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RFID-Based model for remote chicken monitoring: case of free-range chicken farming in Machakos County

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RFID-BASED MODEL FOR REMOTE CHICKEN MONITORING

Case of Free-range chicken farming in Machakos County

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Declaration

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

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Nthusi, Gift Musyoka

8th June, 2017

Approval

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Dedication

I dedicate this work to my family. The journey has been long, but we are nearing the end. The long days I spent away from home due to research were among my hardest. I however appreciate your sacrifice and support all along. For being there for me, I wish to dedicate this thesis to you; David Nthusi my Dad for your wisdom and advise that motivated me all through, Ruth Mutheu my mum you always pushed me and believed in me, my brothers Victor Kyalo and Nathan Muema for being supportive and ultimately my Best Friend Sheba Nyaronga for always being helpful despite the challenges. Without your support, I would not have completed my research. A special debt of gratitude is due.

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Abstract

Poultry farming is an important economic activity among Kenyan farmers. In order to earn income, they have to raise chicken and sell them once fully matured. This Indigenous chicken farming not only requires time investment but also money. However, security of chicken is an inevitability every farmer has to face. This is because, this category of chicken needs a free-range environment where it can move around, scratching for food, worms and other edibles. The chicken farmer faces challenges majorly theft of chicken by workers or strangers who randomly visit the farm. In this study, we developed a model that tracks chicken using RFID tags. This model enables a farmer to remotely monitor chicken from anywhere using the internet. The model constantly records and stores chicken data captured by the reader and updates this information in a database. The farmer can thereafter retrieve the tagged chicken information using a user interface designed to simplify the process of monitoring the chicken to minimise theft. The RFID model was designed to identify the chicken, each with its specific tag, containing particular information about it. To demonstrate this, an Arduino Uno microcontroller is set up with an encoded RFID system for chicken tracking. The RFID system uploads data sketches to a remote server via an Ethernet shield.

Key Words: Free-range Chicken, Radio frequency identification (RFID), Indigenous, remote monitoring and data sketches.

Abbreviations/Acronyms

GSM	-	Global System for Mobile
GPRS	-	General Packet Radio Service
RF	-	Radio Frequency
RFID	-	Radio Frequency Identification
SDLC	-	Software Development Life Cycle
SGSN	-	Servicing GPRS Support Node
UHF	-	Ultra High Frequency
UML	-	Unified Modeling Language
VHF	-	Very High Frequency

Definition of Terms

Arduino - A microcontroller chipset with the ability to accommodate most modern electronic controllers (Ferdoush & Li, 2014).

Free-range chicken - Chicken raised in open environments, without consideration for their location most of the time; while feeding (Damerow &Gail, 2002)

RFID device - is a small microchip designed for wireless data transmission. It is generally attached to an antenna in a package that resembles an ordinary adhesive sticker. The microchip itself can be as small as a grain of sand, some 0.4 mm (Takaragi et al, 2001)

Remote monitoring – Remote monitoring is the ability to track the location and status of a person, item or animal, by tagging an aspect of their wearables, limbs or even feature they have, to always know where they are geographically located at all times (Varma, et al., 2010).

RFID Reader – A radio frequency identification sensor that reads code on a tag, indicating the passing of information between one device and the next. A reader reads information that is pre-determined but which can change based on aspects that are dynamic in nature such as the information on a Mayfair classic card or Europay MasterCard and Visa (Nikitin & Rao, 2006).

RFID tag - A device installed on an item of value, so as to contain important information about the item or commodity. A tag can be used to gather data of a geo-positional nature, identity of the item that is affixed to the tag, or secure the commodity using codes stored within it (Nikitin & Rao, 2006).

Tagging	-	Placement of plastic chips with electromagnetic sensors on the chicken’s foot so as to track its location always (White,2005)

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CHAPTER 1: INTRODUCTION

1.1 Background

Chicken farming is the rearing of chicken for commercial reasons. Chicken are bread either through free-range farming or the use of specialized farming techniques (Martinez, 2012). These include; organic egg-laying systems, yarding, battery caging and the use of furnished cages. Many chicken farmers in Kenya practise yarding. Yarding is the raising of cattle alongside chicken. This is done so as to ensure that the chicken benefit from some of the resources used in keeping the cattle. A farmer will thus consider keeping chicken where cattle have been so as to ensure that they have some leftover to feed on. Many indigenous chicken species prefer scratching the ground for food to being fed through a feeding system (Maina, 2013). In order to ensure a reasonable yield, there is need for chicken tracking and identification within a yard, or any free-range chicken.

All over the world, more than 300 breeds of the domestic chicken species (Gallus domesticus) exist. We distinguish three main categories of chicken breeds: pure commercial breeds, hybrid breeds resulting from cross-breeding, and local breeds or land races. We can roughly divide commercial breeds according to their main production aim: egg laying, mainly with lightweight laying breeds or layers; meat production, mainly by heavyweight breeds or broilers and both egg-laying and meat production by so-called dual-purpose breeds. Layer, broiler and dual purpose breeds can be distinguished according to their shape (Guèye, 2009)

A large percentage of farmers in Machakos County depend on poultry rearing to earn a living (Government of Kenya, 2013). Poultry farming and related activities are crucial in poverty alleviation all over the world, especially in developing countries. In Kenya, there are approximately 22 million free range chickens. Most of these chickens are reared under free-range systems and in small flocks of about thirty chickens (Kingori, Wachira, & Tuitoek, 2010). While the essence of poultry rearing is to provide staple food, many households waste time and resources keeping the chicken safe. It is because of the imminent threats, which include theft. In order to improve farm management approaches, and even increase control over chicken, it is necessary to adopt technology in tracking of poultry. Despite the cost implications of acquiring a new technology, installation of the technology and even maintenance costs, it is important to get a solution that serves chicken farmers effectively, and one that can be accessed remotely.

This work discusses the various indigenous chicken in Kenya. This is done to ensure that these birds provide food security and family income and play an important role in socio-cultural events. Poultry is an important farm species in almost all countries. It is an important source of animal protein, and can be raised in situations with limited feed and housing resources. Chickens are ‘waste-converters’: they ‘convert’ a scavenged feed resource base into animal protein (Martinez, 2012). They are therefore by far the most important species for generating income for rural families. People raise chickens all around the world under widely varying circumstances. Their main objective is generally the same: maximum production for minimum costs and with minimum risks. The two main forms of keeping small-scale chicken are small-scale subsistence farming and commercial farming. If poultry is mainly kept for home consumption of eggs and meat, costs and effort can be kept to a minimum. However for a poultry enterprise to be successful, it must have a reliable market for its products and a steady supply of reasonably priced quality feed.

1.2 Problem Statement

In order to identify and track chicken, many farmers do a head count every morning as they release the chicken to roam around their compounds and in the evenings as the chicken return to their shelters. The indication is often that while some chicken may be missing, there is no sure way to know their whereabouts during the day. Many farmers also do not have time to keep searching for the chicken at daytime hence would rather count their losses (Blatchford, et al., 2009). Tracking using information system identifiers is thus crucial in the tracking of poultry, especially free-range chicken.

1.2 Research Objectives

i. To investigate challenges in chicken farming
ii. To investigate technologies and methods used in chicken monitoring
iii. To test the suitability of RFID model in chicken monitoring and identification
iv. To test the suitability of RFID technology to poultry farmers in Machakos County

1.3 Research Questions

i. What challenges are realised in chicken farming?
ii. What technologies are available in chicken tracking?
iii. How suitable is an RFID model for chicken monitoring and identification?
iv. How can RFID technology be made suitable for poultry farmers in Machakos County?

1.5 Justification

This study introduces information technology in poultry farming and management. A model is developed using an Arduino board chipset. The model is then tested using free-range chicken in Machakos County. The Arduino model is a proof of concept that chicken tracking and identification can be done remotely. This is why the test is done with equipment that can be operated hands-free, with minimal support from farmers as well. The overall result is that chicken identification is guaranteed while tracking can be done while the farmer is away.

Secondly, through presenting solutions to the challenges of searching and controlling the movements, the farmers can specialize in other areas, without having to worry about the chicken they keep. The farmers will invest resources and energy towards developing best practices in farm management, and will dedicate time in improving the farming procedures. Moreover, the research will provide information on how farmers can best utilize their farms as better in chicken rearing.

Lastly, the research is useful in the application of wireless technology in poultry and livestock farming, and also contributes to the literature on the intersection between agriculture and ICT. The findings will represent a context for further studies, and act as a point of reference to other researchers and scholars. Furthermore, the results can also guide skeptical farmers to adopt technology in poultry farming.

1.6 Scope

Poultry farming is a process that includes feeding chicken and providing a conducive environment for chicken to lay and hatch eggs, this research will focus on the maturity stage. The stages begin with the acquisition of poultry and partnering the breeds. Additional steps include the control of the population, as well as the sale of the mature produce to farmers and other stakeholders for commercial and domestic consumption. All the attention in this research will be shifted towards monitoring and identification of the poultry. The research will exclusively focus on the maturity phase of the chicken.

1.7 Limitations

This project has a limited duration, and which cannot favor developing a commercial solution to address all problems chicken farmers face. Developing a conclusive system will require additional time that the duration stipulated in the academic requirements. Because of the academic requirements, this project is also limited to a single type of poultry, the *free-range chicken*.

Moreover, this project is also limited by financial constraints. Because of the insufficient funds, it is impossible to procure the best technologies for the research. Furthermore, it is also a challenge to coordinate with manufacturers in customizing the RFID system, and so develop the most effective system. Also, the financial constraints will limit the data collection process for the project. The RFID device acquired shall thus be sufficient to offer the desired illustration on effective chicken tracking using RFID.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The literature review details the different technologies applied in chicken farming. It provides data on indigenous chicken in Kenya; the main chicken category used in the study. The literature offers data on how to identify these chickens, and the challenges one faces in identifying these chickens. The research also identifies RFID technology, how it is applied and what it entails. The literature concludes with a conceptual framework for the proposed RFID system.

2.2 Indigenous chicken in Kenya

According to King'ori, Wachira and Tuitoek (2010), indigenous chicken in Kenya are bred in almost every region. Essentially, these chickens are kept in rural areas in Kenya, with about 90 per cent of the rural communities keeping these chickens. The chicken population is about 22 million in Kenya, which is distributed as shown in figure 2.1. Basically, regions such as Nyanza, Western, Rift Valley and Eastern make up more than 50 per cent of the chicken population in the country. King'ori el al (2010) argues that the production of indigenous species by communities in rural areas of Kenya is common among women, youth and landless/marginalized farmers due to the scarce land resource and dense population.

PROVINCE	EST. NO. OF INDIGENOUS CHICKEN
Rift Valley	5,752,411
Western	1,996,070
Coast	2,865,250
Nyanza	5,491,538
Central	1,879,393
Eastern	4,092,859
North Eastern	170,345
Nairobi	161,422
TOTAL	22,045,810

Figure 2.1 Distribution of indigenous chicken in Kenya

Sourced from King'ori, Wachira and Tuitoek, sourced from *International Journal of Poultry Science, pg. 310*. Copyright [2010], retrieved with permission.

According to Okeno, Kahi and Peters (2012), there are three major categories of chicken bread by Kenyan farmers. These include; indigenous chicken, broilers, hybrid layers. However, Kenya does have a category of unidentified chicken bread for commercial reasons, including export. However, more than seventy five per cent of Kenyan farmers maintain a breed of Kienyeji chicken that is generally kept for subsistent and commercial use. These chickens are the most prized possession of the poultry flock and are very expensive to acquire. This is as shown in figure 2.2

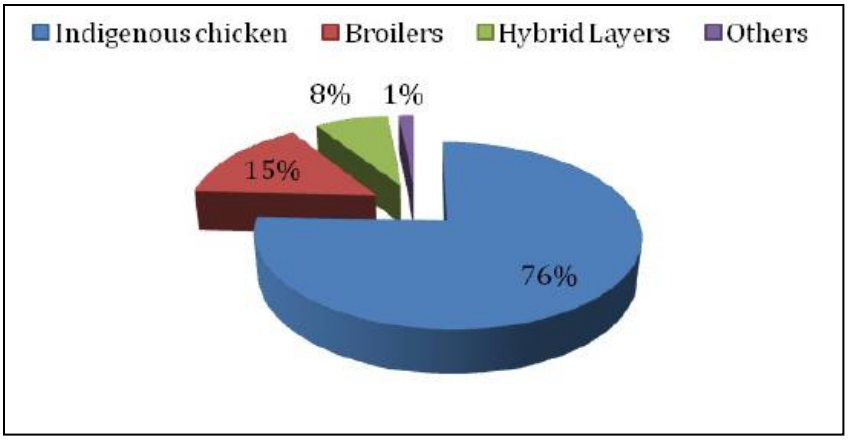

Figure 2.2 Percentage of indigenous chicken compared to other chicken breeds in Kenya

Sourced from Wachira, A. *Indigenous chicken-Kienyenji.* Retrieved on March 14, 2017. Copyright (2017). Retrieved with permission.

There are several indigenous chicken ecotypes as identified by Wachira, et al. (2010). These include; *the frizzled feathered chicken, the naked neck chicken, the molo mushunu, the feathered shanks, the bearded chicken and the dwarf sized ecotype*. All these ecotypes are distributed in different parts of the country, with some more prevalent in some regions than others. Regardless, Kenyans do keep these chickens comfortably in their farms regardless of the regions they get them from. Figure 2.3 demonstrates some of these ecotypes and their physical appearance. However, these are not the distinct distinctions. There are further features that identify these chickens among most poultry farmers. They include; strong talons, lack of a particular distinct colour, irregular laying and brooding patterns, resistance to diseases and longer time to maturity (above three months).

