Mobile-Based Decision Support System for Poultry Farmers: A Case of Tanzania

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A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Master's in Information and Communication Science and Engineering of the Nelson Mandela African Institution of Science and Technology

Arusha, Tanzania

November, 2021

ABSTRACT

In Tanzania, many poultry farms are considered to have ineffective poultry management practices mainly due to the lack of adequate systems and procedures to assist poultry farmers in making decisions. However, in a range of industries and agricultural sectors, including poultry farming, information is widely recognized as a crucial component for good decision-making. Furthermore, many researchers agree that using mobile decision-support systems to assist farmers in making better decisions is an effective technique. The goal of this research was to create a mobile-based decision support system that will assist small-scale poultry farmers in Tanzania in obtaining trustworthy poultry farming information that would enable them to make informed decisions about their farming operations. Decision Support Systems (DSS) are well-known in this context as interactive computer-based systems that assist individuals in problem-solving and decision-making using information technology, data, documents, and knowledge. This study outlines how a data-driven strategy was utilized to construct a decision-support system for Tanzanian poultry farmers. The systematic approach used in this study comprised of the following steps: The first step was to perform a thorough literature analysis to identify and assess the information management needs of Tanzanian small-scale poultry farmers. Poultry farmers commonly seek information about chicken health, housing, egg production, chicken diets, and chicken breeds, among other things. Second, the gathered data was processed and used to create user requirements for the decision support system. Finally, after determining user needs, the implementation of the mobile-based decision support system began. Using Android Studio and RASA, an open-source machine learning framework for developing chat and voice context assistants, a conversational, mobile-based decision support application that offers information to farmers based on their needs through a text-based chat conversation was developed. The study findings identified that majority of the small-scale poultry lack reliable sources to obtain poultry management information like poultry diseases, poultry feeds, housing, and breed types. Furthermore, after conducting a user acceptance test, the study findings indicated that the developed system will be very helpful to the small-scale poultry farmers, and therefore it was recommended that the extension officers and small-scale poultry farmers should be made aware of the developed mobile-based decision support system (KaPU) for productive poultry management practices.

DECLARATION

I, Martha Philemon Shapa hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this dissertation titled "*Mobile-Based Decision Support System for Poultry Farmers: A Case of Tanzania*" is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

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22nd of November 2021

Name and signature of supervisor 2   Date

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology a dissertation titled *"Mobile-Based Decision Support System for Poultry Farmers: A Case of Tanzania"* in partial fulfillment of the requirements for the degree awards of master's in Information and Communication Science and Engineering of the Nelson Mandela African Institution of Science and Technology.

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ACKNOWLEDGEMENT

First and foremost, I want to thank Almighty God for granting me the perseverance to accomplish this work, but also the Nelson Mandela Africa Institution of Science and Technology for allowing me to pursue my Masters' degree for two years.

My very special acknowledgment goes to my supervisor, Dr. Dina Machuve for being a mentor and the greatest facilitator for accomplishing this work and also Prof. Lena Trojer from Blekinge Institute of Technology, Sweden for her positive and great support of this research work.

Sincerely, this work would not have gone as smoothly if it hadn't been for the African Development Bank's support in all financial matters relating to the completion of this work, as well as my classmates from ICSE cohort eight's support from the introduction of this study idea to the dissertation's completion. In a unique way, I'd want to thank my family for their unwavering support, love, and encouragement during my study and till the completion of this research.

Lastly, it will be with great unjust if the following people were not recognized for their constructive ideas in accomplishing various phases of this research: Mr. Michael Hudson, Dr. Neema Mduma, Dr. Everest Maguo, and Mr. Stivin Nchimbi were very helpful from the concept note presentation, data collection, development of the system, and testing.

May the Almighty God bless you all.

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LIST OF ABBREVIATIONS AND SYMBOLS

API	Application Programming Interface
DFD	Data Flow Diagram
DM	Dialogue Manager
DSS	Decision Support System
GDP	Gross Domestic Product
HTML	Hyper Text Markup Language
IBM	International Business Machines Corporation
ICT	Information Communication Technology
IDE	Integrated Development Environment
JSON	JavaScript Object Notation
MySQL	My Structured Query Language
NBS	National Bureau of Statistics
NLG	Natural Language Generation
NLP	Natural Language Processing
NLU	Natural Language Understanding
OS	Operating System
PC	Personal Computer
PHP	Hypertext Preprocessor
RAD	Rapid Application Development
SDK	Software Development Kit
SDLC	Software Development Life Cycle
SMS	Short Message Service
SQL	Structured Query Language
TCRA	Tanzania Communications Regulatory Authority
UI	User Interface
UML	Unified Modeling Language
XML	Extensible Markup Language

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

The agricultural sector is one of the primary sectors that contributes to the economic development of developing countries. According to World Bank (2015), agriculture is the most prominent sector for poverty reduction in Tanzania. Significantly, Tanzania's National Bureau of Statistics (NBS) points that out of 55 million country's population 60%-70% of the population is employed in agriculture and 80% of this population are smallholder farmers (NBS, 2019). Agriculture is the main contributor to the growth of Tanzania's economy accounting for more than 25.7% of national gross domestic product (GDP), 30.9% of export earnings, and employs over one-quarter of the population (Lyatuu *et al.*, 2015; Saleque *et al.*, 2016).

Poultry farming is one of the important agricultural sectors that is practiced by the majority of small-scale farmers. It deals with the keeping of domestic birds mainly for generating income, or meat and eggs consumption (Temba *et al.*, 2016). Studies have identified that in Tanzania there are nearly 36.2 million chicken, with over 95% of them being raised by small-scale farmers in rural areas (Saleque *et al.*, 2016). The growth and advancement of poultry production accelerated for the last few decades due to the increase in demand for poultry products, and fast urbanization (Vernooij *et al.*, 2018). Poultry farming is one of the sources of income to many families, and therefore, it has gained prominent interest among women and entrepreneurs, according to various studies, the majority of poultry farmers are women, which is over 80% of Tanzania's farming population (Isaya *et al.*, 2018).

It has been identified that the poultry farming agricultural sector faces numerous challenges that hinder the development of this sector, they include inadequate extension information, poultry diseases, unreliable markets, and insufficient inputs (Temba *et al.*, 2016). Furthermore, shortage of extension officers, distant locations for consultations, and lack of awareness on available information sources constitute major problems to the Tanzanian poultry farmers (Lwoga *et al.*, 2011). It has been observed that lack of knowledge on proper poultry farming management practices has been attributed as one of the main challenges for the development of this sector, this is mainly caused by lack of trusted systems that offer reliable information concerning poultry management and help farmers in decision making. Therefore, rural poultry farmers highly depend on unreliable, and local sources of information to guide them in poultry farming (Msoffe *et al.*, 2018; Msoffe & Ngulube, 2015). As information highly contributes to the development of numerous agricultural sectors including poultry farming, the unreliable sources may offer information that hinders the development of this sector, particularly to the small-scale farmers in rural, peri-urban areas (Temba *et al.*, 2016).

Technology advancement highly contributes to the growth of the agricultural sectors, particularly poultry farming. The proper usage of Information Communication Technologies (ICTs) will make a significant improvement in poultry farming by assisting poultry farmers to have proper means of information attainment for making an informed decision. Studies show that mobile decision support tools have proven to be a successful way of assisting farmers in making decisions, which may include: Supporting farmers make decisions regarding the selling of their products, disease control, and health tips (Msoffe *et al.,* 2018; Singh *et al.*, 2017). According to International Business Machines Corporation (BMI, 2016), due to a growth in the usage of mobile communication technology, this research will contribute to and improve effective information acquisition for poultry producers, assisting them in decision making.

1.2 Statement of the Problem

Poultry farmers in peri-urban areas of Tanzania, who usually own 200 to 3000 chickens use: Paper and computer-based applications, mainly Excel for record-keeping, social media (WhatsApp and Facebook groups) to access information on poultry farming including farm health tips, and advertising their products to consumers. In contrast, rural poultry farmers seldom keep records of their poultry enterprises. They rely mainly on word of mouth from a few (two-to-three) neighboring farmers for market information and tips for managing their poultry health (Msoffe *et al.,* 2018). The information exchanged among poultry farmers and other stakeholders is subjective and usually unreliable. The proposed system will incorporate trust in the deployment of the proposed tools to enable farmers to make an informed decision for best management practices. The poultry farmers will be consulted during the design, and deployment of the mobile application to make sure the tool applies to their needs, hence increase the chance of usage.

However, various studies have identified that decision support system are used in helping the development of various sectors including: Health sector, academic sector, customer service industries, as well as the environmental, social, and economic sectors. The study by Mardhiyyah *et al.* (2019) described how Decision Support System (DSS) tools were used in the academic sector, for educational purposes and aiding the scholarship grantee selection. In the environmental sector, various technologies and DSS helps to aid solid waste management and hence help in environmental conversation (Vitorino de Souza *et al.,* 2017). Furthermore, chatbots as one of the DSS tools widely used in the customer service industries, as well as the health industry by supporting health professions trainees according to the study by Corral (2021). Conclusively, studies highlighted that DSS tools could help solve various problems in different sectors.

1.3 Rationale of the Study

In many industries and agricultural sectors, including poultry farming, information is critical to making informed decisions. It has been observed that there is a positive relationship between information flow and agricultural development, therefore proper knowledge and information contribute much to the development of poultry farming, particularly to small-scale poultry farmers in Tanzania (Lwoga *et al.,* 2010). The usage of mobile decision-support tools has been highlighted by a number of researchers as a successful method for helping farmers in making informed decisions (Msoffe *et al.,* 2018; Ogunti *et al.,* 2018). As this study aims to address the problem of reliable information shortage for the Tanzanian small-scale poultry farmers and assisting them to get proper and trusted information, the results will aid them in making informed decisions concerning poultry farming.

1.4 Research Objectives

1.4.1 Main Objective

To develop a mobile application that will enable poultry farmers to make informed decisions for productive poultry management practices.

1.4.2 Specific Objectives

(i) To assess the information management requirements of small-scale poultry farmers in Tanzania.

(ii) To develop a decision support-mobile application that can be adopted by small-scale poultry farmers in Tanzania.

(iii) To validate the developed mobile application.

1.5 Research Questions

(i) What types of information do small-scale poultry farmers in Tanzania need and seek most?

(ii) What are the development requirements for a decision support-mobile application?

(iii) What are the testing and validating processes for the developed mobile application?

1.6 Significance of the Study

The purpose of this research was to provide small-scale poultry farmers in Tanzania with convenient, fast, and secure access to vital poultry farming information which includes: Chicken health and diseases, chicken feeds, chicken breeds, housing, and eggs production, as well as enabling them to make informed decisions for productive poultry farming management practices. However, a shortage of extension officers is the major problem in this agricultural sector that could lead to time and money wastage for the small-scale poultry farmers. Therefore, proper usage of the developed mobile-based decision support system can significantly save time and cost for small-scale poultry farmers, for that reason, small-scale poultry farmers must not have to physically visit the distantly located extension officers for consultation since they will be able to attain basic poultry farming management information through the developed decision support system and make an informed decision.

1.7 Delineation of the Study

The goal of this research was to create a mobile-based decision support system that will assist small-scale poultry farmers in Tanzania in obtaining trustworthy poultry farming information that would enable them to make informed decisions about their farming operations. This study outlines how a data-driven strategy was utilized to construct a decision-support system for Tanzanian poultry farmers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, different works of literature that are relevant to this research study were analyzed. This literature has been examined in relation to decision support systems for various farming methods, as well as other comparable research projects.

2.2 Information Needs of Small-scale Poultry Farmers in Tanzania

Information is very important for the development of the agricultural sector. Information need is often linked with the information use, whereas the farmers require particular farming information when in need of using it. It has been observed that an informed person can make better decisions in solving a problem or accomplishing a certain task, and will be able to acquire benefits associated with information utilization (Msoffe & Ngulube, 2017). Similarly, a poultry farmer can make better decisions in proper poultry farming management practices, as well as solving problems associated with poultry farming, which may include disease problems or health tips of the chickens, chick feeds, and attainment of the poultry market.

According to Temba *et al.* (2016) the information needs of poultry farmers can be categorized into three categories, these include: Poultry farming inputs, market situation, and Extension education on poultry farming. Poultry farming inputs include chicken feeds, housing, and all essential tools needed in poultry keeping, market situation information is highly needed by poultry farmers to connect them with buyers, and also Extension education on poultry farming is the information and knowledge that poultry farmers need on the poultry diseases, poultry health, and chickens' nutrition, for the aim of making an informed decision on poultry keeping. This research applied the proper use of Information Communication Technologies (ICTs), particularly mobile technologies, by assisting poultry farmers to meet these information needs.

2.3 The use of Mobile Technology in Tanzania

Mobile technology and mobile computing refer to the computing devices, which include software, hardware, and communications with a characteristic of mobility. These mobile devices include mobile phones, laptops, pocket PCs, and smartwatches (Mramba, 2018). In this study's context, it refers to the poultry farming information dissemination through the use of mobile phones, as the medium of disseminating that information to the poultry farmers, to aid them in making an informed decision.

In Tanzania, mobile technology has become widely used in a variety of sectors including the agricultural sector, particularly poultry farming. In the past six years, there has been a radical increase in mobile communication usage in Tanzania. According to Tanzania Communications Regulatory Authority (TCRA, 2019) the mobile communication usage in Tanzania by December 2018; there were 43 621 499 registered subscribers which is equivalent to 81% penetration. Furthermore, the smartphone penetration in Tanzania has nearly quadrupled to 18.5% since 2010, with more than 8 million new smartphone subscribers (Mulamula, 2019). Taking advantage of the ever-growing mobile communication usage and smartphone penetration in Tanzania, this research aims at improving the means through which poultry farmers will attain trusted information for making an informed decision on proper poultry farming management practices.

