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CHAPTER 1

Introduction

1.1 Executive Summary

The agricultural sector is critical in the global economy for food security and global development. Information communication technologies (ICT) are being widely used in all sectors of the economy, including agriculture, but there is still a clear under-usage of the potential of these technologies in the less developed communities.

In this paper, the author aims to understand the extent to which ICT is being utilized in the developing world in the agriculture sector; more specifically for small- to medium-scale farmers. Larger farms are able to enjoy the full benefits of technological advances but the smaller ones are often lagging when it comes to this.

There is a clear need for this research and development of tools to assist these farmers. The need is economical, social and technological. For developing nations' economy, and in the long run the global economy, to prosper it is important to make full use of available resources. Without the right technologies farmers aren't able to reap all possible benefits from their arable lands. Furthermore, there is great technological potential that is being left untapped, which it shouldn't. In addition, food security and social inclusion and growth of small- to medium- scale farmers in developing nations is a concern of global magnitude.

The author thus proposes an information system, mCrop, which would be accessible via mobile telephones, from the most basic to the most advanced. mCrop is to be developed with the use of expert knowledge systems, APSIM (a platform for development of agricultural solutions), collaborative filtering techniques, data obtained from field research and Android Developer Tools, among others. This system will be developed using an incremental system development life cycle method so as to allow for continuous improvement and easier user adaptability purposes. Additionally, the development of the system will be based on data obtained from the state of Perak. The use of this geographical sample will allow for simplified development and testing while remaining objective. The results obtained from the development for a comparatively small geographical area can then be extrapolated at a national, regional and global level, with the necessary adjustments being done to it.

1.2 Background of the Study

The development of technology has never before occurred at such a rapid rate; the last decade has seen emerging solutions and gadgets that the late twentieth century did not imagine would be possible. At its onset, the field of information communication technology was not given much importance and was often not part of the factors involved in decision-making.

Over time, ICT proved that it was crucial not only as a standalone area but needed to be integrated into every sector of the economy as well as into the various business industries.

In areas such as infrastructure growth, education and healthcare system reforms, and improvement of the financial system, the African continent and other developing nations of the world have repeatedly followed an evolution path, which the developed world had undergone at a different rhythm. In the field of ICT development, however, the trend appears to be different, the technological evolutions in Africa and Asia are occurring almost simultaneously with the ones of the Western more developed societies. The small- to medium- to high-scale technology hubs being set up throughout these two continents are evidence of this. One of the reasons behind the development gap may be the lack of adequate basic infrastructure such as mobile networks, bandwidth and broadband access and quality outside the major cities. Additionally, it may be due to cultural factors as well as needed changes in the mindset of the inhabitants of these countries. Nevertheless, these new advances need to and should be leveraged upon by the developing areas and not only by the developed locations.

Agriculture is one sector that can reap great benefits from new technologies; as this is such a critical sector in our economy due to the predicted future food scarcity; the opportunity for both public and private sector in to greatly benefit should not be missed. Furthermore, small- to medium-scale farmers should not be left out of the picture and should be provided with the right tools and technologies to allow them to grow. Their financial standing should not equate to life stagnation.

There is therefore a need to explore how ICT and agriculture overlap, what solutions are already provided and what possible solutions could be created. The suggested solutions need to provide benefits to the users – small- to medium-scale farmers – as well as identify how the private and public sector of the economy in these developing nations could assist in improving agricultural input and output efficiency.

1.3 Problem Statement

Despite the current rapid development of mobile applications, the less privileged are still not reaping all possible benefits from modern technologies. One area in particular where the developing world still falls behind is in the use of information technology within agriculture. Large-scale or commercial farmers have a relatively easy access to such technologies and these assist them in decision-making for their farms. Small-scale or subsistence farmers, on the other hand, have limited to no access to data that could allow them to make more informed decisions on how to best use their land. This barrier between the small-scale farmers and the immeasurable amount of agricultural information available is a main contributor to the slow growth and development of the least developed societies.

Agriculture has been cited by many as being the mainstay of the African continent, despite the development of other sectors in the economy, agriculture still remains a vital sector since a predominant portion of the rural population in developing countries depends on it. The latter is true even for the more industrialized developing nations. The World Bank states that this industry employs approximately 65 percent of the total labour force and is accountable for 32 percent of the continent's gross domestic product (GDP), [1]. With economic stability and prosperity in mind, one should not undermine the significance of this sector and should examine and consider the application of ways to further improve it.

The proposed technical solution(s) should carefully take into consideration the infrastructural drawbacks, which exist and should try to obtain maximum leverage from the advantages provided by this same infrastructure. A technological solution which would start to address this issue is therefore in need, not only would it benefit the farmers, it would also benefit society as a whole as the agricultural sector is a critical one due to the predicted future food scarcity.

In short, the three main problems the system aims at resolving are:

- The lack of technology adoption from smaller scale farmers
- The fact that the developing world still falls behind on adoption of ICT within the agricultural sector
- The issue, which arises as a result of the barrier between the small-scale farmers and the immeasurable amount of agricultural information available thus making it a main contributor to the slow growth and development of the least developed societies.

1.4 Objective of the Study

The main objective of the study is to develop a system to enhance small- to medium-scale farmers overall agricultural experience. This is to aid farmers in better planning their crops to best leverage on their land, weather and financial conditions, provide them with an easier access to market prices and other relevant crop related information.

Additionally, it aims at providing farmers with a better method to monitor their farming progress.

This study aims at identifying existing technologies used in agricultural systems whether for small –scale or larger-scale farms. Through this, the author hopes to find technologies or platforms that can be used to develop a mobile information system that would allow small-scale farmers to have access to information that would assist them in better planning their crops so that they can get the most out of their conditions: land, weather and financial.

The study looks at whether the currently available information systems can be simplified and made available at a minimal cost to small-scale farmers. Furthermore it looks at alternative ways to provide these farmers with information on what crops best suit the area and weather conditions the farmers are in, real-time market prices for their crops and other types of information they may require to enhance their agricultural activities and allow them to get the most out of their resources. This will allow for sustainable use of the natural resources and allow the farmers to obtain a greater monetary gain and thus allow for sector and regional development. Furthermore, in the long run it will address the issue of possible global food scarcity.

1.5 Scope Of The Study

1.5.1 FYP I

For the first half of this study, FYP1, the author has subdivided the scope into four different areas that are as follows.