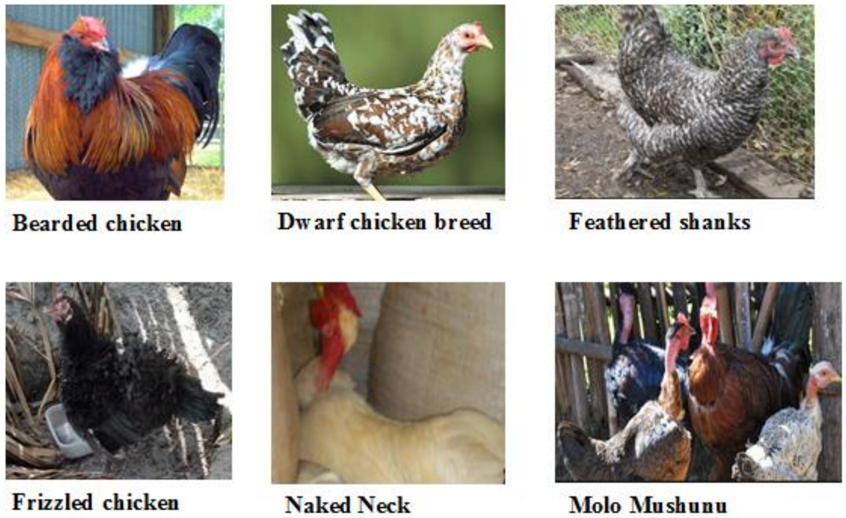

Figure 2.3 Chicken ecotypes in Kenya.

Sourced from; Hans, L. V. *Chickens in Africa.* Retrieved on March 16, 2017. Copyright (2017).

2.3 RFID technology

2.3.1 The RFID tag

A tag is a device that is set to a certain resonance, in order to store and transmit electromagnetic information (Juels & Wagner, 2005). Tags are attached to the item that needs to be tracked, in order to communicate to receivers/transceivers closest to them via radio waves. The chip and antenna are both called a tag. This tag can also be classified into two groups (Clampitt, 2006). RFID tags can either be passive or active. Passive tags are cheaper to acquire and are quite small, thus easy to manage (Juels & Wagner, 2005). However, they have a very short reading range. Active RFID tags can read up to 100 meters and often use include input such as; temperature, humidity and photosensitivity. They are however larger, bulkier and more expensive than the passive tags (Clampitt, 2006).

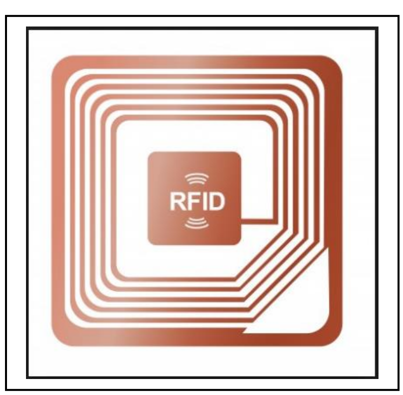

Figure 2.4 RFID tag image

2.3.2 The RFID Reader

An RFID reader often establishes a connection between the host computer and the electromagnetic field within it. The reader receives the electromagnetic signal from the tag through radio or microwave technology. It then transmits the signal to the broad spectrum of electromagnetic waves to a remote computer or uses alternative technology such as the Global System for Mobile (GSM) to achieve this functionality. The tag constantly transmits electromagnetic signals. These signals can be captured by the reader through internal antenna signals.

Figure 2.5 RFID Reader

2.4 Different RFID settings for tracking systems

2.4.1 Hand-held Reader

A handheld reader is a portable transceiver that is carried by hand to the proximity of a tag, to capture the electromagnetic waves within reading distance (Sweeney, 2006). This reader is common where the information required from the tags is from different passive tags within a large facility. The operator/manning person has to carry the hand-held device and scheme through a host of tags to probably do a headcount within a facility with tagged items or to determine available and lost stock commodities in a production line or warehouse. This makes it easy for the inventory manager to determine the whereabouts of stock at any point in time.

Figure 2.6 Hand-held RFID reader

Adapted from A. Trevarthen, 2005, *The Importance of Utilising Electronic Identification for farm Management: A Case Study of Dairy Farms on the South Coast of NSW.* Copyright 2005 by Trevarthen.

2.4.2 Fixed Reader Installed in Area

A fixed reader is installed on a stationary point to capture data from tags that pass through the point at any particular time (Sweeney, 2006). This reader can either be active or passive, but it has to be connected to an RFID system so that the captured data is stored at all times, whenever collected. The sensitivity of the reader depends on the tag being read. However, it is often necessary to have a reader that covers the entire extract of the facility within which tags are stored. For production lines for instance, the reader has to be able to capture tag information on any part of the production line, where information on the product is required.

2.4.3 Fixed Reader Installed at Chokepoint

A fixed reader at a chokepoint is located at the intersection of a good-monitoring point and an entrance or exit port. This implies that the goods moving into a consumer market can be tracked while those exiting the consumer market can be tracked as well. This information is especially useful for customs management. However, there are applications of chokepoint readers such as project monitoring systems and quality assurance systems. One such example is the farm monitoring system using RFID

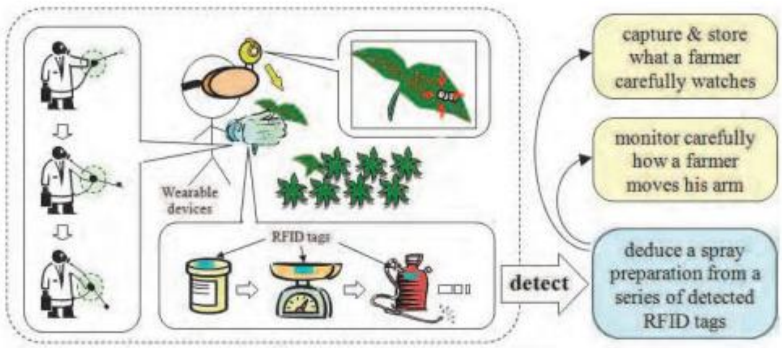

Figure 2.7 Farm monitoring using RFID

Adapted from B. Glover and H. Bhatt, 2010, *RFID Essentials*. Copyright 2010 by Glover and Bhatt.

2.5 Active RFID tags

Active RFID tags are used where the information required from the specimen being tracked is needed in real-time. The tag thus relays the information to the reader through a transmitter. The tag is also powered from its own batter. It is thus bulky and can only suffice where the specimen or object being tracked can comfortably carry the tag around for long distances and virtually every minute of the day. Tags are normally implanted permanently to act as markers for the object or specimen being tracked. They bear information about the object such as the name, the blood type, the serialization or classification of the asset as well as vital reproduction information. It is thus necessary that the tag is not interfered with. Active tags enable relay of information to be real-time and faster, when needed (Stankovski et al., 2010). For chicken tracking and identification however, they cannot be used given the small size of the birds.

2.6 Applications of RFID technology and Related works

2.6.1 RFID in Grain Tracking

In grain tracking, RFID tags are inserted in a sack or bag of grains during harvesting. The RFID Grain Tracking Tag is placed within the sack with the grains. Ordinarily, this is done for sacks with large grains such as maize grains, beans and French beans. This makes the process of identification of the sack easier, especially with each tag accompanied by a description of the contents of the bag (Sweeney, 2006). Figure 2.8 illustrates the conceptual approach in RFID grain tracking. The RFID Grain Tracking Tag is a passive RFID device. This implies that it does not have a processor. Instead, the tag has to be used within a system with a processor such as the microcontroller that can then control the information by reading the sketches within the tag. The tags are magnetic in nature, implying that they can be read by any proximity device and do have a magnetic range for readers utilizing near field communication technology. Durable exterior is needed so that the tag's packaging does not wear appreciably after thousands of cycles of reuse (Sweeney, 2006).

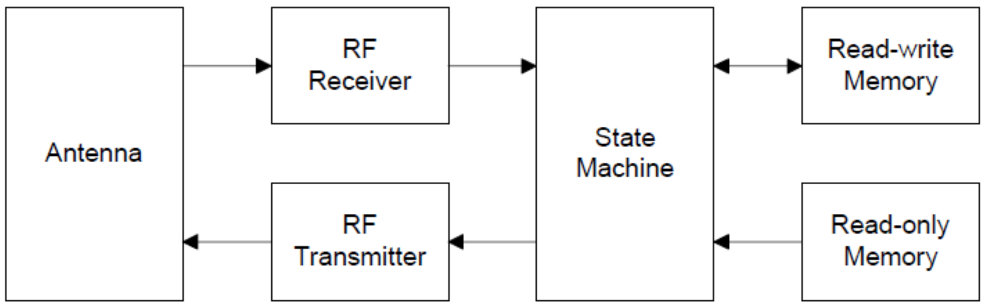

Figure 2.8 RFID in Grain tracking. Adapted from P. Sweeney, 2006, *RFID basics for dummies*. Copyright 2006 by Sweeney.

2.6.2 RFID in Tracking Wild Poultry

Before considering RFID as the most appropriate system, it is important to consider the alternatives. One such example is the Global System for Mobile (GSM). GSM is applicable to bulky animals, such as rhinos, and also requires a larger battery. For that matter, it is inappropriate for wireless systems used in the location and monitoring of poultry (Trevarthen, 2005). An RFID system is thus effective in tracking of poultry. Furthermore, when implementing the RFID system, it is appropriate to declare the range of the system, and hence establish a wireless network.

According to Stankovski et al. (2010), RFID is more cost effective than the alternative tracking systems. Two technologies preceded the RFID, and which are the VHF and GPS. GPS is a satellite based technology, and is used for tracking within extensive territories (Dyo et al, 2009). This technology has mainly been beneficial in wildlife tracking. Apart from capturing extensive territories, GPS technology is also efficient. However, GPS technology requires a power source for the terminals, and which make them bulky (Dyo et al, 2009). VHF tracking is analogous, and so inefficient. The limitations of these technologies, in terms of application and cost, are shadowed by the capabilities of the RFID technology (Stankovski et al., 2010).

2.6.3 Precision Livestock Farming

Precision Livestock Farming (PLF) is also referred to as smart agriculture. PLF involves the use of specialized sensors placed strategically on livestock to maintain information about the breeds and the numbers (Wang et al., 2010). This is used especially in experimental breeding of cattle. The breeds are selected, notched and the information within the tracking device loaded onto a database for monitoring purposes. Berckmans (2008) stated that PLF is effective where the animals are of many breeds and can be collectively inter-bred. This is then applied in many technologies that can be proposed by veterinary researchers to deal with the diseases, especially those that result from interbreeding.

2.6.4 Vocalization analysis techniques for determination of animal welfare

Very little research has been conducted on the use of noise recognition to determine the welfare state of broilers. Factors which affect the animal's physiology such as temperature, humidity, air flow, light and carbon dioxide has been widely studied. The major advantage vocal-based analysis is that it is a non-invasive process. The study of the relationship between poultry vocalisations and their environment falls under a category called bioacoustics. Jahns (2014) believes that understanding the vocal information animals provide us will assist in producing an efficient management tool to enhance animal welfare and farm efficiency. Studies have shown that an increased vocalisation rate in pigs and calves is indicative of their excitement and their degree of fearfulness to novelty and social separation.

2.6.5 Image analysis using digital imaging and infrared technology in broiler production

The use of video analysis technology in broiler monitoring is an emerging technology. According to Aydin et al. (2010), it is a relatively affordable and predictive technology that allows the user to acquire consistent data about a phenomenon, for long durations of time. An analysing algorithm in real time is used, which negates the need for large amounts of data storage. Several studies have already investigated image capturing techniques as a beneficial tool in precision agriculture. Collins (2008) used video analysis to investigate the behavioural pattern of broiler chickens under different stocking densities. Collins (2008) placed cameras at a fairly medium height; about 1.5 meters and at an angle of 75^{o} to the floor of the house. Focal broilers were randomly chosen, and were tracked (every 5 s) from the point at which the stood up, to the point at which they arrived at the feeder. The following data was taken; X, Y coordinates of birds, behaviour of the birds, and number of chickens between the focal broiler and the closest point along the trough used for feeding. Results from the experiment showed that broilers tended to walk further than needed to reach the nearest feeder, and in general their route was not affected by different stocking densities.

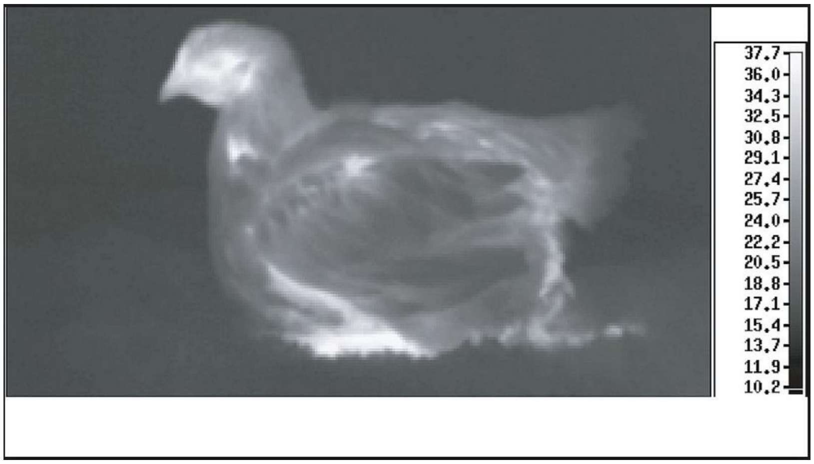

Figure 2.9 Infrared technology in broiler production

Adapted from G. Corkery, S. Ward, C. Kenny and P. Hemmingway, 2013, *Incorporating smart sensing technologies into the poultry industry*. Copyright 2013 by Corkery, Ward, Kenny and Hemmingway.

