Computer Science and Engineering 2023, 13(1): 1-7
DOI: 10.5923/j.computer.20231301.01

Design and Implement a Crop Management System

Gregory Kakoma Chikanwa*, Simon Tembo, Ir. Donat M. Ngendo

Department of Electrical Engineering, University of Zambia, School of Engineering, Lusaka, Zambia

Abstract Farmers in Zambia of Chongwe District rely primarily on services provided by agricultural extension officers to boost crop production. These officials aim to visit farmers throughout the agricultural calendar covering all eight (8) zones within each agricultural camp at least twenty-four (24) times a year and twice (2) a month to impart farmers with knowledge on crop management. They face various challenges, in terms of reaching remote and rural areas. This project highlights the necessity and importance of agricultural extension services in supporting farmers. To solve this problem, an e-agriculture extension application has been designed and developed to alleviate the challenges faced by the field workers. The e-agriculture extension application aims to provide basic knowledge in crop management and how to plan for a successful agricultural calendar, especially for remote and rural farmers. Extension workers typically rely on the agricultural calendar produced by the Department of Agricultural Methodologists. The application was built using an agile methodology that allows each sprint to be carefully planned and approved by the client before moving on to the next.

Keywords Extension Officer, Agile, Scrum, Agriculture Camp, Agriculture Zone, System, ICT

1. Introduction

Farmers in Zambia primarily rely on the services provided by agriculture extension officers to bolster their crop production. While it is expected that farmers should receive regular visits from extension officers throughout the agricultural calendar, they often encounter various challenges in reaching remote and rural areas [1]. This article underscores the imperative need and significance of agricultural extension services in supporting farmers. In response to these challenges, we introduce an e-agriculture extension application designed and developed to alleviate the issues faced by extension officers.

This innovative application is aimed at equipping remote and rural farmers with fundamental knowledge of crop management and facilitating the creation of successful agricultural calendars. Extension officers typically employ an agriculture calendar prescribed by the agriculture methodologist at the Ministry of Agriculture's headquarters as their primary tool for crop management and planning.

This article will provide an overview of the introduction, objectives, project scope, literature review, the methodology employed in system development, results, challenges, and conclusive summary.

The government of the Republic of Zambia has adopted the use of electronic extension services by embracing the use of information and communication technology (ICT) to cover areas that do not have sufficient agriculture extension officers. The adoption of this technology is meant to benefit from the 2,000 towers that the Ministry of Transport and Communication planned to erect countrywide [2]. Amid the Coronavirus Disease 2019 (COVID-19) pandemic, farmers encountered challenges in crop management due to the unavailability of extension officers as a result of COVID-19. Farmers possess knowledge about their environment and farming system. However, they are mandated to receive visits from agricultural extension officers at least twenty-four (24) times a year, twice (2) a month in each of the eight (8) Zones within each agriculture Camp. These visits assist in crop and disease management and the recommendation of suitable pesticides for specific crops. Unfortunately, the funding reduction due to COVID-19 made it difficult for farmers to access these extension officers [1].

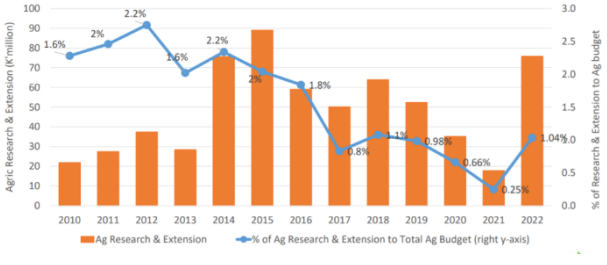

Figure 1. Budget allocation towards Extension services for 2022

The agriculture extension officers are not always available to assist farmers in identifying the diseases affecting their crops in the fields. The extension officers whenever

* Corresponding author:
onechiks@gmail.com (Gregory Kakoma Chikanwa)
Received: Nov. 13, 2023; Accepted: Dec. 1, 2023; Published: Dec. 13, 2023
Published online at http://journal.sapub.org/computer

available, are made to cover long distances to reach out to the farmers due to inadequate staff in the Ministry of Agriculture. Some areas are not reachable due to bad roads [3]. One of the factors contributing to non-accessibility for extension services is reduced funding. As it was seen during the COVID-19 epidemic. Figure 1 above shows the allocation of the agriculture budget towards the extension services from 2010 to 2022 as produced by the Indaba Agricultural Policy Research Institute (IAPRI).