- **Identification of the crops**
  - In order to develop this system, an in-depth knowledge of existing crops is required. This will involve the use of expert systems to

extract the necessary data as well as extensive research. Identification is extremely important, as the type of crops is one of the focal points of the information system. It is critical to gain insight on the crops' names, attributes and geographical areas as this will aid in designing the predictive systems that the farmers will leverage upon.

- **Identification of technology for development**
  - Research needs to be carried out to identify the technology, in terms of both hardware and software that is to be used. The identification of technology is closely linked with the cost and usability factors. Since this system is to be used by small-scale farmers, the complexity and cost of the technology should be minimal. The reason behind the cost factor is that this information system should be attainable by most, if not all, small scale farmers, As for the complexity, a vast majority of farmers in the developing world have very little hands-on experience with technology and thus making it sufficiently user-friendly would help in ensuring adherence to the system and would save on training time and costs.

- **Possibility of leveraging on existing technology**
  - Existing open-source technology needs to be identified and carefully analyzed for the possibility of being developed further. This would allow the author to add more functionality to the system as time would be saved from developing it from scratch. In addition to desk research, field research also needs to be undertaken. This should be through visiting farm sites as well as governing bodies of agriculture in Malaysia. These visits would allow to better identify the needs which would then lead to better requirement definition.

- **Feasibility analysis**

- By the end of this study, the author has to have identified the economic and technical feasibility of the system. In addition to this, the applicability and adaptability of the system to countries other than Malaysia must be identified. It is important for the system to be able to adapt to more than one environment, as this would increase its marketability.

The system requirements, system architecture, user interface as well as other informative items will be further discussed and developed by the author on the next stage of the development – the interim report.

1.5.1.1 Milestones

1.1 Crop identification

Identify expert systems

Search for existing crop databases by geographical region

Compile database of crops

Select crops to be used for the system development

1.2 Technology identification

Identify cost-effective hardware and software

Identify existing agriculture technology

Carry out desk and field research

Identify functionality needs

Define user and system requirements

1.3 Feasibility analysis

Identify technical feasibility

Identify economic feasibility

Determine product marketability

1.4 Develop system architecture

1.5 Develop user interface

1.5.1.2Gantt Chart

See in Appendix I

1.5.2 FYP 2

1.5.2.2 System Development

Ensure that the identified development methods are adequate and will provide the desired results. Then proceed with the first iteration of the system development. In the event that the method identified does not produce desired results, proceed with research of a better alternative and develop. At least one function of the system needs to be completed by the end of the first iteration.

1.5.2.3 System Testing

Undergo unit, functionality, user and system testing after the development of each iteration.

1.5.3 Milestones

1.5.3.2 Develop Crop Determining Screens

1.5.3.3 Develop Crop Determining Algorithm

1.5.3.4 Populate Crop and Location Database

1.5.3.5 Develop Additional Information Screen

1.5.3.6 Undergo Phase 1Testing

CHAPTER 2

Literature Review

Stienen, Bruinsma and Neuman [2] believe that ICT can make a significant contribution in increasing the efficiency, productivity and sustainability of small-scale farms. Key improvements to farming originate from having timely and accurate information regarding pest and disease control, particularly warning systems, new varieties, new methods to optimize production and guidelines for quality control. The ability of farmers to receive adequate information as soon as it is made available will considerably improve their decision- making capacities. Knowing when a disease or pest outbreak has occurred will allow them to take preventive measures needed to save their crops or will alert them that certain crops should not be planted for a certain period of time. This will allow the farmers to reduce the amount of harvested material that has to go to waste as well as prevent them from spending on seeds that would not reap any fruits for that planting season. What they will have maintained can then be put for further use within the farm. Farmers in remote areas are seldom aware of new farming methods or crop varieties and thus only plant the basic varieties, which they are accustomed to. As societies become more informed, so do people's dietary habits and hence the need for new crops emerges; in order to maintain their competitiveness with the local, regional and global markets, farmers must be well informed of any new discoveries or upgrades to current varieties. Improved farming methods generally imply a better use of available resources in order to obtain greater yields and reduce waste. Furthermore, going beyond prevention systems and improved techniques, there is a need for quality control and following the rules and regulations for such. Without the required quality standards, a farmer's harvest may lose its value and hinder its ability to compete. Demand is what ultimately drives the supply of goods and services in today's markets, therefore knowledge of the latest customer's preferences and trends can have a considerable impact on farmers' product mixes. Their livelihoods can also be significantly impacted through having awareness of up-to- the-minute prices of commodities and other inputs. This type of information will be crucial in making decisions on what crops to plant and the best place and time to sell their products. Furthermore, having knowledge on world prices will give farmers a greater bargaining power when trying to sell their products. In several countries various initiatives have emerged as a way to address this issue, simple websites to match offer and demand of agricultural produce are a start of more complex agricultural trade systems. Price information is generally collected from the main regional markets and stored in a central database[2]. To reach a wider audience, information is broadcast via rural radio, TV, or mobile phones thus creating a stronger bridge between traders and farmers in the region. In recent years, short message services (SMSs) have improved and made the delivery of price and trade information via mobile more effective to farmers in places such as Senegal, Benin and Zambia[2].

Within the developing world, there are already two successfully implemented applications, which operate via SMS, to aid farmers and they are '*Farmer's Friend'* and '*Nokia Life Tools'*.

Farmer's Friend: Ugandan Mobile Application [2]

This application provides on demand information to farmers. It was made possible by an agreement between Uganda's Mobile network Provider, MTN Uganda, and Google's SMS search platform.

The information made available includes weather forecasts, agricultural advice and a Google trading service for agricultural commodities as well as other products. Farmers or other interested individuals send their query and location to a number provided by Google and they will instantly receive a reply. This service is free of charge from Google but users are charged their standard data rates. During its trial phase, the 8,000 users contributed to 54,000 inquiries. Farmer's Friend follows a business model aimed at increasing access and this is done by making it available on all types of handsets – including the most basic ones – and allowing users to pay for the service based on demand rather than charging them a fixed monthly fee. Besides the increased access, this service provides farmers with more than just general advice; it allows users to make specific queries based on their needs. Although its impact was not immediately visible in the rural areas, these numbers show that there is a clear need as well as market acceptance of the app. Once the impact of the usage of this mobile solution becomes visible and more people adhere to it, governments and mobile operators in neighbouring countries may want to consider introducing this service in their countries so that farmers may benefit from a greater access to information.