2.7 Conceptual Model

The microcontroller selected for the implementation of the prototype is the Arduino Uno micro-processor chipset. This setup is efficient for adjusting functions and capabilities of the RFID reader to serve the purpose of the prototyping and also communicate with a web-based portal. The microcontroller allows the use of a programmable RFID sensor as well as a network shield and Light Emitting Diodes. The concept will involve a chicken being read by the system, from the proximity of the tag on the chicken’s foot to the Arduino setup. The reader will then sense and read the radio frequency signal on the microcontroller using the tree-based anti-collision algorithm implemented. The data shall then be stored in a database and processed effectively to output the necessary information about the chicken location and identity.

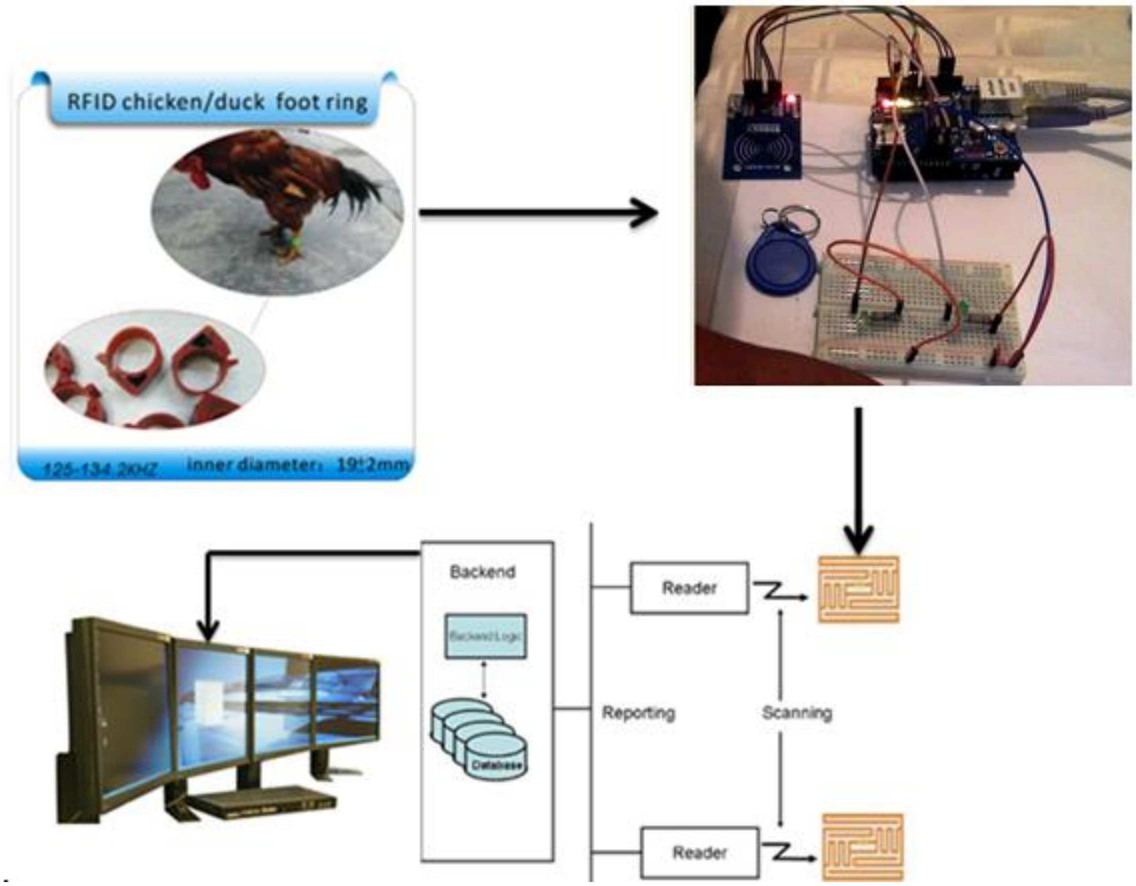

Figure 2.10 Conceptual model of the RFID Chicken tracking system

Source: self

The model includes RFID tags, an Arduino board with an Ethernet shield and RFID reader, a demonstration of the scanning mechanism as well as the storage and display mechanisms. The backend system is a series of databases for the different poultry flock. The front-end display is for displaying chicken whose tags have been read each day. Most of the components and working of the system is on the Arduino chipset. With the sensors and the internet relay technology (Ethernet shield), the setup makes tag reading possible. Basically, the prototype will require a transponder (tag), tied on a movable object. The transponder shall then relay the data to an RFID reader, which will interrogate the data for capture using the tree-based anti-collision algorithm that is often used with the short range RFID readers (Fu, Deng, & Wu, 2016). However, for an actual system, different components can be readjusted; such as the reader; to ensure a larger range of tags is read as well as the proximity sensing is enhanced.

CHAPTER 3: METHODOLOGY

3.1 Overview

This chapter describes the methods and techniques used during the research study as well as the development of the system. The selection of a specific method is important because it details the study approach towards attainment of the research objectives. This is important because there are numerous options of data collection tools and research designs that a researcher can use. Therefore, reasons have been used to expound on the suitability of the chosen approaches during the research study.

3.2 Research Design

A mixed methods research was done. The study targeted poultry farmers in Machakos County. The poultry farmers sampled are within Yatta Constituency, a region with proximity to Machakos town and sufficient data from agricultural extension officers. The study population was chicken farmers who practice free-range chicken farming. These farmers were asked to offer their consent before the research was done. They were also expected to show interest in dealing with a recurrent problem of chicken loss and death that had been hypothesized.

Systematic random sampling was selected as the sampling technique of choice. This is because, the research population was strategically chosen from a list of constituencies in Machakos, with the expert help of agricultural extension officers based in Machakos County. The strategy not only saved time in the sampling exercise, but greatly minimized errors associated with non-probabilistic sampling techniques. The unit of analysis is the applicability and usability of RFID system to poultry tracking and identification.

3.3 Study Site

The research was conducted in Yatta Constituency, Machakos County. This is due to the high numbers of chicken farmers in this constituency. This was based on information gathered from agricultural extension officers within Machakos County Department of Agriculture. The correct number of chicken farms in Yatta Constituency cannot be estimated properly. However, it is the highest in the county. Within this site, the goal was to get a sample of 30 chicken farmers, from which to effectively interview using questionnaires. These tools would be administered on site. It was thus important to have a locality that is within proximity from the tarmac roads, as well as near the town center, where the poultry experts were inherently located. The input of poultry experts was critical to this research.

3.4 Data sources and Collection methods

The primary sources of data were the farmers, the poultry experts in Machakos County and the poultry organizations situated in Machakos County. Their data would provide first-hand information about the rearing of free-range chicken in Machakos County. Literature used in the study provided secondary information to this research.

This research proposes to develop a web-based tool that will accept RFID data from the transponder as data as input, process this data using a global positioning system markup algorithm. The web portal with then use the analysis derived in order to predict the suitability of the RFID tag on the chicken. The research shall be based within a setting in Machakos County, encompassing reviews from farmers in the region. The poultry farmers' organizations targeted for the study includes; the Kenya Poultry Farmers' Association (KEPOFA) and the Kenya Agricultural Research Institute (KARI). The design of the research allowed the data collected to be manipulated in the best way possible to achieve substantial results.

The collection method used for getting the primary data was the questionnaire. The questionnaire is a detailed set of questions that will enable the researcher to gather the appropriate, relevant data. The questionnaire was developed for three sets of respondents; free-range chicken farmers, poultry experts in Machakos County (agricultural extension officers) and non-governmental organizations participating in poultry research.

3.5 Data Analysis

In order to analyze the data effectively, we got a sample from each of the response categories given by the stakeholders. Basically, there will be three stakeholders; farmers, poultry experts and agricultural organizations. We then estimate the effectiveness of the tool used (RFID tracking) by performing correlation analysis using the Spearman's Rank correlation coefficient shall then be applied using the formula;

$$r_s = [6\sum di^2/n(n^2-1)]$$

Equation 3.1 Spearman's rank correlation analysis

The rank correlation analysis was used to rank correlation between two variables; acceptance of RFID technology for chicken tracking and identification (dependent variable), and the poultry farming stakeholders (independent variable).

3.6 Development methodology

The methodology for development is the technique with which the programmer of software engineer will approach the issue of software development. In this particular research, the technique that will be approached is the Software Development Life cycle (SDLC). The software development life cycle is the process that documents software evolution slowly, from the time the idea of the software is conceived to the realization of the final product. This involves; specification of the software's expected inputs, processes and outputs; a design layout of the software's major components; a validation tool for the software developed; and an evolution mechanism to track new changes or versions of the software.

This is based on the waterfall model which is a sequential design process often used in software development process. The development is seen as a owing downwards steadily. In the Model, one phase has to be finalized before the process can progress to the next phase.

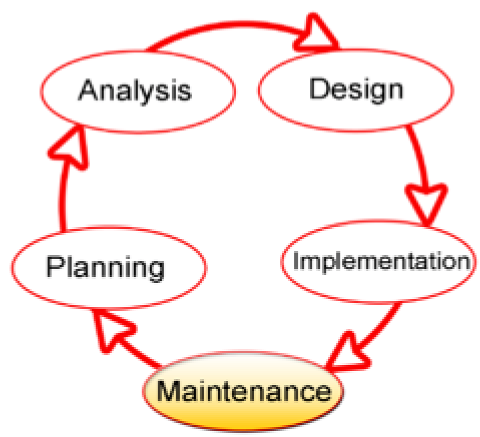

Figure 3.1 The SDLC life cycle

Source: self

Structured system analysis and design methodology also uses several techniques such as:

Logical Data Modeling: A process of identifying, modeling and documenting the data requirements of the system being designed.

Data Flow Modeling: A process of identifying, modeling and documenting how data moves around an information system.

Entity Behavior Modeling: This is the process of identifying, modeling and documenting the events that affect each entity and the sequence in which these events occur.

Technical System options: This a process in which the physical implementation of the system requirements are put into consideration and an analysis of their interaction, availability of software and hardware to use, limitations of the system and cost are still checked. The desired and chosen technical system is picked at this phase.

Requirement specification: The development will involve the use of data flow diagrams and entity relationship diagrams to define the system requirements. Their analysis produces function definitions of every function which the users will require of the system which are models of how each event interacts with the system. These will be continually matched against the requirements and where necessary, the requirements will be added to and completed. The deliverables are:

1. Data Catalogue;
2. Requirements Catalogue;
3. Processing specification;
4. User role/function matrix;
5. Function definitions;
6. Required logical data model

3.7 Confidentiality/Ethical Consideration

Before data was collected, consent was sought from the respondents as well as the relevant authorities. The research ensured that all ethical codes of conduct were adhered to. This included, gathering data only from the sample selected, maintaining the confidentiality of the respondents, presenting accurate and truthful data concerning the findings of the research and making amply investigate recommendations based on the data studied from both the literature sources and the responses gathered.

CHAPTER 4: OBSERVATIONS

4.1 Introduction

Data analysis is important after every data collection process. It is the process that ensures all data collected from a research activity is fully represented and tabulated in a way that can be understood by other readers or researchers. For this particular research, the analysis was from two major respondents; farmers and experts. Questionnaires were issued to these groups in two separate occasions. The first occasion was the preliminary research. In this research, the questions focussed on the suitability of an RFID system in chicken tracking and Identification. In the second occasion, the developed system was presented to the two separate groups of respondents. Questions were then asked of the respondents, which would be filled in new questionnaire leaflets. A select number of interviews were also conducted and the information used to effectively improve the developed prototype.

4.2 Response Rate

4.2.1 Rate of Questionnaire responses

Twenty eight questionnaires were distributed equally among the seven sub-counties in Machakos. These questionnaires were sent to the farmers who had indicated interest in participating for the research. Although their names were not indicated on the questionnaires, there was a clear indication which homestead the questionnaire targeted. The researcher personally conducted these farmers, with the help of a few assistants to get the questionnaires distributed. The data sought was preliminary in nature. Two weeks later, the next set of questionnaires was issued to the same set of farmers, after having demonstrated the prototype to them. From the first set of questionnaires, all were returned. However, only 21 had the prerequisite data required. In the second phase of questioning, 18 questionnaires were deemed usable. This was based on the legibility of the handwriting, as well as the applicability of the responses given with regard to the questions asked. All the ten interviews conducted before and after the prototype development were deemed to be sample-worthy. Table 4.1 presents a proper analysis of the response rate realized.

Round of questioning	Number of questionnaires sent	Number of questionnaires returned	Number of usable questionnaires	Percentage completion (%)	Percentage usability (%)
First round (preliminary research)	28	28	21	100	75
Second round (actual research)	28	28	18	100	64
Totals	56	56	39	100	70

Table 4.1 Response rate from research

Response rate from research

The response rate to the questionnaire by the farmers was 100%. However, the usability of the questionnaires returned was 70%. This was basically due to the challenges some of the farmers had understanding the questionnaire questions.

4.2.2 Response to interviews

The interviews however presented significant data that was crucial to this research. A total of 20 interviews were held, with 10 interviews held before and another 10 interviews conducted after the research exercise was completed. Interviews were conducted among agricultural experts from select offices in Nairobi and three major organizations that deal with poultry farming within the country. The responses were analysed and presented separately from the responses gathered from the farmers.