The paper is organised as follows, Section 2 discusses the literature review and related works done by other scholars, Section 3 discusses the methodology used, section 4 looks at results and discussion, Section 5 discusses challenges likely to be encountered and how these challenges can be resolved and lastly, section 6 discusses the conclusion and future plans.

1.1. Specific Objectives

The objectives of the research were as follows to:

i) To identify the system used by Farmers in crop management.
ii) Evaluate the system for any improvement to enhance their knowledge in crop management.
iii) Design and implement a system that will answer to their needs.

1.2. Scope of the Project

This project will be piloted for farmers in Chongwe District of Zambia.

2. Literature Review

The literature review provides a brief history of the research topic, identifying pivotal studies and publications that focus on the advantages and disadvantages of the specific study. It underscores the key issues in the study by highlighting the gaps that need to be addressed [4]. Other developers have created similar applications for farmers. This review aims to compare various mobile applications developed by different parties.

2.1. Related Works

The main concern that has been observed in many institutions and organizations is the lack of good systems that provide suitable information to their clients or users. This problem has made most of the institutions depend on manual systems that have proved to be inefficient and ineffective. Ministry of Agriculture in collaboration with Smart Zambia Institute and the University of Zambia developed a system that allows farmers to access e-extension services in Zambia. The portal provides information modules on how to manage the crops in Zambia in text and picture format only. It does not have an agriculture calendar showing activities for each month. The new system for e-extension has a provision where Farmers can either choose a video or text with pictures [5].

The use of Android mobile applications in Agriculture contributes to an increase in agriculture production. It is a core component that helps in increasing the productivity of crops and indirectly increases the *Gross domestic product* (*GDP*) of India to reduce poverty. Koli and Raut developed an application that is user-friendly and able to be used by farmers and agriculture institutes to determine the average pH of the soil, soil type, and average temperature, by doing this a farmer may exactly know the type of crops that can be cultivated on a particular land with a certain soil type [6]. This shows that e-extension can still be achieved by providing accurate information to the farmers.

Shiferaw and his colleagues developed a system that was only able to manage potato crops for the farmers in Ethiopia. The system was aimed at examining two types of disease namely wilt and late blight. The system built by Shiferaw and friends was used as a survey, to ascertain the knowledge that farmers have concerning the two diseases compared to what the system was able to identify. The only drawback with this system is that it was only able to deal with one specific crop and two specific diseases that would have reduced the yield of potatoes in the selected religion. The developed system will cover a wide range of crops mostly cultivated by the farmers in Zambia [7].

India State Agriculture University develops systems that provide extension services to farmers. These technologies are important because they are the backbone of agricultural development in the country. One of the reasons cited for the promotion of these technologies is the absence of extension officers [8].

For farmers, having the correct agricultural information is crucial because it helps them maximize output while making the most use of the resources that are available. Farmers are guaranteed fair and prompt access to the best extension services by the extension officers. The conventional door-to-door extension method is still crucial for disseminating agricultural information, but it is presently facing harsh criticism for its inability to provide timely and equitable access to such information. The majority of farmers are looking for electronic information systems since they can be accessed from anywhere at any time. The e-extension could be considered the future extension approach of agriculture information [9].

Saravanan Raj observed that the e-agriculture prototype demonstrated a 3.6 times reduction in the cost of providing extension services to each farmer from Rs. 2,400 (USD 53) compared to the conventional extension system. However, this article argues that areas that are less developed need to use a hybrid form of extension services to take care of the post-harvest reviews of India to reduce poverty [10].