Nokia Life Tools: [3]

Nokia Life is an SMS based, subscription information service designed for emerging markets, which offers a wide range of information services covering healthcare, agriculture, education and entertainment. Currently, the service is only available in one African country – Nigeria. It was first launched in India, and as it proved successful, gradually expanded to China, Indonesia and Nigeria. Thus far, over 15 million people have used and benefited from the service. The agricultural component of the application is made up of location-customized information on weather conditions, advice on crop cycles, advice on agricultural techniques as well as market prices for the crops. Via getting the most recent information on their cellphones, farmers are able to overcome barriers created by uncertainty and obtain the adequate information they need to grow and sell their crops. Farmers' dependency on agents for basic information was heavily reduced through receiving daily price information on their mobile devices. Furthermore, this has enabled farmers to negotiate with greater confidence. To make service possible, Nokia has partnered with Syngenta, an agricultural domain expert, and Reuters Market Light as the content service provider.

A World Bank study conducted in the Philippines established a strong link between the purchase of a cellphone and higher growth of incomes, in the range of 11 and 17 percent [4]. This is a result of farmers' greater bargaining power and ability to seek out other markets with the help of mobile phones. A study conducted in Uganda adds a rise in market participation, promoted by cellphones, to the reasons for the increase in incomes. Furthermore, as cellphones can serve as the main infrastructure for warning systems, it prevents agricultural losses and therefore also contributes to rising farmers' incomes.

One of the underlying causes of market distortion in African, and much of the developing world's, agriculture is price dispersion of commodities; farmers often have little information on market prices locally and internationally. This gives producers an unfair trade disadvantage as their customers, who may be better informed, may try to bargain for lower prices than the market benchmark. The spread of price information via cellphones provides all farmers with the same price information and thus allows them to better negotiate and also forces farmers to compete based on the quality of their products rather than on a low price basis. Regional and international market price information received on mobile devices not only improves trade; it also allows farmers to seek out places where their goods can be sold for better prices.

Beyond the use of mobile phones for crop related decisions and ways to market farmers' goods, ICT is present in more advanced forms throughout the entire agriculture value chain. Many small-scale farmers in Africa still do not have access to these advanced systems. The crop cultivation phase involves preparation of the land, sowing, managing all inputs – including water and fertilizers – as well as ensuring that the area is safe from pests or other diseases. Individually, many small-scale farmers do not have the monetary capability to automate all of their operations. Collaboration between several farmers in the same area could overcome this problem. That way they would be able to purchase computer or remote controlled machinery that would significantly improve the way the land and time is used. These machines could be used in turns in between all the farmers that contributed to the purchase. These machines would be connected to sensor networks that would be part of a DSS. This would allow farmers to track their progress and rethink their decisions. The use of the DSS would have added value if the farmers were to be remotely educated and assisted via mobile learning and consulting.

From the available literature, it is clear that there has already been a significant amount of research done on the impact that ICT has and can have in the agricultural sector of the developing world. Basic cellphone platforms and PC collaborations have emerged in various places and have been tested with a meaningful sample. It can however be contested that applications and systems for basic planning prior to starting a new farming season in these areas and for smaller scale farmers are still lacking. The planning stage is extremely crucial, as the success of this is directly linked with the performance of other stages of development.

APSIM [5], The Agricultural Production Systems sIMulator, is an internationally recognised highly advanced simulator of agricultural systems. . It contains a suite of modules, which enable the simulation of systems that cover a range of plant, animal, soil, climate and management interactions. APSIM is undergoing continual development, with new capability added to regular releases of official versions. Its development and maintenance is underpinned by rigorous science and software engineering standards. The APSIM Initiative has been established to promote the development and use of the science modules and infrastructure software of APSIM.

Platforms such as APSIM can be used in combination with other expert systems and added knowledge in order to develop systems that would initially contribute to assisting farmers in better planning and at later stages serve as a comprehensive decision support system.

CHAPTER 3

Methodology

For the purpose of this project, the author employed two methodologies; one for the research portion and a different one for the actual development of the system.

3.1 Research Methodology

The main aim of undertaking the research is to determine the feasibility and acceptance of the proposed system. Although desk research can be thorough and extensive enough to evaluate whether mCrop would or not succeed and whether the need for it is justified, a field research is critical nonetheless. The system is to be used on the field and it is thus important to ensure applicability of such a system.

Furthermore, the research would determine the level of support that the application would receive and identify the technology to be leveraged upon.

The research was to be conducted using interviews with relevant individuals, such as members of the governing bodies of agriculture in Malaysia, and through observation and interviewing of farmers in their workplace. Furthermore, surveys will be undertaken to allow for comparison on the basis of the same criteria among different individuals and/or farm sites. This would allow for the necessary qualitative and quantitative information to be gathered and analyzed.

The main questions to be answered with this research included but were not limited to:

- How literate are the farmers? Do they possess the basic knowledge to operate simple information systems?
- To what extent would an information system assist farmers in improving their crop and financial yield?

- What kind of support would be available from the local community and governing bodies to promote the use of the system?
- How far could costs be cut or could the system be subsidized so that everyone can benefit from it?
- What current systems exist, what regulations have been imposed on them and how can these systems be put to further use?

Although the system is aimed at fitting small- to medium-scale farmers in the developing world as a whole for research and development purposes the focus was on the state of Perak in Malaysia. The reason for this being the current location of the author and thus it facilitates the data collection and further testing. Furthermore, starting off with a small sample, seeing how the system operates and how the users adapt to it and from there deciding on whether or not to spread the system to a larger geographical area is a cost and resource effective way of deploying the system.

If the system were to fail the user acceptance testing in this state, improvements could be done to it so as to ensure that similar problems wouldn't be encountered once the system is deployed throughout the rest of the country. An implementation on a larger geographical scale would require further modifications, as the profile of the farmers in other parts of the world may not be the same as the ones of Malaysia. Additionally, the land and weather conditions vary not only from state to state but also from nation to nation.

3.2 Development Methodology

A systems development life cycle (SDLC) represents a process for creating or altering information systems, and the models and methodologies that people use to develop these systems. The SDLC is a methodology that also forms the framework for planning and controlling the creation, testing, and delivery of an information system [6].

For the development of mCrop, an incremental and iterative model is to be used. An incremental model is an intuitive approach to the traditional waterfall model. Multiple development cycles take place thus making the life cycle a “multi-waterfall” cycle. Cycles are divided up into smaller, more easily managed iterations. Each iteration passes through the requirements, design, implementation and testing phases. [7]

A working version of software is produced during the first iteration, so as to have working software early on during the software life cycle. Subsequent iterations build on the initial software produced during the first iteration.