2.4 Other Related Works

According to Fue *et al.* (2016) farmers were served by an agro-advisory, online-based, and mobile-based system named 'Ushaurikilimo,' which allowed them to obtain advisory services from the extension officer through the web or mobile phone. It also serves as a two-way SMS communication method for farmers and specialists. Farmers can ask for help from specialists in agricultural-related matters such as livestock care, farming methods, marketing activities, and aquaculture via SMS on the site, which is now only available in Tanzania.

A chatbot called FarmChat by Jain *et al.* (2018) was designed to provide information to the small-scale farmers in rural India. Furthermore, this system operates by answering the farmers' farming-related questions. According to Jain *et al.* (2018) the system used IBM Watson in developing the Farmchat. It has two different interface modes: Audio-only and audio+text. The authors indicated that the study was conducted in rural India with 34 potato farmers, these farmers said the chatbot provided them with enough knowledge to help them. The authors also suggested that varied conversational help provided via smartphones could be an efficient strategy to improve information access for those in rural areas who have limited information sources and literacy.

According to Arora *et al.* (2020) Agribot is an interactive chatbot developed to assists farmers in solving various farm-related problems, weather prediction, and crop disease detection. The authors' Agribot chatbot was developed using sequence-to-sequence learning, this method enables the machine to learn by matching the questions and their responses (Arora *et al.,* 2020). The authors suggested that the model should be trained with a huge amount of data, for the chatbot to be more generalized in terms of conversation (Arora *et al.*, 2020).

Kilimo Salama is an East-African, index-based insurance platform that offers advice to the small-scale farmers dealing with crop cultivation, crops like wheat and maize, on harsh weather conditions like heavy rainfall or strong winds, that may hinder the growth of their crops (Arnoult, 2019). It is Index-based since the payouts are determined by comparison with regional rainfall patterns. 'Kilimo Salama' platform helps farmers to avoid the risks of heavy rainfall that may directly affect their crops and livestock and offers advice on the best time for the farmers to cultivate their crops.

The M-farm is an existing application based in Kenya, according to Baumüller (2015) the M-farm platform identifies and connects farmers with buyers by offering information on the price, quantity, and locations of the crops. The main purpose of this platform helps farmers plan on the production processes better aiming at getting higher profits since it reduces the uncertainty of projected profit.

This study is different from the previously discussed related works in that, this study addressed the small-scale poultry farmers' information attainment problems. The approach used by this study was to develop a mobile-based decision support system that would offer basic information regarding poultry health and diseases, feeds, housing, egg production, and breeding. The main tools used in the development of the mobile-based decision support system are the android studio and Rasa framework. However, the approach and tools used in the accomplishment of this study are different from the approaches and tools used in the previously discussed related studies in that, Rasa framework is identified to be more versatile and effective in the development of contextual conversational assistants compared to other methods like Google Dialogflow, Microsoft bot, IBM Watson, and sequence-to-sequence learning (Sharma, 2020). Conclusively, the approach and tools used in this study make it more efficient and effective in solving the Tanzanian small-scale poultry farmers' information attainment problem.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

This chapter deliberates the various research methodologies employed in this study. Furthermore, this chapter discusses the research study area as well as the data collection methods used, requirements gathering, research architecture design, along with how the decision support system has been developed and validated. Moreover, in addressing the second specific objective of this study, this chapter explains how a mobile-based decision support system was developed and implemented to help Tanzanian small-scale poultry farmers make proper decisions.

3.2 Research Study Area

This research was conducted in Tanzania, based in the Arusha, Morogoro, and Manyara regions. Morogoro was chosen because it indicates one among the leading regions in Tanzania in poultry keeping, ranging from approximately more than two million chickens respectively, other leading regions in poultry keeping include Tabora, Singida, and Shinyanga. Manyara was chosen to represent one among the second leading regions in poultry keeping at a range of one to two million chickens, other regions include Kilimanjaro, Dar es Salaam, and Dodoma. Lastly, Arusha was chosen to represent the least poultry-keeping regions in Tanzania that keep the least chickens ranging from zero to one million chickens, other regions that keep the least chickens include Njombe, Kigoma, Lindi, and Katavi.

The study areas were selected based on the range of the chickens that they keep as indicated in Fig. 1. The main aim was to study the information-seeking behaviors of the poultry farmers in different regions and identify the information that they mostly seek, based on the range of the number of chickens that they keep.

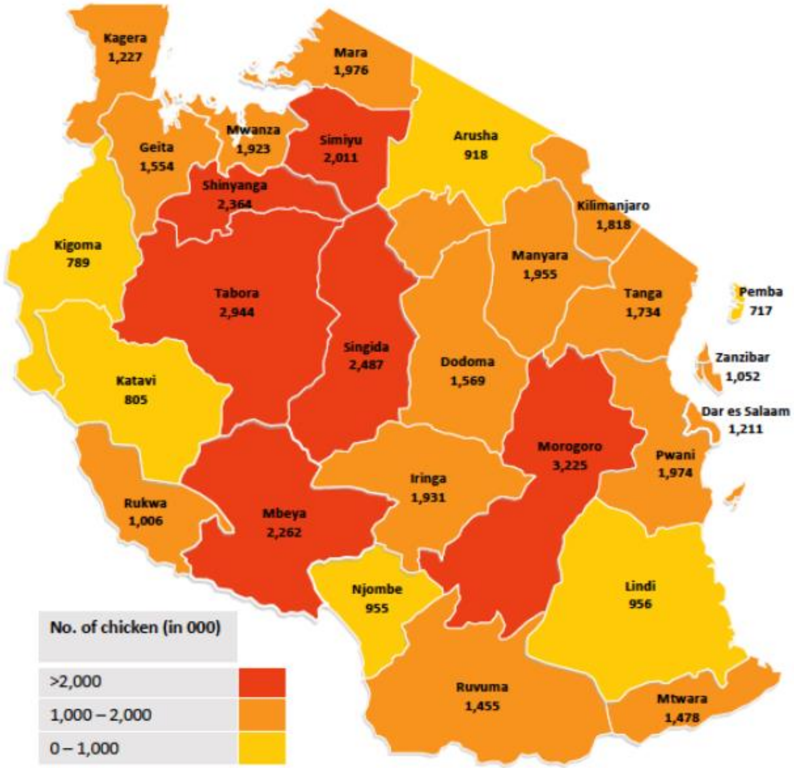

Figure 1: Tanzania map indicating a poultry-keeping range in the selected regions

3.3 Requirements Gathering

The primary goal of this research was to develop a mobile application that would enable poultry farmers to make informed decisions for productive and effective poultry management practices, therefore in the process of the development of the Decision-support system for poultry farmers, the information requirements for the development of the system were first gathered and assessed. The information management requirements were gathered through both unstructured interviews and casual conversations with the veterinarians and the small-scale poultry farmers, as well as the literature review. The unstructured interview was done to determine the small-scale poultry farmers' information-gathering activities, the information that they most frequently seek, and the sources that they use for the attainment of information for poultry farming. The unstructured interview was conducted to obtain a loose set of requirements among 5 small-scale poultry farmers and one extension officer in Morogoro, 6 small-scale poultry farmers, one extension officer in Manyara, and 10 small-scale poultry farmers, two extension officers in Arusha.

An extensive literature analysis was used to determine and evaluate the information management needs of poultry farmers. The functional requirements for the mobile-based decision support system for poultry farmers were based on the stated information management requirements, by providing them with important poultry farming information that they mostly seek for productive management practices. The information that small-scale poultry farmers most seek for better and productive poultry management techniques was determined through extensive literature analysis, and it includes information regarding chicken health, chicken feeds, housing, egg production, and chicken breeds (Khobragade *et al.,* 2019; Folitse *et al.,* 2018). The assessment of the information management requirements for small-scale poultry farmers determined through the literature review as summarized in Table 1.

Table 1: Information management requirements of poultry farmers

S/N	Literature Author	Sample Space (N)	Information Need	Frequency	Percentage (%)
1.	Msofe *et al.* (2018)	187	• Disease Control • Breads and Breading • Housing and Shelter • Feeding and Nutrition	187 78 56 47	100 41.7 29.9 25.1
2.	Temba *et al.* (2016)	160	• Poultry Disease • Poultry Nutrition • Housing	112 92 92	70 57.5 57.5
3.	Folitse *et al.* (2018)	150	• Disease Management • Eggs Production • Feeding and Nutrition • Shelter	145 114 112 108	96.7 76 74.7 72
4.	Khobragade *et al.* (2019)	60	• Health and Disease • Feeding Management • Housing Management	56 55 53	93.34 91.67 88.34

From the information management requirements obtained and assessed in Table 1, the information that the small-scale poultry farmers mostly seek is information about poultry health and disease control, feeding management and nutrition, eggs production, breed, and breeding, as well as housing and shelter. Table 1 has illustrated that the majority of the small-scale poultry farmers mostly seek health and disease control information compared to other information management requirements. The study by Msoffe *et al.* (2018) that was conducted on a sample space of 187 people, indicated that 100% of the population (sample space) frequently seek information about poultry disease control, other information management requirements frequently sought include:

41.7% for breeds and breeding, 29.9% for housing and shelter, and the least is 25.1% of the population for feeding and nutrition.

Similarly, the studies conducted byTemba *et al.* (2016), on the population of 160 people, Folitse *et al.* (2018) on the population of 150 people, and Khobragade *et al.* (2019) on the population of 60 people, identified that the leading information requirements that the small-scale poultry farmers most frequently seek are poultry health and disease control by 70% of the population, 96% of the population, and 93.34% of the population respectively. On the other hand, as indicated in Table 1, housing and shelter are the least information requirements that the small-scale poultry farmers frequently seek by 57.5% of the population, 72% of the population, and 88.34% of the population respectively.

Finally, the data collection methods that were used to obtain the information management requirements of the small-scale poultry farmers are; unstructured interviews to obtain primary data containing a loose set of requirements, and a thorough literature review to obtain secondary data containing information management requirements of the small-scale poultry farmers that were identified, assessed, and summarized in Table 1.

3.4 System Design Methodology

The Software Development Life Cycle (SDLC) methodology was employed to develop a mobile-based decision-support system. The SDLC refers to the set of steps used by developers in software development. These steps in SDLC divide the development process into tasks that can easily be assigned, completed, and measured to meet the software development objectives (Yeng *et al.*, 2020). There are a number of SDLC models, each of which has its own set of phases for completing tasks in the software development process (Gaikwad, 2015). According to Gaikwad (2015) and Yeng *et al.* (2020) the types include the waterfall model, Agile model, Incremental model, the Spiral Model, and the Rapid Application Development (RAD) model.

This study incorporated the use of the RAD model from requirements gathering to system development and testing. The RAD is one among the software development models that emphasize less cost and fast release of a prototype and system in a short period (Santos *et al.*, 2019). Moreover, RAD focuses on an interactive and incremental delivery of a working system to the user, therefore, it is easier to integrate changing requirements (Santos *et al.*, 2019). It is an appropriate platform for faster development and testing of applications. The RAD model that was employed in this research as shown in Fig. 2.

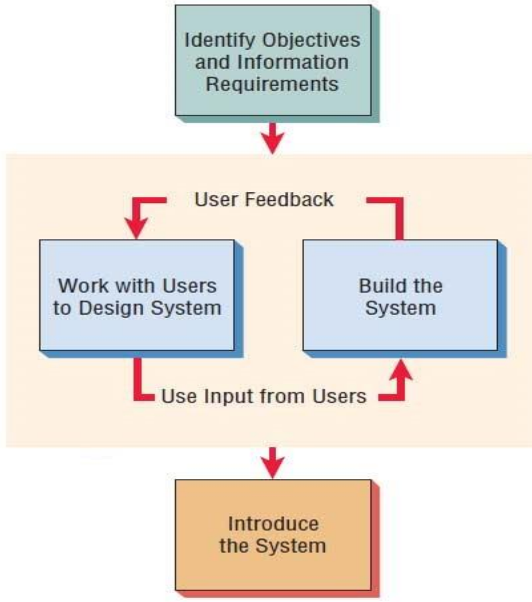

Figure 2: The system's Rapid Application Development model

3.5 System Modeling

In this study, before the implementation of the Mobile-based decision support system, system modeling was conducted. The system modeling process involved developing abstract models of the system. The system structure was modeled using the Unified Modeling Language (UML). Furthermore, UML was used in planning, organizing, and visualizing the system before implementation. The UML was used in mapping the mobile-based decision support system using the Data Flow Diagram (DFD) as indicated in Fig. 3, Use case diagram, and Class diagram.

