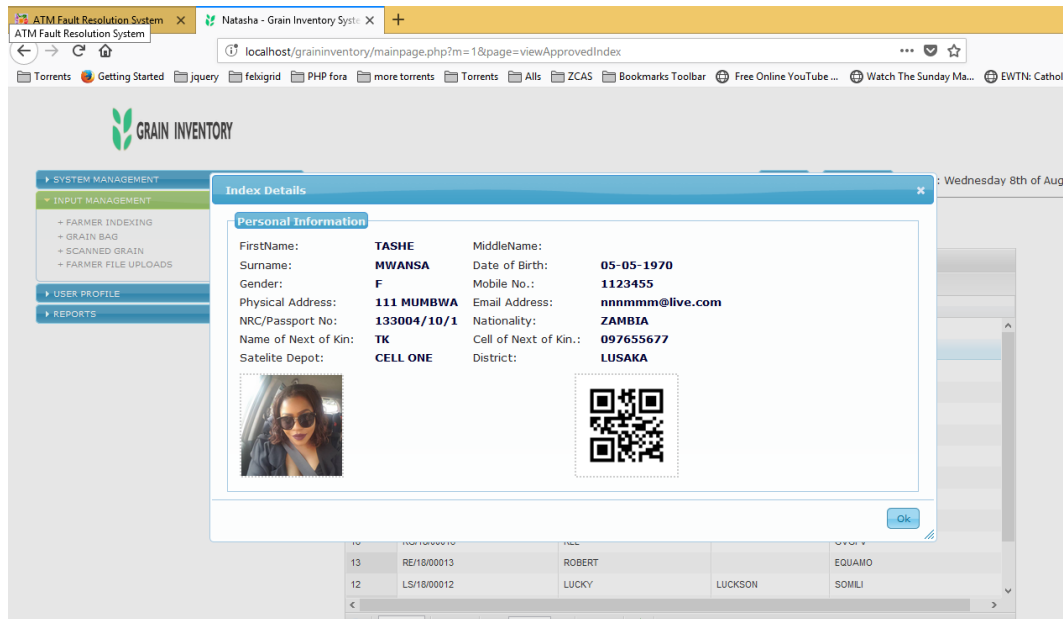


Figure 4.19: Screenshot of Farmer More Details.

Figure 4.20 shows how the farmer ID will be generated, the back of the ID will contain a QR code.

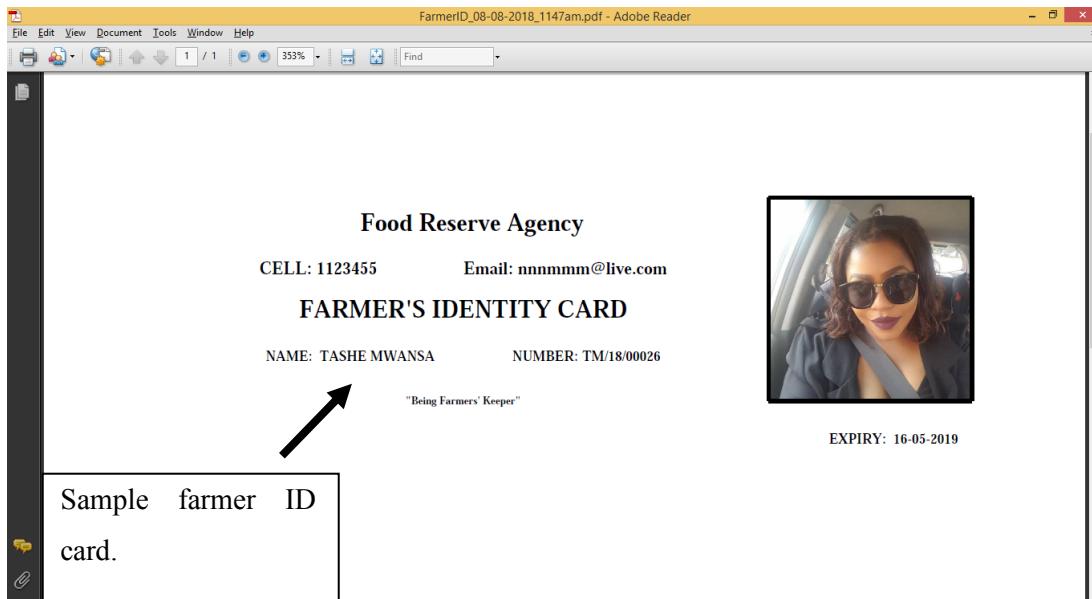


Figure 4.20: Screenshot of Farmer ID card on Print ID click.

Figure 4.21 shows how every grain bag added has to be associated to a farmer. On key up, farmer details are being pulled from the database to avoid typing a farmer name manually.

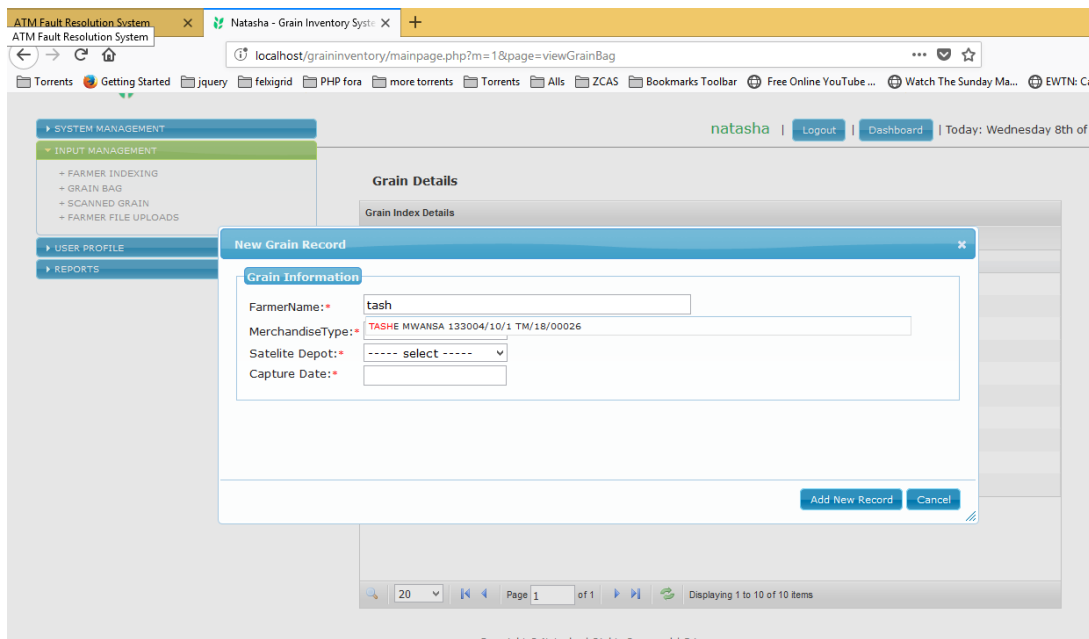


Figure 4.21: Screenshot of Add Farmer Grain bag.

The farmer name and QR code are viewed in a report for the selected grain bag as seen in figure 4.22.

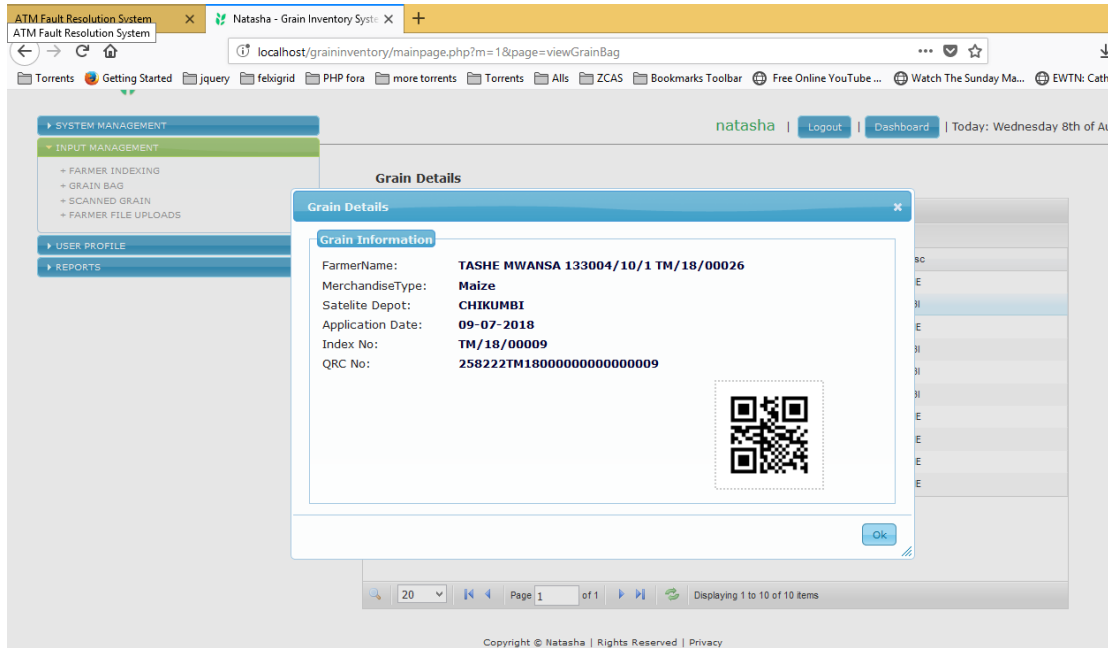


Figure 4.22: Screenshot of Grain bag - More details.

Figure 4.23 shows the system generated qr code, this code is generated by the farmers ProvinceID ,DistrictID, CampID, BlockID, DepotID , first letter of the first name and last name , year of capture and auto incremented number.



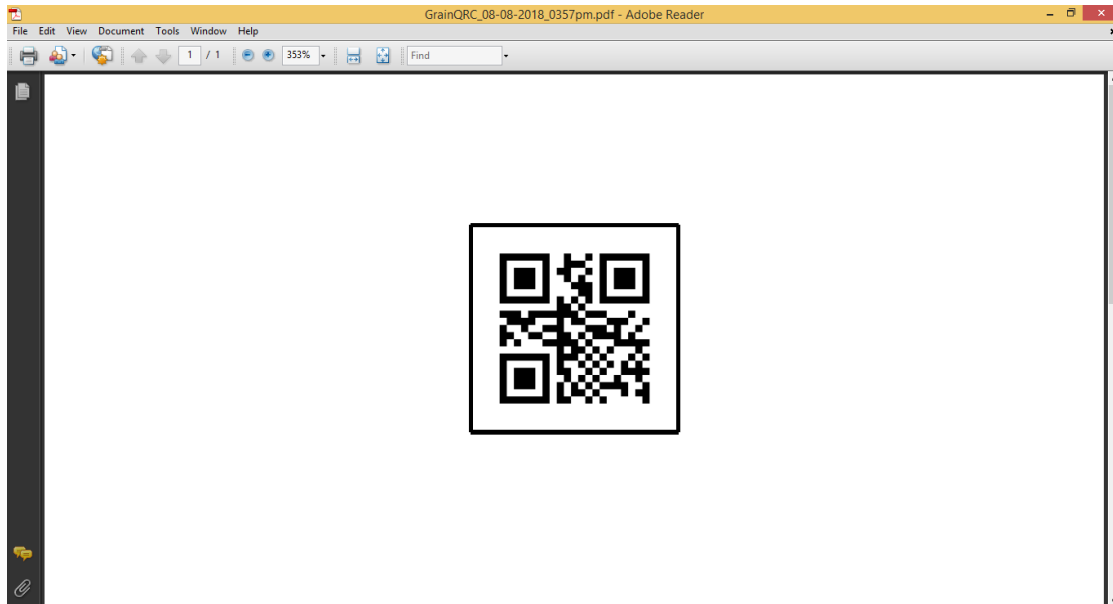


Figure 4.23: Screenshot of QR code for Grain bag.

Once Inventory scans are done by either using QR code or NFC processing, the posted values are viewed on this list. The value once received is checked through the database and all the associated details including the farmer and merchandise type are returned as shown in Figure 4.24.

 A screenshot of a web application titled 'Natasha - Grain Inventory System'. The browser address bar shows 'localhost/graininventory/mainpage.php?m=1&page=viewScannedGrain'. The page has a sidebar menu with options: SYSTEM MANAGEMENT, INPUT MANAGEMENT (selected), USER PROFILE, and REPORTS. Under INPUT MANAGEMENT, there are sub-options: FARMER INDEXING, GRAIN BAG, SCANNED GRAIN, and FARMER FILE UPLOADS. The main content area is titled 'Scanned Grain Details' and contains a table with the following data:
 

Grain Index Details				
Add				
Id	GrainNo	Farmer	MerchandiseType	QRC
2	MJ/18/00003	MILNER JOHNS hmy MJ/18/00018	SoyaBeans	2581111MJ1800003
1	JM/18/00002	JONES MWEWA 2344/11/1 JM/18/00011	Wheat	2581111JM1800002

 The page footer includes 'Copyright © Natasha | Rights Reserved | Privacy' and a status bar indicating 'Page 1 of 1' and 'Displaying 1 to 2 of 2 items'.

Figure 4.24: Screenshot of scanned Grain bags.

To add any file (supporting documents) to farmers, a search has to be done to associate that file accurately as seen in figure 4.25.