4.3 Summary responses from the preliminary research

4.3.1 Loss of Chicken to Predation and theft in Machakos County

The different responses gathered from the farmers were assessed and evaluated. The farmers were asked to estimate the losses they faced periodically due to the existing predators and chicken thieves. The information from the farmers was documented as illustrated in Figure 4.3.1 below;

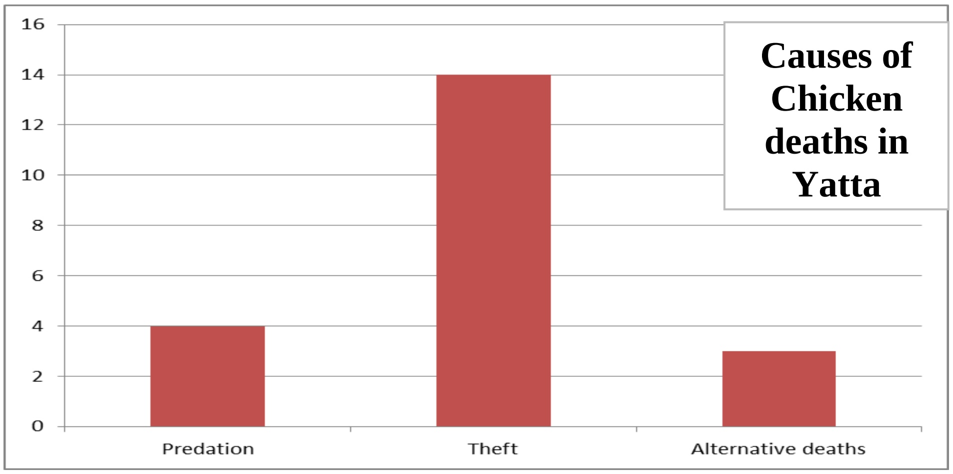

Figure 4.1 Common Causes of chicken deaths in Yatta

The responses gathered from the farmers indicate that theft contributed to most of the chicken losses in Machakos County. The farmers also felt that their inability to count the chicken efficiently as they entered their cages in the evening was of grave concern. Where predation was involved, they felt that the chickens were mostly attacked while brooding. The farmers also felt that most of the attacks were done on the mature chicken. Essentially, these chickens were the most valuable at the farm. Figure 4.2 below indicates the farmers' feelings towards possible solutions to deal with the chicken loss/death problem.

4.3.2 Proposed solutions to handle Loss/Death of Chicken in Machakos County

The farmers were also asked to propose solutions to the chicken loss/death problem. Three main solutions were offered. These were tabulated and a graphical representation drawn. Figure 4.2 shows the responses received represented graphically.

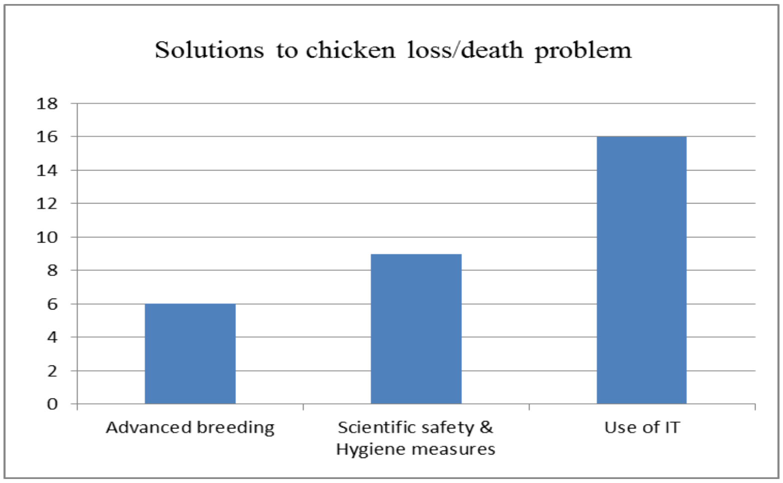

Figure 4.2 Solutions to chicken loss/death

Alternative technologies were considered to be the most preferable solutions to chicken loss or death. Most of the farmers indicated their alternative solutions as; use of information technology, use of advanced breeding techniques to increase production and the use of scientific ways to maintain the safety and hygiene of the breeding and feeding environment. Farmers also suggested that they preferred technologies that allowed them to monitor the chicken remotely as opposed to within the compound.

4.3.3 Preferred technologies for management of chicken breeds

The farmers were asked to consider the three options they had suggested as alternative technologies and choose the technology they thought would best address the challenge of chicken loss/predation. Figure 4.3 indicates the technologies they proposed as well as the popularity ratings among these technologies.

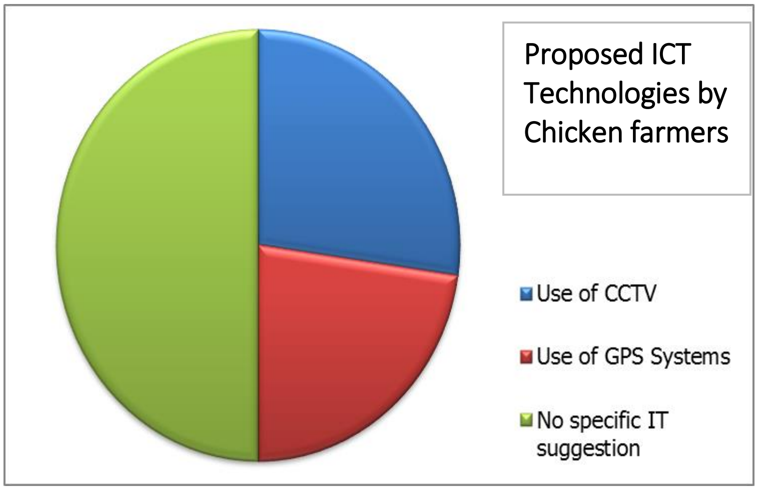

Figure 4.3 Technologies that aid in management of chicken

From the results, it was gathered that chicken management using IT technologies was indeed the most preferred solution for farmers. However, the farmers did not specifically have any particular technology in mind. Most of them suggested CCTV Cameras, while others suggested surveillance using Geo-positioning systems.

4.3.3 Other Considerations for management of chicken in Machakos

An IT solution seems to be the most appropriate solution for the management of chicken using RFID in Machakos County. To effectively ensure that this solution is properly implemented, there is a need to make considerations about the viability of a solution that will best suit the needs of the Machakos chicken farmers. Among other things, the solution should ensure the following is achieved;

a. The chicken should be monitored during feeding and during eating, to guarantee at least 2 to 3 updates on the chicken in the course of the day
b. The system should not interfere with chicken breeding or brooding in any way
c. The system should add value by ensuring that it is both cost-effective and efficient to the anticipated farmers' needs
d. The system should always ensure that its inputs are seamless and smoothly taken
e. Maintenance costs should be very low, if any

4.4 Preliminary responses from the interviews

The interviews sought to establish the experience of the professionals and organizations they worked for, with regard to the management of chicken. The interviews also sought to determine how best to implement the RFID system, from the expert point of view. The responses were also tabulated and presented in graphical formats.

4.4.1 Experience of the experts in poultry management

From all the experts surveyed, it turned out that more than 50 percent had an experience level of 1-15 years in poultry farming and research. Very few experts had more than 15 years of experience. This was similar to the number of experts between 5-10 years of experience. None of the experts had less than 5 years of experience.

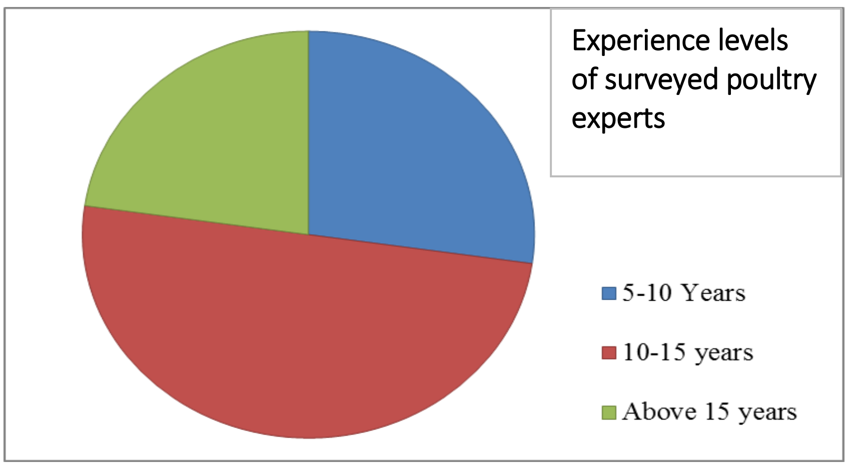

Figure 4.4 Experience levels among surveyed poultry experts

This indicated that most of the poultry experts were quite knowledgeable about handling chicken in Kenya and would indeed be of good reference in this research.

4.4.2 Awareness levels about chicken loss, death and predation

The experts were then quizzed about their awareness on chicken loss, death or predation in Machakos County. The research put to them that this concern was quite recent but it had spiraled to unprecedented levels compared to most parts of the country. 90 percent of the respondents claimed to be aware of this concern while 10 percent were only learning about it in the interview.

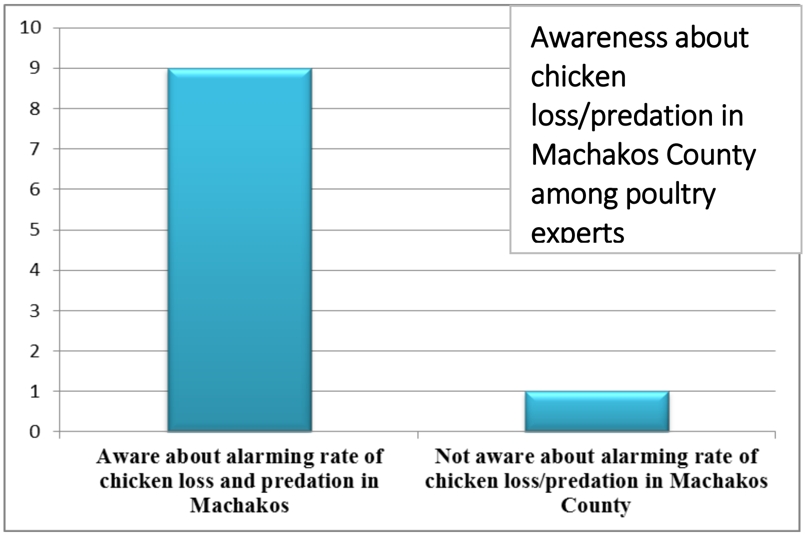

Figure 4.5 Awareness among poultry experts on Chicken loss/predation crisis in Machakos County

4.4.3 Logistical challenges in using RFID for chicken tracking and Identification

The logistical challenges assessed and determined by the professionals were majorly about system support and maintenance. However, other concerns such as the cost of the system, the power and network considerations as well as availability of infrastructure were challenges posed in different degrees of concern. Figure 4.6 represents this data.

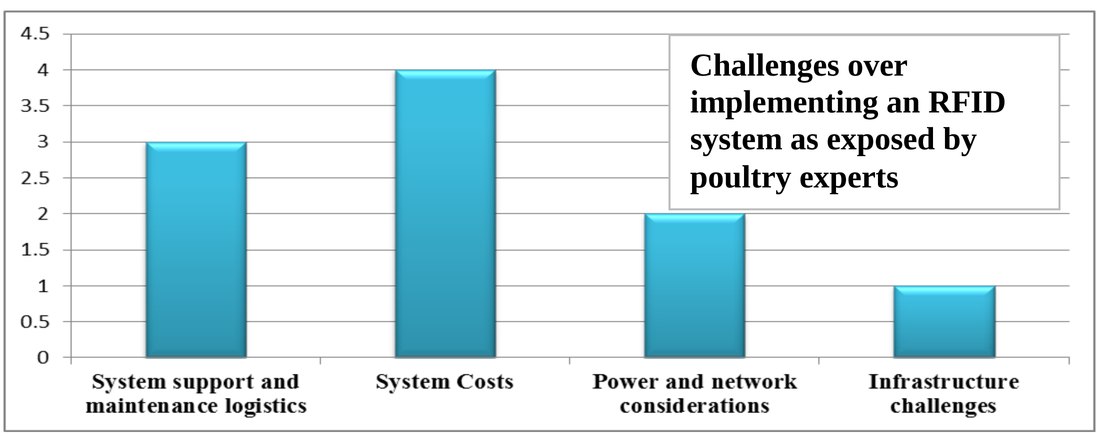

Figure 4.6 Challenges implementing an RFID system

4.4.4 Recommendations for use of the RFID system

The experts were asked whether or not they would recommend the use of an RFID system. The responses were overwhelmingly supportive. Nine of the 10 respondents welcomed the technology. The apprehensive respondents cited the lack of training and prior awareness by farmers as a possible concern that would make the RFID system a destructive technology. Regardless, most of the respondents showed a lot of confidence in the system.

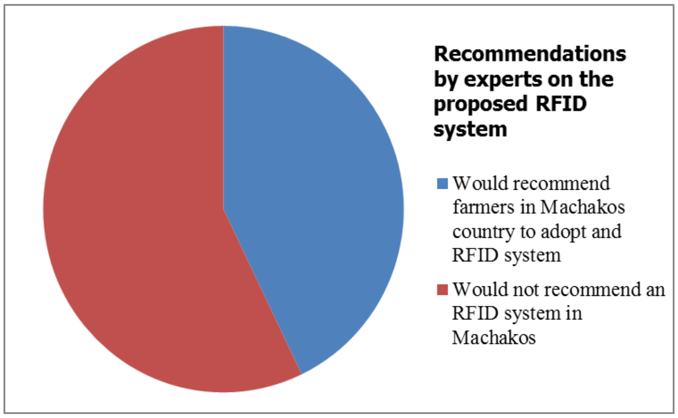

Figure 4.7 Recommended use for the proposed RFID system

Upon review of the questionnaires and interviews, it was clear that the farmers and poultry experts desired an IT system and would be ready to use the RFID system if offered. However, they are advised that only a prototype would be ready in a few weeks for a demonstration, so that further input could be sought from them. The input was sought using questionnaires and inputs upon presentation of the prototype.

CHAPTER 5: SYSTEM ARCHITECTURE AND DESIGN

5.1 Introduction

This chapter was designed to evaluate the conceptual and logical aspects of the system, by explicating the design aspects of the system. Essentially, the design of the system would require that the architecture of the system be well developed and determined. A detailed understanding of the system will thus be realized by assessing the various diagrammatic representations of the system. These diagrams will show the modular flow of data from the RFID tag on the chicken to the RFID reader. The data will then be relayed to the farm manager via an active internet connection. Diagrams indicating how this system shall be developed are well analysed and explored in this chapter. This makes it possible for a developer team to replicate the idea in case it is required in a modified form in a different setting. The chapter also evaluates all possible loopholes in the system to guarantee that it is fail-safe.