Most of the time farmers fail to decide on the type of crops, fertilizers, and pesticides to use when planning during a particular agriculture season. Shubham built an application that helped sustain agriculture development in India. This application was developed to help farmers in decision-making regarding the type of crops and other agricultural

inputs required during the farming season. These are types of applications that can be very useful to bridge the gap between the farmers and the extension officers [11].

2.2. Analysis of the Current System

The current system used by the Ministry of Agriculture e-extension services portal lacks the provision of video tutorials, despite being suggested by farmers for more effective and straightforward demonstrations, as opposed to relying solely on text format. Additionally, the present portal is not user-friendly, particularly when navigating to specific content [12].

2.3. Advantages of the New e-Extension System

It is user-friendly with a simple user graphical interface. Farmers will be able to follow the annual agriculture calendar activity for planning purposes. They will also have the option to watch video tutorials instead of solely relying on text.

3. Methodology

According to Satzinger and friends, research is considered to be a scientific investigation, and the approach used to investigate is called research methodology. The crop management System will provide information about the management of crops and how to eradicate the diseases that commonly affect the crops [13].

Satzinger and friends define an information system as a collection of interrelated components that collect, process, store, and provide the output information that is needed for a complete business undertaking. An application is defined as software that can be executed on a computer device to carry out a specific function [13].

The current system was developed using an Agile methodology. Agile is one of the top software development methodologies mostly used by developers as can be seen by the pie chart below in Figure 2. [20]

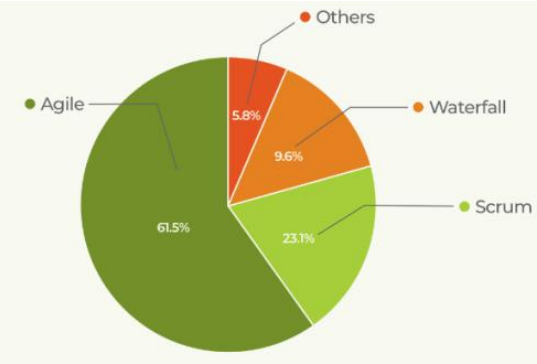

Figure 2. Show different Methodology [20]

This methodology allows the developer to build an application in parts called sprints, one sprint may take one (1) to four (4) weeks in development as per Figure 3 below. Each sprint is designed, coded, and tested just like the completed feature of a working product [21]. The ultimate goal of the sprint is to deliver a working product. For example, if a developer wants to develop a login page, the page can be designed and delivered as a working product.

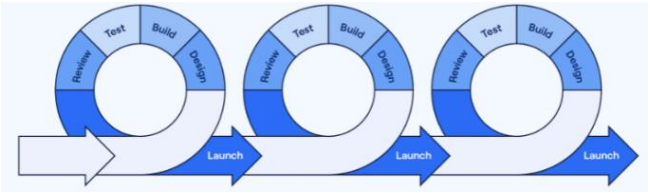

Figure 3. The agile product development process [21]

3.1. System Requirements

The University of Zambia wrote to the Ministry of Agriculture and requested for collaboration in the designing and implementation of an application that will assist the farmers in Zambia with e-extension services. The project was to be piloted in the Chongwe District of Zambia and all the requirements were collected through interviews conducted with agriculture Methodologists and extension Officers under the Ministry of Agriculture.

3.2. Study Design

A research design is nothing but a framework or a plan that guides in collection and analysis of the data. It is a blueprint that is followed in completing a study. It works as a blueprint for the collection measurement and analysis of data. It is like a map that is usually developed to guide researchers in software development [14].

3.3. Research Instruments and Tools

These are tools and methods that are used to collect data for the research being done [15]. In this project, the researcher used the interview method. In collecting data for the project from a methodologist at the Ministry of Agriculture [1].

3.4. Interviews

Interviews were conducted with the Agriculture methodologist at the Ministry of Agriculture and the Extension Officers in Chongwe to ascertain the methods used in the provision of extension services to the farmers in Chongwe.