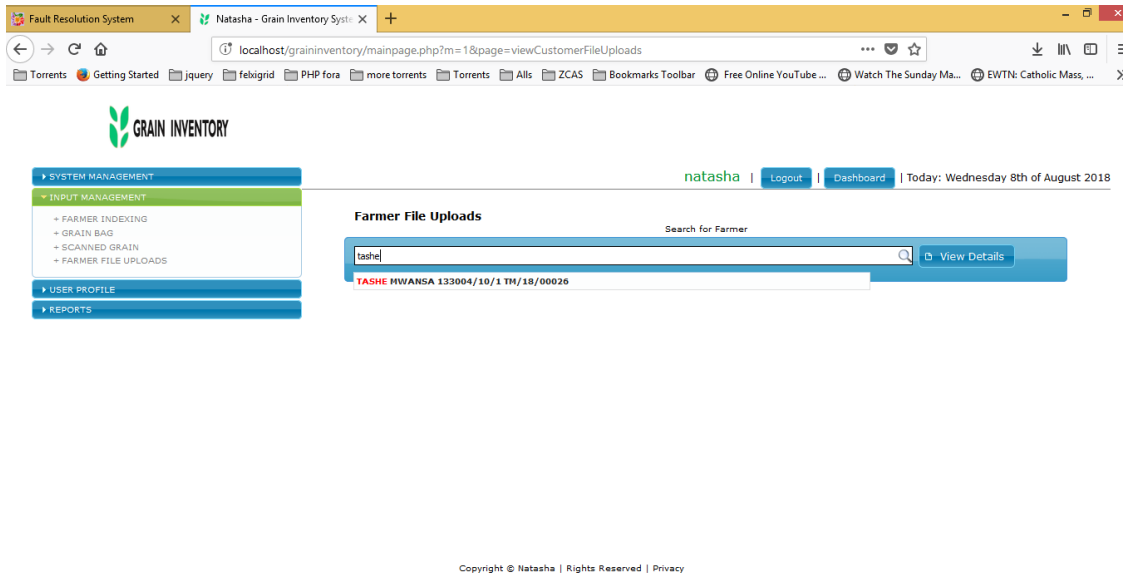


Figure 4.25: Screenshot of searching farmers for file upload.

All files uploaded on a particular farmer are listed here and a provision for adding new ones is on Add button click as demonstrated in Figure 4.26.

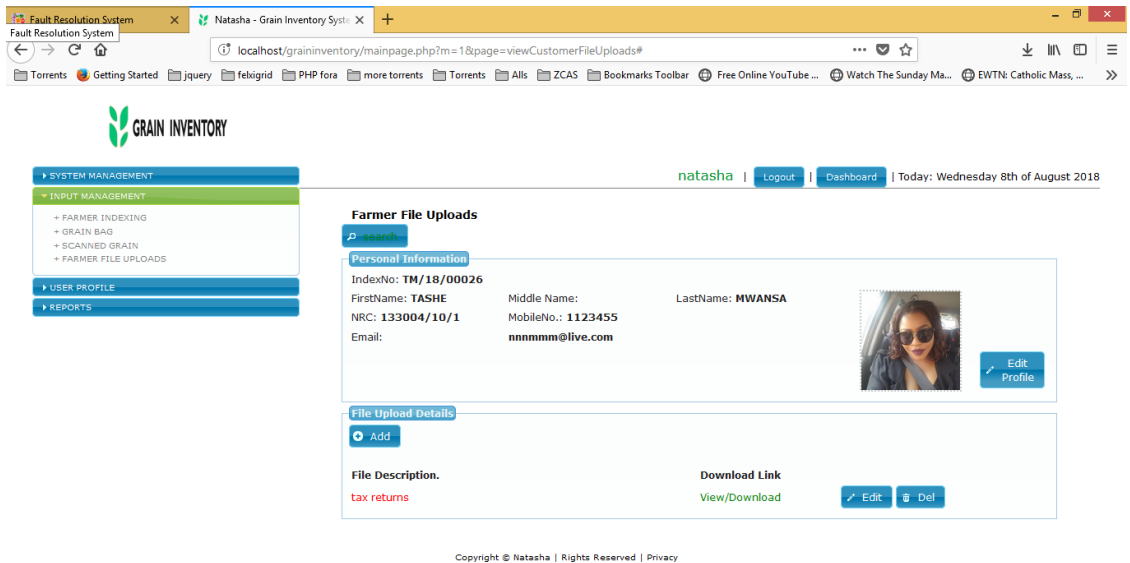


Figure 4.26: Screenshot of farmer file uploads.

Figure 4.27 shows how a user is free to change their password, every time they suspect that it has been compromised.

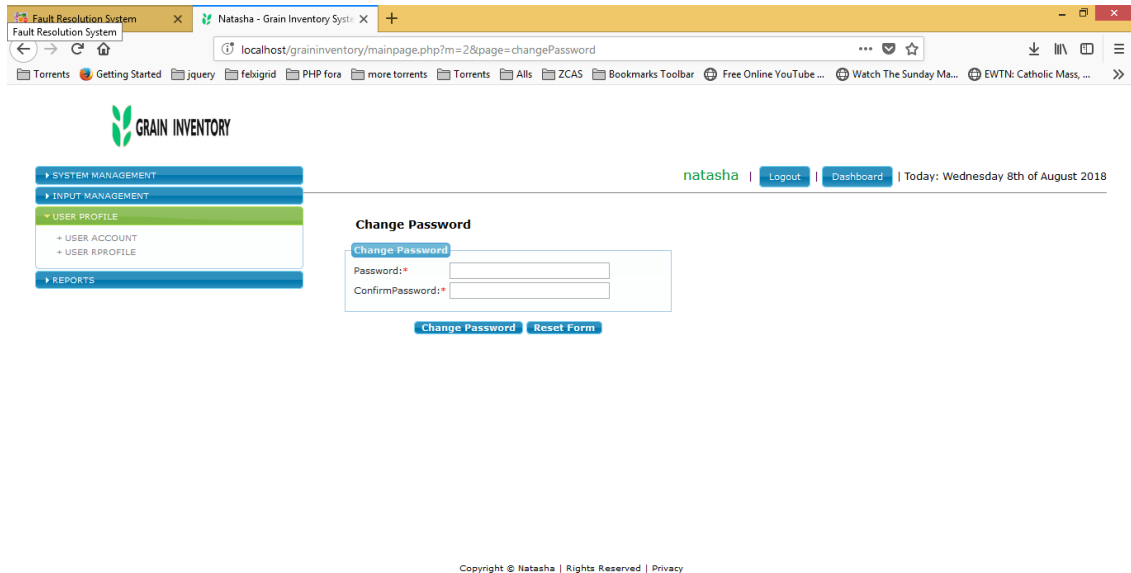


Figure 4.27: Screenshot of user password change.

To view a report for farmers, a user has to select the criterion within a date period and the report format either in PDF or Excel as seen in Figure 4.28:

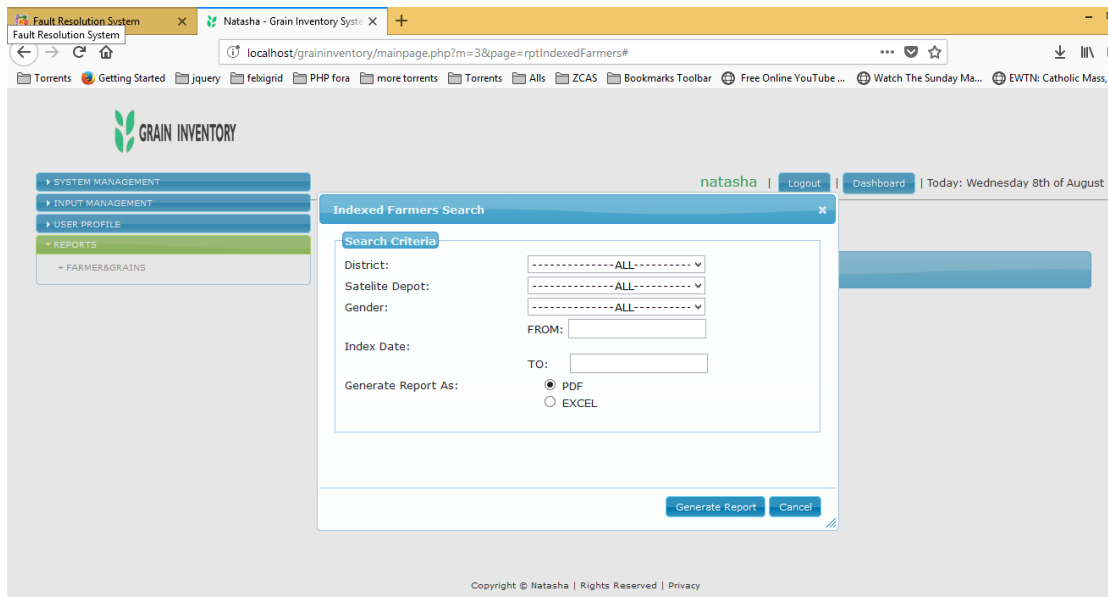


Figure 4.28: Screenshot of Farmer search criterion selection for reporting.

Figure 4.29 shows the report for the queried farmers, once the report is generated we can see the name, NRC, phone number and the depot where they belong. The report header is also customized to suit the organization for official representation of the sought information.

Grain Inventory Food Reserve Agency Farmer Indexing Report

No	IndexNo	Full Name	NRC	Phone Number	Depot
1	JP18/00027	JOHN PHIRI	122222/11/1	09777665432	CHIKUMBI
2	JO18/00017	JAY OKOCHA	1111154/89/5	455555	CELL ONE
3	MJ18/00018	MILNER JOHN	hny	4788	CELL ONE
4	GB18/00019	GEOGEO BIRY	CV	666	CELL ONE
5	TV18/00020	TITUS VERO	56	4	CELL ONE
6	WF18/00021	WINTER ROBERTS	5g	55	CELL ONE
7	VW18/00022	DEBBY KABALKA	555	66	CELL ONE
8	RF18/00024	ROSE FRED	455	66	CELL ONE
9	DG18/00025	DAVID GARRY	45	44	CELL ONE
10	TM18/00026	TASHIE MWANSA	133004/10/1	1123455	CELL ONE
11	RE18/00013	ROBERT EQUAKO	2879625	0950391933	CELL ONE

Figure 4.29: Screenshot of Farmers report in PDF format.

Figure 4.30 shows the same report generated in excel format:

FarmerIndexing\_09-05-2018\_19\_29\_11\_ - Excel

No	IndexNo	Full Name	NRC	MobileNo	DepotDesc
1	JP18/00027	JOHN PHIRI	122222/11/1	977851422	CHIKUMBI
2	JO18/00017	JAY OLIVER	1111154/89/5	97805456	CHIKUMBI
3	MJ18/00018	MILNER JACANTA	122287/5/1	978258661	CHIKUMBI
4	GB18/00019	GREG BANDA	1448709/2/1	96254589	CHIKUMBI
5	TV18/00020	TITUS VERO	1478598/5/1	978951511	CHIKUMBI
6	WF18/00021	WINTER FIELDS	178548/2/1	97789855	CHIKUMBI
7	VW18/00022	VICKY VIMBUSHE	134780/2/1	987546985	CELL ONE
8	RF18/00024	ROSE FIELDS	1458960/8/1	977885265	CELL ONE
9	DG18/00025	DAVID GRAY	155548418/4/1	977785546	CELL ONE
10	TM18/00026	TASHIE MILIMO	133004/10/1	96675437	CELL ONE
11	RE18/00013	ROBERT ELIS	12387995/10/1	924726651	CELL ONE
12	MM18/00010	MOSES MUSENGE	155799/10/1	6945157	CELL ONE
13	JM18/00011	JONES MWANSA	15899363/11/1	211252948	CELL ONE
14	LS18/00012	LUCKY SAKALA	19788962/13/1	978567890	CELL ONE

Figure 4.30: Screenshot of Farmers report in EXCEL format.

To view a report for grain bags, a user has to select the criterion within a date period and the report format either in PDF or Excel. All farmers or a particular farmer can be selected or key up as seen in figure 4.31:

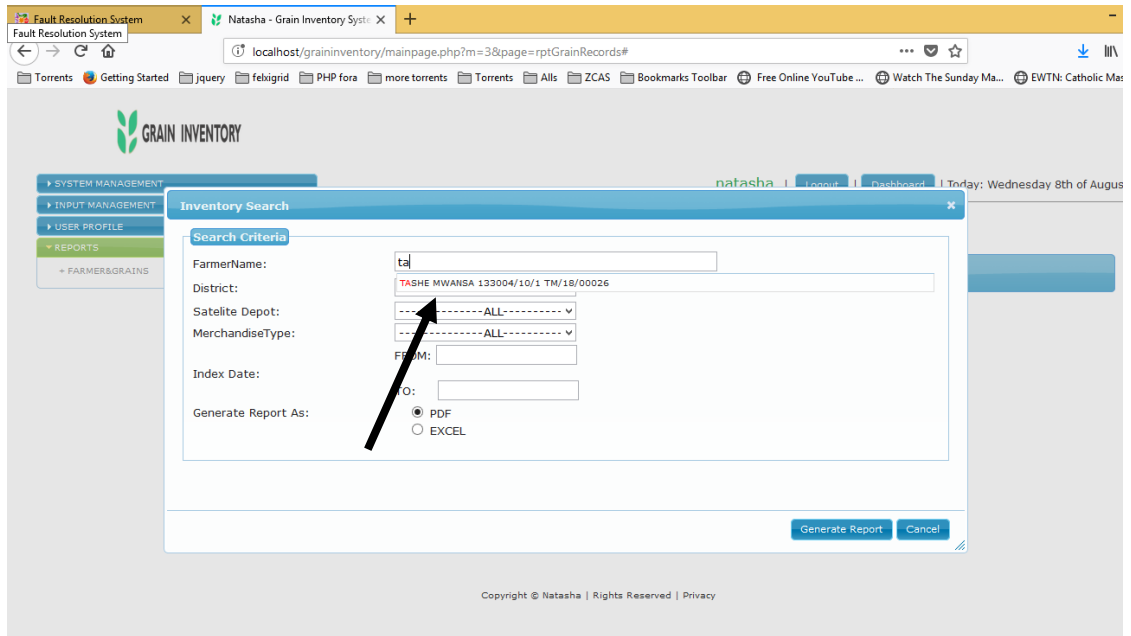


Figure 4.31: Screenshot of Grain bags search criterion selection for reporting.

