UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

GIS SYSTEM FOR CROP DISTRIBUTION

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P15/1222/2018

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A project proposal submitted to the School of Computing and Informatics, University of Nairobi, in partial fulfillment of the Diploma in Computer Science

January 2020

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Agriculture dominates the Kenyan economy, accounting for 70 percent of the workforce and about 25 percent of the annual GDP (https://www.export.gov/article?id=Kenya-Agriculture). The sector accounts for 65 percent of the export earnings, and provides the livelihood (employment, income and food security needs) for more than 80 percent of the Kenyan population. It contributes to improving nutrition through production of safe, diverse and nutrient dense food (http://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/).

Many farmers still rely on traditional farming practices that are often based on indulging in natural factors that were brought about by unorthodox evaluation done by predecessors. According to Mundia (2015) In most farming regions of the country, agriculture depends entirely on rainfall which is sometimes scarce. With result oriented evaluation about environmental conditions, altitude, rainfall and other relevant parameters considered for plant growth in different geographical areas in Kenya. The GIS approach is used to map these factors and provide information that will act solely in assisting crop farmers and investors make solid decisions on crops to plant in different areas. This will reduce time wastage and losses. Agriculture in Kenya is characterized by low productivity

Given the importance of agriculture in rural Kenya where poverty is prevalent, the sector's importance in poverty alleviation cannot be overstated. Strengthening and improving the performance of the agriculture sector and enabling the engagement of the poorest and most vulnerable in the process is therefore a prerequisite and a necessary condition for achieving recovery and growth in Kenya.

1.2 PROBLEM STATEMENT

Lack of information remains the number one problem facing smallholder farmers in Kenya who occupy the majority of land and produce most of the crops. Most miss out on new and improved methods of farming and even those that have access to information lack what it takes to process the information received. In countless instances, situations have propped out of both subsistence and large scale farmers producing low yield or low quality produce. We might realize that conditions that favored plant growth formerly, has since depreciated due to decrease in moisture content, climatic change brought about by global warming, soil precipitation that might have resulted over a longer period of time. This however doesn't imply that the soil is obsolete or unfavorable for plant growth, but on shifting our gauges we might come to a realization of a probability of different types of crops doing better in such areas.

1.3 OBJECTIVES

The objectives of the project are to:

1. Design a system that analyzes environmental and climatic factors in different parts of the country and their specific effects towards different crop production.
2. Implement a prototype system that use GIS to provide information to farmers to help diversify crop production.
3. Test the system using test data availed from

CHAPTER 2

LITERATURE REVIEW

2.1 Challenges in Agriculture in Kenya

The challenges facing crop production in Kenya include Production challenges included lack of space for expansion and lack of sources of information on land use.

2.2 Use of ICT in Agriculture

In recent years, to face these challenges, there has been growing activity around use of digital technology for agricultural and rural development in the Global South, to address the identified knowledge gaps, and to establish the building blocks for new rural services (Duncombe. 2018). The introduction of mobile phones and the internet into rural areas may be one means to improve productivity by strengthening existing agricultural knowledge systems and stimulating forms of intervention incorporating new innovative services.

There is need for creation and sharing of knowledge, examine knowledge intermediaries, the organizations or individuals who stand between the farmers themselves and the markets and institutions with whom they interact (e.g., sup- pliers of inputs and finance, buyers of produce and providers of knowledge and assistance), and to provide different perspectives on how digital technologies can facilitate change in agricultural systems (Duncombe. 2018).

In their study, (Wanjohi & Moturi, 2018) sought to establish the extent to which smartphones can be used to support monitoring activities for agricultural research and development activities in Sub-Saharan Africa.

They used an ODK-based data collection solution to address challenges identified using paper-based monitoring data collection methods for sweet potato research. Their pilot saw a significant improvement in the management of sweet potato vine multiplier databases across countries. This will make it easier to promote the use of standardized data collection tools across the different countries where the pilot has been running with the overall improvement of various data management processes.