3.6 Data Flow Diagram

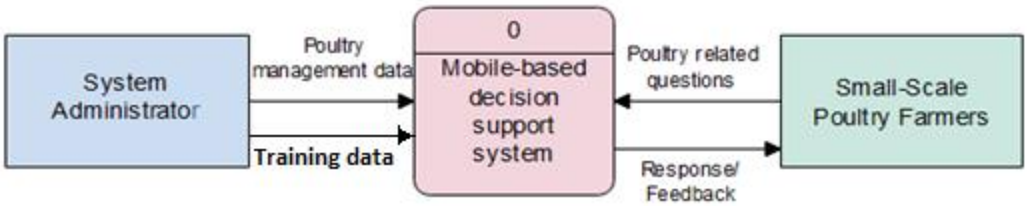

Figure 3: Data Flow Diagram context diagram

3.6.1 Use Case Diagram

The use case diagram was used in this study to explain the system's capabilities and behavior from the perspective of the system user. It was also used to determine how the user would interact with the system and to assist in the definition and organization of system requirements. As indicated below, Fig. 4 and 5 depict the use case diagrams for the system administration and mobile poultry farmer subsystems, respectively. Both, Fig. 4 and 5 depict a fully functional mobile-based poultry farmer's decision support system

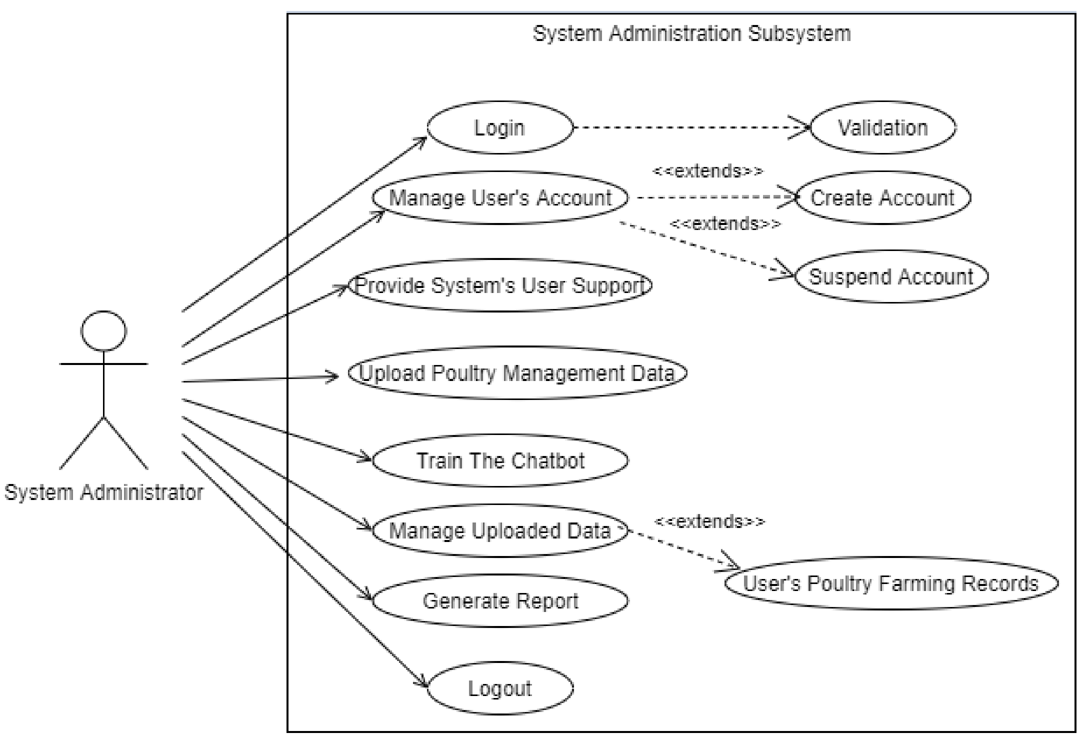

Figure 4: Use case diagram for the system administration subsystem

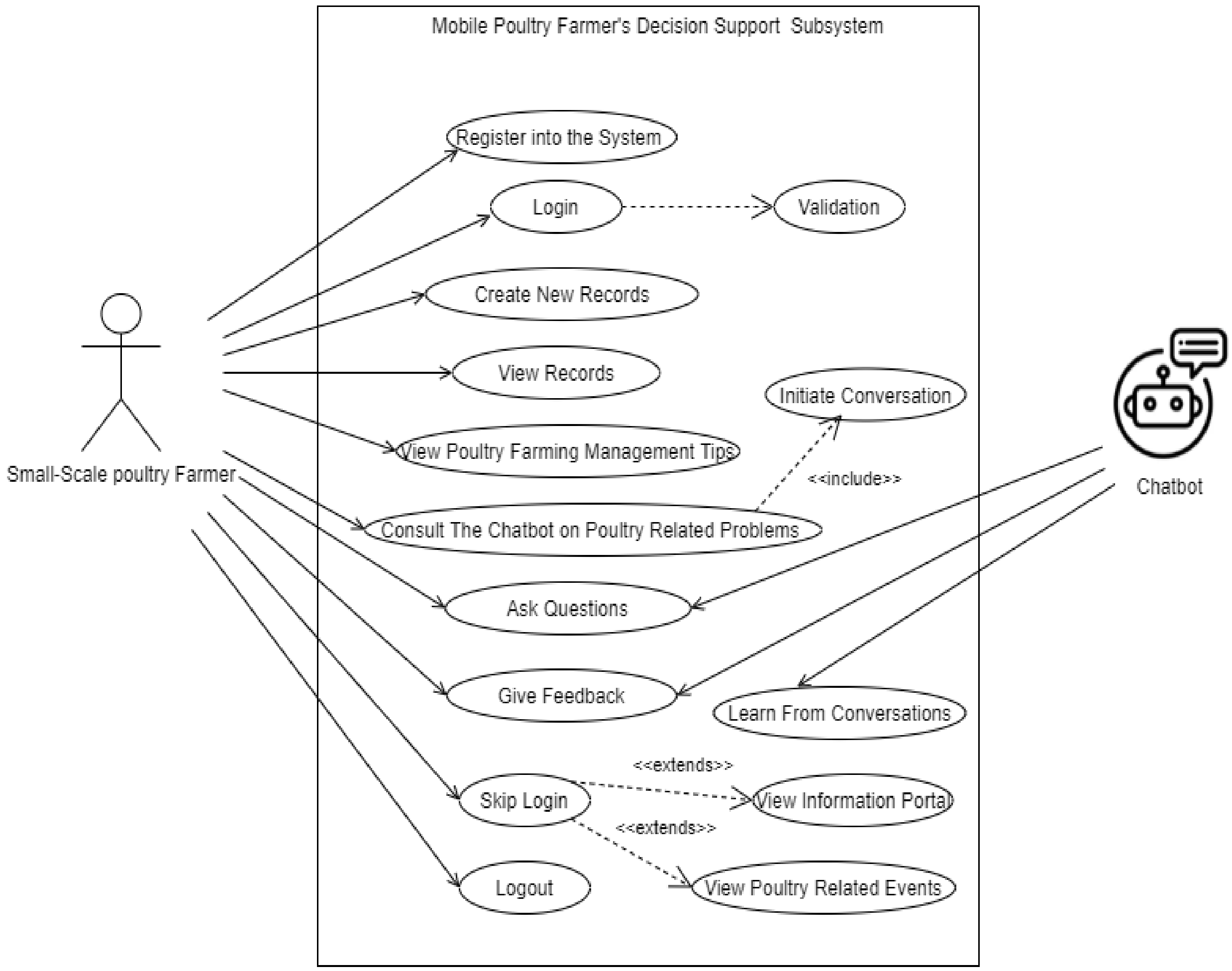

Figure 5: use case diagram for the mobile poultry farmer's subsystem

3.6.2 Class Diagram

The class diagram in the UML model refers to a graphical representation of objects in the system and what they can do. It defines the objects that are present in the system and the relationship that exists among them. Moreover, it provides an overview of how the system was structured before implementation or studying the actual code, this reduces the maintenance time. In this study, as illustrated in Fig. 6, a class diagram was used to map out the structure of a mobile-based decision support system by modeling classes, attributes, methods, and the relationship that exists between the objects.

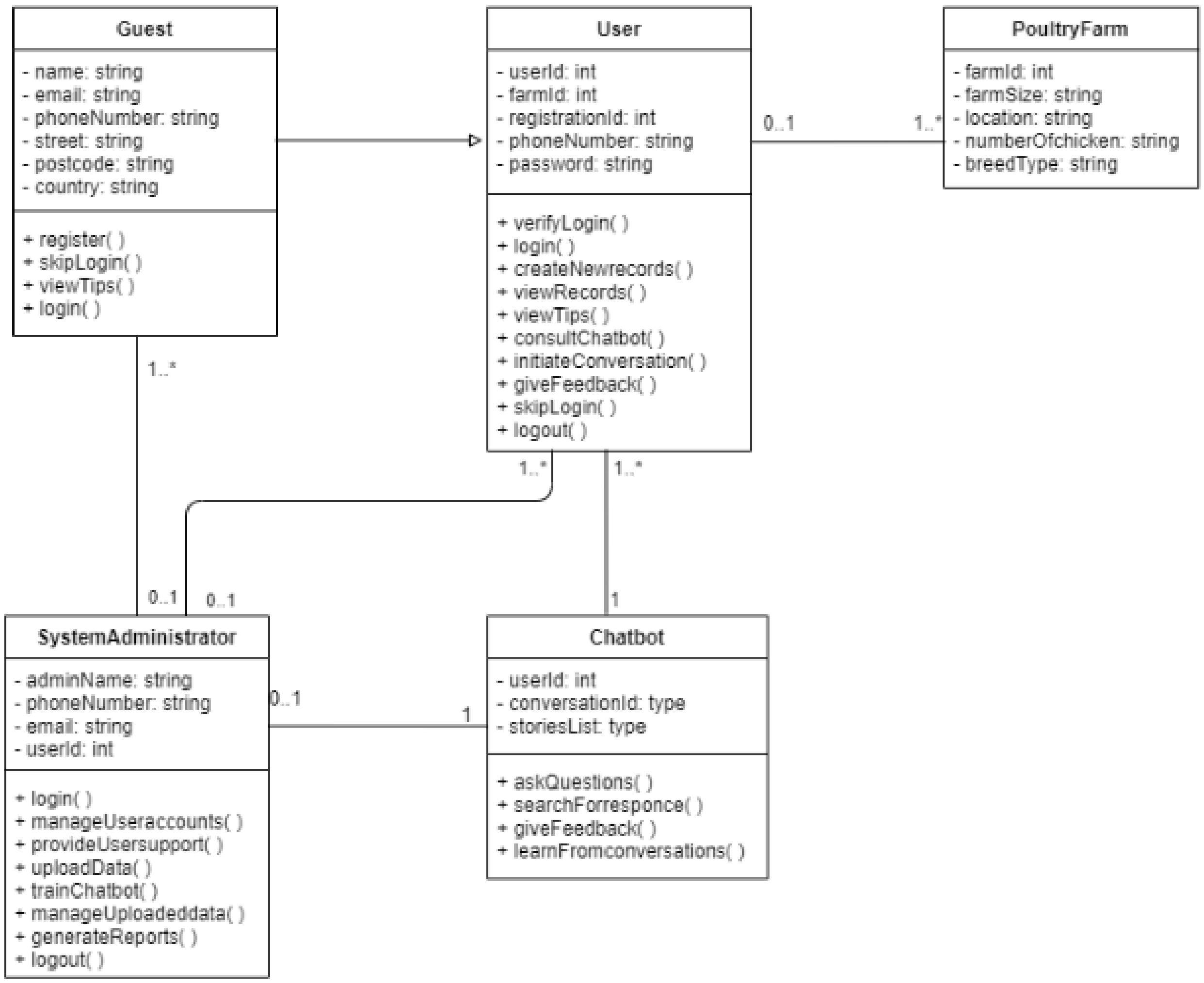

Figure 6: System class diagram

3.7 Architectural System Design

The proposed design of a mobile-based decision support system was divided into two sub-systems: The mobile application, and the decision support sub-system at the Natural Language Processing (NLP) layer.

The mobile application is the major subsystem that the poultry farmers interact with. The android studio, XML, and JAVA programming languages were used to develop the mobile application. In this study, the mobile application is the final subsystem that will help the poultry farmers to keep records of their daily poultry farming activities, view their records, view poultry farming management tips, and be able to interact with the decision support system for consultation for the small-scale poultry farmers to be able to make a proper decision for productive poultry farming.

The decision support subsystem is on the Natural Language Processing Layer. In this study, the decision support subsystem was referred to as a conversational assistant (chatbot) that was developed using a Rasa framework (Sharma, 2020), and then trained using example questions and answers based on the information management requirements that were obtained in requirement gathering. Rasa framework refers to an open-source framework that is used in building conversational assistants known as chatbots, these contextual conversational assistants use Natural Language Processing (NLP) in understanding and giving responses to queries (Bagchi, 2020; Sharma, 2020).

Rasa NLU and Rasa Core are the two primary components of a chatbot created with the Rasa framework (Sharma, 2020). The conversational assistant uses Rasa NLU to retrieve structured data in the form of intents and entities from unstructured common human language inputs (Bagchi, 2020; Sharma, 2020). However, Rasa Core is also known as our assistant's brain. Rasa Core is in charge of producing responses through the Rasa NLG component and anticipates how the chatbot will respond based on the current status of the conversation (Bagchi, 2020; Sharma, 2020).

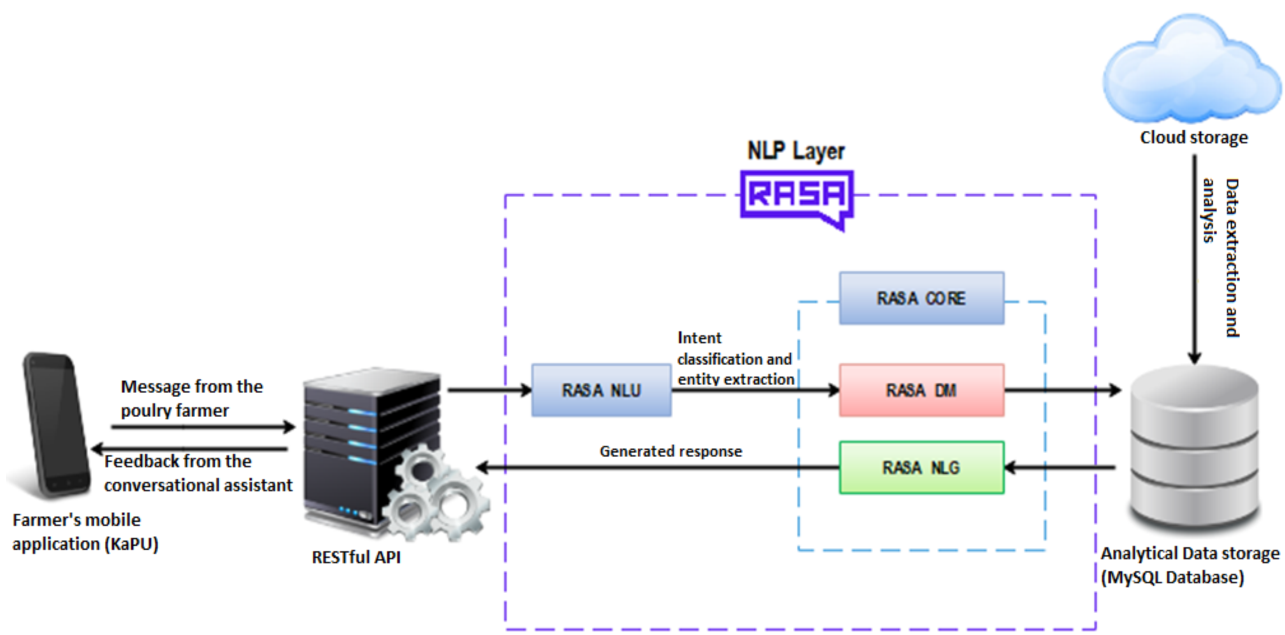

Figure 7: A proposed conceptual framework

3.8 System Implementation

This section of this chapter, explains different software tools that were employed in the implementation of the poultry farmers' mobile-based system for decision support. The tools that were used vary from the integrated development environment, computer programming language, frameworks to the database. Each system implementation tool is as described below in this section:

3.8.1 Android Studio

Android Studio refers to an integrated development environment (IDE) that is widely used for android application development. It is one of the tools used with the JAVA programing language in the development of an android application (Sarkar *et al.*, 2019) in this study. Android studio was chosen in this study because it is extensively used in the creation of android mobile applications (Sarkar *et al.*, 2019). Moreover, android mobile phones are commonly utilized by small-scale farmers, according to Saengwong and Koksantia (2020).