Figure 4.32 shows the grain inventory report of the scanned bags of grain from each satellite depot:

GrainInventory\_08-08-2018\_0432pm.pdf - Adobe Reader

No	GrainNo	Farmer Name	MerchandiseType	Farmer Cell	Depot
1	JM/18/00010	JONES MWEWA	Maize	09888	CELL ONE
2	TM/18/00009	TASHE MWANSA	Maize	1123455	CHIKUMBI
3	VV/18/00006	VDFDVF VEVV	Wheat	66	CHIKUMBI
4	DG/18/00007	DBB GFBB	SoyaBeans	44	CHIKUMBI
5	MM/18/00008	MOSES MWALE	Rice	096623	CELL ONE
6	JP/18/00005	JOHN PHIRI	Maize	0977665432	CHIKUMBI
7	MM/18/00001	MOSES MWALE	Maize	096623	CELL ONE
8	JM/18/00002	JONES MWEWA	Wheat	09888	CELL ONE
9	MJ/18/00003	MILNER JOHNS	SoyaBeans	6788	CELL ONE
10	RE/18/00004	ROBERT EQUAMO	Rice	0950391933	CELL ONE

Figure 4.32: Screenshot of Grain bags report in PDF format.

Figure 4.33 is the excel format of the scanned bags of grain from each satellite depot.

No	GrainNo	FarmerName	MerchandiseType	Farmer Cell	DepotDesc
1	JM/18/00010	JONES MWEWA	MAIZE	9888	CELL ONE
2	TM/18/00009	TASHE MWANSA	MAIZE	1123455	CHIKUMBI
3	VV/18/00006	VDFDVF VEVV	WHEAT	66	CHIKUMBI
4	DG/18/00007	DBB GFBB	SOYABEANS	44	CHIKUMBI
5	MM/18/00008	MOSES MWALE	RICE	96623	CELL ONE
6	JP/18/00005	JOHN PHIRI	MAIZE	9777665432	CHIKUMBI
7	MM/18/00001	MOSES MWALE	MAIZE	96623	CELL ONE
8	JM/18/00002	JONES MWEWA	WHEAT	9888	CELL ONE
9	MJ/18/00003	MILNER JOHNS	SOYABEANS	E788	CELL ONE
10	RE/18/00004	ROBERT EQUAMO	RICE	950391933	CELL ONE

Figure 4.33: Screenshot of Grain bags report in Excel format

### 4.3 Mobile Application

Figure 4.34 shows the mobile application user login screen and the system prompt on password or username mismatch.

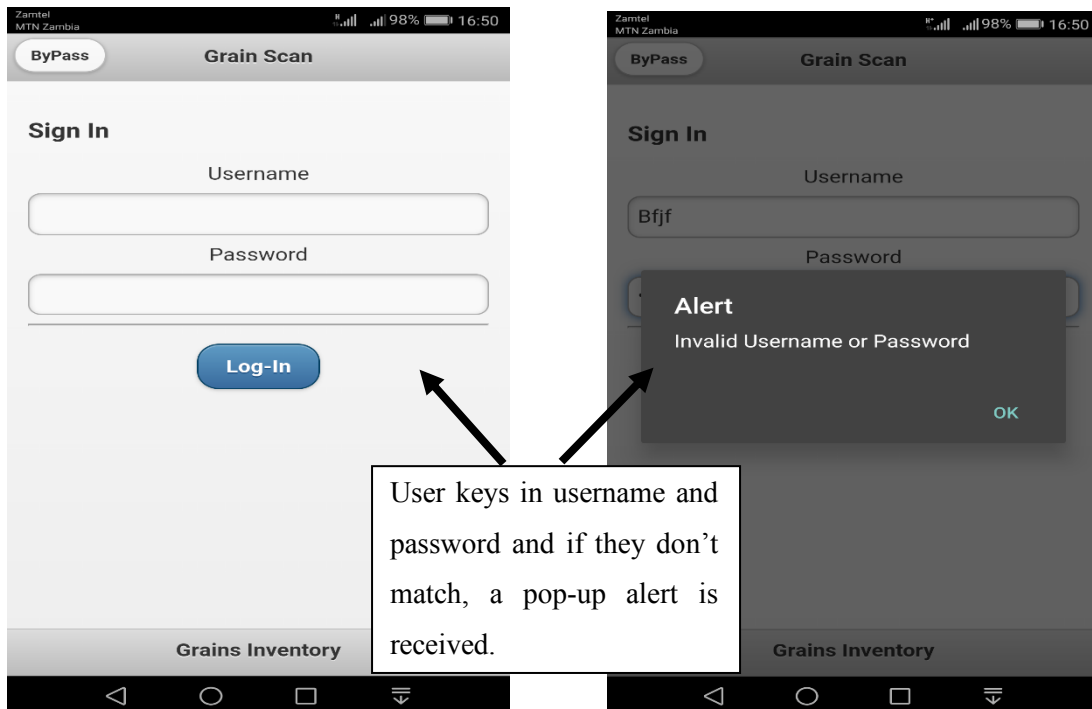


Figure 4.34: User login and prompt on Password & username mismatch.

Figure 4.35 shows the scan QR code screen and the returned results on success.

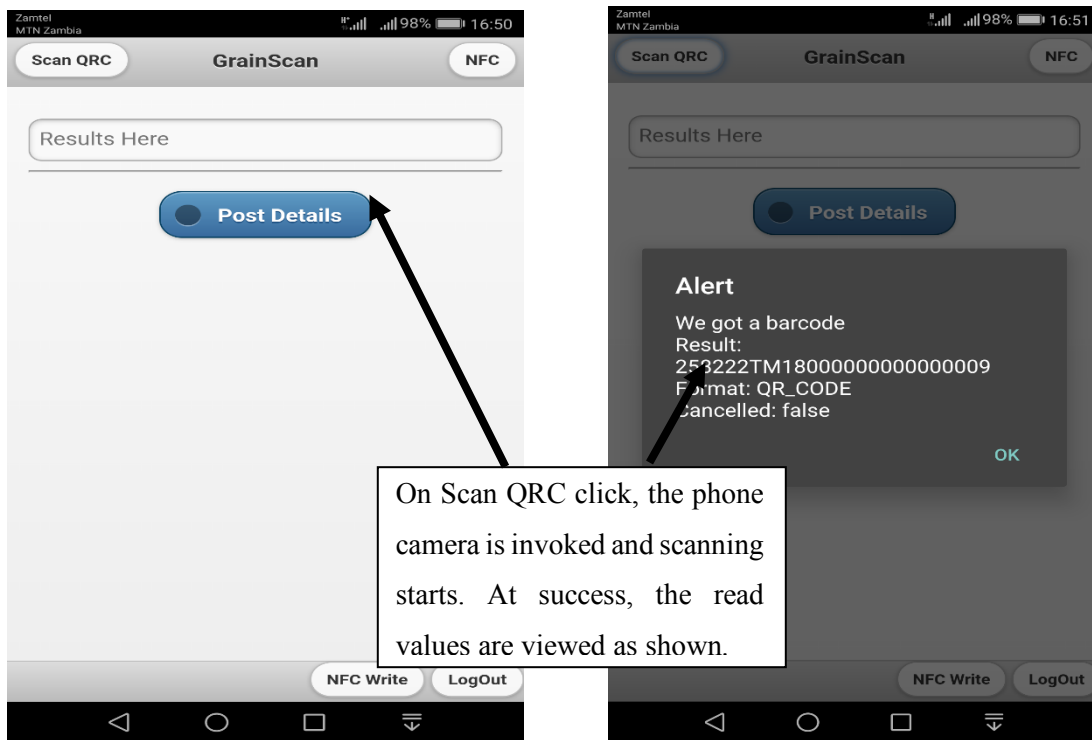


Figure 4.35: QR code scanning and returned results.

Figure 4.36 depicts the QR code value upload status and writing of value on NFC tag

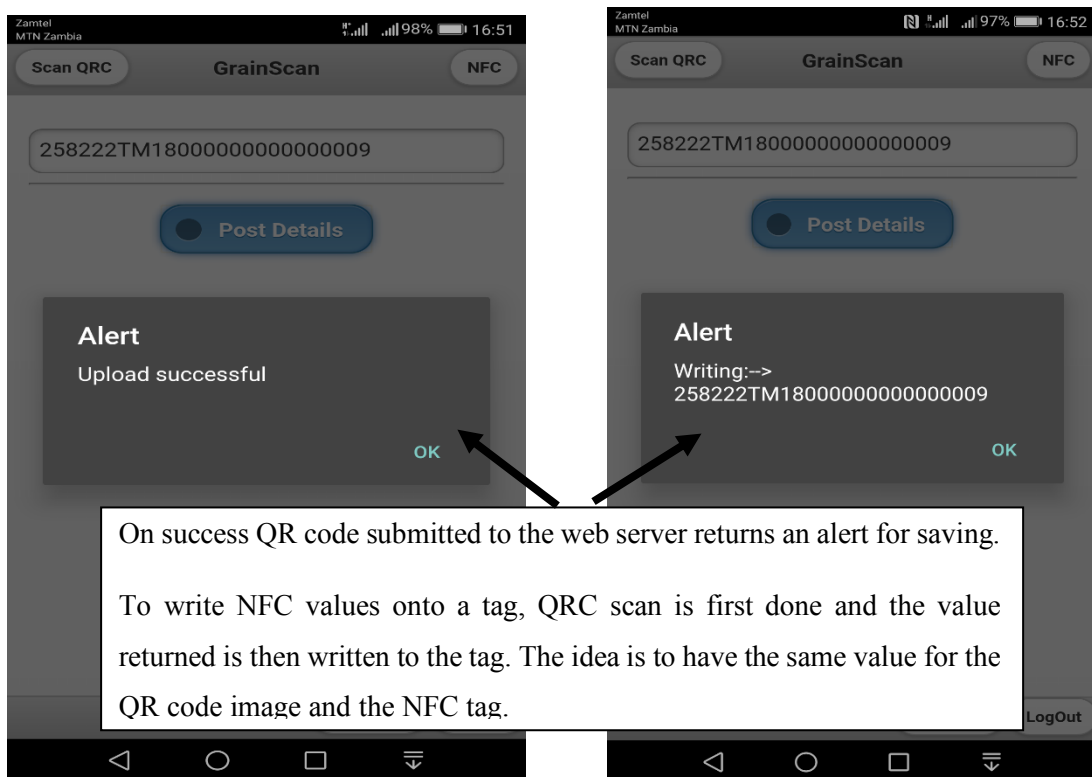


Figure 4.36: QR code value post status & Writing NFC value on a tag.

Figure 4.37 shows the NFC tag writing status and NFC tag reading page

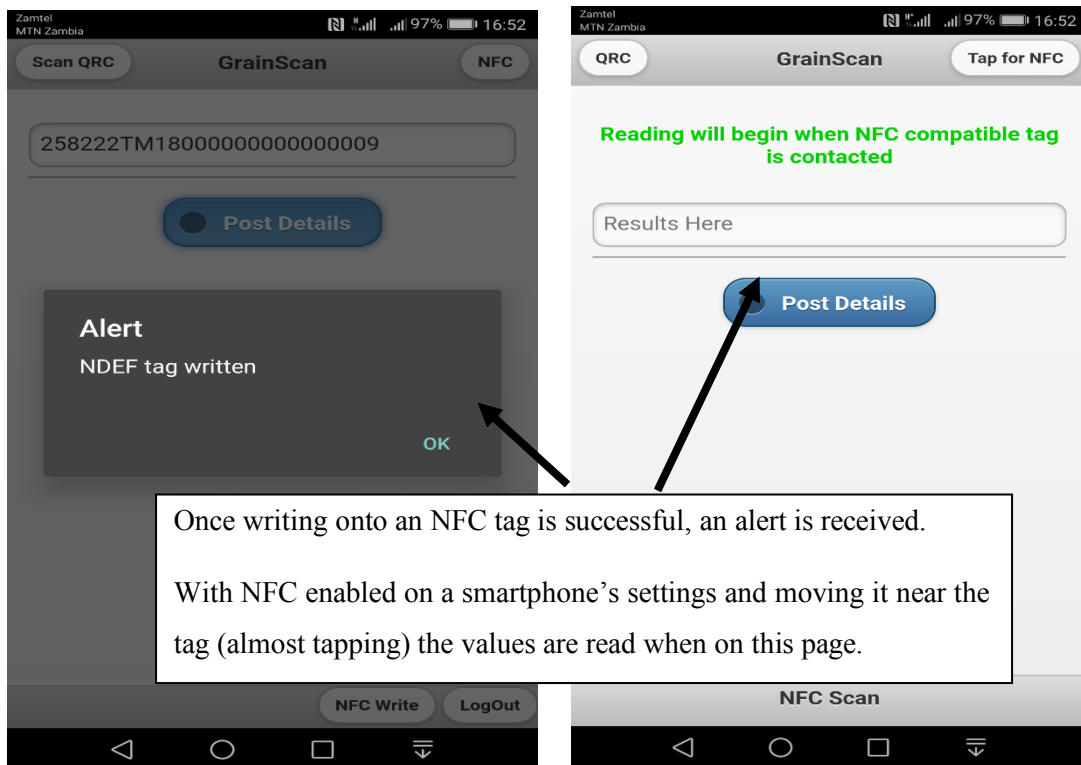


Figure 4.37: NFC tag write status and NFC tag Reading page.