The following were the findings:

The ministry uses an agriculture calendar with outlined activities for each month which farmers are required to follow:-

ii) The extension officers conduct meetings with Farmers at least twenty-four (24) times a year and activities are outlined for every quarter as shown in the table below.

3.5. Agriculture Calendar

Table 1. Shows the Calendar of Activities for the Farmers

General Topic	Objectives	Key Message	Timeline per Quarter
Planning of Agriculture Calendar	Create awareness on the importance of planning in agriculture	User the agriculture calendar to select plants to grow	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sept, Oct, Nov, Dec,
Land Preparation and Soil Nutrient Status	Create awareness on land preparation, soil testing, soil fertility improvement, and early planting preparedness	Start your land preparation early i.e just after harvesting and use basins and ripping where possible	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sept, Oct, Nov, Dec,
Crop residue management	Create awareness of crop residue management	Do not burn crop residues except those for cotton	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sept, Oct, Nov, Dec,
Planting	Create awareness on the importance of planting on time	Plant with the first effective rainfall to ensure crops have enough rain periods to reach maturity.	
Timely weeding	Create awareness on timely weed management.	Use manual, chemical, or mechanical methods for weed control.	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sept, Oct, Nov, Dec,

3.6. System Requirements

Table 2. Hardware requirements

S/N	Hardware	Specifications	
1	PC	Edition	Windows 10 Enterprise
		Version	21H2
		OS build	19044.2364
		RAM	8GB
		System type	64-bit operating system, x64-based processor
2	Android Phone	Tecno Camon 15, Android version 10	

Table 3. Software requirements

S/N	Software	Specifications
1	Visual Studio	Version 1.83
2	Github	Version 3.3.3
3	MongoDB	Version 4.4
2	Notepad++	V8.4.6
3	Microsoft Package	Office 2019
4	Strapi	Version 3
5	Node js	14.1

3.7. System Development

The system was developed using software tools outlined in Table 3 above. The use cases were designed using Unified Modeling Language (UML). UML is a language for specifying, visualizing, and documenting the system. The goal of this was to produce a model of the entities that are involved in the project [22].

There are various kinds of methods that the researcher considered in developing an application as shown below:

(i) A Use Case Diagram
(ii) Sequence Diagram
(iii) Collaboration Diagram

In designing and developing the UML diagrams for the project, two (2) modules were considered by the researcher; namely, the Admin and User (Farmer) modules while considering the requirements as collected from the experts at the Ministry of Agriculture.

The Admin will be able to:

(i) Login
(ii) Manage Crop
(iii) View/Update Crop
(iv) Add Camp
(v) Add Zone
(vi) Create Report
(vii) Manage Calendar

The User (Farmer) will be able to:

(i) View crop
(ii) View Calendar

3.8. Use Case Diagrams

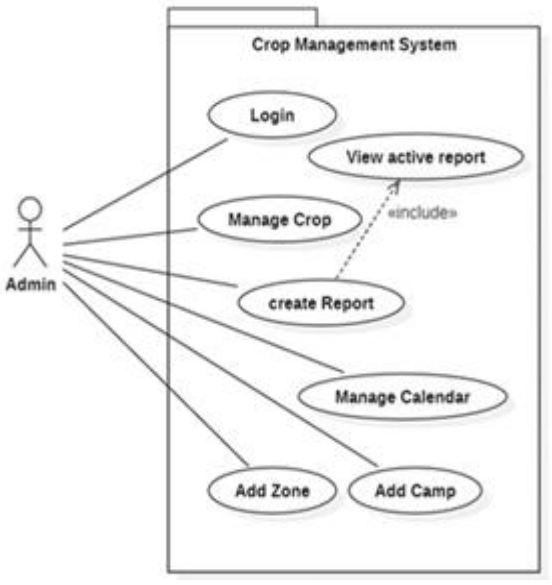

Figure 4. Admin (Extension Officer) Use Case

A use case is a sequence of interactions between the actor and the system. An actor is represented as a stick figure on a use-case diagram. The system is represented as a box. A use case is represented as an ellipse that is inside the box. The Communication associations link actors with the use cases in which they participate. [16, p. 16]. The purpose is to show the interactions between the use cases and the actors and also to represent the system requirements from the user's perspective [17, p. 65].