Figure 1 illustrates the incremental SDLC model:

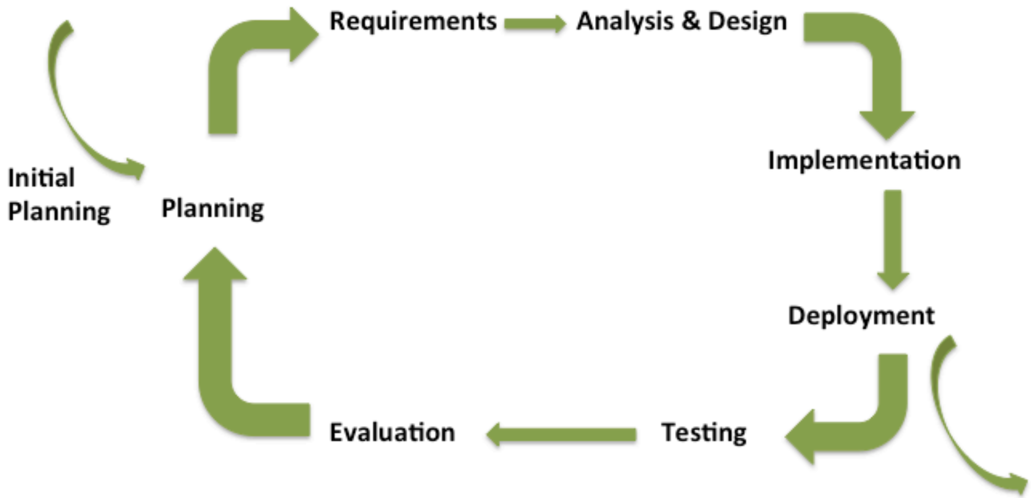


Figure 1: Incremental SDLC

This methodology was chosen mainly due to the fact that mCrop will be developed in an iterative manner; working on one functional requirement at a time and adding on to the functions with every release of the system. The initial stage will focus on developing the crop prediction mechanism, this will be followed by a price monitoring function to allow farmers to know the price of their commodities. Later stages of development will be more focused on the advice provision part of the system; using knowledge gathered from several knowledge bases, the predictive mechanism and the cost function to best advise the farmers on how to undertake their farming activities.

Functionality, user and system testing will be carried on after every iteration; this will allow the system users to familiarize themselves with the system and thus increasing the likelihood of acceptance. Additionally, this testing method will allow for continuous improvement of the system, as users will provide the developer with feedback on what they like or don't like about the system and give suggestions on what could be done to improve it. Once fully developed, the system should provide the aforementioned functionalities and also serve as a warning system for possible pest outbreaks, droughts or other natural disasters that could harm production.

Furthermore, this SDLC model provides several benefits [8] such as:

- Generation of working software quickly and early during the software life cycle.
- Added flexibility thus making it less costly to change scope and requirements
- Ease of testing and debugging during smaller iterations
- Easier risk management as risky pieces are identified and handled with each iteration.

Decision-Making Mechanism

In addition to using an incremental SDLC, the system's intelligence and decision-making process was based on a toned-down version of collaborative filtering. As a means of making the system work intelligently to effectively assist farmers in deciding what crops to plant, collaborative filtering was identified as the method to use. Collaborative filtering is a technique used by some recommender systems. In general, collaborative filtering is the process of filtering for information or patterns using techniques involving collaboration among multiple agents, viewpoints, data sources, among others. Applications of collaborative filtering typically involve very large data sets. [11]

Table 1 displays various crops along its x-axis. The number of crops is vast (Cm) but for analysis purposes only five (5) were chosen. The same goes to the number of users. The system stores information regarding the characteristics (demographic, geographic and personal information) of the various users and registers the crops these users have planted and how successful the harvest was. When the farmer, user m+1, enters the system to enquire about which crops he should plant, the system shall use the farmers characteristics and match them with past user characteristics in order to be able to provide him with a reliable suggestion based on past data.

{C: C1 υC2 υC3 υ…. υ Cm}
{U: U1 υU2 υU3 υ…. υ Um}

Table 1: Collaborative Filtering System for Suggestions

	Crop 1	Crop 2	Crop 3	Crop 4	Crop 5
User 1	+	-	-	+	-
User 2	-	-	-	+	+
User 3	+	+	-	-	+
User 4	-	-	+	-	-
: :					
User m	+	-	+	+	-
m+1					

How collaborative filtering was effectively put into use in the system is displayed in figure 2.

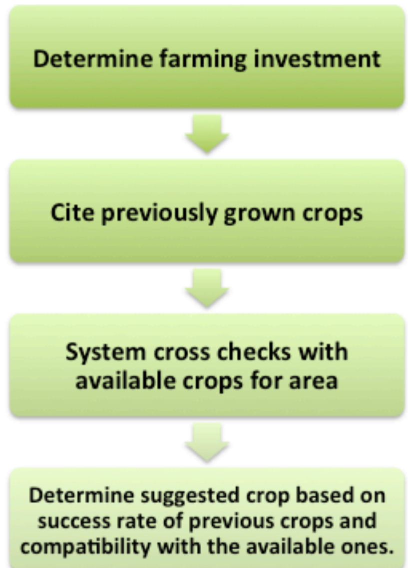


Figure 2: m-Crop Decision-Making Mechanism

Technology to Be Used

Hardware

- MacBook Pro
- Samsung Galaxy S3

Software

- Android Operating Software:
    - Android is an operating system based on the Linux kernel,[9] and designed primarily for touchscreen mobile devices such as smartphones and tablet computers. The user interface of Android is based on direct

manipulation, using touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching and reverse pinching to manipulate on-screen objects.

  - Android is the world's most widely used smartphone platform. Android is popular with technology companies who require a ready-made, low-cost, customizable and lightweight operating system for high tech devices [9].

- Mountain Lion X Operating Software

Developer Tools

- MIT App Inventor 2 – App Inventor for Android is an application originally provided by Google, and now maintained by the Massachusetts Institute of Technology. It allows anyone familiar with computer programming to create software applications for the Android operating system. It uses a graphical interface that allows users to drag-and-drop visual objects to create an application that can run on the Android system, which runs on many mobile devices [10]
- Eclipse/Android Developer Tools - Eclipse is an integrated development environment. It contains a base workspace and an extensible plug-in system for customizing the environment. Written mostly in Java, Eclipse can be used to develop applications. Through the use of various plug-ins, Eclipse may also be used to develop applications in other programming languages: The Eclipse software development kit, which includes the Java development tools, is meant for Java developers.