In this study, the Android Studio was used to create a mobile application. Jelly Bean 4.3 is the bare-bones version of the Android OS, with a minimum SDK version of 16 and an API level of 28 as the desired SDK version; the minimum API level 16 was chosen to allow compatibility of the developed Android application with a wide range of android smartphones.

3.8.2 Java

Java is a general-purpose, object-oriented programming language that is used to support the development of many applications (Ashfaq *et al.*, 2019). To achieve this study's main goal, Java was employed in the development of an android mobile application using an android studio.

In this study, Java was used because it is usually secure, reliable, and fast in application development, and therefore, it ensures high performance, security, and stability of the developed application. Moreover, Java is a more convenient programming language for software development because it runs on numerous operating systems including Windows, and Linux (Ashfaq *et al.*, 2019). The sample Java code used in the implementation of an android mobile application to achieve the objective of this study is as illustrated in Appendix 3.

3.8.3 Extensible Markup Language

The Extensible Markup Language (XML) is a data-encoding markup language. The XML has a high data storage capacity, and therefore it is suitable for being extensible compared to other Markup languages (Silva *et al.,* 2020). Furthermore, XML is proved to be an effective Markup language for Android mobile application development because it is compatible with Java, and both languages are used in the development of android applications. It can easily be merged with a style sheet which helps in creating different outputs.

This study used XML in the development of an android application, particularly in creating layout files. The sample XML code used in the implementation of the developed mobile application is illustrated in Appendix 2.

3.8.4 Rasa Framework

The RASA framework is an open-source machine learning framework that is used in the development of automated text and voice conversational assistants (Gunawan *et al.*, 2019). The conversational assistants are known as chatbots, they can understand messages, hold conversations with a human being, and connect to messaging channels or APIs (Bagchi, 2020; Gunasekara & Vidanage, 2019).

In this study, the Rasa framework was used in the development of a chatbot for holding conversations with the small-scale poultry farmers, and assist to answer their poultry-related queries. The chatbot created in this study was connected to an android mobile application using an API. The sample code used in the Rasa NLU configuration and Rasa chatbot development is illustrated in Appendix 4.

3.8.5 Laravel Framework

Laravel is an open-source PHP framework that is fast and easy to use. Laravel is widely used for web application development because it makes web application development easier and faster because of its built-in features (Zanin & Wernke, 2019). Moreover, Laravel can be used to develop a robust backend of an android application, by providing a significant backend infrastructure to sync the data from the android application and perform functions. A robust backend of an android application was achieved by the use of a Laravel API on a cloud that performs the backend processing, and to build a fully functional yet useful application (Zanin & Wernke, 2019).

In this study, Laravel was used to improve the backend infrastructure of our developed android mobile application to sync the data that was stored through the mobile application to a MySQL server.

3.8.6 Hypertext Preprocessor

The PHP stands for Hypertext Preprocessor and is a server-side scripting language. When embedded into HTML, it can be used to create a web application. The PHP is compatible with all major operating systems (Linux, Windows, Unix, and Mac OS) (Anderson & Hills, 2017; Zanin & Wernke, 2019). The PHP works on many servers and supports a variety of databases. Moreover, it can be used to add, delete, and modify data in the database (Anderson & Hills, 2017).

In this research study, PHP was used in the implementation of an android mobile application, and system administrator’s subsystem because it runs on a wide range of platforms including Android. Furthermore, it was used with the Laravel PHP framework to connect with databases and run queries more easily. The sample PHP codes used in the development of this app are illustrated in Appendix 5.

3.8.7 My Structured Query Language

The MySQL (My Structured Query Language) is a Structured Query Language (SQL)-based open-source relational database management system (Ohyver *et al.*, 2019). It runs on a wide range of platforms Linux, Windows, and Mac OS, which gives the developers flexibility in development processes. Furthermore, it implements a client-server model that consists of a multithreaded SQL server to provide a faster, and easier-to-manage standalone application (Ohyver *et al.*, 2019). The MySQL in association with PHP or Perl scripting languages can be used in the development of a web application that will interact in real-time with the MySQL database (Anderson & Hills, 2017). Additionally, MySQL database can be used in the development of an Android application, using a Web Server, the data in the MySQL database can easily be accessed from the Android application.

This study used MySQL database in the development of an android mobile application with the support of the Laravel framework, this is because Laravel makes it extremely simple to connect with databases, and to run queries. Moreover, the MySQL database server was used in this study because of its outstanding security features, which ensures that only the authorized users can access the database server.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

This chapter discusses the developed mobile application and system testing and validation of the mobile-based decision support system. Furthermore, this chapter also includes the results of the validation process, which addressed the study's third specific objective, which was to validate the developed mobile application, as well as the results of the second specific objective, which was to develop a decision support-mobile application that could be adopted by small-scale poultry farmers in Tanzania.

4.1.1 Development Results

The major goal of this study was to create a mobile application that would allow poultry farmers to make informed decisions about how to manage their flocks more productively. However, the materials and methods used in the implementation of the mobile-based decision support system were outlined in the previous chapter, as well as the tools used for implementation. This section, therefore, discusses the results of the implementation processes using the analyzed materials, tools, and methods in the previous chapter.

(i) Mobile Application

Based on the main objective of this study, the mobile-based decision support system was developed, the main interface in this system that interacts with the small-scale poultry farmers is the mobile application. The mobile application was built with an Android studio and then connected to a chatbot to answer various small-scale poultry farmers' questions about poultry farming and give them with credible poultry farming information for effective poultry management techniques. Furthermore, the mobile application was developed based on the information management needs of the poultry farmers presented in Table 1.

The developed mobile application as demonstrated in Fig. 8 comprises the login user interface and the home interface. On the login interface, the small-scale poultry farmer can register into the system, and the system administrator will approve the registration, and therefore the small-scale poultry farmer becomes an authorized user of the system that will get access to all continents and services of the system. After the user has successfully been registered into the system, the user can log in by using a phone number and a password. As illustrated in Fig. 8, after the user logs in successfully, he or she will access all the services that are provided by the system, these includes: Consultation with our conversational assistant, being able to keep records of the daily poultry farming activities as well as to view the record, lastly, the user will be able to read various poultry farming tips on the information portal, as well as getting updated on the farmer's events that will educate this small-scale poultry farmer, and enable him or her link with other poultry farmers in Tanzania. However, the registered and unregistered users can both skip login, but this will lead to being limited with the services that the developed system offers, therefore, after skipping login, the user will only be able to read the poultry farming management tips, and get updated on the upcoming poultry farmers' events. The user interface of the developed mobile application (KaPu) is illustrated in Fig. 8.

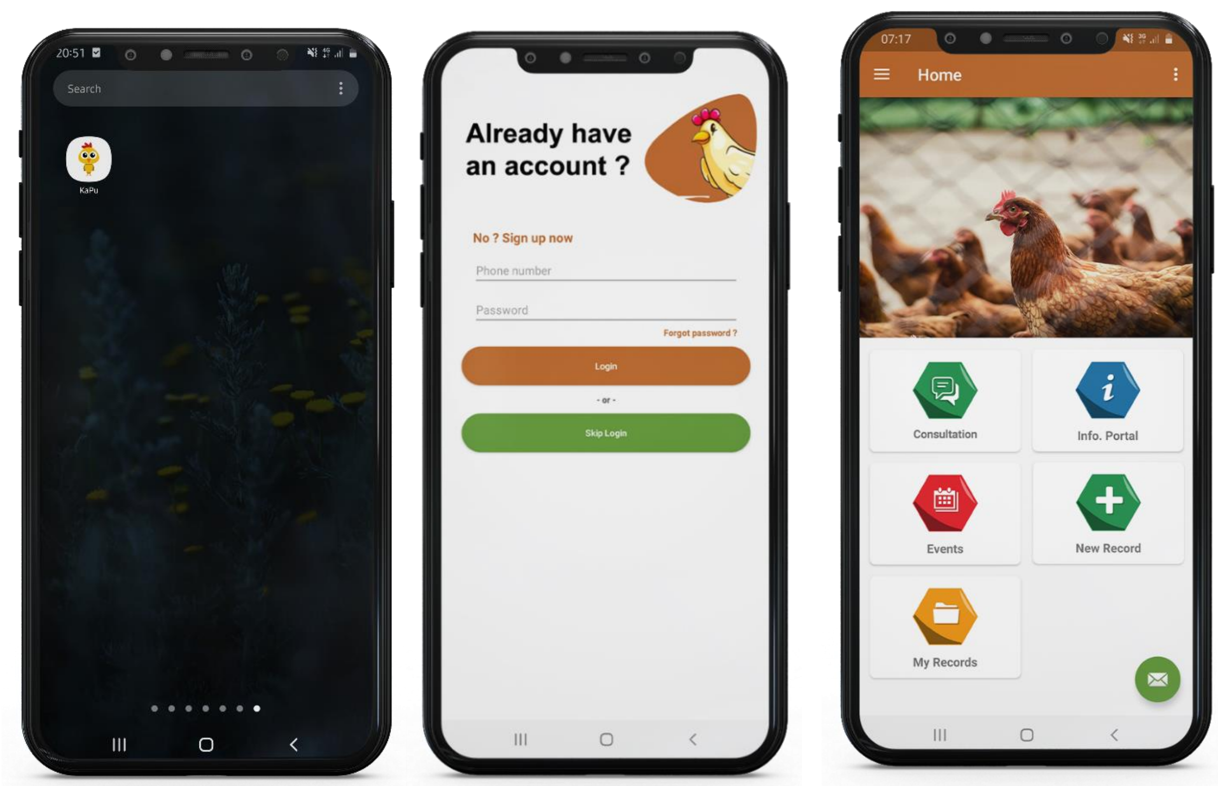

Figure 8: Mobile application User Interface

After an exhaustive literature review and various unstructured interviews, the poultry farmers' indicated information management requirements were evaluated. The requirements that were identified were then used in the implementation of the mobile application specifically in the information provisional module, new records module, and the consultation module. The information management requirements that were identified implied the information that the majority of small-scale poultry farmers are looking for to guide them in their poultry farming activities. These included information about chicken health, housing, egg production, chicken feeds, and chicken breeds. Moreover, the user will be able to read and contents of these requirements on the information portal as illustrated in Fig. 9. The registered user will also be able to keep records on the daily poultry farming activities, which includes; flock management, feed management, medication, and finances. The mobile application records keeping UI is illustrated in Fig. 9.

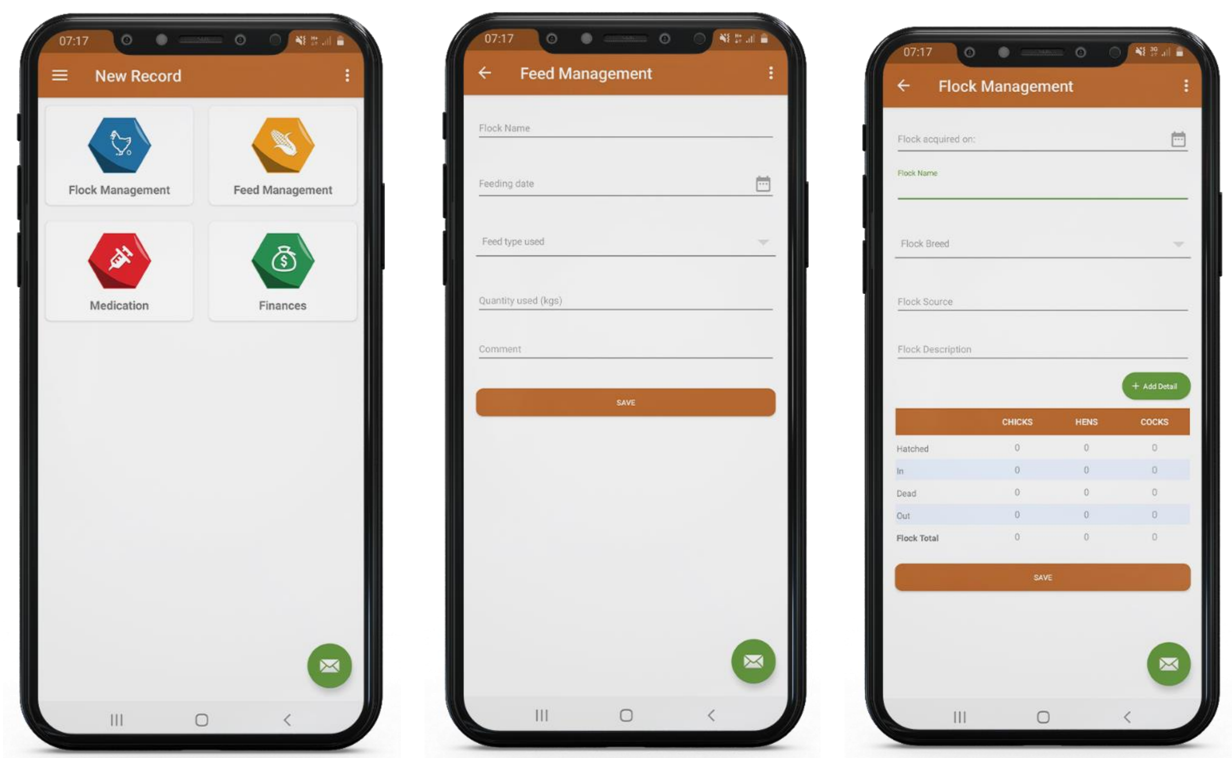

Figure 9: The mobile application records keeping User Interface

(ii) Decision Support Sub-system

The decision support sub-system was implemented using the Rasa framework to create a conversational chatbot that will assist small-scale poultry farmers by responding to their poultry-related questions, providing them with reliable poultry farming information, and assisting them in making decisions for productive poultry management activities. Moreover, RASA framework is one among the trusted frameworks used in developing contextual conversational assistants that are widely known as chatbots, it consists of significant machine learning libraries. The chatbots created by using a Rasa framework consist of Rasa NLU and Rasa Core (Sharma, 2020). In this study, the chatbot assistant was developed, that assists in answering poultry-related questions and problems that face small-scale poultry farmers.