An actor could be the end-user of the system or an external system. Use cases are used for analysis, identification, clarification, and organisation of system requirements. It is also used to drive implementation and generate test cases.

Figure 4 above shows the system administrator while Figure 5 below shows the end user in this a farmer.

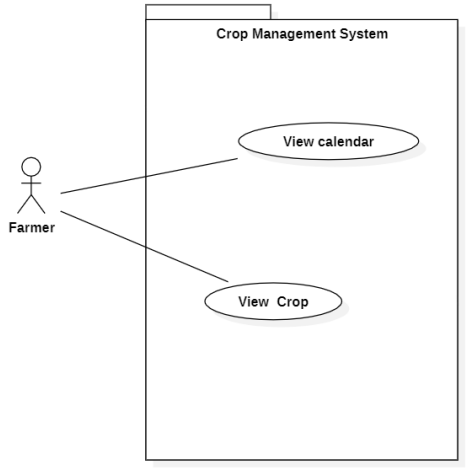

Figure 5. Farmer Use Case

3.9. Sequence Diagram

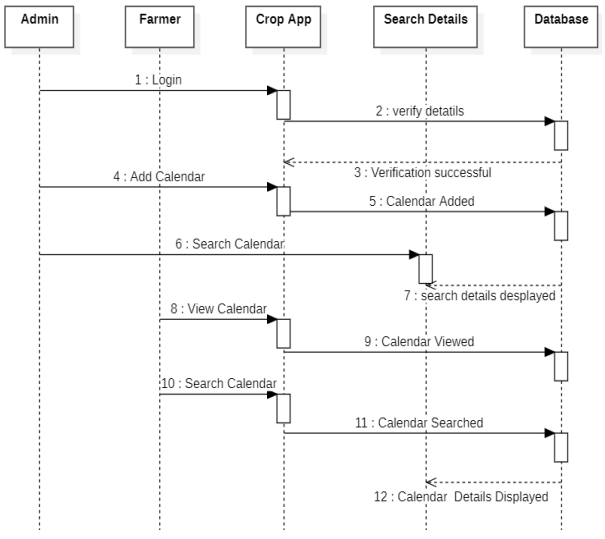

Figure 6. Shows a sequence diagram for the system

A Sequence diagram shows a complete flow of specific use cases. It shows the communication between different objects in their sequence [18]. A Sequence diagram represents the behaviour of a series of sequential steps over time depicting the workflow of messages passing and how elements achieve a result. They capture the flow of information throughout the system [19].

4. Results and Discussion

The system is initiated in GitHub and opened using a visual code terminal Node Package Manager (npm) run then start for both the database and the application. Upon clicking on the crop link a farmer has the option to see the video or read the text. As can be seen, a farmer can only view crops and calendars.