Figure 4.38 shows the NFC tag read value and the upload status.

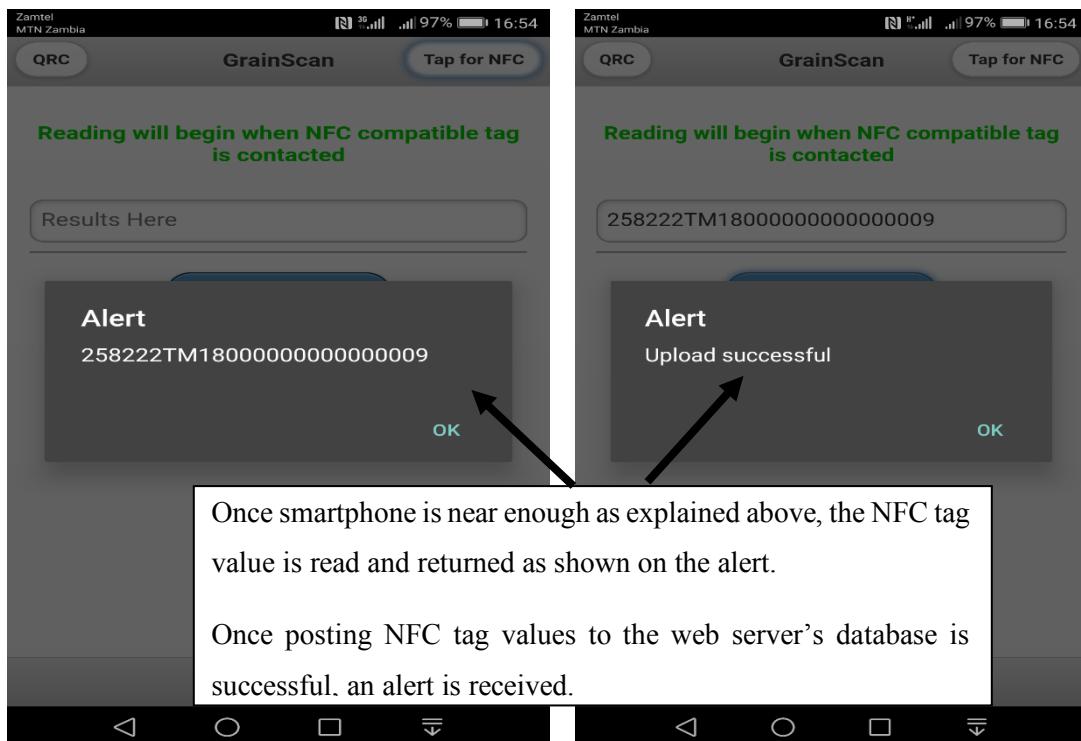


Figure 4.38: NFC tag read value & the upload status.



#### **4.4 Summary**

This chapter covered the results that were gathered from the solution that was delivered. Sample data was captured onto the system and the test plan was developed to check if the user needs were met. The system screen dumps demonstrated how the sought system functionality were achieved. The system proved how the organisation can benefit if it implemented.

## **CHAPTER FIVE**

### **DISCUSSION AND CONCLUSION**

#### **5.1 Introduction**

This closing chapter aims at outlining the challenges that FRA faces at the satellite depots and how the developed prototype comes in to remediate some of these problems. As outlined in the previous chapters on the applications developed to handle the grain capturing and inventory control, this chapter will give an overview and how these applications can be rolled out. Further on, the recommendations and other features for future works will be outlined and finally close with a summary of the entire paper.

#### **5.2 Discussion**

Using a web-based management information system to handle an organisation's business process is always encouraged as the benefits would show. Such a system will cut down on inefficiencies that come with data inconsistency, duplication and repetitive work under a traditional manual system. The solution that is proposed in this paper not only combines a mobile and web application but also demonstrates the ease on how data can be collected, stored and manipulated in the most efficient way as the mobile application would handle the inventory checks and post to the web application for storage and analysis there by giving reporting platforms to even help management make informed decisions. Like observed under the results section, once a farmer brings their merchandise to FRA, their details are first captured (if and only if they have never been captured) to allocate them with a system identification number. The next stage is storing all their grain bags under their names to allow association between farmer and what merchandise that they brought for payment and other purposes. The grain bags are also assigned QR codes and NFC tags to be stuck on them for inventory purposes. The approach undertaken in this study was to basically automate the entire trading process between the agency and the small-scale farmers. Once grain bags have been collected, securely keep/store them for proper inventory checks and have a basis for quick generation of payments to what is owed to the farmers. The said applications tried to achieve this but like every other system, some features couldn't be incorporated at this stage as the future works section in this chapter will document.

### **5.2.1 Challenges FRA faces at the satellite depot**

The following are some of the challenges the Food Reserve Agency faces:

1. Excess Purchase of Crops
2. Excess Stock Losses: these losses are attributed to various factors such as spillages, pilferage (because of lack of tracking and manual counting of bags of grain), insect damages (because of purchasing insect infected grain), rotting and discolouring of grains.
3. Poor Stacking

### **5.2.2 Prototype for grain capturing**

The initial version of the web and mobile applications are developed to handle the complete business process through up to grain bag inventory checks. The base is such that organisation users are given system credentials to access the system according to how much their job/role requires them to perform. These users are assigned a user group to control the said privileges and to ensure that once an audit trail is conducted, only certain personnel are targeted. The users assigned to handle data entry at depot level have an important role of registering farmers and every grain bag associated to them. This means that every grain bag is tied to the farmer who brought it. As these grain bags are added, they are assigned QR codes (chapter 4.2) for tracking. These QR codes are then printed and stuck on the grain bags. For inventory checks, the mobile application comes in handy. The mobile application is QR code and NFC enabled as earlier stipulated. The QR code scanning mode will scan these QRC images stuck on grain bags and post their values to the web application for storage on the database server. A platform for checking all these scans is available on the web application. For the NFC aspect, these are preceded by the QR code scan such that when a value is scanned and returned, this same value is written on the NFC tags and stuck on the grain bag. The idea is to have the same value on the QR code and on the NFC tag on that particular bag. Once an NFC tag is tapped for reading by the mobile application, the sending of the values and storage on the database server is the same as with the QR code process. Once the inventory check process is done, the web application handles the reporting module. The reports range from farmer records, grain bag records and scanned grain records. The farmer records can be selected from depot,

gender and a period when they were added on the system. This search criterion is entirely dependent on the user. Similarly, with the grain bags records, these can be viewed as per farmer, region and the period also. This helps to calculate how many and in also in terms of how much money is owed to a farmer based on the bags associated to them. These reports are designed in Excel and PDF formats. This basically gives an overview of how the proposed system is developed to work.

The system developed tools for the web (desktop) and mobile applications were quiet a combination of some technologies. The web application utilised PHP, HTML, JavaScript and CSS for the front-end development and connection to the database server i.e. MySQL. The mobile application used the recent technologies of Cordova (formally PhoneGap) unlike the native Java for mobile devices i.e Android. Cordova utilises JavaScript, Json and HTML, where HTML is for front end development and the other tools being used for data posting and communication with the server database either local (SQLite) or the server database with the desktop application. This technology covers all platforms, but for this prototype, Android platform was used and this meant using Android Studio to convert these files to run on Android powered devices.

### **5.3 Business Process Mapping and Modelling**

The business processes mapping and models that were designed for the automated grain capture inventory management system. The business processes as described by the food reserve agency satellite depot handbook were translated into diagrams. It was seen that the current business processes the purchasing of grain from small scale farmers is manual and paper based, it was from this that the author proposed and automated business process for real time grain capturing. An automated system has several advantages such as managing satellite knowing how much stock which is at a particular satellite depot so as to stop excess purchases of grain, application will help not only to capture and manage inventory but also help manage satellite depots. With the ability of knowing how much stock is at a particular depot, it will provide the government benchmarks for setting up reorder levels and forecasting on the needed investment in the next seasons. The security feature that the QR codes provide will just be another control measure to manage inventory. The codes generated will be unique and will cut out fraudulence activities, for only codes generated or present on the server will be accepted to be scanned back as net inventory.

## **5.4 System Implementation**

To successfully implement the defined prototype as guided in chapter four, a well define approach was used. The researcher started on with gathering the system and user requirements using both the hard and soft approach. The hard approach was used to understand the technical aspect of the system requirements. This was to gather the actual system functionality/features that meet the organisation business process on grain capturing. The soft approach was to understand what the user culture is like and in terms of how the new system will affect their everyday work. This was vital to try and buy in the users from the onset to ensure that the system is fully accepted from their end. Once requirements were gathered, a prioritisation mechanism called MoSCoW was used to guide on what features are developed and at what stage of the system development.

The system design followed where, the forms were designed for data capture. The forms for Capturing users, farmers, grain bags etc were drawn down to have a pictorial view of how the front end might come up. The database tables were also designed to match with what the front-end forms had. The necessary relationships on the database tables were also derived, for example; a table having grain bag details should have farmer ids to create that association. This stage provided a blueprint and basis for the actual system development stage (writing code).

The actual prototype development first focused on the web desktop application as this handle most of the features on the proposed solution. With the MoSCoW prioritisation followed, the first bits of the Must have features were developed and tested. The users where involved to test and features were iterated until they were satisfied. The same approach was taken for the mobile application. Once the NFC and QR code scanning was completed, sample grain bags were stuck with NFC tags and QR code images for testing as seen in chapter 4.2. To roll out the system to the entire organisation, a comprehensive method was outlined. The benefit of implementation this system is immense as discussed under chapter 4.

## **5.5 Conclusion**

This research aimed at devising methods in which the FRA can better the business process under the grain capturing function. The core objectives were to analyse and map all the business processes at the agency with the view of developing a prototype based on real time data capturing using NFC and QR code technologies. The idea was after interacting with the business owners and the staff that perform the day to day activities, gather their requirements and try to automate the grain capturing and inventory checks unlike the manual present way. The approach was developing a database from existing sources, where the prototype was to develop a web and mobile application to utilise the way records were being stored from spreadsheets and other current means. This was to be done without forgetting the underlying aspect of combatting the challenges faced by the Food Reserve Agency at the Satellite Depots regarding grain capturing through business process mapping and modelling. During the user requirements investigation and gathering, the research was trying to answer the questions of what the major business processes at the FRA satellite depots during the grain purchases and the possibilities of developing a cloud-based inventory management system by using NFC and QR Code technologies.

At the point of successfully developing a prototype for managing and automating the said business process, it can be drawn that indeed such management information systems bring about efficiency in conducting business. The two applications help to keep farmer records, associate the grain bags to the owner farmer for payment purposes and with the incorporation of NFC tagging and QR code image sticking on those bags, bringing about a successful and accurate inventory control process. This further clears out the duplication of work, fraudulent activities and errors on farmer payments as can be gathered from the current manual system. Such management information systems, also help management make informed decisions as these systems give pictorial reports and forecasting based on farmer business trends.

As evident on the results section, the proposed prototype was successfully developed to meet the sought objectives with a clear implementation process delivered. The success score proves that the researcher was well motivated and the agency can be encouraged to implement this prototype.

## **5.6 Recommendations**

Having developed a web-based application working together with a mobile application, the researcher proposes the following guidelines:

1. Investing in internet accessibility on all satellite depots. The idea is to ensure constant communication between the two applications.
2. Securing the web database server on the cloud with close adherence to the international data protection policies once implemented.
3. Farmer and staff sensitisation on the use of such management information systems to build capacity and culture shift from manual to automated business processing.

## **5.7 Future Works**

The two applications were developed to be flexible enough for system interoperability and other modifications. This means that whenever the agency decides to make any changes or have them join into other systems, this becomes possible. The researcher had a lot of ideas on how certain features can be developed better. The first in line was to ensure that the mobile application can handle the inventory checks and save the records on the local phone memory (SQLite database) in cases when internet access is unavailable. Once internet is restored, the application can still sync these records to the web server. The offline mode of mobile applications is really trending as they allow work to continue even in remote parts where there is completely no internet access. Another aspect would be to incorporate the Geolocation technology to work with google maps and give a pictorial location of the satellite depots. As a way of appreciating the system interoperability mechanisms, the web application can communicate into a financial system to help handle the farmer payment process and produce the receipts. A further modification will be adding other mobile platforms like IOS and windows to cater for users that don't have Android powered devices.

## **5.8 Summary**

This concluding chapter tried to discuss the build up to the development of the prototype and all the various stages that were involved in brief. The researcher tried to argue that the research was worth the work starting from deriving the challenges that the agency face at the satellite depot for grain management and how a suitable automated system can help combat those problems. The researcher also suggested

some recommendations on how to successfully implement the developed prototype and what other features can be added to make it even work much more effective.