Caine et al. (2018) have shown how mobile phone applications can be used for weather and climate information for smallholder farmer decision making. The process of developing and testing their apps included establishing user needs, understanding location specific constraints, developing accurate, localized and actionable content and the contextualization by intermediaries.

2.3 Use of GIS in Agriculture

Fuzzy set, AHP, GIS have been used to assess land suitability for tobacco production by (Zhang et al., 2015) whose findings facilitate land resource allocation and management for tobacco production.

In their study, (Halder, 2013) proposes an integrated methodology for analyzing and mapping of land suitability using the Remote Sensing and GIS techniques. A land suitability assessment for two cereal crops, rice and wheat, has been conducted in order to help the decision makers as well as agricultural development planners to decide the areas most suitable for rice and wheat cultivation.

Bharathkumar & Mohammed-Aslam (2015) have done crop pattern mapping for several crops using the NDVI technique and ArcGIS tools to determine which crop consume less water and which use huge amounts of water and therefore suitable or not for the regional climatic conditions. Suitability crop pattern map includes high income and yield to farmers within less maintenance and less water usage with respect to the climatic conditions.

Kihoro, Bosco & Murage (2013) have done suitability analysis for rice growing sites in Mwea region, Kenya, using a multicriteria evaluation and GIS approach. Biophysical variables of soil, climate and topography were considered for suitability analysis. All data was stored in the ArcGIS 9.3 environment and the factor maps were generated. For MCE, Pairwise Comparison Matrix was applied and the suitable areas for rice crop were generated and graduated. The current land cover map of the area was developed from a scanned survey map of the rice growing areas.

Mundia (2015) extrapolated and generated a crop suitability map showing areas suitable for agricultural activities in Taita Hills in Kenya. They utilized the information on environmental conditions, altitude, rainfall and other relevant parameters of the case study where the variability of rainfall and recurrent droughts have a great impact on the lives of people whose livelihood is mainly dependent on subsistence agriculture. The methods used include development of elevation models, watershed mapping, climate variability mapping, soil erosion mapping and multi-criteria evaluation analysis. The study helps farmers to be aware of the environmental conditions of their agricultural land and the impacts that may arise due to varying climate conditions on their cropping patterns.

2.4 Proposed Solution

The future of agriculture must come from new technologies which provide data improvements for better research, better results, and sustainable planning; bridging the gap between knowledge and practice; and judicious land use resource surveys, efficient management practices and sustainable use of natural resources (https://www.geospatialworld.net/blogs/gis-in-agriculture/). We propose a GIS-based solution that will help farmers to conduct crop forecasting and manage their agriculture production. This system will have the capability to analyze available data and determine which crops should be planted where.

The aim is to help farmers to achieve increased production and reduced costs by enabling better management of land resources.

2.5 Review on Existing GIS Systems in Crop distribution

Kephis - Kenya Plant Health Inspectorate Service has a product called crop varieties that uses an SMS service to advise farmers on the recommended maize variety to be planted in their region. To get the recommended variety the farmer sends maize#division to 20441 at an SMS charge of Ksh 2.00.

CHAPTER 3

SYSTEMS ANALYSIS AND DESIGN

3.1 Systems Analysis and Design Methodology

3.1.1 Agile Development

Agile software development refers to a group of development methodologies that push people to do more iterative development and constantly changing by adapting to the situation at hand.The iterative model is a software methodology built around creation of a complete, lightweight version of the main product at any given time. This is achieved through repeated loops of definition, analysis and development.