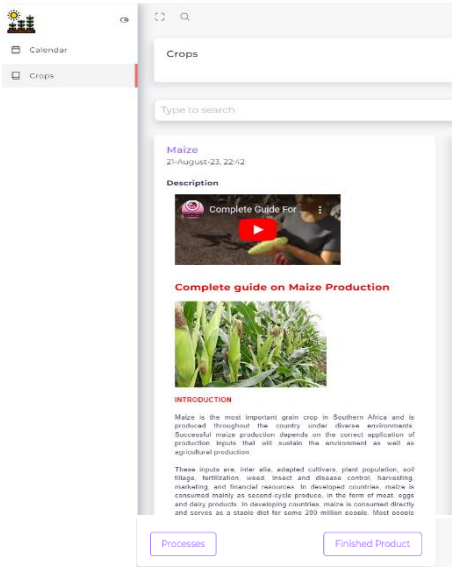

Figure 7. Crop type

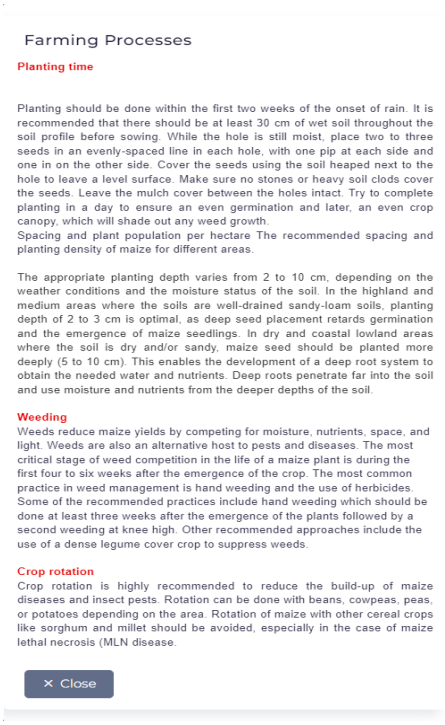

Figure 8. Crop farming process

Below the page are two links namely the process and the finished product. When a process link is clicked another page will open and show details about how the crop is cultivated including all the processes involved as can be seen in Figure 8 above.

Figure 9 below shows the finished product for maize.

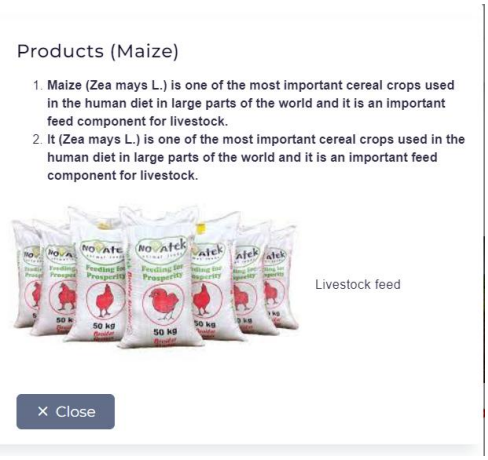

Figure 9. Maize Finished product

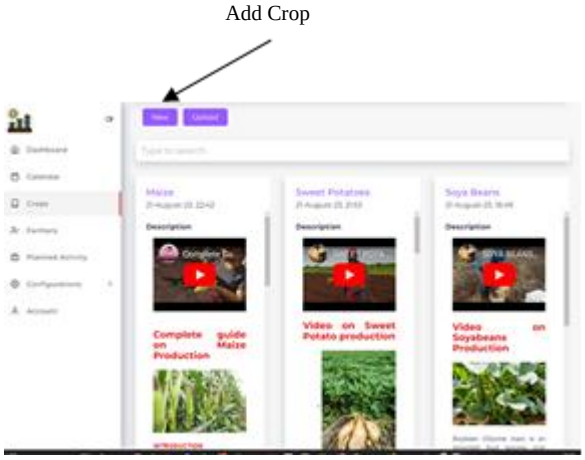

Figure 10. Admin front-end interface

The admin interface is almost the same as the farmer's interface. The only difference is that the admin has more user rights as shown in the diagram above.

5. Challenges

There are a number of obstacles to overcome in the system's implementation, ranging from technical issues to security and operational worries.

Content production and management may be challenging as it will be required to go into the fields with the extension officers to film videos that are then uploaded to the system.

Another challenge is data protection against ransomware and other online cyber-attacks.

5.1. Mitigation

In order to fund the production of content materials that will be uploaded to the system, collaborative partners are required.

The server where the system is housed must be safe against intrusions. This could need financial assistance to cover the cost of the hosting. This will call for collaboration with the Ministry of Agriculture and other NGOs dealing with Farmers.

6. Conclusions

This article's major argument is that it might be difficult for Zambian farmers to obtain agricultural extension services, especially in rural and isolated locations. To tackle this problem, an application for e-agriculture extension has been created to give farmers assistance and information on crop management. One potential remedy is the use of electronic extension services. The aim of the research was to develop and execute a crop management strategy to bolster agricultural output in Zambia, with a focus on the Chongwe district. The system aims to enhance agricultural planning in a more technologically advanced and easily accessible way by offering vital crop management information.