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## APPENDICES

**Appendix A1: Comparisons of different wireless technologies [89]**

<b>Standard</b>	<b>Bluetooth</b>	<b>Infrared</b>	<b>NFC</b>	<b>Wi-Fi</b>	<b>ZigBee</b>
<b>Governing Body</b>	Bluetooth SIG	Infrared Data Association	NFC Forum	WIFI Alliance	ZigBee Alliance
<b>IEEE Specification</b>	802.15.1	802.11	802.2	802.11a/b/g	802.15.4
<b>Frequency Band</b>	2.4 GHz	875 nm +/-	13.56 MHz	2.4 GHz, 5 MHz	868/915 MHz, 2.4 GHz
<b>Standard Range</b>	1-100m	0.2-1m	< 0.2 m	100m	10-100m
<b>Number of RF channels</b>	79	50	1	14	1/10, 16
<b>Max number of nodes</b>	8	2	2	2007	>65000
<b>Data Transfer Rate</b>	3 Mbit/s	4 Mbit/s	424 Kbit/s	54 Mbit/s	250 Kbit/s
<b>Modulation type</b>	GFSK	pulse	ASK	BPSK, QPSK, COFDM, CCK, M-QAM	BPSK (+ASK), O-QPSK
<b>Spreading</b>	FHSS	PPM	NA	DSSS, CCK, OFDM	DSSS
<b>Basic Cell</b>	Piconet	Point to Point	Point to point	BSS	Star
<b>Encryption method</b>	E0 stream cipher	NA	AES	RC4 stream cipher (WEP), AES block cipher	AES block cipher
<b>Authentication</b>	Shared secret	NA	In-built	WPA2	CBC-MAC

<b>Data Protection</b>	16-bit CRC	16-bit CRC	32-bit CRC	32-bit CRC	16-bit CRC
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**Appendix A2: Comparison between different types of common barcodes.**

Barcode :	EAN 13	Code 39	Code 128	Data matrix
Year created	1970	1974	1981	1999
Encoded characters	Numerical (digits 0 to 9)	Alphanumeric (0 to 9, A to Z, Special characters) 43 characters	Complete ASCII (128 characters)	Alphanumeric characters
Identifier coding capacity (varies by size)	Fixed capacity: 13 digits (43 bits)	130 bits for 24 characters	168 bits for 24 characters	862 characters (4.5 kbit) for a tag that is 88 mm × 88 mm
Identifier length	Varies between 20 mm and 37 mm according to printing conditions	95 mm for 24 characters	75 mm for 24 characters	Varies between 10 mm × 10 mm and 144 mm × 144 mm
Properties	Fixed length, Common code in 60 countries	Universal code, read by most equipment	Very dense code but only read by certain readers	Very large coding capacity but requires specific readers
Example of application	Food products, large-scale distribution items	Product management and sales, labelling, distribution, document indexing	Transport, industry, health, distribution	Quick link to online content, exchange payment information, tracking batches or items

Reading device	All barcode readers	Barcode readers	Barcode readers	Smartphones, Imagers
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### Appendix A3: Functional requirements

Feature	Description	MoSCoW Prioritization
<b>Manage Users</b>	This will involve managing how users are added onto the system. Once a user is added the privileged user will have the ability to edit, search and even delete a user.	
Add user	The system must have an option to add new users as a feature.	<b>M</b>
Edit user	Records that are added in the system should allow for amendments in order for corrections or additional information to be included as need arises.	<b>M</b>
Delete user	If a record is no longer need in the database, the system should allow purging out completely.	<b>M</b>
Search user	A defined criterion should allow for a search function in order to display only the desired records.	<b>C</b>
<b>Manage User groups</b>	To administer access control in the user group. Users in the same group will exhibit possess similar access permissions. Its centralized way of managing multiple users who should possess similar permissions.	
Add User Group	Different Users on the system are associated with different groups on the system. Therefore, in order to easily align a grouping of users, there must be defined user groups on the system for easy association of different bands of users.	<b>M</b>
Edit User Group	User groups should allow for amendments or permission changes to suit system needs	<b>M</b>

Delete user group	Groups can be created for specific needs, if they are no longer needed; the system should have ability to remove that group from the system as it will be considered stale.	<b>M</b>
Assign tasks to user group	Each user group to be distinct from another should have its own assigned tasks that is specifically performs. These tasks include but not limited to add, edit, delete, and search on every module. Control of privileges to users based on user group.	<b>S</b>
View tasks assigned	Generate a report that filters by tasks assigned to either a user group or a user.	<b>C</b>
Password reset	Users should have an option to change their passwords if they are suspicious that it has been compromised	<b>S</b>
Assign user role	Every enrolled user on a system on a system is assigned a role	<b>M</b>
View user profile	The system should allow to see all the attributes about a user	<b>C</b>
<b>Manage Provinces</b>	The province takes the root of all location additions on the system	
Add Province	Allows you to add a province if not listed on the drop-down menu	<b>M</b>
Edit Province	Allows to make amendments to the already added province	<b>M</b>
Delete Province	When a province is no longer need, it can be deleted	<b>M</b>
Search Province	The system should allow to search for a specific province from the listed province	<b>C</b>
<b>Manage Districts</b>	All districts that are included in the system should be linked to the province	
Add District	A district is added to the system	<b>M</b>

Edit District	If the district is misspelled, it should allow for correction or amendment if the name has since been changed	<b>M</b>
Delete District	If the district is no longer required in a given province, it can be removed from the list	<b>M</b>
Search District	There should be a way to look for specific districts that long list of districts	<b>C</b>
<b>Manage Camps</b>	Camps will be linked to the districts, and when adding a particular district has to be selected.	
Add camp	This allows system user to add a camp	<b>M</b>
Edit Camp	This allows for any relevant amendments on the camp that currently exists on the system	<b>M</b>
Delete Camp	Any camp that is no longer needed should be removed	<b>M</b>
Search Camp	There should be criteria to look for specific camp from a list of many camps	<b>C</b>
<b>Manage blocks</b>	All blocks fall under a given camp or associated with a certain camp	
Add Block	Allows to add a block	<b>M</b>
Edit Block	Makes changes to any of the added blocks	<b>M</b>
Delete Block	Any block that becomes stale is removed from the list of blocks registered	<b>M</b>
Search Block	Should you be looking for a specific block specifically, the use function would be useful	<b>C</b>
<b>Manager depots</b>	In terms of location on the tree, the depot is at the bottom. This is linked into the blocks that exist within a camp.	
Add depot	To add the block, the province, district, camp, block should have been added as it has total dependency in the order listed. Farmers trade or make their grain submission at the depot level	<b>M</b>



Edit depot	All added depots, their details can be amended	<b>M</b>
Delete Depot	Any depot that will no longer be useful can be dropped from the listing	<b>M</b>
Search Depot	Allows for searching for the specific depot in the system	<b>C</b>
<b>Manage farmers</b>	Any farmer that exists in the system has to be registered in this module and their details administered through this module	
Add farmer	A farmer is added to the system using this menu	<b>M</b>
Edit farmer	To the details already added about a farmer you can make amendments.	<b>M</b>
Delete farmer	For a farmer's record that is no longer needed, it can be removed	<b>M</b>
View farmer details	A report generated on a farmer based on a chosen method to extract the data.	<b>C</b>
Print farmer ID card	Identity cards are produced in the system for each farmer as form of identification as they come to trade at the depot.	<b>C</b>
Print farmer QR code	Unique QR Code is generated by the system to for each farmer to identify which bags of grain belongs to them	<b>C</b>
Farmer file upload	All files relating to the particular can be attached to their profile on the system	<b>C</b>
<b>Manage grains</b>	All grains that is brought into the depot is associated to a particular farmer	
Add grain bag details	A grain bag will be added to the system once a farmer deposits at the depot. All tracked grain bags are associated to the farmer.	<b>M</b>
Edit grain bag details	For wrongly captured grain bags, amendments should be allowed	<b>M</b>

Delete grain bag details	Grain bags that are wrongly captured can be deleted if administrator so wishes.	C
View grain details	Information regarding an added grain bag to the stock of the depot will be available. Information such as District, Camp, block, depot will be searched using a preferred user preference	
Print grain bag QR code	Grain bags will be identified using QR code image stack on each bag. This is used for input during scanning using a mobile application during inventory management.	
View scanned grain	A report to show all grain bags that have been scanned. This is done using QR code scanning and processed using NFC.	
<b>Manage scanned grains</b>	This module will manage all QR code or NFC Tag processing	
View scanned grain bags	A report to show all scanned grain bags	
Search scanned grain bags	Limit what you are able to see in terms of the database records	
<b>Manager user profiles</b>	Users can change passwords and view their system details and make necessary changes.	
View user details	This will be present on every user to basically view their details (demographics) as they are saved onto the system.	C
Edit passwords	All users can edit their passwords independently whenever they see the need.	C
<b>Manage reports</b>	All reports that are listed in different modules of the system will mainly be controlled from the reporting module and feed into various reports such as farmers listed, scanned grain bags by farmer	

Generate report	Once a report criterion is chosen, a report view should be generated in either Excel or PDF formats.	<b>M</b>
<b>Manage QR codes</b>	The system should be able use an algorithm to come up with a unique combination of codes that are used to identified certain commodity	
Generate QR codes	Using a specific criterion, the system should produce codes for grain bags identity	<b>M</b>
Read QR codes	With a specific mechanism of infra-red or radio-active rays, it should scan the unique identity on each grain bag	<b>M</b>
Post QR code values	Once a unique identity of a grain bag has been scanned, it should be posted as part of the record in the database	<b>M</b>
<b>Manage NFC</b>	Information should easily be written and read from the NFC Tag for further manipulation and decision making	
Write NFC value	This is when an NFC Tag accepts new data for storage	<b>M</b>
Read NFC value	Use the NFC reader to obtain data written on the NFC Tag	<b>M</b>
Post NFC value	This is an action of reading data from an NFC Tag and posting that data to the Grain Management System	<b>M</b>

#### Appendix A4: Non-functional requirements

Feature	Description	MoSCoW Prioritization
Hybrid mechanism of mobile application	The application should have a possibility of incorporating other platforms i.e. IOS, blackberry, windows and the like unlike only running on the native Android platform.	<b>S</b>
Online & Offline mode of operation.	The applications should have the capability of running on offline mode so that when there is no internet access, work can still continue.	<b>M</b>
System should be accessible on multiple browsers	The system should not be restricted access to simply one browser but should rather provide for accessibility on major web browsers/interfaces	<b>M</b>
Easy of Navigation	The user interface of the system should be clearly designed to allow for easy switching of menus and pages without the bigger without any challenges. It should easy option to make various selections	<b>M</b>
System Availability	As there are so many interruptions that happen to the system ranging from network downtime, software being corrupt, it is always important to ensure that the system is function when needed and giving normal operating conditions.	<b>M</b>
Easy of Customization	The system should allow the customization of certain features as needs arises. It should be designed in such a way that it allows for new additions of good to have features as additions to the already existing system	<b>M</b>

System Capacity	The system should be designed in such a way that it has been given enough room to take so much of records good enough to make it useable for its primary use	<b>M</b>
System Scalability	The system should be adaptable to growing the system as well as manage increased demands. It should be ideal for changing needs or demands. It should easily respond to present and at the introduction of new competition in functionality	<b>M</b>
The system should be maintainable	This is technically the chances of performing a successful resuscitation action within a given time frame. It about how quickly a can be taken back to a working position after a recorded failure. The system should have	<b>M</b>
Backup, Recovery and Error Handling	The system should have a way to restore data that had been lost, these is done through backing up all core data to either disks or log shipping onto another server drive in order to have mirrored database records. In instances where system is closed out abruptly, the system should not exhibit fatal behavior, but rather should reverse itself to the last normal working position	<b>M</b>
The system should easily be serviceable	The system should have easy of deployment and task monitoring, repairing problems as they occur, allowing the addition and removal of users from the system. It should equally be easy to upgrade its hardware and software without much trouble	<b>M</b>

System Concurrency	The system should allow for the users to be able to access different functions on the system without interrupting what the next user is doing on the system.	<b>M</b>
Accessible from Multiple Locations	The system should allow for accessibility over the network from different locations accessible from centralized database management system	<b>M</b>
Data Archiving	The system should allow for the archiving of data based on a predetermined period once it moves from being part of the actively accessed data	<b>C</b>
System Access Levels	To access the system, the users should have gone past the windows username and password as well as the application level access, sometimes single sign on may acceptable depending on the criticality of the system	<b>M</b>
System Security	The system should allow for only the authorized and properly authenticated users to make amendments to the system otherwise record keeping will be compromised by unwanted data. The passwords on the system should complex enough to meet the minimum 8 characters threshold	<b>M</b>
Session Control	The system should have a time out idle session count. Once user is not active on the system, system should immediately log out that session as a form of content protection on the system	<b>M</b>

User lockout on exceeded login attempts	The user should be locked out of the system for exceeding the number of attempts that have been defined on the system	<b>M</b>
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#### Appendix A5: Manage users and user groups Use Case descriptions

Use case	Description
Add user	All members of staff with roles on the system will be captured. Their details will be stored and given usernames and passwords.
Edit user	For all users added, their details can be further manipulated including making corrections and also adding new information where necessary.
Delete user	For any reason that will cause a user to no longer be needed on the system, this user's record can be removed.
Search user	To look up users, a search based on some criteria was implored.
Add user group	A user group will mean a set of privileges that can be added or associated to a defined type of users, usually based on the position that a user has in the organization. This will be added.
Edit user group	Every user group added, shall be edited to add or remove some details where necessary.
Delete user group	A user group that is no longer functional or has been consumed into another larger one can be deleted. The system will have however have checks to only delete a user group that isn't associated to any active user.
Assign tasks to user group	Tasks on what each user group can perform on the system will be added. Tasks will include add, edit, delete, search and the like, on every module. This will help control to assign privileges to users based on the user group that they have been assigned.
View tasks assigned	A report of some sort for all tasks assigned to a user group or even a user.
Password reset	Where necessary, users are given the opportunity to change passwords. This is ideal when a user suspects that their password has been compromised.
Assign user role	Giving a user a user group will mean assigning roles, as every group bears a set of roles that can be performed.
View user profile	To view a user's details including demographics will be present.