5.2 System Data flow diagram

The data flow diagram of the RFID chicken management system is as shown on Figure 5.1. This design demonstrates the flow of data from the tag on the chicken's leg to the database and the display unit, from where the farmer can monitor the chicken. First, the communication between the tag and the reader needs to be optimally guaranteed. Essentially, there is need to have a properly set-up tag on the chicken's foot. This will make the entire system function as anticipated. Basically, the design will be as follows;

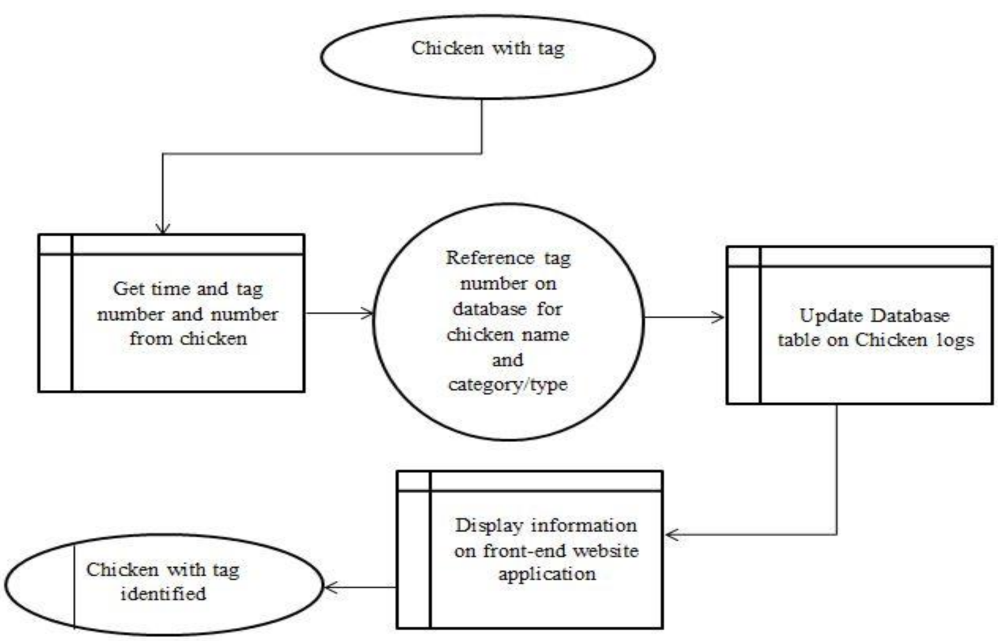

Figure 5.1 System Dataflow Diagram

For the optimal running of the system, there is need for the scanning component of the system; involving the tag on the chicken and the reader on the chicken shelter to be accurate. This is the only bit in the system where complete automation will not be done. It will require that the chicken physically approaches the reader, based on some motivation. The most obvious anticipated motivation shall be the fact that the chicken shall either need to approach a watering point or get into their shed as some point in the day. The reader will thus capture all the chickens which approach these areas. Upon data capture, information shall be sent to the backend database for pre-process storage. The processing shall be done as the data is displayed either on a PC or Smart phone. The display shall be customized in a view that is most suitable for the farmer. This shall be discussed with the farmer upon acquiring the system.

5.3 System Design

The design of the proposed RFID system shall be done using the Unified Modelling Language (UML). This is because; the development shall be done in an Object-Oriented Language, preferably Java. The system models shall guarantee the visualization of the system in a manner that best captures the intention of the developer. The goal shall be to ensure that the flow of data within the system is clearly illustrated from the point of data input to the point of display. The first of these diagrams drawn to UML standards was the Use case diagram as shown in figure 5.2. The diagram illustrates the different players in the system and the relationships between players.

5.3.1 Use Case Diagram

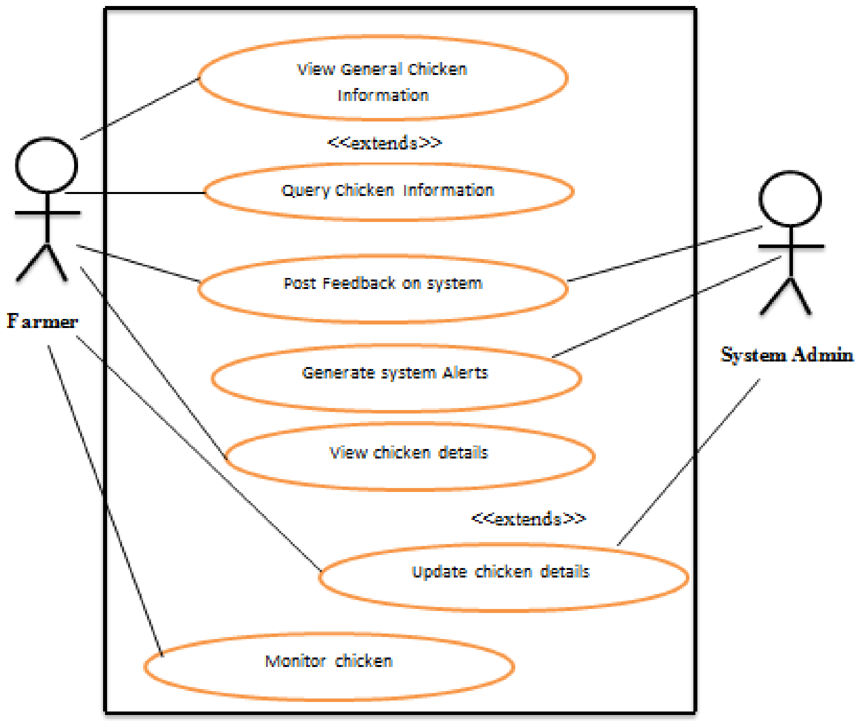

Figure 5.2 Use Case Diagram

Fig 5.2 shows the design of the use cases the system will have. Two main actors shall be needed in the system implementation. The first actor shall be the farmer while the other actor shall be the system administrator. The system administrator shall paly an oversight role on the system. Most of the interaction with the system shall be done by the farmer.

5.3.2 System Sequence Diagram

The main functionalities and activities of the system shall follow a certain sequence of steps. These steps include; reading of tag information from chicken foot, the transmission of the information on the tag and the display of the same in a manner that can be understood and analyzed by the farmer. Basically, the sequence shall show all objects that interact within the process of actualizing the use cases in the system. This shall be as shown in figure 5.3.

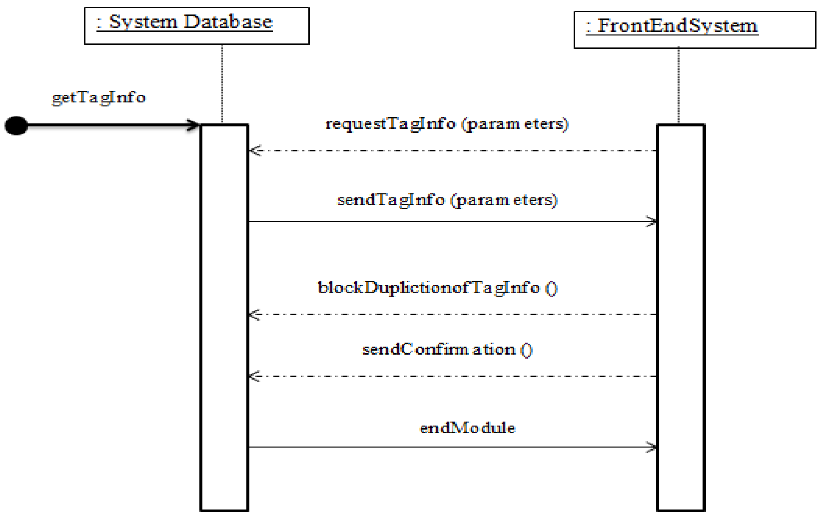

Figure 5.3 Sequence Diagram

5.3.3 Entity Relationship Diagram

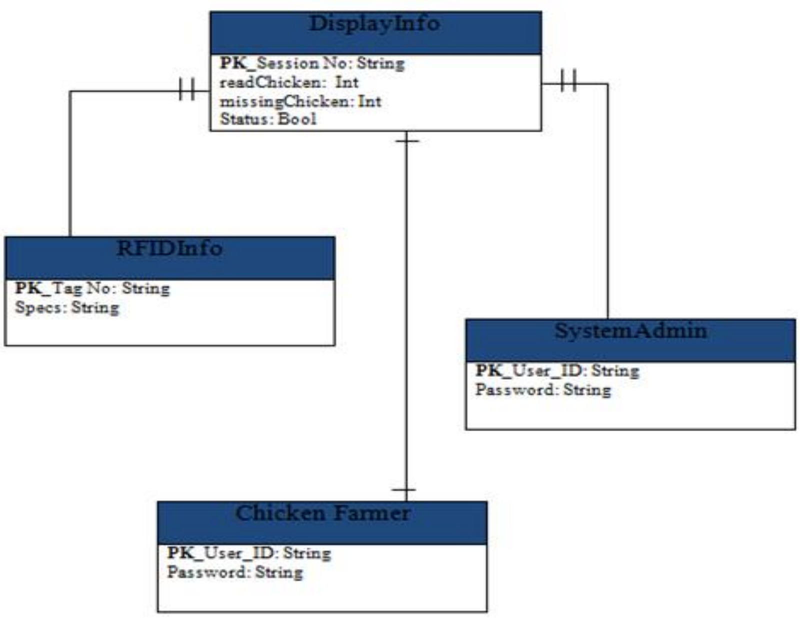

Figure 5.4 Entity Relationship Diagram

The entity relationship diagram on Figure 5.4 shows the various entities of the proposed RFID chicken monitoring system model. These entities will later be transformed into actual classes during the database design. They will each be supported by either one or several such classes, to actualize the synergy in communication between the system players. The entity attribute diagram is vital to show how these key players in the system will interact.

5.3.4 Class Diagram

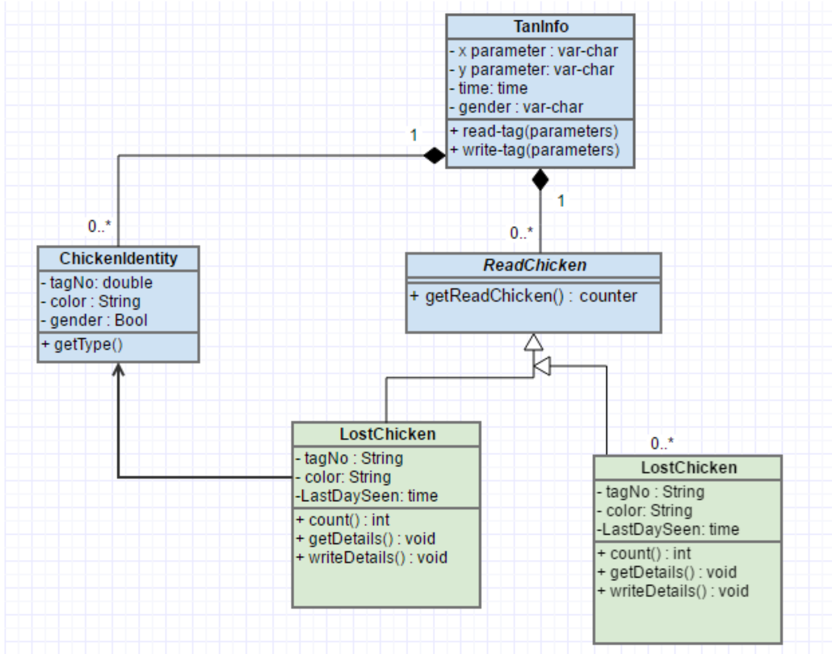

Figure 5.5 Class Diagram

The class diagram in Figure 5.5 illustrates the classes that will be in play for the proposed RFID chicken tracking model. Each class has two main members; first, the objects of the class, which are its main attributed. There is also an accompanying set of member functions/methods to each class. These methods define the class' data capture or relay tools. They allow the communication between other classes through class requests. The diagram basically represents the envisioned classes, necessary for the system to be functional.

5.4 Database Design

The database in the system was modeled from the entity relationship diagram, using a well-defined SQL schema with the requisite tables and queries to fetch the different information from the database. The tables used include; the login table and the chicken information table. However, several select queries were applied to fetch specific data from the tables and represent them on forms, developed in the Hypertext Markup Language interface.

5.5 Interface Design

5.5.1 The RFID detection system hardware setup

The system will have a hardware component, which shall be a set of Arduino components connected to a passive RFID reader. The setup also includes light emitting diodes (LEDs) to indicate different actions that are passive in the system. These include; sensing for network IP, establishing a stable network connection and receiving an electromagnetic pulse from an RFID tag. This shall be interpreted as the tag being 'read' by the system. Figure 5.6 demonstrates the hardware setup, with a tag that is used to demonstrate the prototype.