Agile technique, which has been shown to be the most well-liked approach for system development, was used in the system's design and development [20].

Future plans call for integrating the system with a live chat widget so that Farmers can communicate with extension officers instantly and furthermore, adding an app rating can provide input on how helpful the system is.

ACKNOWLEDGEMENTS

I wish to thank the Ministry of Agriculture extension office for the support and cooperation that was given to me during the system requirements and user acceptance testing.

REFERENCES

[1] N. Dominic, Agriculture Methodologies, Lusaka: Ministry of Agriculture, 2022.

[2] N. A. o. Zambia, Committee On Media, Information And Communication, Lusaka: National Assembly of Zambia, 2017.

[3] A. Chapoto and A. Kuteya, 2022 Agriculture Fisheries, & Livestock Budget Analysis, Lusaka: Indaba Agricultural Policy Research Institute, 2021.

[4] J. Jonker and B. Pennink, The Essence of Research Methodology: A Concise Guide for Master and Ph.D Students, Heidelberg: Springer, 2010.

[5] S. Z. Ministry of Agriculture, E-Extension, Lusaka: Ministry of Agriculture, Smart Zambia, 2022.

[6] S. D. Rachana P. Koli, Android Application Agriculture Decision Support System, vol. Vol. 4, Int. Journal of Engineering

Research and Applications, 2014, pp. pp.63-66.

[7] S. Tafesse, E. Damtew, v. B. Mierlo, R. Lie, B. Lemaga, K. Sharma, C. Leeuwis and P. C. Struika, Farmers' knowledge and practices of potato disease management in Ethiopia, vol. 86–87, Wageningen: NJAS - Wageningen Journal of Life Sciences, 2018.

[8] D. O. Prakash, E-Extension Initiatives In Agricultural Sector, Odisha: S P Publishing, 2023.

[9] E. S. Brindha Gopalakrishnan, improving agricultural information and extension services to increase small-scale farmer productivity, J-PAL Policy Insights, 2023.

[10] J. W. Satzinger, R. B. Jackson and S. D. Burd, Systems Analysis, and Design In a Changing World, Seventh Edition ed., Boston: Cengage Learning, 2012, p. 4.

[11] S. Sharma, V. Patodkar, S. Simant, C. Shah and P. S. Godse, E-Agro Android Application (Integrated Farming Management Systems for sustainable development of farmers), vol. 3, Maharashtra: International Journal of Engineering Research and General Science, 2015.

[12] U. M. o. A. Smart Zambia, Ministry of Agriculture, LUSAKA, 2022.

[13] J. W. Satzinger, R. B. Jackson and S. D. Burd, Systems Analysis, and Design In a Changing World, Seventh Edition ed., Boston: Cengage Learning, 2012, p. 4.

[14] D. M. M. P. Dr. Prabhat Pandey, Research Methodology: Tools And Techniques, Romania: Bridge Center, 2015.

[15] P. B. David Wilkinson, Using Research Instruments: A guide for Researchers, London: Routledge Falmer, 2003.

[16] D. Avison and G. Fitzgerald, Information System Development: methodology, techniques, and tool., New York: McGraw-Hill Companies Inc, 2006.

[17] M. Popovic, Communication Protocol Engineering, Second Edition ed., Boca Raton: Taylor & Francis Group, CRC Press, 2018.

[18] D. Bell, UML basics: An introduction to the Unified Modeling Language, Rational Software, 2003.

[19] S. System, ENTERPRISE ARC, 2021.

[20] M. D, Popular Software Development Methodologies and Frameworks: Full Comparison, Saudi Arabia, 2022.

[21] G. Gastaldello, The agile product development process & methodology explained, Maze, 2021.

[22] W. C. Richardson, D. Avondolio, J. Vitale, S. Schrager, M. W. Mitchell and J. Scanlon, Professional Java, Fifth Edition ed., Canada: John Wiley & Sons, 2005.