### Appendix A6: Test Log

Test ID	Description of test	Expected out come	Final out come	Status
1	<ul style="list-style-type: none"> <li>- User login</li> <li>- Validation of input fields</li> </ul>	<ul style="list-style-type: none"> <li>• To be able to log on to the system by verifying their credentials from the database</li> <li>• If the user didn't enter the correct credentials the system will display an error message</li> </ul>	<ul style="list-style-type: none"> <li>- Users were able to log on to the system successfully</li> <li>- The validation was implemented</li> </ul>	<b>Successful</b>
2	<ul style="list-style-type: none"> <li>- Add, Edit &amp; Delete user.</li> <li>- User password reset.</li> <li>- Assign user roles.</li> </ul>	<ul style="list-style-type: none"> <li>• User records must be added, edited &amp; deleted where necessary.</li> <li>• Password resets to be done.</li> </ul>	<ul style="list-style-type: none"> <li>- User records added, edited &amp; deleted successfully</li> <li>- User passwords changed successfully</li> <li>- Users given tasks that they perform on the system</li> </ul>	<b>Successful</b>

		<ul style="list-style-type: none"> <li>User access tasks/roles (system privileges) must be added.</li> </ul>		
3	<ul style="list-style-type: none"> <li>Add, Edit &amp; Delete user groups.</li> <li>Assign tasks to user group &amp; View tasks assigned to user group.</li> </ul>	<ul style="list-style-type: none"> <li>User group records must be added, edited &amp; deleted where necessary.</li> <li>User groups must be assigned tasks or system roles &amp; view them</li> </ul>	<ul style="list-style-type: none"> <li>User groups were added and some records were edited and deleted.</li> <li>User groups added where assigned tasks and these could be viewed.</li> </ul>	<b>Successful</b>
4	<ul style="list-style-type: none"> <li>Add, edit and delete provinces, districts, camps, blocks and depots.</li> </ul>	<ul style="list-style-type: none"> <li>All geographical location information must be added, edited &amp; deleted where needed.</li> </ul>	<ul style="list-style-type: none"> <li>The records were added from province down to depots, with some records edited and deleted.</li> </ul>	<b>Successful</b>

5	<ul style="list-style-type: none"> <li>- Farmer details can be added, edited, deleted &amp; view them.</li> <li>- Print farmer ID and QR code</li> <li>- Handle a file upload to farmer.</li> </ul>	<ul style="list-style-type: none"> <li>• Farmer details must be captured, edited and deletion provision.</li> <li>• Must be able to print farmer ID and QR code.</li> <li>• Attach any supporting documents to a farmer record</li> </ul>	<ul style="list-style-type: none"> <li>- Farmer details were entered and edited with some records deleted.</li> <li>- IDs and QR codes were printable on a button click.</li> <li>- Files were added to a farmer record.</li> </ul>	<b>Successful</b>
6	<ul style="list-style-type: none"> <li>- Add, edit, delete, view grain bag details.</li> <li>- Print grain bag QR code.</li> <li>- View scanned grain.</li> </ul>	<ul style="list-style-type: none"> <li>• Grain bags be added with an association to a farmer, edit such details and deleted.</li> <li>• Print QR codes for sticking on Grain bags.</li> <li>• View scanned grains for inventory checks.</li> </ul>	<ul style="list-style-type: none"> <li>• Grain bag details were captured, edited and some deleted.</li> <li>• QR codes once generated were stuck on grains bags.</li> <li>• All grain scans that were uploaded via the mobile application were viewed.</li> </ul>	<b>Successful</b>
7	<ul style="list-style-type: none"> <li>- Generate reports based on farmer</li> </ul>	<ul style="list-style-type: none"> <li>• Handle reports based on system information.</li> </ul>	<ul style="list-style-type: none"> <li>• Various reports were generated both in PDF and EXCEL formats based on</li> </ul>	<b>Successful</b>

	details, grain bags and scanned grains.		the farmer details, grains bags and inventory checks from scanned grain bags.	
8.	- To test if mobile application can Read and Post QR codes to web server database.	<ul style="list-style-type: none"> <li>The mobile application should read QR code stuck on grains bags and post values to server database.</li> </ul>	<ul style="list-style-type: none"> <li>The application was able to scan QR codes and communicate with the server database for storage of returned codes.</li> </ul>	<b>Successful</b>
9.	- To test if mobile application can Write, Read and Post NFC tag codes to web server database.	<ul style="list-style-type: none"> <li>The mobile application must first write codes on NFC tags, read them on tap and post values to server database.</li> </ul>	<ul style="list-style-type: none"> <li>Once QR code scanning was done, the returned value was written on the NFC tags and the second run was reading that value and posting value to server database.</li> </ul>	<b>Successful</b>

## APPENDIX B: TECHNICAL MANUAL

```
$sql=("call sp_loginUser('".$username."', '".$password."')");
$resultset=$pdo->query($sql);

if($resultset->fetchColumn() > 0) //Get Resultset returned
{
    /*$data[] = array(
        'status' => 'success',
        'redirect' => 'mainpage.php'
    );*/
    $pdoUserID=new PDOConfig();
    $result=$pdoUserID->query($sql);
    $myresult=$result->fetch();

    //Start New Session
    $ss = new SecureSession();
    $ss->check_browser = true;
    $ss->check_ip_blocks = 2;
    $ss->secure_word = 'SALT_';
    $ss->regenerate_id = true;
    $ss->Open();
    $_SESSION['logged_in'] = true;
    $_SESSION['user']=strtolower($username);
    $_SESSION['UserID']=$myresult['idUsers'];
    $_SESSION['UserType']=$myresult['typeUser'];
    $_SESSION["timer"] = time(); //Set Time
    if($myresult['ResetPassword']==true)
    {
        //header('Location: setPassword.php');
        header('Location: mainpage.php');
    }else{
        header('Location: mainpage.php');
    }

    //exit();

}else
{
    /*$data[] = array(
        'status' => 'failed',
        'redirect' => 'none'
    );*/
    $error="failed";

}

//echo json_encode($data);

}
catch(PDOException $e) {
    die("Could not connect to the database\n");
}
}
?>
```

```

        $sql=("call sp_loginUser('".$username."', '".$password."')");
        $resultset=$pdo->query($sql);

        if($resultset->fetchColumn() > 0) //Get Resultset returned
        {
            /*$data[] = array(
                'status' => 'success',
                'redirect' => 'mainpage.php'
            );*/
            $pdoUserID=new PDOConfig();
            $result=$pdoUserID->query($sql);
            $myresult=$result->fetch();

            //Start New Session
            $ss = new SecureSession();
            $ss->check_browser = true;
            $ss->check_ip_blocks = 2;
            $ss->secure_word = 'SALT_';
            $ss->regenerate_id = true;
            $ss->Open();
            $_SESSION['logged_in'] = true;
            $_SESSION['user']=strtolower($username);
            $_SESSION['UserID']=$myresult['idUsers'];
            $_SESSION['UserType']=$myresult['typeUser'];
            $_SESSION["timer"] = time(); //Set Time
            if($myresult['ResetPassword']==true)
            {
                //header('Location: setPassword.php');
                header('Location: mainpage.php');
            }else{
                header('Location: mainpage.php');
            }
        }

        //exit();

    }else
    {
        /*$data[] = array(
            'status' => 'failed',
            'redirect' => 'none'
        );*/
        $error="failed";

    }

    //echo json_encode($data);

}

catch(PDOException $e) {
    die("Could not connect to the database\n");
}

}

?>

```

The following code is for Adding new user.

```
<?php
require_once("../../classes/clsDbProcess.php");
?>

<script language="javascript">
jQuery(document).ready(function(){

    // binds form submission and fields to the validation engine
    $(".datepicker").datepicker({
        dateFormat: 'dd-mm-yy',
        changeMonth: true,
        changeYear: true
    }); //DatePicker
    $("#user_new").validationEngine();
    $('#user_new').validationEngine('hideAll');

});

$(function(){
    //Load designations For Insert
    $.getJSON("phpscripts/loadSelectbox.php?task=Designation",{id:
$(this).val(), ajax: 'true'}, function(j){
        var options = '<option value="" selected ="selected"> -----
Select Designation ----- </option>';

        for (var i = 0; i < j.length; i++) {
            options += '<option value="' + j[i].id + '">' + j[i].display
+ '</option>';
        }
        $("#select#designation").html(options);
    });

});

</script>
```

```
<div style="width:600px" id="newUserManagement">
<form action="" method="post" id="user_new" class="ui-widget">
<fieldset class="ui-widget-content"><legend class="ui-widget-header ui-
corner-all">User Information</legend>
<table width="700" border="0">
    <tr>
        <td width="18%"><label>UserName:<span style="color:#F00; font-
size:10px;">*</span></label></td>
        <td width="32%"> <input name="username" type="text"
class="validate[required,ajax[ajaxUserCallPhp]]" id="username" size="25"
maxlength="20" /></td>
        <td width="19%">&nbsp;</td>
        <td width="31%">&nbsp;</td>
    </tr>
    <tr>
        <td><label>FirstName:<span style="color:#F00; font-
size:10px;">*</span></label></td>
```

```

        <td><input name="fname" type="text" class="validate[required]"
id="fname" size="25" maxlength="20" /></td>
        <td>LastName:<span style="color:#F00; font-size:10px;">*</span></td>
        <td><label for="lname"></label>
        <input name="lname" type="text" class="validate[required]" id="lname"
size="25" maxlength="20" /></td>
    </tr>
    <tr>
        <td>OtherNames:</td>
        <td><input name="oname" type="text" id="oname" size="25" maxlength="100"
/></td>
        <td><label for="emailAdd">Email Address:<span style="color:#F00; font-
size:10px;">*</span></label></td>
        <td><input name="emailAdd" type="text" class="validate[required,
custom[email]]" id="emailAdd" size="40" maxlength="100" /></td>
    </tr>
    <tr>
        <td>Personnel No.:</td>
        <td><input name="personnelno" type="text" id="personnelno" size="25"
maxlength="30" /></td>
        <td>Designation:<span style="color:#F00; font-size:10px;">*</span></td>
        <td>
            <select name="designation" id="designation"
class="validate[required]" >
                </select>
        </td>
    </tr>
    <tr>
        <td>Password:<span style="color:#F00; font-size:10px;">*</span></td>
        <td><label for="password"></label>
        <input name="password" type="password"
class="validate[required,minSize[8],custom[NumberSp]]" id="password"
size="25" maxlength="20" /></td>
        <td>ConfirmPassword:<span style="color:#F00; font-
size:10px;">*</span></td>
        <td><label for="confirmPassword"></label>
        <input name="confirmPassword" type="password"
class="validate[required,minSize[8],custom[NumberSp],equals[password]]"
id="confirmPassword" size="25" maxlength="20" /></td>
    </tr>
    <tr>
        <td>Account Expiry:<span style="color:#F00; font-size:10px;">*</span></td>
        <td><input name="expiryDate" type="text"
class="validate[required,custom[date]] datepicker" value="<?php echo
date("d-m-Y",strtotime(date("d-m-Y"))); ?>" id="expiryDate" size="25"
maxlength="25" /></td>
        <td>Account Status:<span style="color:#F00; font-size:10px;">*</span></td>
        <td>
            <select name="accountStatus" id="accountStatus"
class="validate[required]">
                <option value="" selected="selected">-----select-----</option>
                <option value="1">Enable</option>
                <option value="0">Disable</option>
            </select>
            <input name="UserID" type="hidden" id="UserID" value="" />
        </td>
    </tr>

```



```

        </tr>
        <tr>
            </tr>
        </table>
    </fieldset>

</form>
</div>

<div id="successMsg" style="display: none;" align="center" >
</div>

```

**The following code is for Saving New User.**

```

<?php
//include('sessionInclude.php');
require_once("../connection/connectPDO.php");
// Get posted data
$username = ($_POST['username']);
$fname = ($_POST['fname']);
$lname = ($_POST['lname']);
if (isset($_POST['oname']) && !empty($_POST['oname']))
{
    $Oname = strtoupper($_POST['oname']);
}
else
{
    $Oname = null;
}

$password = ($_POST['password']);
$email = ($_POST['emailAdd']);
$designation = ($_POST['designation']);
$personnelno = ($_POST['personnelno']);
$expiryDate = ($_POST['expiryDate']);
$expiryDate=date("Y-m-d",strtotime($expiryDate));
if (isset($_GET['CreateBy'])) {
    $createdBy = $_GET['CreateBy'];
}
//$AssignedRoles = $_POST['selectto'];

//echo $uRole;
//$uRole=1;

$accountStatus=(int) ($_POST['accountStatus']);

$vStatus='success';

try {
    $pdo = new PDOConfig();
    // /* Begin a transaction, turning off autocommit */
    $pdo->beginTransaction();

    $pdo->setAttribute(PDO::ATTR_ERRMODE, PDO::ERRMODE_EXCEPTION);
    ////Assign & Prepare Statement

```

```

    $stmt = $pdo->prepare("CALL sp_UserInsert(:p_username, :p_password,
:p_firstname, :p_lastname, :p_oothername, :p_email, :p_status,
:p_expiry, :p_createby, :p_designation, :p_PersonnelNo, @p_userID )");
    $stmt->bindValue(':p_username', $uname);
    $stmt->bindValue(':p_password', $pword);
    $stmt->bindValue(':p_firstname', strtoupper($fname));
    $stmt->bindValue(':p_lastname', strtoupper($lname));
    $stmt->bindValue(':p_oothername', $Oname);
    $stmt->bindValue(':p_email', $email);
    $stmt->bindValue(':p_status', $accountStatus);
    $stmt->bindValue(':p_expiry', $expiryDate);
    $stmt->bindValue(':p_createby', $createdBy);
    $stmt->bindValue(':p_designation', strtoupper($designation));
    $stmt->bindValue(':p_PersonnelNo', strtoupper($personnelno));

    ///Execute The Statement
    $stmt->execute();//Save User Details

    $pdo->commit(); //Commit Transaction */
    $status = array($vStatus => 'New User: '. ucfirst($uname) . ' Created
Successfully');

    echo json_encode($status);

} catch (PDOException $e) {
    // /* Recognize mistake and roll back changes */
    $pdo->rollBack();
    $error=$e->getMessage();
    $status = array($vStatus => $error);
    echo json_encode($status );
    // /* Database connection is now back in autocommit mode */
}
?>

```

**The following code is a Stored Procedure for Generating QR code values.**

```

CREATE DEFINER=`root`@`localhost` PROCEDURE `sp_GrainInsert`(IN
    vIndexNo text ,
    vfarmerID int,
    vApplicationDate date,
    vMerchandiseType varchar(45),
    vCreateBy int,
    vDepot int,
    OUT vIndexID int,
    OUT vIndexNoAssigned varchar(60),
    OUT vqrc text)
BEGIN
    declare VIndexYear varchar(4);
    declare VInitials varchar(4);
    declare VqrcPart text;

    set VIndexYear = DATE_FORMAT(vApplicationDate, '%y');
    set VInitials = (select Upper(concat(left(FirstName,1),left(Surname,1)))
from indextbl where IndexID= vfarmerID);

    IF((vIndexNo IS NULL) OR (vIndexNo=''))

```

**THEN**

```
INSERT INTO graintbl(  
    IndexID,  
    CreateDate,  
    MerchandiseType,  
    CreateBy,  
    DepotID)  
VALUES (  
    vfarmerID,  
    vApplicationDate,  
    vMerchandiseType,  
    vCreateBy,  
    vDepot  
);
```

**ELSE**

```
INSERT INTO graintbl(  
GrainNo,  
    IndexID,  
    CreateDate,  
    MerchandiseType,  
    CreateBy,  
    DepotID)  
VALUES (  
    vIndexNo,  
    vfarmerID,  
    vApplicationDate,  
    vMerchandiseType,  
    vCreateBy,  
    vDepot  
);  
END IF;
```

**SET** vIndexID=(**SELECT** LAST\_INSERT\_ID());

**SET** vIndexNoAssigned=(**SELECT** GrainNo **FROM** graintbl **WHERE** GrainID=vIndexID);

-- generate the index no.