Rasa Natural Language Understanding

Rasa NLU is one of Rasa's reliable libraries for Natural Language Understanding, it mainly performs entity extraction, and intent classification (Bagchi, 2020). It operates by taking user inputs and extracts intents and entities (Bagchi, 2020; Braun *et al.*, 2017). In rasa NLU, the developed chatbot assistant takes the poultry-related questions asked by the small-scale poultry farmer and extracts intents and entities from the user input. Entities are information that the developed chatbot may need in a specific situation, and intents are labels that are assigned to every user's request based on the message's main purpose. Furthermore, Rasa NLU teaches our developed chatbot assistant to understands the inputs of the small-scale poultry farmer, and therefore it is considered as the ear of the chatbot (Sharma, 2020). Figure 10 illustrates the console on which after the development of our chatbot assistant, the system administrator can view and edit the NLU examples on the console, this is to assist in training the developed chatbot and increase its accuracy and context in intent extraction and entity classification.

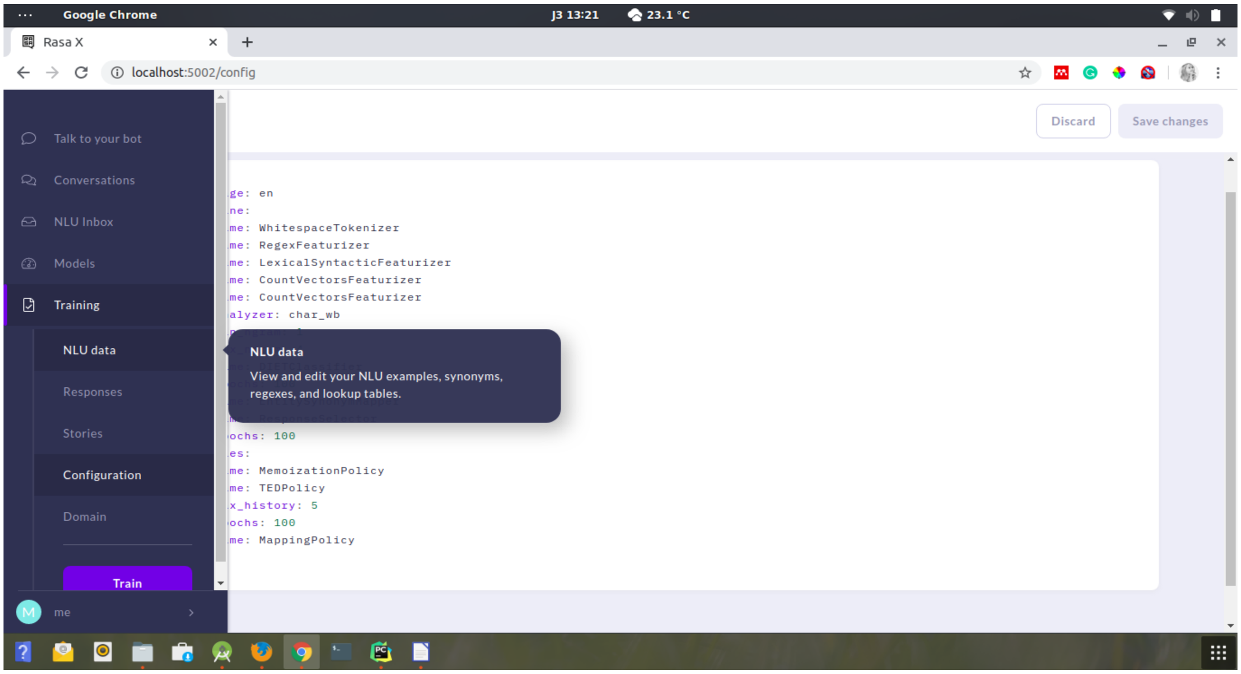

Figure 10: Natural Language Understanding data training on Rasa console

Rasa Core

Rasa Core refers to a machine learning-based framework also known as the brain of the developed chatbot because it predicts the responses of the developed chatbot to the small-scale poultry farmer based on the context along with the status of the conversation (Bagchi, 2020; Sharma, 2020). Furthermore, rasa core learns by observing the pattern from the previous conversations, these conversational data are known as stories.

In the developed conversational assistant, rasa Core manages the dialogue flow, whereby the dialogue management component in rasa core uses Machine learning to learn the stories and predict how the developed conversational assistant should respond to the user's queries based on the context, and conversational history (Bagchi, 2020; Bocklisch *et al.*, 2017). In Dialogue management, the training Data was formatted in a particular manner. User inputs were represented as related intents and entities in this format, as they were in the NLU training data, while the produced chatbot assistant's responses were represented as action names (Bocklisch *et al.*, 2017).

Furthermore, Natural Language Generation (NLG) capabilities are strong in rasa core, allowing the developed conversational assistant for small-scale poultry farmers to understand what response to give corresponding to a user inquiry (Bagchi, 2020).

Training of the Rasa conversational system model

Both Rasa NLU and Rasa Core on the developed conversational assistant work with training data formats that are human-readable. The rasa NLU is made up of a list of statements that contain intents and entities assigned to them (Bocklisch *et al.,* 2017). During implementation, we employed both the JSON structure and the markdown format to train our chatbot (Bocklisch *et al.,* 2017). The developed chatbot was trained using approximately 200 example questions and answers. These sample training questions and answers consisted of marked entities that were used to train the Rasa NLU trainer (Bocklisch *et al.,* 2017; Gunasekara & Vidanage, 2019).

Additionally, Rasa Core contains machine teaching capabilities that enable the system administrator to correct actions made by the system, this practical approach was used in generating training data (Bocklisch *et al.,* 2017; Deepika *et al.,* 2020). The Training data that were used in the Rasa core training are the sample conversations between the developed chatbot assistance and the small-scale poultry farmer (Deepika *et al.,* 2020). Furthermore, The system can learn from these previous conversations through rasa core's learning capabilities (Bagchi, 2020).

Consultation Module

Based on the main objective of this study, a mobile-based Decision Support system was implemented, during implementation, an API was used to integrate the developed conversation assistant and mobile application. An API is a software intermediary that allows the developed chatbot and mobile application to communicate by sending the poultry farmer's questions as a message to the chatbot helper and then returning the generated feedback to the poultry farmer (Gunawan *et al.,* 2019). Figure 11 below presents the conversations between the poultry farmer and our developed chatbot on the consultation module, after the integration.

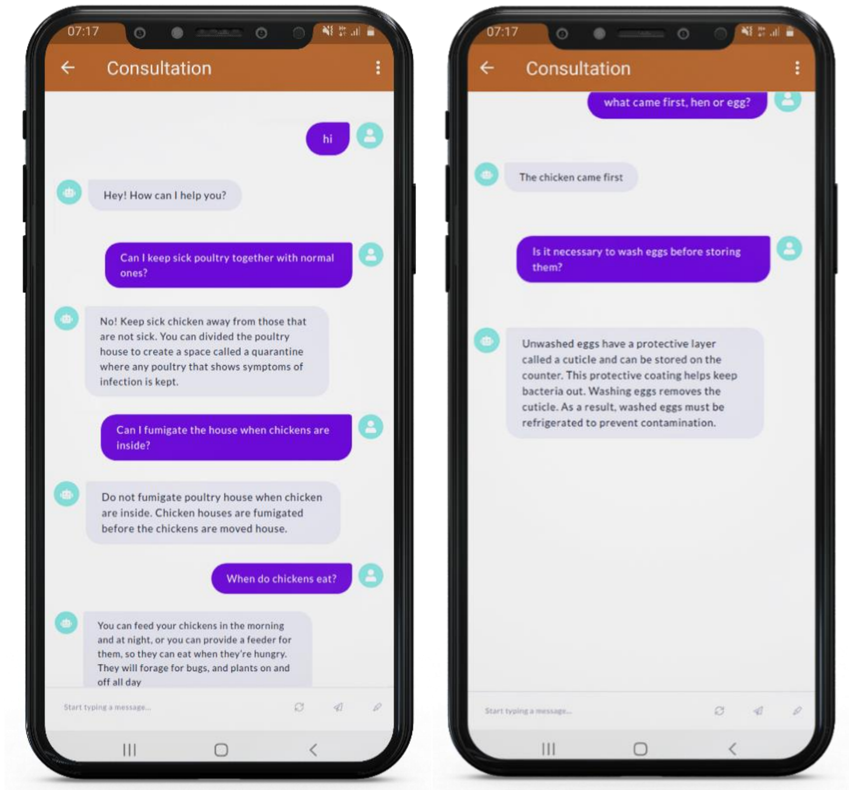

Figure 11: Consultation with our conversational assistant

4.1.2 System Validation

(i) System Unit Testing

The developed system's modules were tested to see if they function according to the established system requirements. The test results for the various system modules that were examined are shown in Table 2.

Table 2: System's unit testing results

S/N	System Requirements	Results
1.	The system allows registered users to log in and out	PASS
2.	The system allows the non-registered users to skip login and be able to read the poultry-related questions posed by the user	PASS
3.	The system responds to the poultry related questions posed by the user	PASS
4.	When the user keeps records, the database is updated	PASS
5.	The system allows registered users to view his or her records that were kept	PASS

4.1.3 Sample Size and Sampling Technique

Small-scale poultry farmers and extension staff made up the study's sample size. For the usability test, a total of 50 people, comprising of small-scale poultry farmers and extension officers, responded to the same questionnaire. The respondents were chosen using a simple random sampling technique, this was done to give equal chance for the poultry farmers to participate in the study and to give their views on the usability of the system.

4.1.4 Study Tools

This study used a working prototype of an integrated poultry farmers' mobile-based decision support system and a semi-structured questionnaire. The users were given access to the prototype and gave their feedback through the questionnaire.

4.1.5 Ethical Consideration

In the validation process, this study adhered to ethical practices, because the validation process required handling of people's information. The participants were made aware of the purpose of the system, how the system works, and were made aware of how the system will save some of their personal data that includes names, and phone numbers in the registration process. The participants were ensured confidentiality, privacy, and disclosure of their identifying information. Furthermore, Participants were given the flexibility of withdrawing from the study at any time.

4.1.6 User Acceptance Validation

The validation of this system focused on evaluating the produced system's usability and user acceptance testing. Moreover, the working prototype that was developed was taken to the small-scale poultry farmers that participated in understanding than using the system, and eventually, give their views and feedback on the system through filling a questionnaire as attached in Appendix 1. The developed mobile application (KaPU) was shared to the participants and was downloaded using WeTransfer link. A Google form containing the same questionnaire questions was shared with the small-scale poultry farmers after they were introduced to the system so that they would share their views on the developed system. Table 3 presents the results of the user acceptance test for the validation of the system.

Table 3: User acceptance test

Items	Strongly Agree (%)	Agree	Strongly Disagree	Disagree	Not sure
I found the interface of this system interesting and easy to use	60	34	2	0	4
I think the system is important and helps the small scale farmers	62	34	0	0	6
The content of this system is easy to learn and understand	52	36	2	2	8
The system helps me to keep proper decision in poultry farming	52	42	0	2	4
The system is interactive	70	22	0	0	8
I think the system will assist me in poultry farming record keeping	66	32	0	0	2
I am generally satisfied with this system	68	30	0	0	2
I would like to continue using this system	48	34	6	0	12

4.2 Discussion

This section demonstrates the developed mobile application and the testing techniques that were used in the system validation. The testing included unit testing, and user acceptance testing, which was done on a mobile-based decision support system and passed successfully. In unit testing, different system module's functionalities were tested, then the modules were integrated and tested as a whole system. Thereafter, the developed system was taken to the targeted users for a user acceptability test, which was done to validate and assess the system's effectiveness with the targeted users, and then to see if the study's main goal was met. Table 3 demonstrated the results and views of randomly selected users, conclusively they all strongly agreed to the developed mobile-based decision support system.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This research was carried out for the purpose of developing a mobile application that assists the small-scale poultry farmers in decision making process by providing them with trustworthy poultry farming information for productive poultry management activities. The study was validated through usability and user acceptance test. Furthermore, the results for the user acceptance test identified the importance of this study to the community of Tanzanian small-scale poultry farmers. This research study considerably aims at offering the proper poultry farming management tips to not only the poultry farmers, but also to anyone who would like to learn different tips and what it takes to become a poultry farmer, the requirements for a poultry farm, and therefore, attain important information before starting a poultry farm.