3.3 User Requirements

- The UI language used shall be simple enough for users with minimal education to be able to understand.

- The system shall be user-friendly and menu-driven. It shall provide dialog boxes, help screens, radio buttons and drop-down menus all for user input.
- When the user presses a responsive button, the system must respond within two seconds.
- The lust keep a record of past usage history of the system to facilitate future visits.

3.4 System Requirements

3.4.1 Non-Functional Requirements

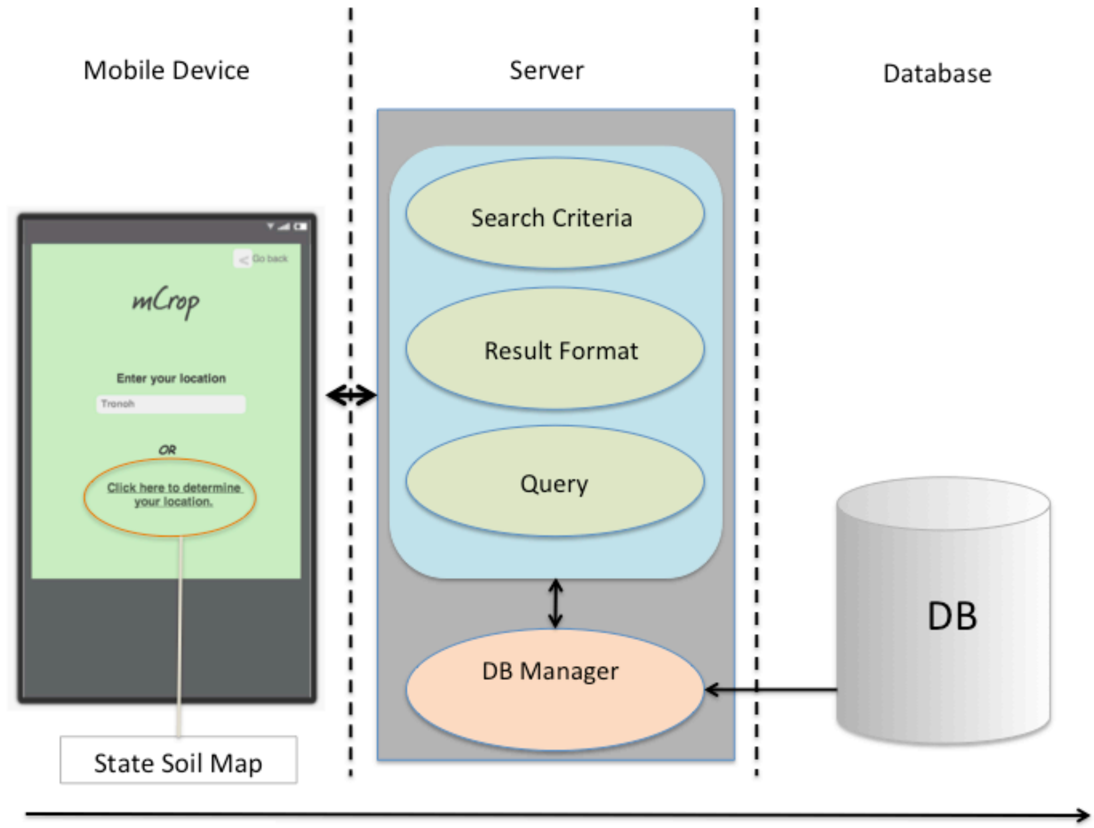
- The system should be able to fit in a pocket or a small bag
- The system should be able to work with minimal mobile Internet access
- The system should be available 24/7 all year round
- The system should be able to integrate with already existing expert systems
- The system should be able to provide prices in local currency

3.4.2 Functional Requirements

- The user can request the system to assist with locating the farm
- Explicitly typed-in user input shall be minimal
- The system shall provide the users with broad choices but will stray void from confusion
- The system shall provide the user with the relevant response screens
- The system shall allow the user to perform ‘back’ and ‘forward’ actions in the event of an [un]intentional mistake
- The system shall, at all full transactions, provide more than one possible

suggestion.