**if** (( vIndexNoAssigned **is null** ) **or** ( vIndexNoAssigned=' '))  
 **then**

**set** vIndexNoAssigned =  
 (**concat**(VInitials,'/',VIndexYear,'/',**lpad**(**trim**(vIndexID),5,'0')));  
 **else**

**set** vIndexNoAssigned =  
 (**concat**(VInitials,'/',VIndexYear,'/',**lpad**(**trim**(vIndexID),5,'0')));  
 **end if;**

**update** graintbl **set** GrainNo=vIndexNoAssigned **where** GrainID = vIndexID;

-- QRC computation--

```
    set VqrcPart=(select distinct concat(  
b.ProvinceID,  
c.DistrictID,  
d.CampID,  
e.BlockID,  
f.DepotID) as qrc
```

```

from
    graintbl as a
inner join depotttbl as f on a.DepotID=f.DepotID
left outer join blocktbl as e on f.BlockID=e.BlockID
left outer join camptbl as d on e.CampID=d.CampID
left outer join districttbl as c on d.DistrictID=c.DistrictID
left outer join provincetbl as b on c.ProvinceID=b.ProvinceID
where
    IndexID=vfarmerID);
set vqrc =
(concat(VqrcPart,VInitials,VIndexYear,lpad(trim(vIndexID),15,'0')));

update graintbl set QRC=vqrc where GrainID = vIndexID;
END

```

The following code is for main index file for the mobile application(index.html).

```

<!DOCTYPE html>
<html>
<head>
    <link rel="stylesheet" href="jquery/jquery.mobile-1.3.1.min.css">
    <link rel="stylesheet" href="css/custom.css"/>
    <script src="jquery/jquery-1.9.1.min.js"></script>
    <script src="jquery/jquery.mobile-1.3.1.min.js"></script>
    <script type="text/javascript" src="cordova.js"></script>
    <meta name="format-detection" content="telephone=no">
    <meta name="msapplication-tap-highlight" content="no">
    <meta name="viewport" content="user-scalable=no, initial-scale=1,
maximum-scale=1, minimum-scale=1, width=device-width">
    <title>Grain Scan</title>
    <script type="text/javascript">
        app.initialize();
    </script>
    <script type="text/javascript">
        function writeNFC()
        {
            //Getting value for writting to NFC tag
            var msg = $("#qrc").val();
            alert("Writing:--> " +msg);

            // Write NDEF formatted NFC Tags
            nfc.addNdefListener (
                function () {

                    var message = [
                        ndef.textRecord($("#qrc").val()),
                        ndef.uriRecord("http://xxx.com/graininventory")
                    ];

                    nfc.write(message);
                },
                function () { // success callback
                    alert("NDEF tag written");
                },
                function (error) { // error callback
                    alert("Error adding NDEF listener " + JSON.stringify(error));
                }
            );
        }
    </script>

```

```

}

</script>
<script type="text/javascript">
    function NFC()
    {
        // Read NDEF formatted NFC Tags
        nfc.addNdefListener (
            function (nfcEvent) {
                var tag = nfcEvent.tag,
                    ndefMessage = tag.ndefMessage;
                //ndefMessage =(tag.ndefMessage, tag.type, tag.maxsize);

                // assuming the first record in the message has a payload that can
                be converted to a string.
                alert(nfc.bytesToString(ndefMessage[0].payload).substring(3));

                //Getting nfc values
                var vv =
                (nfc.bytesToString(ndefMessage[0].payload).substring(3));
                $('#v').val(vv);
            },
            function () { // success callback
                //alert("NDEF tag detected");
            },
            function (error) { // error callback
                alert("Error adding NDEF listener " + JSON.stringify(error));
            }
        );
    }
}

</script>
<script type="text/javascript">
    function scan()
    {
        cordova.plugins.barcodeScanner.scan(
            function (result) {
                var qrc = result.text;
                alert("We got a barcode\n" +
                    "Result: " + result.text + "\n" +
                    "Format: " + result.format + "\n" +
                    "Cancelled: " + result.cancelled);
                $('#qrc').val(qrc);
            },
            function (error) {
                alert("Scanning failed: " + error);
            }
        );
    }
}
</script>
<script type="text/javascript" charset="utf-8">
    function handleQRC() {
        var form = $("#Insert");
        var n = $("#qrc", form).val();
    }

```

```

console.log("click");
if(n != "") {

    console.log("Entering Insert()");
    //online server access URL
    $.post("http://xxx.com/graininventory/phpscripts/saveScannedGrainb.php",
    //Local server access. Get IP for your computer to put before
    /graininventory...
    //go to CMD and type ipconfig then get IPv4 Address value

    //$.post("http://192.168.43.211/graininventory/phpscripts/saveScannedGrainb.p
    hp",
    $("#Insert :input").serializeArray(),
    function(json){
        if(json== null || json == 'undefined')
            alert("Upload failed");
        else
            alert("Upload successful");
    });
}

else {
    //if the email and password is empty
    alert("You must enter qrc values!");
}

return false;
}
</script>
<script type="text/javascript" charset="utf-8">
function handleNFC() {
var form = $("#InsertNFC");
var n = $("#v", form).val();

console.log("click");
if(n != "") {

    console.log("Entering InsertNFC()");
    //online server access URL
    $.post("http://xxx.com/graininventory/phpscripts/saveScannedGrainc.php",
    //Local server access. Get IP for your computer to put before
    /graininventory...
    //go to CMD and type ipconfig then get IPv4 Address value

    //$.post("http://192.168.43.211/graininventory/phpscripts/saveScannedGrainb.p
    hp",
    $("#InsertNFC :input").serializeArray(),
    function(json){
        if(json== null || json == 'undefined')
            alert("Upload failed");
        else
            alert("Upload successful");
    });
}

else {

```

```

        //if the email and password is empty
        alert("You must enter nfc");
    }
    return false;
}
</script>
<script type="text/javascript" charset="utf-8">
function handleLogin() {
var form = $("#loginForm");
var e = $("#Username", form).val();
var p = $("#Password", form).val();

console.log("click");
if(e != "" && p != "") {
    //var str = form.serialize();
    //alert(str);
    $.ajax({
        type: 'POST',
        //online server access URL
        url:
'http://xxx.com/graininventory/phpscripts/loginb.php',
        //Local server access. Get IP for your computer to put
before /graininventory...
        //go to CMD and type ipconfig then get IPv4 Address
value
        //url:
'http://192.168.43.211/graininventory/phpscripts/loginb.php',
        crossDomain: true,
        data: {Username: e, Password :p},
        dataType: 'json',
        async: false,

        success: function (response) {
            //alert ("response");
            if (response.success) {
                // alert("you're logged in");
                //window.localStorage["Username"] = e;
                //window.localStorage["Password"] = SHA1(p);
                //window.location.replace(main.html);
                $.mobile.changePage("#pageone");
            }
            else {

                alert("Invalid Username or Password");
                //window.location("main.html");
            }

        },
        error: function(error) {
            //alert(response.success);
            alert('Could not connect to the database' + error);
            //window.location = "main.html";
        }
    });
}
}

```

```

else {
    //if the email and password is empty
    alert("You must enter username and password");
}
return false;
}
</script>
</head>
<body>

<!--Home page-->
<div data-role="page" id="signin" class="type-interior">

    <div data-role="header" data-position="fixed" data-theme="d">
        <h1>Grain Scan</h1>
    </div><!-- /header -->
    <div role="main" class="ui-content">
        <h3>Sign In</h3>
        <div align="center">
            <form id="loginForm" method="POST">
                <div id="ctn-err" class="bi-invisible"></div>
                <label for="txt-email-address">Username</label>
                <input type="text" name="Username" id="Username" value="">
                <label for="txt-password">Password</label>
                <input type="password" name="Password" id="Password" value=""><hr>
                <input type="button" data-role="button" data-inline="true"
value="Log-In" onClick="handleLogin()" data-theme="b">
            </form>
        </div>
    </div>

    <div data-role="footer" data-position="fixed" data-theme="d">
        <h1>Grains Inventory</h1>
    </div>

</div>

<!--QRC page-->
<div data-role="page" id="pageone" class="type-interior">

    <div data-role="header" data-position="fixed" data-theme="d">
        <a href="" data-role="button" onclick="scan()" >Scan QRC</a>
        <h1>GrainScan</h1>
        <a href="#pagetwo" data-role="button">NFC</a>
    </div>

    <div data-role="main" class="ui-content">
        <!--<a href="" data-role="button" onclick="scan()" >Scan QRC</a>-->
        <fieldset data-role="fieldcontain">
            <form id="Insert" method="POST">
                <div align="center">
                    <input type="text" name="qrc" id="qrc" value=""
placeholder="Results Here" class="required" required/><hr>
                    <input type="button" data-role="button" data-inline="true"
value="Post Details" onClick="handleQRC()" data-icon="check" data-theme="b">
                </div>
            </form>
        </fieldset>
    </div>
</div>

```



```

        </form>
    </fieldset>
</div>

    <div data-role="footer" data-position="fixed" data-theme="d"
align="right">
    <a href="" data-transition="fade" onclick="writeNFC()" >NFC
Write</a></li>
    <a href="index.html" data-role="button">LogOut</a>

</div>
</div>

<!--NFC page-->
<div data-role="page" id="pagetwo">

    <div data-role="header" data-position="fixed" data-theme="d">
        <a href="#pageone" data-role="button">QRC</a>
        <h1>GrainScan</h1>
        <a href="" data-role="button" onclick="NFC()" >Tap for NFC</a>
    </div>

    <div data-role="main" class="ui-content">
        <p align="center"> <span style="font-weight:bold; color:#0C0">Reading
will begin when NFC compatible tag is contacted</span></p>

        <fieldset data-role="fieldcontain">
            <form id="InsertNFC" method="POST">
                <div align="center">
                    <input type="text" name="v" id="v" value="" placeholder="Results
Here" class="required" required/><hr>
                    <input type="button" data-role="button" data-inline="true"
value="Post Details" onClick="handleNFC()" data-icon="check" data-theme="b">
                </div>
            </form>
        </fieldset>
    </div>

    <div data-role="footer" data-position="fixed" data-theme="d">
<!--<a href="#pagetwo" data-transition="fade" onclick="writeNFC()" >NFC
Write</a></li>-->
        <h1>NFC Scan</h1>
    </div>

</div>
</body>
</html>

```

The following code is for interpreting the Cordova files into a mobile platform (MainActivity.java).

```

package io.cordova.hellocordova;

import android.os.Bundle;
import org.apache.cordova.*;

public class MainActivity extends CordovaActivity

```

```

{
    @Override
    public void onCreate(Bundle savedInstanceState)
    {
        super.onCreate(savedInstanceState);

        // enable Cordova apps to be started in the background
        Bundle extras = getIntent().getExtras();
        if (extras != null && extras.getBoolean("cdvStartInBackground",
false)) {
            moveTaskToBack(true);
        }

        // Set by <content src="index.html" /> in config.xml
        loadUrl(launchUrl);
    }
}

```

## APPENDIX C: DATA DICTIONARY

### Data dictionary:

Column	Type	Null	Default
BlockID	int(11)	No	
CampID	int(11)	Yes	1
BlockDesc	varchar(100)	No	
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
Notes	text	Yes	<i>NULL</i>

### *Indexes*

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	BlockID	2	A	No
BlockDesc_UNIQUE	BTREE	Yes	No	BlockDesc	2	A	No
campfk_idx	BTREE	No	No	CampID	2	A	Yes

### *Camp table*

Column	Type	Null	Default
CampID	int(11)	No	

DistrictID	int(11)	Yes	1
CampDesc	varchar(100)	No	
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
Notes	text	Yes	<i>NULL</i>