This research study has presented a mobile-based conversational assistant that provides the poultry farmers with intelligent decision support during a consultation with the developed mobile-based conversational assistant. The developed system was implemented by utilizing the Rasa framework to create an interactive chatbot assistant and Android Studio to create an Android-based mobile application. The final working prototype of the mobile-based decision support system has proved to be helpful to the small-scale poultry farmers, as shown in the user acceptance results in Table 3. The results showed that the study was identified to help the small-scale poultry farmers make proper decisions in poultry farming.

On the daily poultry management activities of the small-scale poultry farmers, this decision support system is going to help the small-scale poultry farmers keep a record of their daily poultry management activities, that includes health management of the chicken, feeds management, flock management, and financial management, this is going to help the small-scale poultry farmers in managing their poultry farming activities and resources well. Furthermore, it will help the extension officers that offer proper treatment or advice on the chicken in a particular farm by reading the records that were kept. The extension officers will have a better experience diagnosing the health of the chicken because the system will make it easier to trace back the chickens' vaccination history, and feed types.

5.2 Recommendations

The extension officers and veterinary doctors should work on these findings and introduce this system to the small-scale poultry farmers in their areas. This system will help them solve numerous poultry-related problems, particularly the poultry farmers that are located far from the veterinary centers. Moreover, the presence of the findings has been indicated to be helpful to the extension officers and veterinary doctors, by assisting them in various poultry-related problems identification, by tracing back the records that were kept by the small-scale poultry farmers using our mobile-based decision support system.

The developed mobile-based decision support system should be introduced to the public so that anyone would attain a guide for poultry farming management practices before starting to practice poultry farming and during the poultry farming period. Small-scale poultry farmers including the ones raring chicken for commercial purposes, and the ones raring for meat and eggs consumption should be made aware of this system because it will enhance the poultry management productivity by aiding them with trusted information that will help them in making an informed decision.

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APPENDICES

Appendix 1: Questionnaire for System Validation

SYSTEM VALIDATION

Introduction

My name is Martha Shapa, and I am a master's student at NM-AIST Arusha. I'm now working on a mobile application that will help Tanzanian small-scale poultry farmers make informed decisions about how to manage their flocks more productively. The purpose of this questionnaire is to validate the developed decision support system by introducing it to users and having them provide feedback by filling out the questionnaire.

Personal Information					
Name:					
Sex:					
Professional:					
	Strongly agree	Agree	Strongly disagree	Disagree	Not sure
I found the interface of this system interesting and easy to use					
I think the system is important and helps small-scale poultry farmers.					
The content of this system is easy to learn and understand					
The system helps me to make proper decisions in poultry farming					
The system is interactive					
I think the system will assist me in poultry farming record keeping					
I am generally satisfied with this system					
I would like to continue using this system					

Appendix 2: Sample XML Codes used in Mobile Application Development

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    xmlns:app="http://schemas.android.com/apk/res-auto"
    android:orientation="vertical"
    android:padding="10dp">
    <LinearLayout
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:paddingLeft="10dp"
        android:paddingRight="10dp"
        android:orientation="vertical">
        <fr.ganfra.materialspinner.MaterialSpinner
            android:id="@+id/detail_type"
            android:layout_width="fill_parent"
            android:layout_height="wrap_content"
            android:layout_marginTop="5dp"
            android:layout_marginBottom="10dp"
            app:ms_arrowColor="#d7d7d7"
            app:ms_arrowSize="15dp"
            app:ms_floatingLabelColor="@color/colorLightGreen"
            app:ms_floatingLabelText="@string/detail_type"
            app:ms_hint="@string/detail_type"
            app:ms_hintColor="@color/colorLightGrey"
            app:ms_hintTextSize="15sp"
            app:ms_multiline="true" />
        <com.google.android.material.textfield.TextInputLayout
            android:id="@+id/flock_chicks_no_view"
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:layout_marginTop="5dp"
            android:layout_marginBottom="10dp">
            <EditText
                android:id="@+id/flock_chicks_no"
                android:layout_width="match_parent"
```

```xml
                android:layout_height="wrap_content"
                android:hint="@string/flock_chk_no"
                android:inputType="number"
                android:maxLines="1"
                android:textSize="15sp" />
        </com.google.android.material.textfield.TextInputLayout>
        <com.google.android.material.textfield.TextInputLayout
            android:id="@+id/flock_hens_no_view"
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:layout_marginTop="5dp"
            android:layout_marginBottom="10dp">
            <EditText
                android:id="@+id/flock_hens_no"
                android:layout_width="match_parent"
                android:layout_height="wrap_content"
                android:hint="@string/flock_hen_no"
                android:inputType="number"
                android:maxLines="1"
                android:textSize="15sp" />
        </com.google.android.material.textfield.TextInputLayout>
        <com.google.android.material.textfield.TextInputLayout
            android:id="@+id/flock_cocks_no_view"
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:layout_marginTop="5dp"
            android:layout_marginBottom="10dp">
            <EditText
                android:id="@+id/flock_cocks_no"
                android:layout_width="match_parent"
                android:layout_height="wrap_content"
                android:hint="@string/flock_cock_no"
                android:inputType="number"
                android:maxLines="1"
                android:textSize="15sp" />
        </com.google.android.material.textfield.TextInputLayout>
    </LinearLayout>
</LinearLayout>
```

Appendix 3: Sample JAVA Codes used in Mobile application Development

```java
package daressalaam.development.kapu.ui.form_flock_management;
import android.app.AlertDialog;
import android.app.DatePickerDialog;
import android.content.DialogInterface;
import android.os.Bundle;
import android.view.LayoutInflater;
import android.view.View;
import android.view.ViewGroup;
import android.widget.AdapterView;
import android.widget.ArrayAdapter;
import android.widget.Button;
import android.widget.DatePicker;
import android.widget.EditText;
import java.util.Calendar;
import androidx.annotation.NonNull;
import androidx.fragment.app.Fragment;
import androidx.lifecycle.ViewModelProviders;
import daressalaam.development.kapu.R;
import fr.ganfra.materialspinner.MaterialSpinner;
public class FlockManagementFragment extends Fragment {
    private FlockManagementViewModel mViewModel;
    private EditText flockAcquiredDate;
    private MaterialSpinner flockBreedSpinner;
    private Button addDetailButton;
    private EditText dialogChicksNoEditText;
    private EditText dialogHensNoEditText;
    private EditText dialogCocksNoEditText;
    private EditText chicksHatchedNoEditText;
    private EditText hensHatchedNoEditText;
    private EditText cocksHatchedNoEditText;
    private EditText chicksInNoEditText;
    private EditText hensInNoEditText;
    private EditText cocksInNoEditText;
    private EditText chicksDeadNoEditText;
    private EditText hensDeadNoEditText;
    private EditText cocksDeadNoEditText;
```

```java
private EditText chicksOutNoEditText;
private EditText hensOutNoEditText;
private EditText cocksOutNoEditText;
private EditText totalChicksEditText;
private EditText totalHensEditText;
private EditText totalCocksEditText;
private MaterialSpinner detailTypeSpinner;
private String selectedDetailType;
public View onCreateView(@NonNull LayoutInflater inflater,
                         ViewGroup container, Bundle savedInstanceState) {
    mViewModel = ViewModelProviders.of(this).get(FlockManagementViewModel.class);
    View view = inflater.inflate(R.layout.fragment_form_flock_management, container,
false);
    flockAcquiredDate = view.findViewById(R.id.flock_acquire_date);
    chicksHatchedNoEditText = view.findViewById(R.id.chicks_hatched);
    hensHatchedNoEditText = view.findViewById(R.id.hens_hatched);
    cocksHatchedNoEditText = view.findViewById(R.id.cocks_hatched);
    chicksInNoEditText = view.findViewById(R.id.chicks_in);
    hensInNoEditText = view.findViewById(R.id.hens_in);
    cocksInNoEditText = view.findViewById(R.id.cocks_in);
    chicksDeadNoEditText = view.findViewById(R.id.chicks_dead);
    hensDeadNoEditText = view.findViewById(R.id.hens_dead);
    cocksDeadNoEditText = view.findViewById(R.id.cocks_dead);
    chicksOutNoEditText = view.findViewById(R.id.chicks_out);
    hensOutNoEditText = view.findViewById(R.id.hens_out);
    cocksOutNoEditText = view.findViewById(R.id.cocks_out);
    totalChicksEditText = view.findViewById(R.id.total_chicks);
    totalHensEditText = view.findViewById(R.id.total_hens);
    totalCocksEditText = view.findViewById(R.id.total_cocks);
    flockAcquiredDate.setOnClickListener(new View.OnClickListener() {
        @Override
        public void onClick(View v) {
            getFlockAcquiredDatePicker();
        }
    });

    setFlockBreedSpinner(view);
    addDetailButton = view.findViewById(R.id.add_details);
    addDetailButton.setOnClickListener(new View.OnClickListener() {
        @Override
```

```
                public void onClick(View v) {
                    AlertDialog.Builder builder = new AlertDialog.Builder(getActivity());
                    builder.setTitle("Flock items");
                    View inflate =
LayoutInflater.from(getActivity()).inflate(R.layout.custom_dialog_flock_management_details,
null, false);
                    dialogChicksNoEditText = inflate.findViewById(R.id.flock_chicks_no);
                    dialogHensNoEditText = inflate.findViewById(R.id.flock_hens_no);
                    dialogCocksNoEditText = inflate.findViewById(R.id.flock_cocks_no);
                    detailTypeSpinner = inflate.findViewById(R.id.detail_type);
                    final String[] detailTypes = {"Hatched", "In", "Dead", "Out"};
                    ArrayAdapter<String> adapter = new ArrayAdapter<>(getActivity(),
android.R.layout.simple_spinner_item, detailTypes);

adapter.setDropDownViewResource(android.R.layout.simple_spinner_dropdown_item);
                    detailTypeSpinner.setAdapter(adapter);
                    detailTypeSpinner.setOnItemSelectedListener(new
AdapterView.OnItemSelectedListener() {
                        @Override
                        public void onItemSelected(AdapterView<?> parent, View view, int
position, long id) {
                            if(position>-1)
                            {
                                selectedDetailType = detailTypes[position];
                                if(selectedDetailType.equals("Hatched"))
                                {

dialogChicksNoEditText.setText(chicksHatchedNoEditText.getText());

dialogHensNoEditText.setText(hensHatchedNoEditText.getText());

dialogCocksNoEditText.setText(cocksHatchedNoEditText.getText());
                                }
                                else if(selectedDetailType.equals("In"))
                                {

dialogChicksNoEditText.setText(chicksInNoEditText.getText());

dialogHensNoEditText.setText(hensInNoEditText.getText());
```

```
dialogCocksNoEditText.setText(cocksInNoEditText.getText());
                                        }
                                        else if(selectedDetailType.equals("Dead"))
                                        {

dialogChicksNoEditText.setText(chicksDeadNoEditText.getText());

dialogHensNoEditText.setText(hensDeadNoEditText.getText());

dialogCocksNoEditText.setText(cocksDeadNoEditText.getText());
                                        }
                                        else if(selectedDetailType.equals("Out"))
                                        {

dialogChicksNoEditText.setText(chicksOutNoEditText.getText());

dialogHensNoEditText.setText(hensOutNoEditText.getText());

dialogCocksNoEditText.setText(cocksOutNoEditText.getText());
                                        }
                                    }
                                    else
                                    {
                                        selectedDetailType = null;
                                    }
                                }
                                @Override
                                public void onNothingSelected(AdapterView<?> parent) {
                                }
                            });
                            builder.setView(inflate);
                            builder.setCancelable(false);
                            builder.setNegativeButton(android.R.string.cancel, new
DialogInterface.OnClickListener() {
                                @Override
                                public void onClick(DialogInterface dialogInterface, int i) {
                                    dialogInterface.cancel();
                                }
```

```
                    });
                    builder.setPositiveButton(android.R.string.ok, null);
                    final AlertDialog alertDialog = builder.create();
                    alertDialog.setOnShowListener(new DialogInterface.OnShowListener() {
                        @Override
                        public void onShow(final DialogInterface dialogInterface) {
                            Button button =
alertDialog.getButton(AlertDialog.BUTTON_POSITIVE);
                            button.setOnClickListener(new View.OnClickListener() {
                                @Override
                                public void onClick(View view) {
                                    String hensNo =
String.valueOf(getNumericValue(dialogHensNoEditText.getText().toString()));
                                    String chicksNo =
String.valueOf(getNumericValue(dialogChicksNoEditText.getText().toString()));
                                    String cocksNo =
String.valueOf(getNumericValue(dialogCocksNoEditText.getText().toString()));
                                    if(selectedDetailType==null)
                                    {

detailTypeSpinner.setError(R.string.must_select_detail_type);
                                    }
                                    else
                                    {
                                        switch (selectedDetailType) {
                                            case "Hatched":

chicksHatchedNoEditText.setText(chicksNo);

hensHatchedNoEditText.setText(hensNo);

cocksHatchedNoEditText.setText(cocksNo);
                                                break;
                                            case "In":
                                                chicksInNoEditText.setText(chicksNo);
                                                hensInNoEditText.setText(hensNo);
                                                cocksInNoEditText.setText(cocksNo);
                                                break;
                                            case "Dead":
```