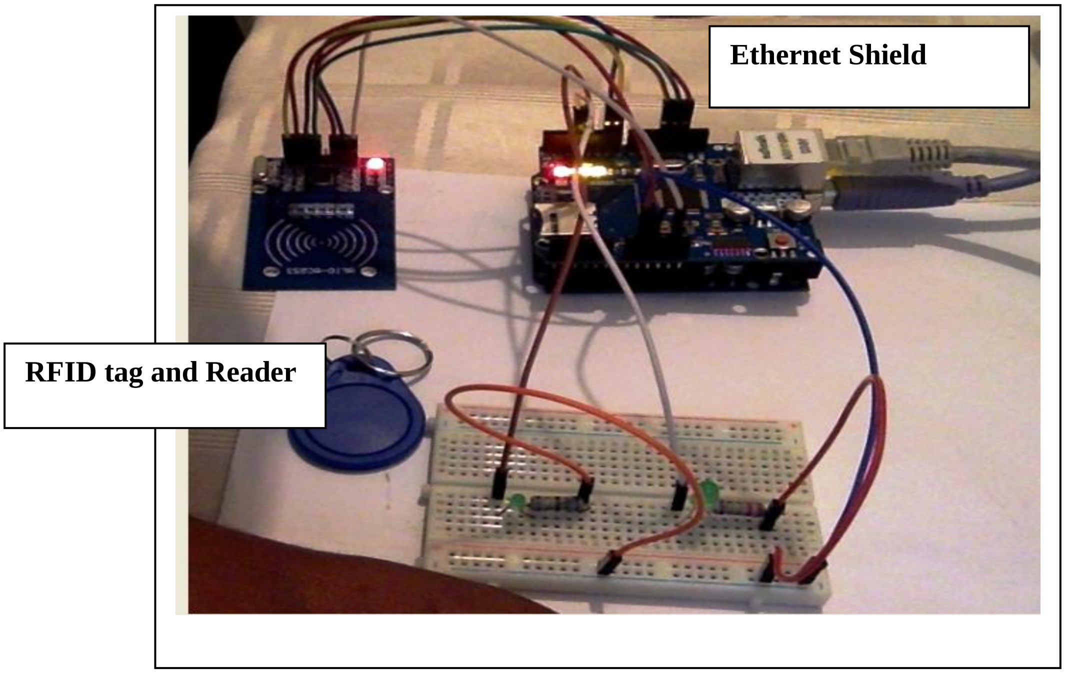

Figure 5.6 The setup of the Arduino-RFID system

5.5.2 The login interface

Upon login in, the interface in figure 5.7 will appear. It will require the user to enter their specific user ID and enter a password in order to access the dashboard. This will form the welcome screen for the system.

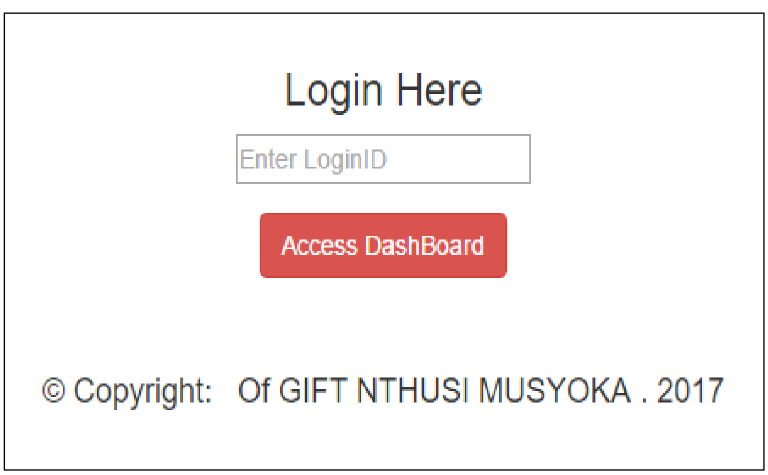

Figure 5.7 welcome screen for the interface

Upon logging into the system, the user will encounter another interface, which will be their final interface for which to view as the system tracks and monitors the free range chicken.

5.5.3 The System Dashboard

The system dashboard shall be launched once the user logs into the system by providing the requisite username and password, which shall be the parameters required to gain access to the system.

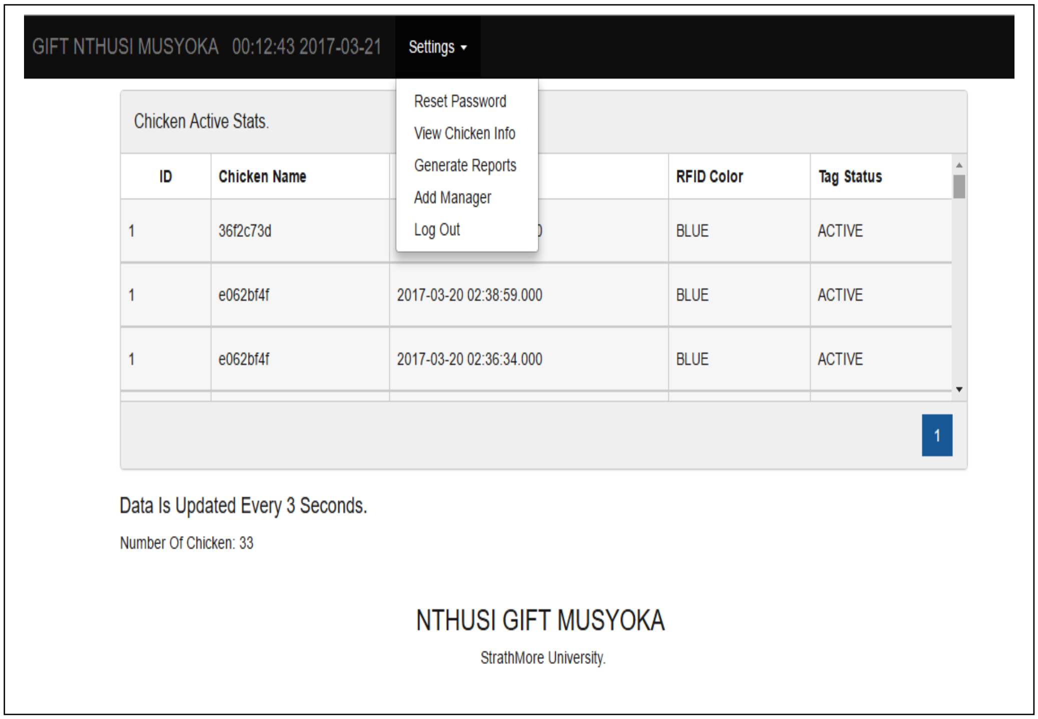

Figure 5.8 The system dashboard

CHAPTER 6: SYSTEM TESTING AND IMPLEMENTATION

6.1 Introduction

Before the prototype could be implemented, it had to be tested to ensure that it served the purpose intended. The intention of the developers was to have the prototype well-modeled to mirror the actual system, which would be developed and implemented on a large scale in Machakos County. The prototype was tested in two ways; unit testing, integration testing and user testing.

6.2 System Testing

6.2.1 Unit Testing

Unit testing involved in testing the actual components and modules of the prototype to confirm that they are in proper working condition. The unit tests done on the prototype include; testing the RFID reader, testing the Arduino Uno board, testing the Ethernet shield, testing the light emitting diodes and the tags as well. Modular tests were also done on all of the system's components, including the login interface, validation rules for data and testing of system and server capacities.

6.2.2 Integration Testing

Integration testing is the testing of software modules as a group. In this research, the integration testing was done by letting a user use the system to read a tag, check status of tags and edit records on the database tables. All these functionalities are directly involved in chicken identification. The findings from the integration testing indicated that the system was indeed feasible and necessary, with the modules integrating effectively to form the system. This can be verified in the appendix section of this document.

6.2.3 User Acceptance Testing

User acceptance testing was based on two aspects of the system. They include; ability of the system to read tags and relay the information remotely, and the ability of the system to present the manifest of existing birds within the farm. The responses from the post-development interviews were framed to address the concern of user acceptance for the system holistically.

6.3 System Implementation

6.3.1 System Development

Coding for the system was done upon completion of the design. The code was developed in basic Structured Query language for the tables stored in the database. Due to the use of the Arduino microcontroller, it was necessary to use basic C language to set pretexts for the system. PHP was then used to map the database to the system, while presenting an interface for the access of either the database or the sensor (RFID). The development phase also incorporated hosting of the prototype on a remotely secured server, to test for validity of remote communication using the system.

6.3.2 System Security

System security was modeled into a login form. The form requires valid inputs for the user to access the dashboard. Security of the system is also enhanced by the location of the reader; in a place where only chicken can interact with it, while human interference is kept at a minimum.

6.4: Results and discussions

6.4.1 Farmers who attended the presentation

In as much as the researcher sought the audience of all farmers participating in the research, not all was privileged to attend the final presentation of the prototype. Of the 28 farmers invited, only 15 attended. This can be represented in figure 6.1

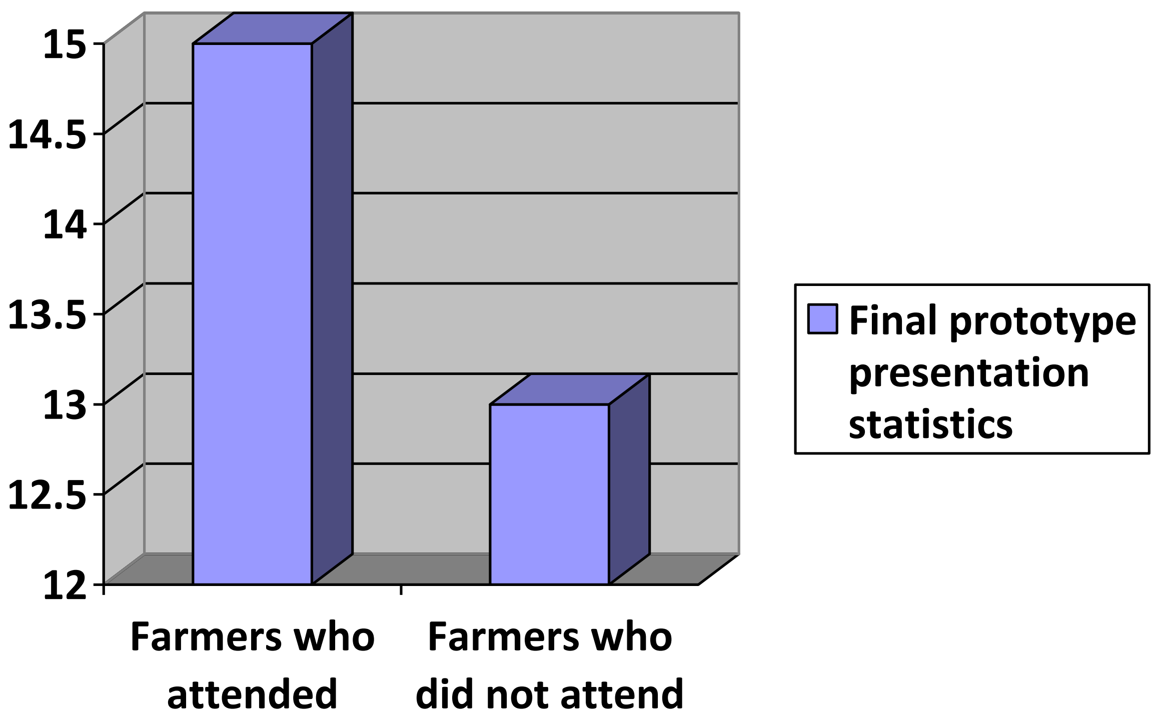

Figure 6.1 How farmers responded to final prototype presentation invitation

6.4.2 Applicability of prototype to solving poultry farmer's problems

The farmers were quizzed on whether or not they felt that the prototype addressed the problems they had in their farms. Of the 15 who attended the presentation, 9 thought it was a welcomed idea for them. Of the 13 who did not attend the presentation, six argued that they would still consider it. Five farmers were however not sure about whether or not to implement, and argued they needed time to consider it. This was as represented in figure 6.2

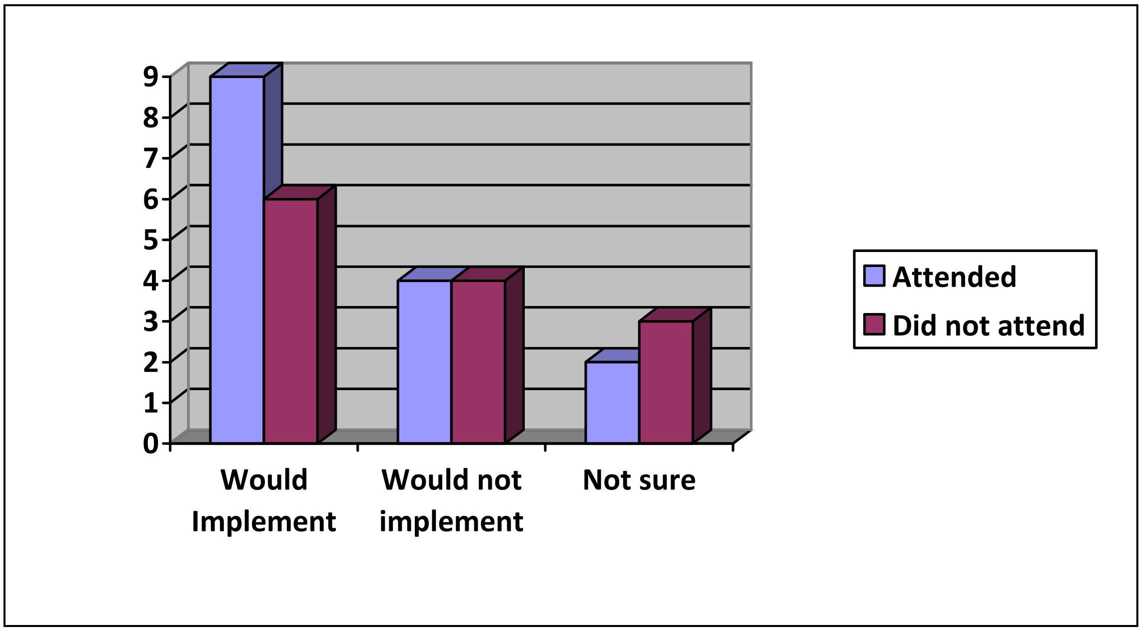

Figure 6.2 Willingness to implement the system

6.4 Post-development responses from poultry experts

Among poultry experts, all attended the presentation. They were eager to see what had been developed and indeed, had a lot of expectations about the system. Upon completion of the presentation, they were allowed to ask questions, and then quizzed on a few issues regarding the prototype.