### ***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	CampID	2	A	No
campDesc_UNIQUE	BTREE	Yes	No	CampDesc	2	A	No
districkFK_idx	BTREE	No	No	DistrictID	2	A	Yes

### ***Country table***

Column	Type	Null	Default
CountryID	int(11)	No	
CountryCode	char(10)	Yes	<i>NULL</i>
CountryName	varchar(255)	Yes	<i>NULL</i>
IsFromEAC	tinyint(1)	Yes	0
CreateDate	datetime	Yes	<i>NULL</i>

ChangeDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
Notes	text	Yes	<i>NULL</i>

### ***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null	Comment
PRIMARY	BTREE	Yes	No	CountryID	244	A	No	

### ***Farmer files table***

Column	Type	Null	Default
FilesID	int(11)	No	
IndexID	int(11)	Yes	<i>NULL</i>
Description	text	Yes	<i>NULL</i>
FileName	longblob	Yes	<i>NULL</i>
FilePath	text	Yes	<i>NULL</i>
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	varchar(45)	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>

IsActive	tinyint(1)	Yes	1
IsDeleted	tinyint(1)	Yes	0

### *Indexes*

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	FilesID	5	A	No
studentID_idx	BTREE	No	No	IndexID	5	A	Yes

### *Depot table*

Column	Type	Null	Default
DepotID	int(11)	No	
BlockID	int(11)	Yes	1
DepotDesc	varchar(100)	No	
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
Notes	text	Yes	<i>NULL</i>

### *Indexes*

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	DepotID	2	A	No

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
DepotDesc_UNIQUE	BTREE	Yes	No	DepotDesc	2	A	No
blockFK_idx	BTREE	No	No	BlockID	2	A	Yes

***District table***

Column	Type	Null	Default
DistrictID	int(11)	No	
ProvinceID	int(11)	Yes	1
DistrictDesc	varchar(100)	No	
CreateDate	datetime	Yes	NULL
ChangeDate	datetime	Yes	NULL
CreateBy	int(11)	Yes	NULL
ChangeBy	int(11)	Yes	NULL
Notes	text	Yes	NULL

***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null	Comment
PRIMARY	BTREE	Yes	No	DistrictID	109	A	No	
DistrictDesc_UNIQUE	BTREE	Yes	No	DistrictDesc	109	A	No	

Keyname	Type	Uniq ue	Pack ed	Column	Cardinal ity	Collati on	Nu ll	Comm ent
ProvinceID	BTR EE	No	No	ProvinceID	27	A	Yes	

***Grain table***

Column	Type	Null	Default
GrainID	int(11)	No	
IndexID	int(11)	Yes	<i>NULL</i>
DepotID	int(11)	Yes	<i>NULL</i>
GrainNo	varchar(767)	Yes	<i>NULL</i>
MerchandiseType	varchar(255)	Yes	<i>NULL</i>
QRC	text	Yes	<i>NULL</i>
CreateDate	date	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
Notes	text	Yes	<i>NULL</i>
IsDeleted	tinyint(1)	Yes	0

***Indexes***



Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	GrainID	9	A	No
FarmerID_idx	BTREE	No	No	IndexID	9	A	Yes
DepotFK_idx	BTREE	No	No	DepotID	4	A	Yes

***Index table***

Column	Type	Null	Default
IndexID	int(11)	No	
DepotID	int(11)	Yes	<i>NULL</i>
IndexNo	varchar(767)	Yes	<i>NULL</i>
QRC	text	Yes	<i>NULL</i>
ApplicationDate	date	Yes	<i>NULL</i>
IndexDate	date	Yes	<i>NULL</i>
CitizenShip	int(11)	No	
Surname	varchar(45)	Yes	<i>NULL</i>
FirstName	varchar(45)	Yes	<i>NULL</i>
MiddleName	varchar(45)	Yes	<i>NULL</i>
DateOfBirth	date	Yes	<i>NULL</i>
Gender	char(10)	Yes	<i>NULL</i>
NRC	varchar(20)	Yes	<i>NULL</i>

Address	varchar(255)	Yes	<i>NULL</i>
Photo	varbinary(2000)	Yes	<i>NULL</i>
photoPath	varchar(200)	Yes	<i>NULL</i>
PhotoBlob	longblob	Yes	<i>NULL</i>
MobileNo	varchar(45)	Yes	<i>NULL</i>
Email	varchar(255)	Yes	<i>NULL</i>
KinName	varchar(45)	Yes	<i>NULL</i>
KinCell	varchar(45)	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
Notes	text	Yes	<i>NULL</i>
PhotoType	varchar(35)	Yes	<i>NULL</i>
IsDeleted	tinyint(1)	Yes	0

### ***Indexes***

<b>Keyname</b>	<b>Type</b>	<b>Unique</b>	<b>Packed</b>	<b>Column</b>	<b>Cardinality</b>	<b>Collation</b>	<b>Null</b>
PRIMARY	BTREE	Yes	No	IndexID	1369	A	No
NRC_UNIQUE	BTREE	Yes	No	NRC	30	A	Yes
IndexNo_UNIQUE	BTREE	Yes	No	IndexNo	30	A	Yes

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
CitizenShip	BTREE	No	No	CitizenShip	2	A	No
DepotFk_idx	BTREE	No	No	DepotID	4	A	Yes

#### Province table

Column	Type	Null	Default
ProvinceID	int(11)	No	
CountryID	int(11)	No	
ProvinceDesc	varchar(100)	No	
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
Notes	text	Yes	<i>NULL</i>

#### Indexes

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	ProvinceID	11	A	No
ProvinceDesc_UNIQUE	BTREE	Yes	No	ProvinceDesc	11	A	No
CountryID	BTREE	No	No	CountryID	2	A	No

***Scanned grain table***

Column	Type	Null	Default
SGrainID	int(11)	No	
QRC	varchar(255)	Yes	<i>NULL</i>
GrainNo	varchar(767)	Yes	<i>NULL</i>
IndexID	int(11)	Yes	<i>NULL</i>
FarmerDesc	text	Yes	<i>NULL</i>
MerchandiseType	varchar(255)	Yes	<i>NULL</i>
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
Notes	text	Yes	<i>NULL</i>
IsDeleted	tinyint(1)	Yes	0

***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	SGrainID	2	A	No
QRC_UNIQUE	BTREE	Yes	No	QRC	2	A	Yes

**Table\_sysactions**

Column	Type	Null	Default
actionID	int(11)	No	
SysTaskId	int(11)	No	
CreateBy	int(11)	No	
ChangeBy	int(11)	Yes	<i>NULL</i>
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>

### ***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	actionID	0	A	No
FK_sysTaskID_Main	BTREE	No	No	SysTaskId	0	A	No

### **Table\_system mainmenu**

Column	Type	Null	Default
MainMenuId	int(11)	No	
MenuName	varchar(50)	No	
menuPosition	int(11)	No	
CreateBy	int(11)	No	
ChangeBy	int(11)	Yes	<i>NULL</i>
CreateDate	datetime	Yes	<i>NULL</i>

ChangeDate	datetime	Yes	<i>NULL</i>
------------	----------	-----	-------------

***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	MainMenuId	4	A	No
MenuName_UNIQUE	BTREE	Yes	No	MenuName	4	A	No

**Table\_system submenu**

Column	Type	Null	Default
SubMenuId	int(11)	No	
MainMenuId	int(11)	No	
subMenu	varchar(50)	No	
SubMenuPage	varchar(255)	Yes	<i>NULL</i>
subMenuPosition	int(11)	No	
CreateBy	int(11)	No	
ChangeBy	int(11)	Yes	<i>NULL</i>
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>

***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	SubMenuId	19	A	No
mainMenu_SubMenu	BTREE	No	No	MainMenuId	9	A	No

**Table\_system task**

Column	Type	Null	Default
SysTaskId	int(11)	No	
SubMenuId	int(11)	No	
taskName	varchar(50)	No	
taskPage	varchar(255)	Yes	<i>NULL</i>
CreateBy	int(11)	No	
ChangeBy	int(11)	Yes	<i>NULL</i>
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>

***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	SysTaskId	50	A	No
Task_SubMenu	BTREE	No	No	SubMenuId	50	A	No

**Table\_useraccess**

Column	Type	Null	Default
idUserAccess	int(11)	No	
userId	int(11)	No	
grpId	int(11)	No	0
FromDate	datetime	Yes	<i>NULL</i>
ToDate	datetime	Yes	<i>NULL</i>
CreatedDate	date	Yes	<i>NULL</i>
CreatedBy	int(11)	Yes	<i>NULL</i>
ChangeDate	date	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>

### ***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	idUserAccess	6	A	No
access_grp	BTREE	No	No	grpId	6	A	No
access_users	BTREE	No	No	userId	6	A	No

### **Table\_usergroups**

Column	Type	Null	Default
idGroups	int(11)	No	
grpName	varchar(60)	No	



grpDesc	varchar(100)	No	
CreateBy	int(11)	No	
ChangeBy	int(11)	Yes	<i>NULL</i>
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>

### ***Indexes***

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	idGroups	4	A	No
grpName_UNIQUE	BTREE	Yes	No	grpName	4	A	No

### **Table\_users**

Column	Type	Null	Default
idUsers	int(11)	No	
DesignationID	int(11)	Yes	<i>NULL</i>
username	varchar(25)	No	
password	varchar(255)	No	
firstName	varchar(25)	No	
OtherNames	varchar(25)	Yes	<i>NULL</i>
lastName	varchar(25)	No	
PersonnelNo	varchar(50)	Yes	<i>NULL</i>
Designation	varchar(200)	Yes	<i>NULL</i>

Email	varchar(100)	No	
accountStatus	bit(1)	No	
dateEntered	datetime	No	
ExpiryDate	date	Yes	<i>NULL</i>
ResetPassword	bit(1)	Yes	b'1'
CreateBy	int(11)	Yes	<i>NULL</i>
CreateDate	datetime	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>

### *Indexes*

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	idUsers	5	A	No
username_UNIQUE	BTREE	Yes	No	username	5	A	No
UserDesignationFk_idx	BTREE	No	No	DesignationID	5	A	Yes

### **table\_usertasks**

Column	Type	Null	Default
UserTaskid	int(11)	No	
SysTaskId	int(11)	No	

grpId	int(11)	No	
CreateDate	datetime	Yes	<i>NULL</i>
CreateBy	int(11)	Yes	<i>NULL</i>
ChangeBy	int(11)	Yes	<i>NULL</i>
ChangeDate	datetime	Yes	<i>NULL</i>

#### **Indexes**

Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null
PRIMARY	BTREE	Yes	No	UserTaskId	270	A	No
task_sysTasks	BTREE	No	No	SysTaskId	270	A	No
userTask_userGrp	BTREE	No	No	grpId	24	A	No

#### **View\_approvedindex**

Column	Type	Null	Default
IndexID	int(11)	No	0
IndexNo	varchar(767)	Yes	<i>NULL</i>
CountryName	varchar(255)	Yes	<i>NULL</i>
Surname	varchar(45)	Yes	<i>NULL</i>
FirstName	varchar(45)	Yes	<i>NULL</i>
MiddleName	varchar(45)	Yes	<i>NULL</i>
DateOfBirth	date	Yes	<i>NULL</i>

Gender	char(10)	Yes	<i>NULL</i>
NRC	varchar(20)	Yes	<i>NULL</i>
Address	varchar(255)	Yes	<i>NULL</i>
MobileNo	varchar(45)	Yes	<i>NULL</i>
Email	varchar(255)	Yes	<i>NULL</i>
ApplicationDate	date	Yes	<i>NULL</i>
ProvinceID	int(11)	Yes	0
ProvinceDesc	varchar(100)	Yes	<i>NULL</i>
DistrictID	int(11)	Yes	0
DistrictDesc	varchar(100)	Yes	<i>NULL</i>
CampID	int(11)	Yes	0
CampDesc	varchar(100)	Yes	<i>NULL</i>
BlockID	int(11)	Yes	0
BlockDesc	varchar(100)	Yes	<i>NULL</i>
DepotID	int(11)	No	0
DepotDesc	varchar(100)	No	

#### View\_grains

Column	Type	Null	Default
GrainID	int(11)	No	0

GrainNo	varchar(767)	Yes	<i>NULL</i>
MerchandiseType	varchar(255)	Yes	<i>NULL</i>
QRC	text	Yes	<i>NULL</i>
CreateDate	date	Yes	<i>NULL</i>
IndexID	int(11)	Yes	0
Farmer	varchar(137)	Yes	<i>NULL</i>
ProvinceID	int(11)	Yes	0
ProvinceDesc	varchar(100)	Yes	<i>NULL</i>
DistrictID	int(11)	Yes	0
DistrictDesc	varchar(100)	Yes	<i>NULL</i>
CampID	int(11)	Yes	0
CampDesc	varchar(100)	Yes	<i>NULL</i>
BlockID	int(11)	Yes	0
BlockDesc	varchar(100)	Yes	<i>NULL</i>
DepotID	int(11)	Yes	0
DepotDesc	varchar(100)	Yes	<i>NULL</i>

#### View\_system submenu

Column	Type	Null	Default
SubMenuId	int(11)	No	0

subMenu	varchar(50)	No	
SubMenuPage	varchar(255)	Yes	<i>NULL</i>
subMenuPosition	int(11)	No	
MainMenuId	int(11)	No	0
MenuName	varchar(50)	No	

**Table comments: VIEW**

Column	Type	Null	Default
systaskid	int(11)	No	0
menuname	varchar(50)	No	
submenu	varchar(50)	No	
taskname	varchar(50)	No	
taskPage	varchar(255)	Yes	<i>NULL</i>
submenuid	int(11)	No	
mainmenuid	int(11)	No	0