```
                                        chicksDeadNoEditText.setText(chicksNo);
                                        hensDeadNoEditText.setText(hensNo);
                                        cocksDeadNoEditText.setText(cocksNo);
                                        break;
                                    case "Out":
                                        chicksOutNoEditText.setText(chicksNo);
                                        hensOutNoEditText.setText(hensNo);
                                        cocksOutNoEditText.setText(cocksNo);
                                        break;
                                }
                                int totalHens, totalChicks, totalCocks;
                                totalChicks =
getNumericValue(chicksHatchedNoEditText.getText().toString()) +

getNumericValue(chicksInNoEditText.getText().toString()) +

getNumericValue(chicksDeadNoEditText.getText().toString()) +

getNumericValue(chicksOutNoEditText.getText().toString());
                                totalHens =
getNumericValue(hensHatchedNoEditText.getText().toString()) +

getNumericValue(hensInNoEditText.getText().toString()) +

getNumericValue(hensDeadNoEditText.getText().toString()) +

getNumericValue(hensOutNoEditText.getText().toString());
                                totalCocks =
getNumericValue(cocksHatchedNoEditText.getText().toString()) +

getNumericValue(cocksInNoEditText.getText().toString()) +

getNumericValue(cocksInNoEditText.getText().toString()) +

getNumericValue(cocksOutNoEditText.getText().toString());

totalChicksEditText.setText(String.valueOf(totalChicks));

totalHensEditText.setText(String.valueOf(totalHens));
```

```
totalCocksEditText.setText(String.valueOf(totalCocks));
                                                dialogInterface.dismiss();
                                            }
                                        }
                                    });
                                }
                        });
                        alertDialog.show();
                    }
            });
            return view;
        }
        private int getNumericValue(String number){
            if(number.isEmpty())
                return 0;
            return Integer.parseInt(number);
        }
        private void setFlockBreedSpinner(View view)
        {
            String[] ITEMS = {"Layers", "Broiler", "Kienyeji", "Sasso", "Kuroiler"};
            ArrayAdapter<String> adapter = new ArrayAdapter<String>(getActivity(),
android.R.layout.simple_spinner_item, ITEMS);
            adapter.setDropDownViewResource(android.R.layout.simple_spinner_dropdown_item);
            flockBreedSpinner = view.findViewById(R.id.flock_breed);
            flockBreedSpinner.setAdapter(adapter);
        }
        private void getFlockAcquiredDatePicker(){
            // Get Current Date
            final Calendar c = Calendar.getInstance();
            int mYear = c.get(Calendar.YEAR);
            int mMonth = c.get(Calendar.MONTH);
            int mDay = c.get(Calendar.DAY_OF_MONTH);
            DatePickerDialog datePickerDialog = new DatePickerDialog(getActivity(),
                    new DatePickerDialog.OnDateSetListener() {
                        @Override
                        public void onDateSet(DatePicker view, int year,
                                                        int monthOfYear, int dayOfMonth) {


                            flockAcquiredDate.setText(dayOfMonth + "-" + (monthOfYear + 1)
 + "-" + year);
                        }
                    }, mYear, mMonth, mDay);
            datePickerDialog.show();
        }
 }
```

Appendix 4: Sample Codes used for Chatbot Development

```yaml
# Configuration for Rasa NLU.
# https://rasa.com/docs/rasa/nlu/components/
language: en
pipeline:
  - name: WhitespaceTokenizer
  - name: RegexFeaturizer
  - name: LexicalSyntacticFeaturizer
  - name: CountVectorsFeaturizer
  - name: CountVectorsFeaturizer
    analyzer: "char_wb"
    min_ngram: 1
    max_ngram: 4
  - name: DIETClassifier
    epochs: 100
  - name: EntitySynonymMapper
  - name: ResponseSelector
    epochs: 100
# Configuration for Rasa Core.
# https://rasa.com/docs/rasa/core/policies/
policies:
  - name: MemoizationPolicy
  - name: TEDPolicy
    max_history: 5
    epochs: 100
  - name: MappingPolicy
```

Appendix 5: Sample PHP Codes Used for System Administrator's Sub-system development

```
<?php
namespace App\Http\Controllers\Web;
use App\Http\Controllers\Controller;
class DashboardController extends Controller
{
    public function index(){
        $menuItems[0] = ['title'=>'Feed Management','icon'=>'ic_menu_feeds.png','body'=>'Click
to view feed management data from your application','link'=>route('feed.management.index')];
        $menuItems[1] = ['title'=>'Medication
Management','icon'=>'ic_menu_medication.png','body'=>'Click to view medication management data
from your application','link'=>route('feed.management.index')];
        $menuItems[2] = ['title'=>'Finances
Management','icon'=>'ic_menu_finances.png','body'=>'Click to view finances management data from
your application','link'=>route('feed.management.index')];
        $menuItems[3] = ['title'=>'Flock
Management','icon'=>'ic_menu_flock_management.png','body'=>'Click to view flock management
data from your application','link'=>route('feed.management.index')];
        $menuItems[4] = ['title'=>'Events','icon'=>'ic_menu_events.png','body'=>'Click to view
events data from your application','link'=>route('feed.management.index')];
        return view('dashboard',['menuItems'=>$menuItems]);
    }
}
```

```
<?php
namespace App;
use Illuminate\Database\Eloquent\Model;
use Illuminate\Support\Facades\DB;
class FeedManagementRecord extends Model
{
    public static function getRecords($options){
        $queryBuilder = DB::table('feed_management_records')
            ->orderBy('record_id','DESC');
        if(!empty($options['flockName']))
        {
            $queryBuilder
```

```
                ->where('flock_name', 'like', '%' . $options['flockName'] . '%');
        }
        if(!empty($options['feedTypeUsed']))
        {
            $queryBuilder
                ->where('feed_type_used', 'like', '%' . $options['feedTypeUsed'] . '%');
        }
         $records = $queryBuilder->paginate($options['maxPerPage']);
        return $records;
    }
}
```

RESEARCH OUTPUTS

Publication

Martha, S., Lena, T., & Dina, M. (2021). Mobile-based Decision Support System for Poultry Farmers: A Case of Tanzania. *International Journal of Advanced Computer Science and Applications*, 12 (2), 584-590. DOI: 10.14569/IJACSA.2021.0120273

Poster Presentation

Mobile-based Decision Support System for Poultry Farmers: A Case of Tanzania

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***Abstract*—Poultry farms in Tanzania are characterized by inadequate management practices which are mainly caused by the lack of adequate systems to guide the small-scale poultry farmers in decision making. It is well-established that information is a key factor in making effective decisions in numerous sectors including poultry farming. Furthermore, various researchers have identified the use of mobile decision support tools to be an effective way of aiding farmers in making informed decisions. In this paper, we present a mobile-based decision support system that will aid rural and small-scale poultry farmers in Tanzania to obtain reliable information that is crucial for making proper decisions in their farming activities. In this context, a mobile-based decision support system was achieved through a mobile application integrated with a chatbot assistant to provide a solution to various poultry farming-related problems and simplify their decision-making process. We used a data-driven approach towards developing an informational chatbot assistant for Android smartphones that is capable of interacting with small-scale poultry farmers through natural conversations by utilizing the RASA framework.**

***Keywords*—Decision support system; chatbot; mobile application; poultry farming; data-driven approach**

I. Introduction

Poultry farming is one of the prominent agricultural sectors dealing with the keeping of various domestic birds to produce eggs and meat for consumption and trade [1]. Similarly, it is one of the important agricultural areas for generating income for farmers in Tanzania. Studies indicate that there are approximately 36.2 million chickens in Tanzania, of which approximately 95% are local chickens reared by rural households [2]. Over the past decade, the growth of poultry production has accelerated, due to the rapid urbanization and increase in demand for poultry products, which include chicken meat and eggs [3]. Poultry farming has a direct impact on the farmers and has gained a notable attraction among entrepreneurs and women. Generally, it is the source of the poultry farmer's family income and protein. In this sector, women constitute the majority of poultry farmers as they constitute over 80% of the farming population in Tanzania [4].

The majority of small-scale farmers in Tanzania rely on poultry farming as their major source of income [5]. However, poultry production is hindered by several challenges including unreliable markets, poultry diseases, scarce inputs, and shortage of timely extension information due to scarcity of extension officers as well as distant locations for consultation [1]. It has been observed that rural and small-scale poultry farmers rely mainly on unreliable sources of information for poultry management such as word of mouth from family members, neighbors, and friends with previous poultry keeping experience due to the lack of adequate systems to guide them in decision making [6]. Moreover, information is very important in the development of poultry farming and agriculture at large, therefore the information obtained from unreliable sources may lead to underdevelopment of this sector, especially to rural, peri-urban, and small-scale poultry farmers [1].

Technology advancement plays a great role in the agricultural sector development, including poultry farming. It has been argued that the use of mobile decision support tools is an effective way of aiding farmers to make informed decisions [6]. Due to an increase in the use of mobile communication technologies in different sectors in the country [7], this study will contribute and improve proper information attainment for poultry farming, and aiding farmers to make informed decisions.

Along with the technological advancement and the increase in the information-seeking behavior of the small-scale poultry farmers in Tanzania [6], this study will play a great role in aiding the small-scale poultry farmers attain crucial poultry farming information in time and make informed decisions. A mobile-based decision support system is achieved through a mobile application with a chatbot assistant that provides a solution to various poultry farming-related problems and simplifies their decision-making process. Furthermore, the conversational assistant, chatbot, is a modern human-computer interaction technology that was introduced in the 1960s when the earliest chatbot ever was developed [8], [9], and gained popularity in 2016. It has been argued that chatbot is one of the most advanced and effective ways to provide information and facilitate the decision-making process in various sectors [10]. According to [8], [11], chatbots can be used to aid farmers by providing information and solutions through responding to poultry farming-related problems and facilitate their decision-making process in poultry farming.

This paper introduces a decision support mobile application, for providing poultry farming-related information to small-scale poultry farmers in Tanzania. For this purpose, the mobile application was developed using Android Studio, and integrated with a chatbot.

The remainder of this paper is organized as follows: Section II presents the related works carried out in solving various farm-related problems. Section III demonstrates the methodology used in the requirements gathering, the approach and tools used in the development of the mobile-based Decision Support system. Section IV discusses the results of the proposed system, and followed by conclusion in Section V.

II. Related Works

Various researchers have revealed that the use of mobile-based conversational assistants is an effective way to aid farmers with farm-related information and problem-solving. In the early days after the first chatbot was developed, chatbots had limited effectiveness and maintained a simple conversational flow. As the research progresses, recent chatbots are capable of understanding the context of the user and the flow of the conversations and provide a suitable response. Several studies have been conducted to develop chatbots that will assist farmers in solving their farm-related problems.

Jain et al. [11] designed a chatbot called FarmChat that aims to meet the information needs of farmers in rural India. The system offers information to the farmers by answering their farming-related queries. It was developed using the IBM Watson Assistant and consists of two interface modalities: Audio-only, and Audio+Text [11]. The study was conducted with 34 potato farmers in rural India and indicated that the chatbot offered satisfying information that supported them [11]. Thus, the authors suggested that conversational assistance delivered through smartphones could be an effective way to improve the information accessible to people with limited literacy in rural areas.

Arora et al. [8] developed an interactive chatbot named Agribot, that assists farmers in problem-solving, crop disease detection, and weather prediction. They developed the chatbot using sequence-to-sequence learning, an approach that allows the model to learn the mapping between questions and their suitable response [8]. The authors suggested that the chatbot could be more generalized in terms of conversations if the model is trained in a massive amount of data-points [8].

Fue et al [12] developed an agro-advisory web and mobile-based system called 'Ushaurikilimo' that allows farmers to request advisory services from an agriculture extension officer using either the web or mobile phone [12]. 'Ushaurikilimo' operates in Tanzania. It is a two-way communication platform between farmers and experts [12]. It functions by allowing farmers to ask questions through SMS and get a response from the agricultural expert [12]. The platform allows farmers to ask for advice on agricultural-related issues like; farm management, livestock keeping, marketing information, and aquaculture [12], whereby it depends on the presence of the experts in order for the farmers' problems to be solved. The proposed system aims at solving this gap.

III. Methodology

The methodological approach we used in the development of a mobile-based Decision Support system for small-scale poultry farmers in Tanzania in this study is the utilization of Android Studio in the mobile application development and a Rasa framework in the development of a chatbot that will aid small scale poultry farmers in Tanzania by giving answers to their poultry-related problems and help them make an informed decision in their poultry management practices.

As illustrated in Fig. 1, when the small-scale poultry farmer types his or her poultry-related query in the mobile application's chat window and sends it, the text is fed into Rasa NLU through the Application Programming Interface (API). An API software intermediary allows the farmer's mobile application and our assistant to communicate by delivering the requests from the poultry farmer to the chatbot assistant and delivering the response back to the poultry farmer [13]. After the Rasa NLU receives the text message from the poultry farmer in form of a natural human language, performs intent classification, entity extraction, and converts it into the form of structured data that our chatbot assistant could understand what the farmer is saying.

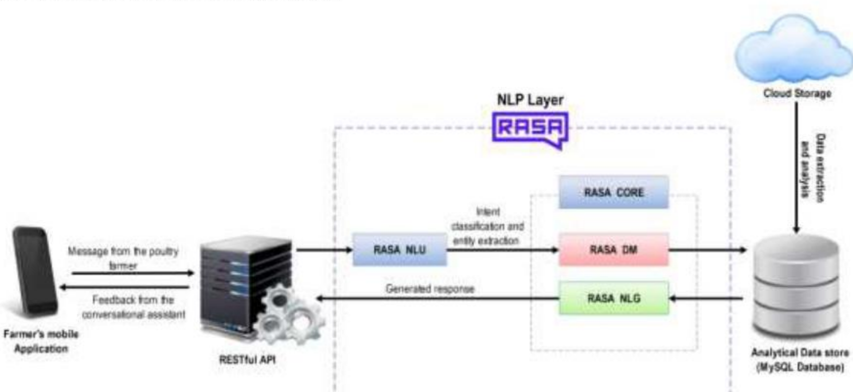

Fig. 1. A Proposed Conceptual Framework

Furthermore, based on the intents and entities, the Rasa Core takes structured inputs from the Rasa NLU through the dialogue management and predicts the next desirable action using a probabilistic model called Long short-term memory (LSTM) neural network [14], through the LSTM based supervised learning (SL) and Reinforced learning (RL) rather than the if/else statement [14]. Reinforced Learning (RL) is used to improve the next best action. Therefore, Rasa Core performs Dialogue Management by keeping track of the conversation and decide the next set of actions to be performed by the chatbot [15]. An action can be a simple utterance that means sending a feedback message to the poultry farmer, or an arbitrary function to execute. After the action has been executed, it passes a tracker instance to use any relative information collected in the dialogue history and previous actions [15].

Additionally, Rasa Core has high Natural Language Generation (NLG) capabilities [16], [17]. Therefore, upon retrieval, the Rasa Core uses its NLG capabilities to prepare a natural language human-like response to the poultry farmer based on the intent and context information returned from the Rasa NLU [17]. The dialogue manager generates raw responses that will be passed to the Natural Language Generator component that refines the text response and construct the understandable text responses in natural human language in machine representation. NLG process converts structured data into text, therefore it generates an appropriate response that a human can understand [16]. Finally, the generated feedback is sent back to the farmer's mobile application User interface via the API.

A. Data Collection and Requirements Gathering

An exhaustive literature review was conducted to identify and assess the information management requirements of small-scale poultry farmers. The identified information management requirements as summarized in Table I. Includes literature, frequency, and percentage of frequently asked questions by poultry farmers in attempts to attain proper information for their proper poultry management practices. The identified information management requirements of poultry farmers according to Table I, includes:

1) Chicken health: From an exhaustive literature review, various studies have identified that the majority of the small-scale poultry farmers in Tanzania are facing challenges in maintaining the good health of their poultry [6]. The studies show that small-scale poultry farmers in Tanzania face many health-related problems in their poultry farms and hence tend to seek various information concerning poultry health from various sources of information, mostly unreliable sources. The health information they mostly seek includes; disease control, diagnosis of the chicken diseases, the transmission of diseases, and vaccination of chickens against different diseases [1], [6].

2) Chicken feeds: One of the most important information needs that small-scale poultry farmers in Tanzania seek includes chicken feeds information [1]. The small-scale poultry farmers frequently ask questions about the availability of the chicken feeds, Types of feeds for their chicken types, amount of feeds per chicken, and feed formulation and preparation for the chicken feed, to maintain the proper production [6].

3) Chicken breeds: According to [6], poultry farmers are interested in knowing the different types of chicken breeds for various purposes before starting up a poultry farm. The factors that the majority of small-scale poultry farmers consider include; diseases resistant breed types, breed types that are best for commercial purposes, and breed types for egg production [6]. The poultry farmers also seek general information on chicken breeds to help them in proper keeping of a particular chicken breed, and rearing techniques of different types of chicken breeds.

4) Egg production: Among the frequently asked questions by many small-scale poultry farmers in Tanzania includes questions about egg production, particularly for commercial purposes. [6], [18] highlights that small-scale poultry farmers seek information about egg production, which includes improving the quality and production of eggs, proper storage of eggs, and need to know the best method for incubation of eggs [6].

5) Housing: Various studies have highlighted that majority of the startup small-scale poultry farmers tend to seek information on the housing of the chicken shelter before they start practicing poultry farming [6]. The farmers are more interested in attaining the information about the startup capital for poultry farming, characteristics of the chicken house and how to build it regarding the geographical position of the farm, and size of the chicken house for a certain number of chickens [1].

The identified information management requirements of small-scale poultry farmers through literature review were the requirements gathered and used in the development of the mobile application for poultry farming data collection, and training of our chatbot assistant to offer reliable poultry farming information that will enable the small-scale poultry farmers to make informed decisions. The information management requirements gathered helped in the identification and attainment of the 200 sample questions and answers for poultry farming-related problems, these sample questions and answers were used in training the NLU model of our chatbot assistant.

B. Approach for Mobile Application Development

This study aims at the development of a mobile-based decision support system, which involves the development of a mobile application. The approach used in the development of the mobile application is the Android studio with JAVA programming language [20]. This approach was chosen due to the reasons that the Android mobile operating systems are widely used by the targeted users [21]. Android Studio was selected because it is suitable for the development of Android-based applications for smartphones with Android operating systems [20]. The minimal version of the Android operating system supported by the developed mobile application is Jelly Bean 4.3, this was selected because it is more inviting for the average user.

TABLE I. INFORMATION MANAGEMENT REQUIREMENTS FOR POULTRY FARMERS

Number	Literature Author	Sample Space	Information need	Frequency	Percentage
1.	Grace Msoffe et al. [6]	187	Disease control	187	100
			Breeds and breeding	78	41.7
			Housing and shelter	56	29.9
			Feeding and nutrition	47	25.1
2.	Temba B et al. [1]	160	Poultry diseases	112	70
			Poultry nutrition	92	57.5
			Housing	92	57.5
3.	Benjamin Folitse et al. [18]	150	Disease management	145	96.7
			Eggs production	114	76
			Feeding and nutrition	112	74.7
			Shelter	108	72
4.	Jotshana Khobragade et al. [19]	60	Health and disease control	56	93.34
			Feeding management	55	91.67
			Housing management	53	88.34

C. Natural Language Processing Layer

The methodological approach we used in this study is the utilization of a Rasa framework in the development of a chatbot that will aid small scale poultry farmers in Tanzania by giving answers to their poultry-related problems and help them make an informed decision in their poultry management practices. The Rasa framework is an open-source machine learning framework for building contextual conversational assistants called chatbots, these assistants consist of two components which are Rasa NLU and Rasa Core [22].

1) Rasa NLU: This is the Rasa's desirable library for Natural Language Understanding that performs intent classification and entity extraction [17]. It takes user inputs in a simple unstructured human language and extracts structured semantic information in the form of intents and entities [17], [23]. Intents are labels that are attached to each user's input based on the overall goal of the user's message, and entities are pieces of information that our conversational assistant may need in a certain context. Furthermore, Rasa NLU is treated as the ear of the chatbot, because it teaches the chatbot to understands the inputs of the user [22].

2) Rasa Core: This is a framework for machine learning-based contextual decision making so-called the brain of our assistant because it predicts how our assistant will respond based on a specific state of the conversation as well as the context [17], [22]. It learns by observing the pattern from example conversational data between the user and the assistant also called stories.

Rasa Core is responsible for Dialogue management (Rasa DM). In Rasa, Dialogue management learns the patterns of the conversations from the example conversational data using Machine learning and predict how our assistant should respond in a specific situation based on the history of the conversation and the context [15], [17]. In Dialogue management the training Data for our conversational assistant is called stories, these are example conversations between the small-scale poultry farmer and our assistant, written in a specific format. This format includes expressing the user inputs as relative intents and entities, the same way as they were expressed in the NLU training Data, while the responses of our assistant were expressed as action names [15].

Furthermore, Rasa Core has high NLG capabilities that enable the chatbot to intelligently know the exact and clear response that is to be generated for a corresponding user message [17].

D. Training of the Rasa Conversational System Model

In the training of our conversational model, both Rasa NLU and Rasa Core use human-readable training data formats. Rasa NLU requires a list of utterances that are annotated with intents and entities for training our chatbot assistant [15]. We used both JSON structure and markdown format in the training of our chatbot assistant [15]. Using the Rasa NLU pipeline, we prepared a training data set to classify the intents and extract the entities. The training data includes several intents: greet, goodbye, chicken_feeds, chicken_breeds, eggs_production, chicken_diseases, and chicken_shelter. We use about 200 sample questions and answers with marked entities to train the Rasa NLU [15], [16].

In addition to the supervised learning, Rasa Core supports a machine teaching approach whereby, the actions made by the system can be corrected by the developers, we used this approach in generating training data and inspecting the space of credible conversations efficiently [15], [24]. The Training data used in training the Rasa Core are known as stories, these are the sample conversations between the user and our chatbot assistance [24]. Furthermore, Rasa core's Machine Learning libraries give it the capability of learning from the previous conversations between the user particularly the poultry farmer, and our chatbot assistant [17].

1) Markdown training data format example