6.4.1 Willingness of poultry experts to implement the actual system

Eighty percent of the poultry experts were very willing to implement the actual system upon being opposed to the prototype. This is as represented in figure 6.3.

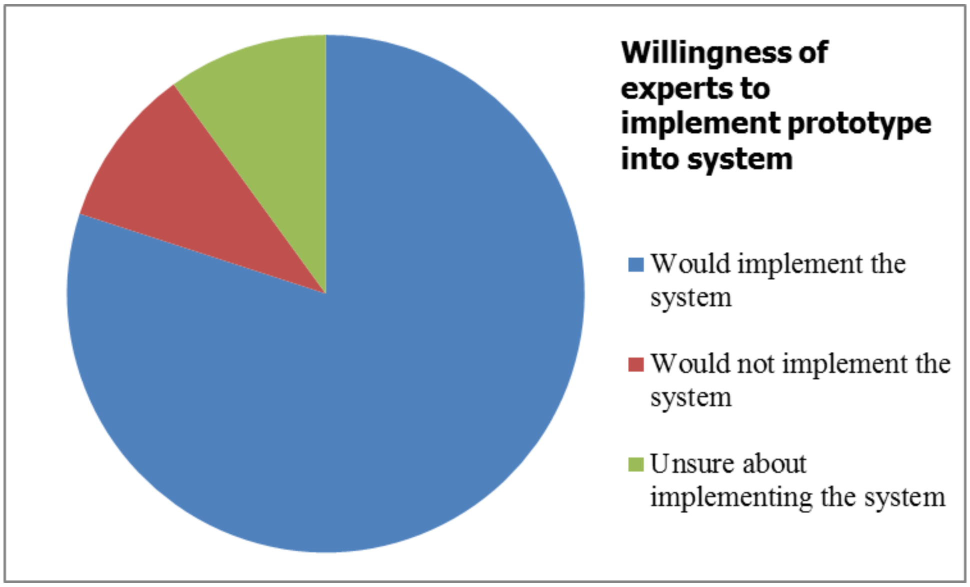

Figure 6.3 Willingness of experts to implement prototype into system

6.4.2 What they would change about the prototype

Most of the respondents; farmers and experts mentioned a few similarities about aspects they would change in the prototype. This can be represented in figure 6.4, indicating the most popular suggestions among the farmers and the experts.

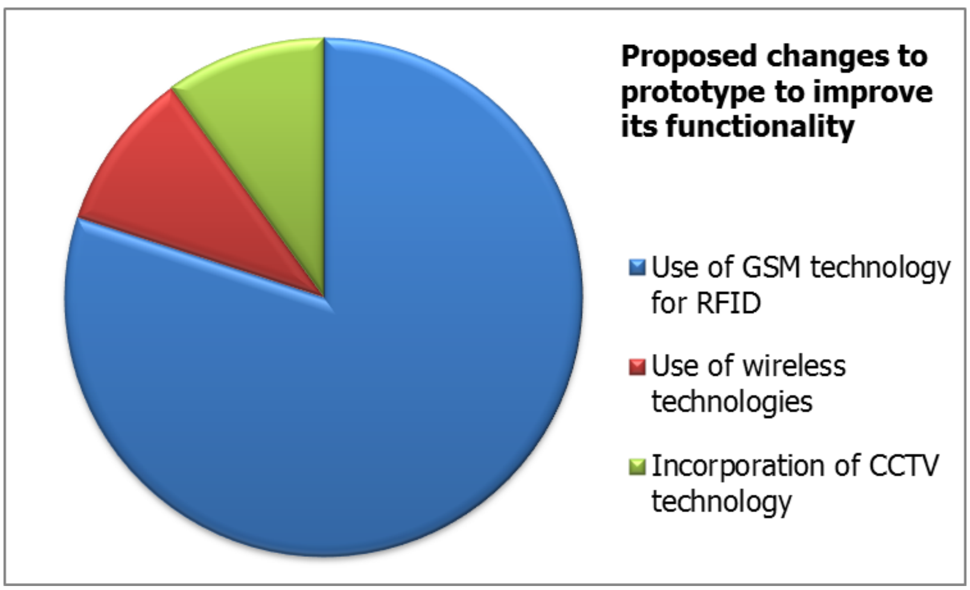

Figure 6.4 Proposed changes to the prototype

6.5 Analysis using Spearman's Rank Correlation coefficient

The significance of the rank correlation co-efficient is to get the rising rank of the variables and get the relationship of the likert value for the variables. Each variable is ranked separately from lowest to highest, which implies; 1, 2, 3, in an ascending order. The difference between ranks for each data pair is recorded. If the data are correlated, then the sum of the square of the difference between ranks will be small. The magnitude of the sum is related to the significance of the correlation. The Spearman rank correlation coefficient is calculated according to equation 3.1. For this particular case, the variables were classified as follows

INDEPENDENT	DEPENDENT
Acceptance of RFID Model	Use of Model in chicken tracking
	Use of model in chicken identification

Table 6.1 Variables used in the research

Stakeholder	Use of RFID system in chicken tracking	Use of RFID system in chicken identification	Average acceptance level	Stakeholder rank	Acceptability rank	Squared difference between ranks
Farmers, after prototype was developed	7	9	8	1	2	1
Agricultural experts in Nairobi, after prototype was developed	7	7	7	3	3	0
Agricultural organizations,	8	8	8	5	1	16

Table 6.2 Table for Pearson's rank analysis

Taking the two dependent variables, we assign them values based on the responses from the questionnaires. We seek the average response in a likert manner, to assess the comparison between, acceptance of the model in chicken tracking and acceptance of the model in chicken identification. Based on the positive or negative correlations, we seek to estimate the acceptance of the chicken tracking and identification model by stakeholders.

The likert scale used is between 1 and 9. It can be represented as shown;

Rank	1	2	3	4	5	6	7	8	9
Acceptance level	Extremely unacceptable	Very unacceptable	Unacceptable	Slightly unacceptable	Neutral	Acceptable	Fairly acceptable	Very Acceptable	Extremely acceptable

Table 6.3 Likert scale used

The graph of acceptance against stakeholder rank

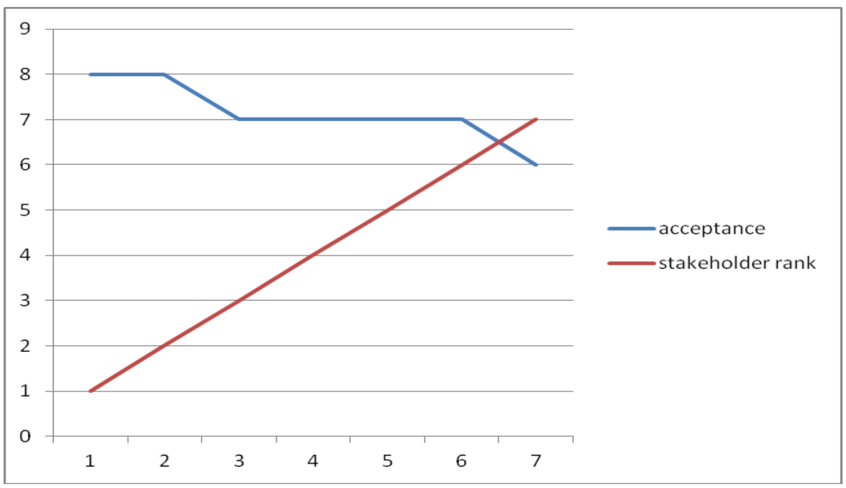

Figure 6.5 Acceptance among shareholder ranks

The spearman's rank can be calculated as follows; 204/210

$r_s =$ $[6\sum di^2/n(n^2\text{-}1)]$

$= [6(34)/6(6^2\text{-}1)]$

$= 0.9714$

Comparison between the values for data pairs; n (α) and the correlation coefficient can be done using the table shown in figure 13.

Number of data pairs	Level of significance (α) - one-tailed test			
	0.100	0.050	0.025	0.010
4	1.000	1.000	—	—
5	0.800	0.900	1.000	1.000
6	0.657	0.829	0.886	0.943
7	0.571	0.714	0.786	0.893
8	0.524	0.643	0.738	0.833
9	0.483	0.600	0.700	0.783
10	0.455	0.564	0.648	0.745
11	0.427	0.536	0.618	0.709
12	0.406	0.503	0.587	0.671
13	0.385	0.484	0.560	0.648
14	0.367	0.464	0.538	0.622
15	0.354	0.443	0.521	0.604
16	0.341	0.429	0.503	0.582
17	0.328	0.414	0.485	0.566
18	0.317	0.401	0.472	0.550
19	0.309	0.391	0.460	0.535
20	0.299	0.380	0.447	0.520
21	0.292	0.370	0.435	0.508
22	0.284	0.361	0.425	0.496
23	0.278	0.353	0.415	0.486
24	0.271	0.344	0.406	0.476
25	0.265	0.337	0.398	0.466
26	0.259	0.331	0.390	0.457
27	0.255	0.324	0.382	0.448
28	0.250	0.317	0.375	0.440
29	0.245	0.312	0.368	0.433
30	0.240	0.306	0.362	0.425

Figure 6.6 Spearman's correlation comparison table

From the table, it can be revealed that given the 6 pairs compared in the analysis, the value of 0.9714 is above the critical value for six pairs; comparing with the 95 percent critical level, $c_{ritical}$ = 0.829 indicates that the data has a correlation level above 95 percent, thus indeed significant. The significant level demonstrates that the RFID model is an acceptable system for chicken tracking and identification in Machakos County.

6.8 Summary on Findings

From the responses given by the farmers, it was clear that about 60% of the farmers felt the need for an IT system to be introduced for chicken tracking and management in Machakos County. The farmers determined to ensure that they help the research in any way possible to guarantee a better solution for them. Essentially, this was mitigated by the fact that a solution was already in the making. Discussion on how to deal with predators was extensive. There were different solutions proposed by the farmers. However, the use of the chicken tracking system was necessary to solve most of the problems faced by the farmers.

CHAPTER 7: DISCUSSIONS

7.1 General Research conclusions

The research done in this project entailed both primary and secondary data. Primary data was sourced from different stakeholders involved in chicken farming and poultry research. From their findings, there was need for a system to be developed. The proposed RFID system was effective in handling the challenges these farmers faced to some extent. However, there was need for more study on how best to implement the system so that it is active, and not passive as is the current solution. Many farmers were willing to invest more in an active system that consistently determined the position of their chicken at all times.

Secondary data revealed that there are six major different breeds of chicken in Kenya. These breeds are identified by their coloration, location of feathers, and absence of feathers on the neck and even the size of the chicken. These ecotypes include; the Molo Mushunu, the bearded cockerel, the feathered shanks, the frizzled chicken, the dwarf chicken and the naked neck chicken. All these chickens were consistently available in most parts of the country, as they were evenly distributed. Information on previous tracking systems developed using RFID technology was very fundamental in the development of the RFID system for chicken tracking and identification.

7.2 Achievement of Research objectives

7.2.1 Exploring existing solutions with regard to tracking of poultry

The exploration of existing solutions in chicken farming was greatly explored in the literature section of the research. These solutions include; precision farming, application of sensing technologies, vocalization analysis techniques and digital imaging systems. The systems available in the market were considered to be more expensive and complicated for the chicken farmer to understand and apply. They were also mostly in prototype stages and could not be availed for mass production.

7.2.2 Evaluating the reliability of RFID tracking as a solution to chicken tracking

This part of the research was the most difficult. Several prototypes were proposed for implementing the RFID tracking system. However, many of these systems were pre-emptive thus the researcher settled on the Arduino microcontroller. The reliability of the system was discussed by farmers and other poultry experts in various presentations and questionnaires. It was found to be efficient and reliable for the research. However, only a prototype could be developed with the time given.

7.2.3 Validation of an information system for chicken tracking of free-range chicken

The information system was validated through primary research. Stake holders were asked about how they felt about an information system for tracking free range chicken. Based on the responses given, most of them were willing to try. The research also tested the validity of the concept using a prototype, proving that the actual system would follow a similar line of implementation and reasoning. However, further research would be required to develop an efficient chicken farm management system and test it efficiently.

7.2.4 Determining the cost-effectiveness of RFID technology over other alternatives

The cost of the RFID system was basically more effective compared to the existing technologies. First, this was due to the availability of RFID systems. The prevalence of RFID readers and transponders within the country made the research less costly than anticipated. Alternative systems also require scientific experiments involving birds. In this case, it was not necessary to have these experiments, given that the prototype was consented and approved by poultry farmers in Machakos County.

7.3 Development of the RFID System

The RFID system was feasible in terms of the time limitations as well as the existing technologies. It required achieving cost-effectiveness and functionalities desired, imminently at the same time. The development also took advantage of the market-available tools that would not make it difficult for the farmer to develop an efficient system locally. The development included hardware encoding and interface development. All these functionalities were achieved simultaneously and in a synchronized fashion so as to have the system achieve the requisite functionalities.

CHAPTER EIGHT: CONCLUSIONS

8.1 General Research Conclusions

The research was done in Machakos County, among Chicken farmers. The goal was to get the farmers to appreciate the RFID technology, discuss possible implementation techniques as well as realize changes to the developed model to suit their individual needs. The farmers were made aware of the research intentions and objectives. They were provided with consent forms to indicate their agreement to participate in the research and their observations were recorded in accordance with the ethical research practices prescribed by Strathmore University. The research met its objectives in several ways; questionnaires were designed with a bias to meet objectives and research questions, interviews were conducted among specialists in poultry farming and management, modelling was done with the latest technology in the market and the model was in line with stakeholder needs and requirements. The overall result was that the developed model met the objective of the research and proved that chicken monitoring and identification could be done using RFID technology.