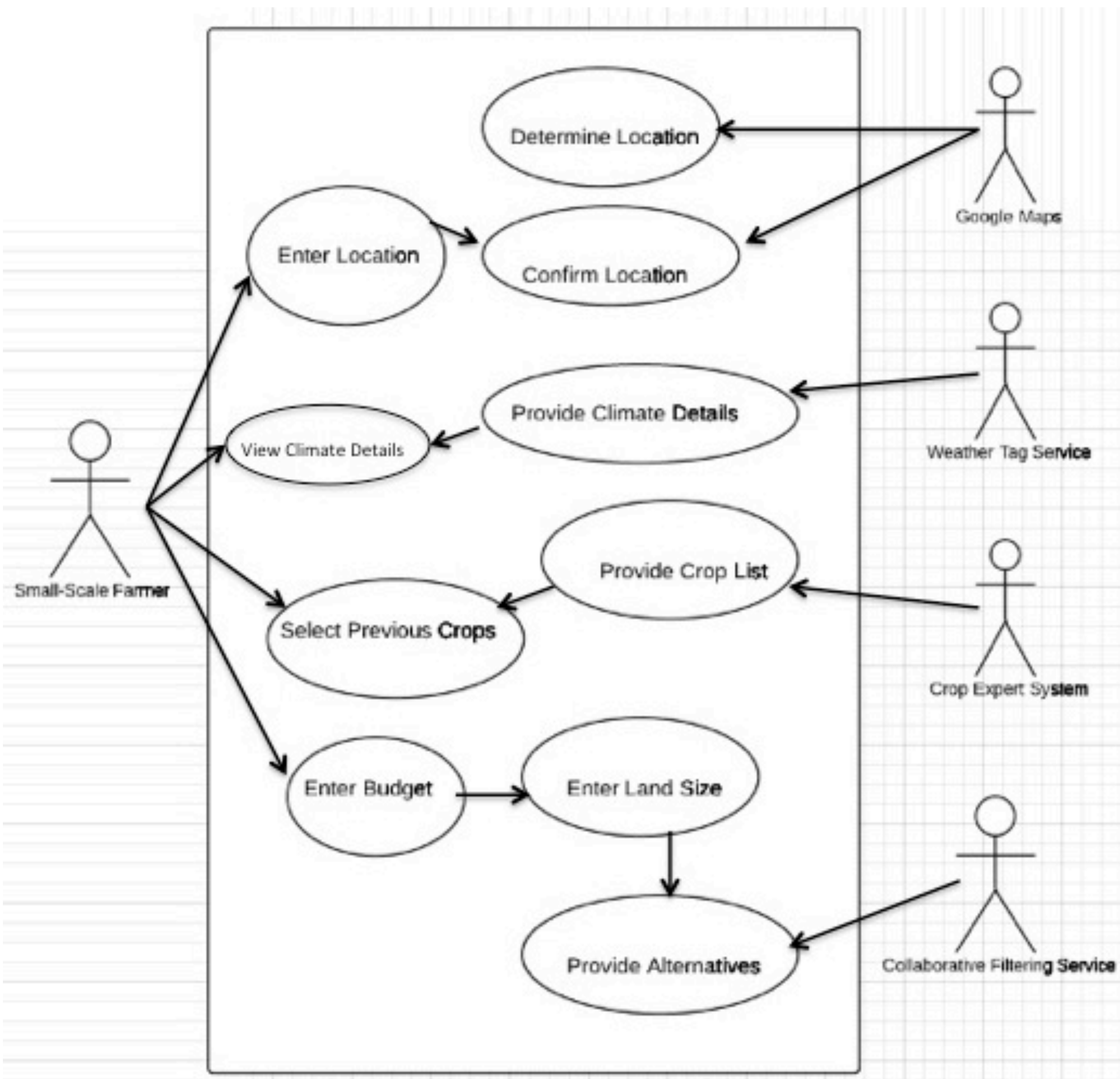
3.5 System Architecture



3.6 UML Diagrams

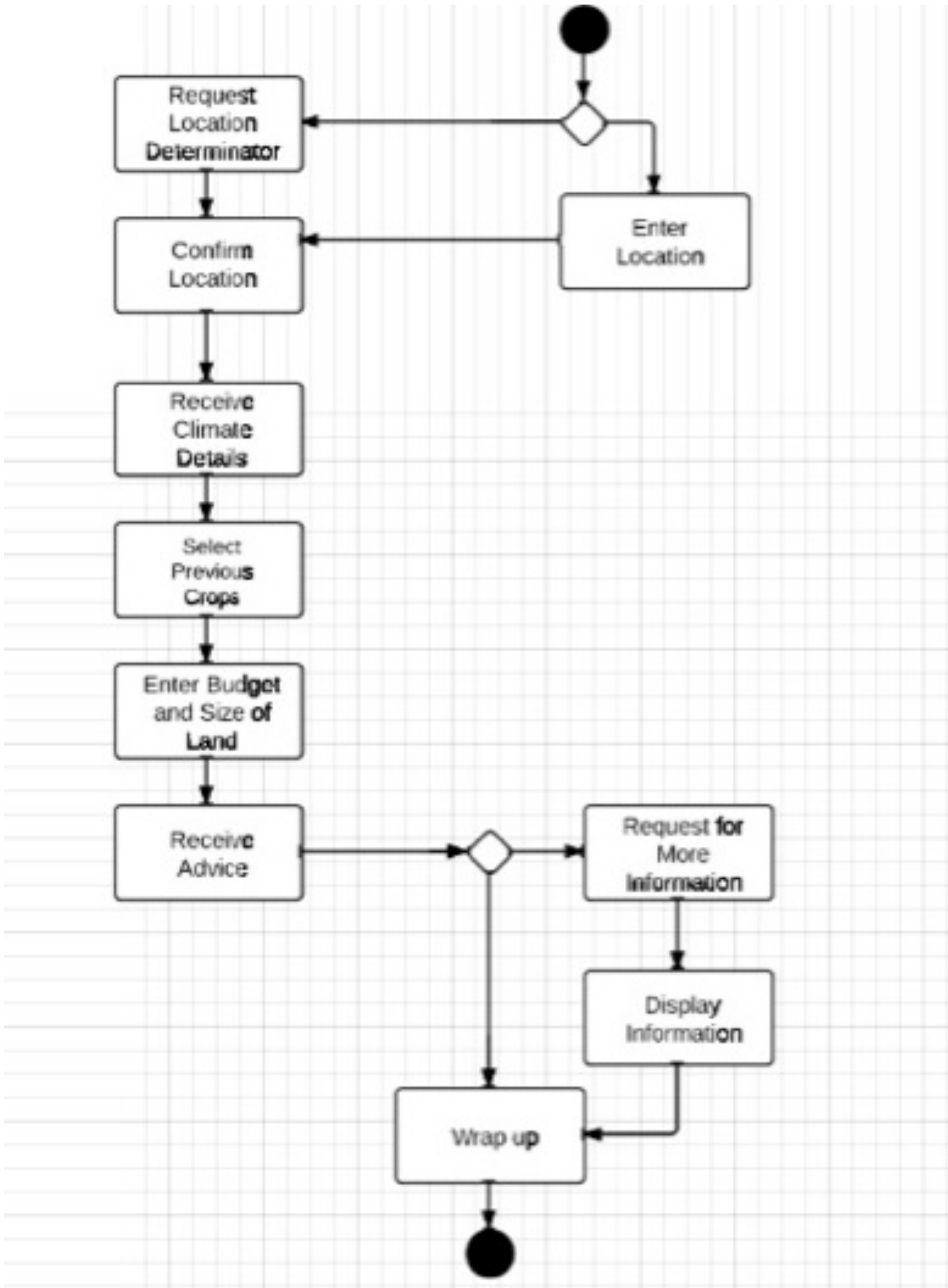
3.6.1. Use Case Diagram

Use Case Diagram for mCrop



3.6.2 Activity Diagram

Activity Diagram for mCrop



3.7 User Interface

The first screen allows the user to choose the district in which the individual is conducting the farming activities. The second screen allows display the crops which the system has stored are available for that geographical location. Following this, the user is promoted to enter the crops previously grown there and the farming investment he or she wishes to make. These four pieces of information are then matched in order to provide the user with the best-fit crops for his or her conditions. Following the suggestion, the user may choose to stick to that suggestion and proceed to view more information and the crop calendar for that specific crop or the individual may choose to restart the process in order obtain a different suggestion.

CHAPTER 4

Results And Discussion

4.1 Desk Research

The following are the results obtained by the author based on desk research.

Malaysian Agricultural Scene

According to the Ministry of Agriculture and Agro-Based Industry [12] the total agricultural area of Malaysia is of 6.6 million hectares, which accounts for 20% of the total land area in Malaysia.