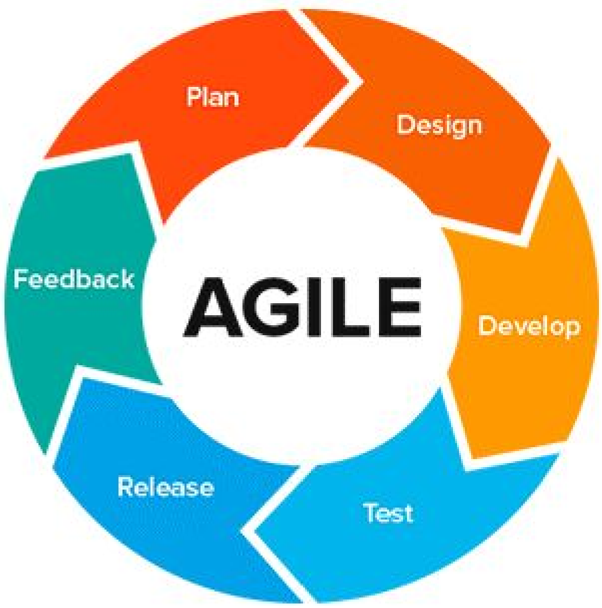

Figure 1:Agile development methodology (Source: medium.com)

Each cycle goes through the following processes:

1. Planning: New proposed requirements and feedback from the previous cycle are gathered and documented to create a list of formal requirements for the new sprint
2. Design: New designs are made from the previous cycle so as to accommodate the new changes in requirements into the application.
3. Develop: A prototype of the system is made while meeting the list of

the requirements. Emphasis is on the speed of delivery and completeness of the product.

4. Test: The reality of the application is compared to the objectives set to evaluate if they have been met.
5. Release: The prototype of the solution is released for test use in the live environment.
6. Feedback: Input from prototype users and other stakeholders is collected.

3.2.1.1 Planning Stage

3.2.1.2 Design Stage

3.2.1.3 Development Stage

3.2.1.4 Testing Stage

3.2.2 Justification for Agile methodology for this project

The iterative methodology is best suited for scenarios where the requirements are not known at the very beginning. The process allows for new requirements to be added to the development process without a major halt or change to the schedule or objectives. Since data analysis and data mining is explorative, many of the outcomes or objectives are not clear at the beginning of the project. It is as more and more tests are done tht the objectives become clearer and the means towards reaching the end become more clearly defined.

3.2.3 Prototyping

The prototyping approach used aims to satisfy 2 principles

Frequent delivery. Continuous delivery of new/updated prototypes over repeated period of time

Incremental development. That subsequent prototypes are an improvement and upgrade on the previous prototypes.

The prototyping approach ensures critical functionality of the project is implemented in the initial stages so that users can observe any shortcomings early and submit their feedback to be implemented in subsequent prototypes.

3.2 Systems Analysis

3.2.1 Introduction

System analysis is a problem-solving technique that decomposes a system into its components for the purpose of studying how well the component parts work and interact to accomplish their purpose.

3.2.2 Feasibility Analysis

Feasibility is the measure of how beneficial or practical the implementation of a proposed system is. Feasibility analysis is therefore the process by which feasibility is measured. The feasibilities carried out for this system are as follows:

Operational feasibility

This is the measure of how well a specific solution will work in an organization. It can also be defined as a measure of how people feel about the system. It involves analyzing the extent of the proposed solution. This feasibility

Technical feasibility

This is type of feasibility that refers to the measure of the practicality of specific technical solution and the availability of technical resources and expertise required to carry out the project. This feasibility was carried out to determine whether the level of software and hardware technology available was sufficient to undertake the development of this system. The technical know-how was assessed to determine if the system would be completed successfully.

Schedule feasibility

This is the measure of how reasonable the project timetable is. This feasibility study checks to see whether the project can be completed and implemented successfully within the time available. The time allotted to this was three months which was enough to implement most functionalities of the systems which were proposed.

Economic feasibility

This is the measure of cost effectiveness of a solution. It is also referred to as

cost benefit analysis. It aims at analysis of the cost of the hardware and software needed and the cost of deploying the system to the intended users. The following were observations made regarding this feasibility:
The software tools needed to build the system were open source and readily available to undertake the project. At the same time, the hardware needed (a Personal Computer) was readily available thus the cost of undertaking the project was economically feasible.

Resource feasibility

This includes analyzing the hardware and software requirements needed. The required hardware was available, which included a personal computer. The software were also available and were freely downloadable from the internet.