```
## intent:chicken_diseases
- How do you treat a chicken's skin wounds?"
- Can I keep sick poultry together with normal ones?
- What is causing your hen's swollen foot and her limping?

## intent:egg_production
- How often do [layers](flock_name) lay eggs?
- When will my hens start laying?
- How long do chickens lay eggs?
- Why do some eggs have soft shells or no shells?

## intent:greet
- hi
- hey
- hello
```

2) JSON training data format example


```
"rasa_nlu_data": {
  "common_examples": [
    {
      "text": "Hello",
      "intent": "greeting",
      "entities": []
    },
    {
      "text": "How do you treat a chicken's skin wounds?",
      "intent": "chicken_diseases",
      "entities": []
    },
    {
      "text": " Can I keep sick poultry together with normal ones?",
      "intent": " chicken_diseases",
      "entities": []
    },
    {
      "text": " When will my hens start laying?",
      "intent": "egg_production"
    }
  ],
  "regex_features": [],
  "entity_synonyms": []
  }
}
```


IV. RESULTS AND DISCUSSION

Based on the study described, a mobile-based Decision Support system for poultry farmers was implemented. The developed Android-based mobile application for poultry-related data storage and poultry farming-related information provision was integrated with our chatbot assistant, for the aim of aiding small-scale poultry farmers with reliable information for productive management practices.

The developed mobile application as illustrated in Fig. 2, consists of five modules; Consultation module, Information portal, events, new records, and my records. The information portal contains various general information that the small-scale poultry farmer will require in poultry farming.

The new records module allows the small-scale poultry farmer to keep records of his or her day to day flock management activities, feed management, which includes the amount and type of feeds the farmer offers to the chicken. Medication records, the farmer will be able to keep records of all medications provided to the chickens, which includes the vaccination record, vitamins provision, and general medications offered to the farmer's flock, lastly are the records of the finances, the farmer can keep records of the sales and expenditures of the poultry farm. The farmer can view the farming records and keep track of the development of the poultry farm on a timely basis.

The recorded poultry farming data are stored in the cloud storage, together with the stored previous conversations are used by our chatbot assistant in responding to various poultry-related questions, and advice the farmer regarding the particular poultry farmer's farm and flock condition. This Data-driven Approach used in the development of our mobile-based decision support system makes our system intelligent enough to help the poultry farmers in their decision making for productive poultry management practices [25].

The developed mobile application consists of a consultation module. The consultation module is the chatbot assistant that responds to the poultry farmers' questions concerning chicken health, chicken feeds, chicken eggs production, and the chicken breeds. The chatbot assistant was trained to offer consultation to the small-scale poultry farmers regarding the most common poultry-related problems that mostly face them, and help the poultry farmer make proper decisions in practicing poultry farming. The consultation chat between the user and our chatbot assistant is illustrated in Fig. 3.

Fig. 2. Poultry Farmer's Mobile Application.

Fig. 3. Conversations on the Consultation Module.

V. Conclusion

This paper has presented an exploratory study using a mobile conversational agent-based interaction to facilitate intelligent decision support to the small-scale poultry farmers during a consultation with our assistant. We implemented the proposed mobile-based decision support system for poultry farmers via an interactive chatbot assistant using a Rasa framework, and an Android-based mobile application using Android studio.

Future work focuses on the validation of the mobile application developed to ensure the extent to which this study contributes in aiding farmers with the crucial poultry farming information that they frequently seek for making informed decisions. This process will involve user acceptance testing, to testing, by letting the small-scale poultry farmers use the mobile application by storing their poultry-related data and consult our chatbot assistant via the mobile application.

ACKNOWLEDGMENT

The authors would like to acknowledge the support in this study from the Organization for Women in Science for the Developing World (OWSD) Early Career Fellowship Programme (Agreement number 506575) and the African Development Bank (AfDB).

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Mobile-based Decision Support System for Poultry Farmers: A Case of Tanzania

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Background

Poultry farms in Tanzania are characterized by inadequate management practices which are mainly caused by the lack of adequate systems to guide the small-scale poultry farmers in decision making. It is well-established that information is a key factor in making effective decisions in numerous sectors including poultry farming. Furthermore, various researchers have identified the use of mobile decision support tools to be an effective way of aiding farmers in making informed decisions.

Problem statement

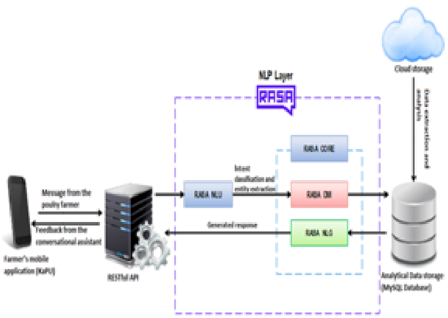
The majority of small-scale farmers in Tanzania rely on poultry farming as their major source of income. However, poultry production is hindered by several challenges including unreliable markets, poultry diseases, scarce inputs, and shortage of timely extension information due to scarcity of extension officers as well as distant locations for consultation

Research Objectives

In this study, we present a mobile-based decision support system that will aid rural and small-scale poultry farmers in Tanzania to obtain reliable information that is crucial for making proper decisions in their farming activities.

Methods

The methodological approach we used in the development of a mobile-based Decision Support system for small-scale poultry farmers in Tanzania in this study is the utilization of Android Studio in the mobile application development and a Rasa framework in the development of a chatbot that will aid small scale poultry farmers in Tanzania by giving answers to their poultry-related problems and help them make an informed decision in their poultry management practices and day schools; no night clubs were observed.



A proposed conceptual framework

Results

Poultry farmer's mobile application user interface and conversation on the consultation module

Conclusion

In this study, the developed mobile-based decision support system was validated through usability and user acceptance test. The results for the user acceptance test identified the importance of this study to the community of Tanzanian small-scale poultry farmers and helped them make proper decisions in poultry farming.

Martha, S., Lena, T., & Dina, M. (2021). Mobile-based Decision Support System for Poultry Farmers: A Case of Tanzania. *International Journal of Advanced Computer Science and Application*, 12 (2), 584-590. DOI: 10.14569/IJACSA.2021.0120273