The industrial crops, which are grown and occupy 77% of the total agricultural land are palm oil, rubber, cocoa, tobacco and pepper. Other crops, covering about 16% of the total agricultural land are paddy, fruits, vegetables and coconut.

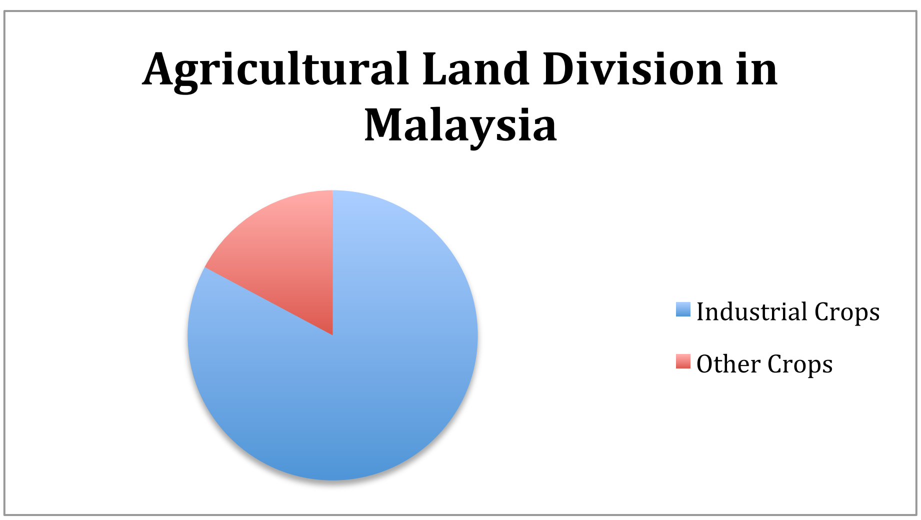


Figure 3: Agricultural Land Division in Malaysia

A sub-sector of the Agriculture Sector in Malaysia is called the *Smallholders' sub-sector*. The average farm size is approximately 1.45 hectares and is generally owned by individual farmers. This sector is less commercialized and less efficiently managed. Nonetheless, they are the main contributors to food crop production as well as industrial crop production.

The following graph shows the crop zoning for Malaysia. This will assist in helping the farmers identify what crops to plant depending on their geographical coordinates.