8.2 Recommendations

The recommended solutions to poultry farming in Machakos County include the following;

i. Introduction of an RFID system to monitor large scale chicken farms that exceed a poultry population of 100 in order to have the technology costs succinctly met by the production in the farm

ii. Use of GSM (Global System for Mobile) when implementing RFID technology in regions where internet connection is poor as well as areas when Internet Service Providers are unavailable

iii. Use of mifare classic technology for the tags to minimize cost of tags among large poultry flocks

iv. Use of smart technology such as smart phones and personal digital assistants to monitor the dashboard as opposed to having computers which offer minimal portability

8.3 Areas for further study

Among the areas noted for further study research include; the use of microwave technology in conjunction with radio waves for wireless monitoring and tracking, the use of Global Position Systems and Global System for Mobile to track sensors on chicken, as well the General packet Radio Service (GPRS) as alternatives to RFID. All these technologies utilize proximity sensor systems. With electromagnetic waves used, such as is the case in the application of RFID, there are many possibilities on wireless chicken tracking within long range proximity sensors. Research should also be extended to the realization of better identification technologies, using special scanning devices.

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Appendix A Research Questionnaire

A.1 Preliminary Research Questionnaire

Preliminary research questionnaire were used to gather information from stakeholders, before the system was developed. The list below demonstrates the questionnaire used to gather data from the respondents before the development of the system was done.

<u>Pre-Development Questionnaire on Suitability of RFID in Chicken Tracking and Identification</u>

Note: Every bit of information on this work shall be treated as confidential and as such, will not be used in any way to the disadvantage of the respondent. All respondents remain anonymous in the research.

SECTION A: For Poultry Farmers in Machakos County

1) How many chicken got lost in the course of the research?
   a) 20-50 ☐
   b) Less than 20 ☐
2) Did you face any challenges using the system?
   a) Yes ☐
   b) No ☐
3) What were some of the challenges you faced?

4) What was the main cause of loss or untimely death of chicken at your farm after introduction of RFID technology?
   a) Predation ☐
   b) Chicken theft ☐
5) Would you say that the technology was effective in chicken tracking and identification?
   a) Yes ☐
   b) No ☐

   If no, briefly explain your views on the system

6) Are you satisfied with the measures put in place by the RFID system to prevent chicken loss?

a) Very satisfied. ☐ b) Satisfied. ☐

c) Not satisfied ☐ d) Very dissatisfied ☐

7) Would you recommend the system to another farmer in Machakos?

    a) Yes. ☐

    b) No. ☐

8) Do you think the RFID system can be improved to serve you better?

    a) Yes ☐

    b) No ☐

    If yes, explain briefly

9) Any additional comments you like to give?

SECTION B: For Agricultural Extension officers in Machakos County

10) How many years have you been involved with poultry?

11) What are some of the concerns that lead to chicken death or loss at farms?

12) What measures/technologies are currently in place to minimize chicken theft or loss?

13) Have you ever considered an IT solution for chicken tracking and identification? If yes, which solution?

14) Would you consider the issue of chicken loss a major concern among poultry farmers? (Explain)

15) Would you be welcome to a technology that relies on IT infrastructure?

16) What would be the shortcomings of an IT-related chicken tracking and identification system?

17) Would you recommend the farmers in Machakos County to adopt an IT-related solution? If yes, explain briefly

SECTION C: For Non-Governmental organization practising poultry farming

18) How many years has this organization been involved in poultry research?

19) Are you aware about the concern of chicken loss, untimely death and theft in farms?

20) What can you day about the issue of chicken loss, as it impacts poultry farmers?

21) Are there any IT solutions to chicken tracking and identification currently in the market?

22) What identification techniques does your organization use for managing free range poultry?

23) Would you consider the issue of chicken loss a major concern among poultry farmers? (Explain)

24) Would you be welcome to a technology that relies on RFID technology?

25) What logistical challenges would one face with regard to chicken management using RFID technology?

26) Would you recommend the farmers in Machakos County to adopt an IT-related solution? If yes, explain briefly

27) Any additional comments you like to give?

Thank you for your time. We appreciate your input

A.2: Post-Development interviews

The respondents were interviewed twice in the course of the research. The interview questions used to gather preliminary information from the farmers, poultry experts and agricultural organizations after the system had been developed are as listed below;

Appendix B: User Manual for the RFID chicken tracking and identification system

B.1 Login into the system

In order to log into the system, the user has to input their code in the dashboard and press the return key (Enter). The dashboard is as shown in figure B.1

Figure B.1 The system dashboard

Upon login to the system, the interface shown in figure B.2 Appears

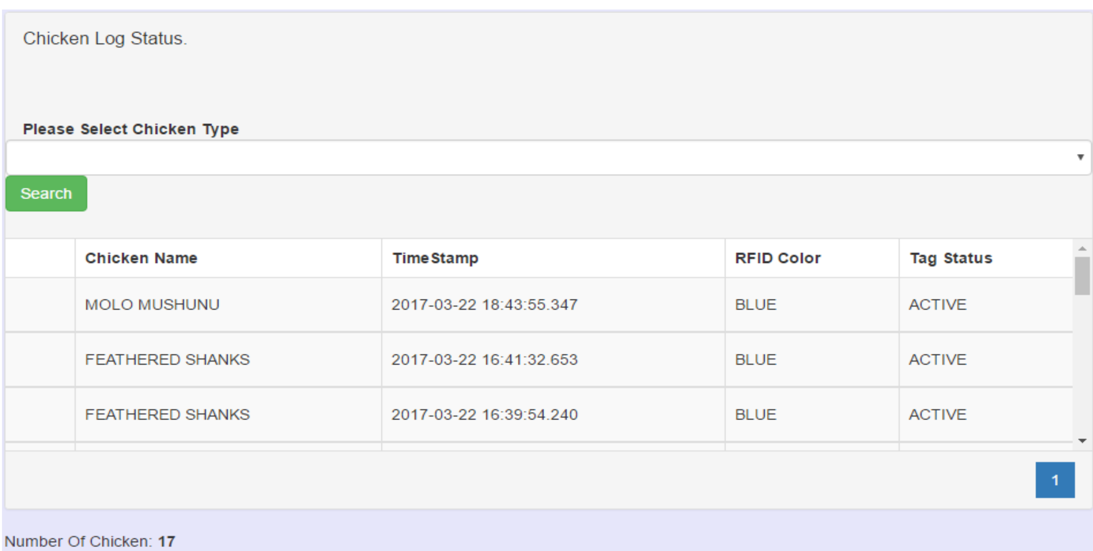


Figure B.2 Interactive web application for RFID chicken tracking system

B.2 Adding Records to the system

In order to add a new tag (with chicken) into the system, the user needs to press on the **settings** tab and select **Add Manager.** This will display a form for adding a new tag and its respective chicken. This can be demonstrated as shown in figure B.3

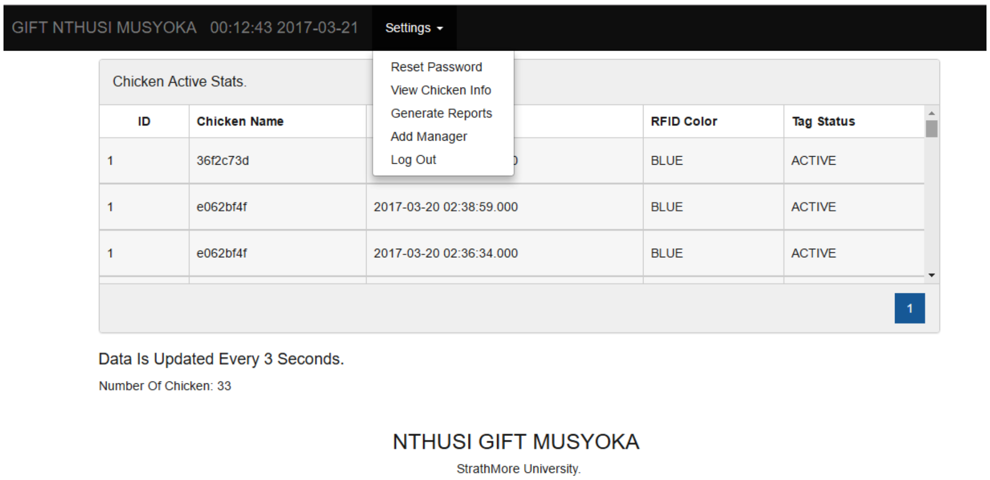


Figure B.3 Adding new chicken and tags onto the system

B.3 Log out from the system

From the settings tab, one simply selects; **logout** in order to log out from the system. This is as shown in figure B.4

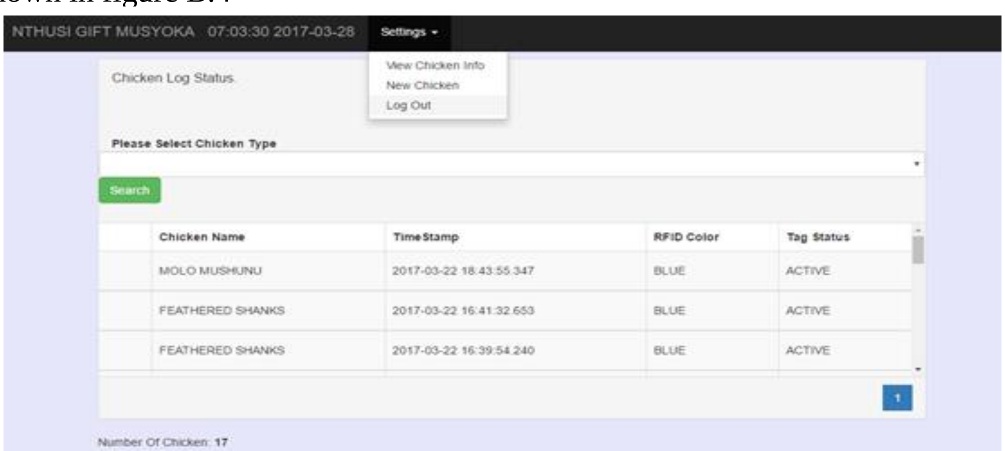
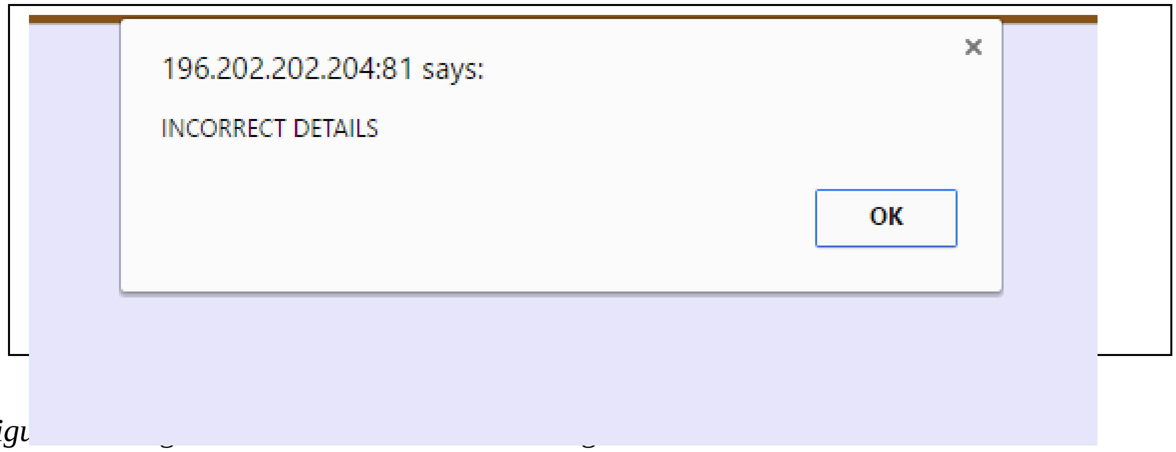


Figure B.4 How to log out from the system

Appendix C: System testing for the RFID chicken tracking and identification system

C.1 Integrity Testing

The usability of the system is important to the user. This is based on the system's validity tests and ability to accept data of varied nature. While login into the system, validation is guaranteed as shown;



Figu

The system also enforces data integrity within the database. This is as shown in C. 2;

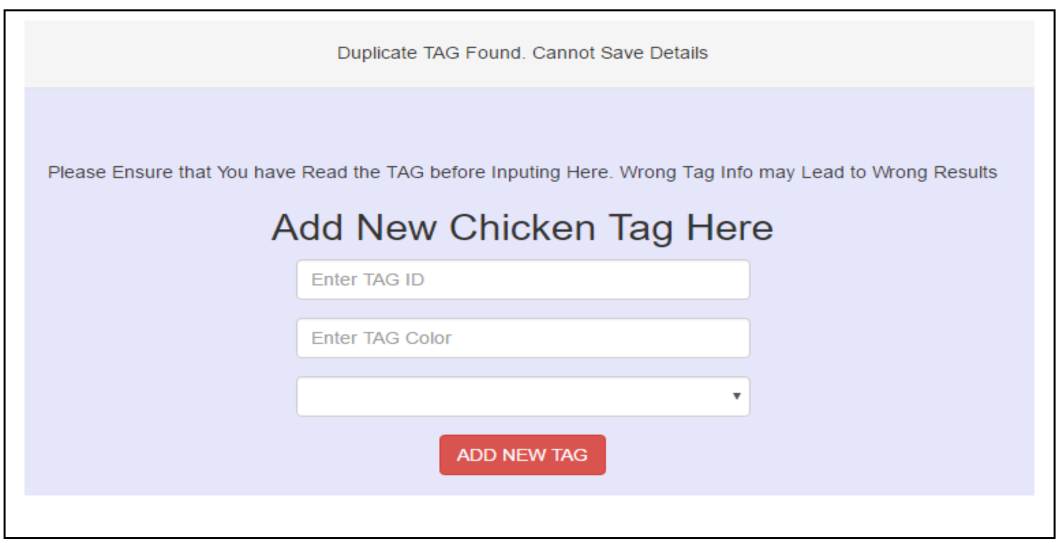


Figure C.2 Data integrity validation

Appendix D: Turn it In Report