3.2.2 Data Gathering and Collection

Different approaches were used to gather data that was important and relevant to the development of the system. The data collection methods used for this project was conducting online research and interviewing

a) Interviews

This entailed going to the Kenya Meteorological Department to find data on weather patterns over the past five years.

b) Online Research

A number of websites, policy and research papers were viewed to find out how GIS has been used to solve agricultural problems. Online research also helped in finding out about the existing systems currently being used in the agricultural industry.

3.2.3 Requirement Specification

This is the process of describing the functionalities that have to be implemented in the final system. They are basically the user needs that have to be achieved in the system to be developed. The requirements are as follows:

a) **Functional Requirements**

These refer to the features that must be there for the system to meet user needs. The system should be able to do the following:

i. Storage of information- The most important means of storage is the system's database which will hold all records related to crop growth.
ii. Retrieval of information- Retrieval from the database will be through the use of queries to display relevant information
iii. Processing information that is required in the form of output.

b) **Non Functional Requirements**

i. Scalability - the system can be scaled to include more features and functionalities
ii. Usability – the system should have a good interface which is easy for users to learn and interact with.
iii. Ease of update of the weather and soil conditions.

c) **User Requirements**

Administrator Requirements

It will enable the administrator to do the following:

i. Update the database with current factors affecting crops

Farmers Requirements

It will enable the clients to do the following:

i. Request information on crops to grow

3.2.4 Use Case Models

Use cases are used to show how the system will function under various conditions as the system responds to requests from users of the application. The use case diagrams consist of actor; who represent the users of the system; and use cases that represent the services provided to those users by the system. The figures below should show the different use cases for the system users.

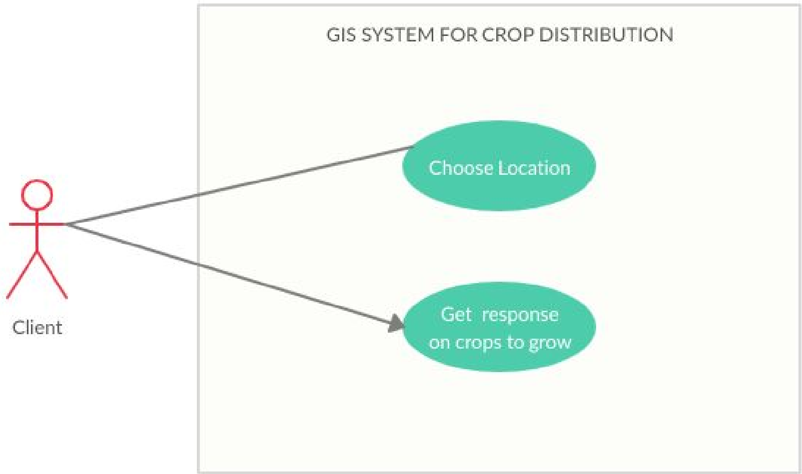

Figure 2:Client interacting with sysem using website

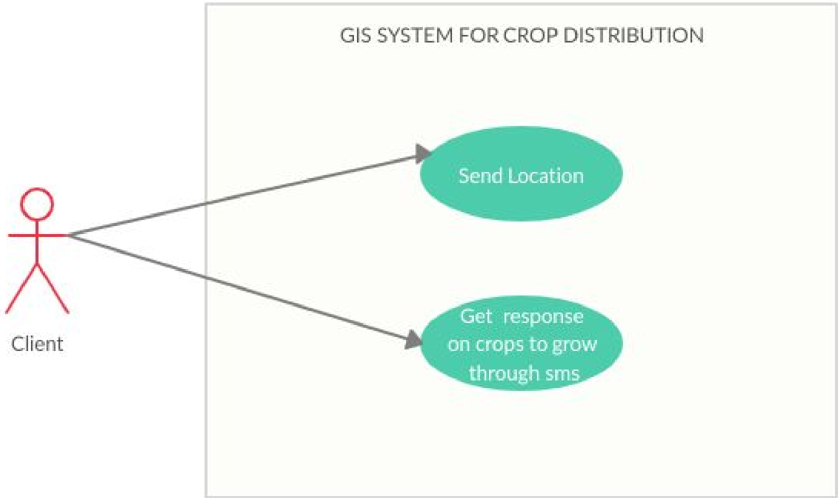

Figure 3: Client interacting with sytem using SMS

3.2.5 Data Flow Diagrams

These are diagrams that show the data flow through the system and processes that act on the data.

Context diagram

A context diagram shows the external agents interacting with the system and the data flowing in and out of the system based on these interactions.

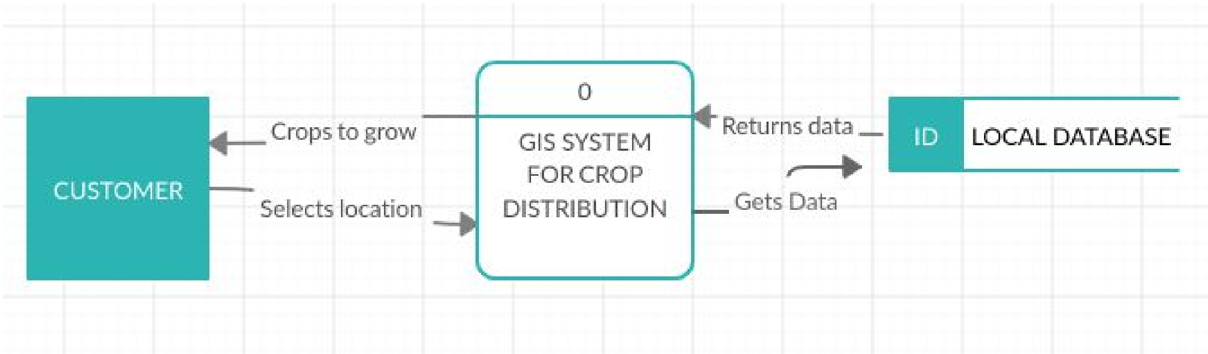

Figure 4: Context Diagram

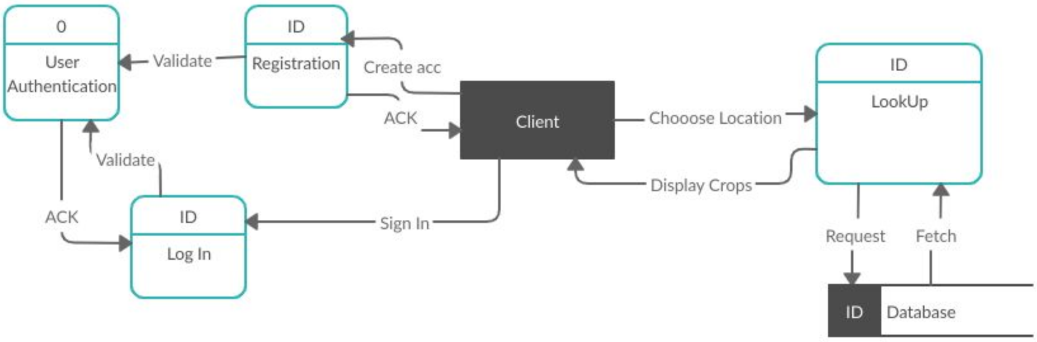

Figure 5: Level 1 DFD Diagram

3.3 Systems Design

3.3.1 Introduction

The purpose of this document is to come up with a technical solution that satisfies the functional requirements for the system. The functional specification that was arrived at during the system analysis is translated into a representation of the system thto the implementation stage.

This is a very crucial stage as it results in the system architecture, models and interfaces that satisfy the requirement specifications.

3.3.2 Database Design

3.3.3 Sitemap

3.3.4 Sequence Diagram

3.3.5 Deployment Diagram

3.3.1 Systems Architecture

Draw a diagram and describe it

Data layer, functional layer and the presentation layer, assisted farmers to achieve through names, coordinates other search methods to find the point where their own land, as well as other farmers and home-grown crops

CHAPTER 4

SYSTEMS IMPLEMENTATION

4.1 Overview

4.2 Hardware Specifications

4.3 Software Specifications

4.4 Testing

4.5 Sample Outputs

4.6 ??

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