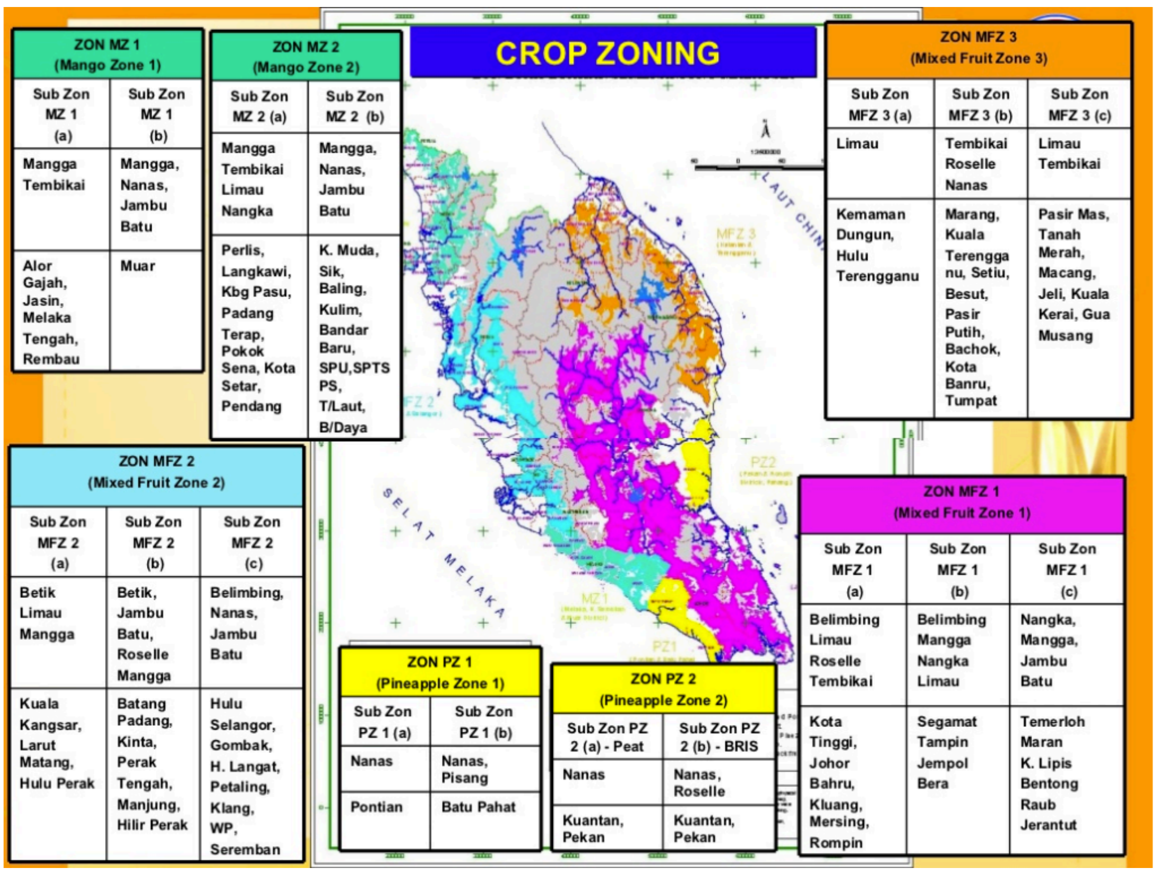


Figure 4: Crop Zoning in Malaysia

Farmers' Profile

<45 years old: 30 %
45-55 years old: 25%
>55 years old: 45%

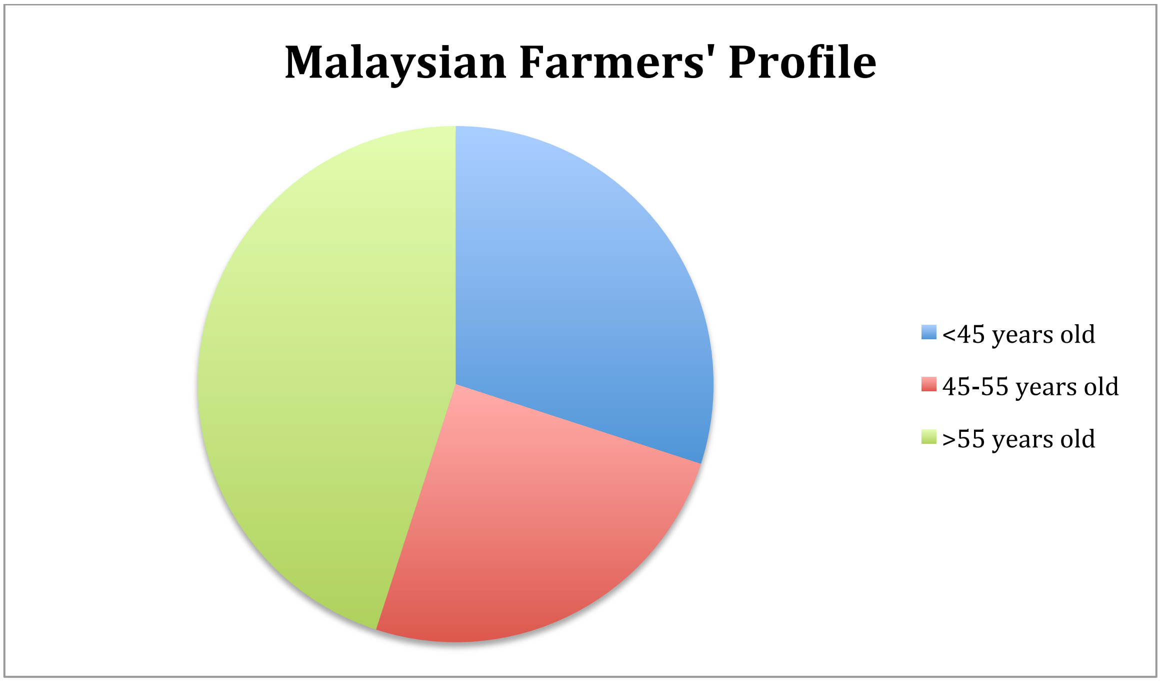


Figure 5: Farmers' Profile

The ageing farmers are an issue in the agricultural sector. This demographic factor affects their acceptance of change and of new technologies. The older generations have a belief that their methods have always been reasonably successful and there is thus no need to change. Furthermore, learning how to use modern technologies is not something they are keen to do as it takes longer for them and at times they find themselves unable to actually use the technology even after extensive training.

The younger generations are not attracted to the agricultural sector; adding technology to this sector would potentially increase the attractiveness of the sector. The Ministry of Agriculture states that there is a need to increase the attractiveness of agricultural products in Malaysia; there is lower level of productivity in the sector, which definitely needs to be enhanced.

The Ministry also admits that there is a need to transform small-scale agro-industry into commercial ventures. Furthermore, the sustainable development of this sector needs to be ensured so as to also increase its competitiveness.

Potential Crops

The tropical climate of Malaysia allows the country to be able to produce tropical fruits, which could compete in the international market in areas like the European Union, Northern America and Hong Kong, which are all major consumers of tropical fruits.

The Ministry has identified the following fruits as potential crops:

- Papaya
- Star Fruit
- Pineapple
- Melon
- Guava
- Jackfruit
- Banana
- Citrus
- Mango

The knowledge obtained on the situation of the Malaysian agricultural sector and the characteristics of the farmers will allow the developer to narrow down the number of crops to focus on and to determine the complexity level as well as ease of use of the system for development purposes. The geographical data obtained will also assist in accordingly setting up the system to provide data as accurate as possible to future users.

4.2 Field Research

Participants

Participants for this research were a mix of purposeful and random choice. For the interview, the head of the transformation department of the Agricultural Department of the State of Perak, mr. Hirwan, was interviewed. For the survey a random sample of 10 farmers was chosen; this sample included males and females of three different racial backgrounds, Chinese, Malay and Indian.

Materials

Quantitative and qualitative methods, which are a set of questionnaires and an interview session, were used in this research. A three-page self-developed questionnaire was designed, consisting of 20 questions, which studied various aspects of the farming habits of the farmers. The questionnaire consists of only thirteen multiple-choice questions (MCQ) and only seven open ended questions, which required the participants' detailed explanation.

Interview

The interview held with Mr. Hirwan bin Dato' Ahamed Hambal, the head of the Transformation Department of the Perak Agricultural Department provided the author with a great insight as to how agricultural planning is undertaken throughout Malaysia and what systems are used. The results are discussed below and an interview transcript is available in Appendix I.

The planning for agricultural activities in Malaysia is done on a 5 by 5 year basis. However, random checks of the soil may be done from time to time to update the soil map to ensure maximum accuracy of the system. There is a soil map developed for each state, and each of these maps is divided into several districts. Every time a farmer wishes to start or change its farming activity, the map is their main point of reference.

If farmers so wish, they may choose to plant crops not dictated by the state and the soil map, however, even in such cases, farmers must still abide to guidelines; the land needs to be adequately worked on and the business plan they have must receive the green light from the state prior to them starting with their activity.

In addition to these soil maps, each state has agents scattered throughout the districts to provide assistance to the farmers. All agents conduct their operations based on a crop calendar. The state of Perak alone has 120 agents spread in 30 offices to assist its 44, 000 farmers. The crop calendar and visit schedules are not yet digitized, and according to Mr. Hirwan it would be of great assistance if they were to become digital.

A common worry is that farmers do not possess recent technology or are too illiterate and are therefore not able to operate the modern devices. However, throughout Malaysia the demographics have changed, many of the farmers are either graduates or retirees. There are still a few uneducated ones but the government is making serious effort in educating all of them. All farmers can now read. This shows that the system can have a certain level of complexity and still be understood and adequately used by the farmers. Mr. Hirwan defines current farmers as a *new era of farmers*; he calls them professionals rather than amateurs or people who do it with little to no knowledge.

As far as the selling process goes, the Malaysian Agricultural Division provides a certain level of autonomy to the farmers but they provide assistance to the farmers where it is needed. The FAMA agency assists in selling and marketing whereas the

Department of Agriculture assists in the production process.

The main source of where the farmers can obtain information is the agents and the offices scattered throughout the state. Having access to crop related information at their fingertips would greatly facilitate their planning and growing process. One fear that is present among the planning authorities is the fact that the farmers may use the Internet to obtain inaccurate information and thus could jeopardize their entire process.

Lastly, the top crops grown in Perak are rice, durian, rambutan and citrus fruits. Rice is the crop that provides the state with the largest revenue but it also requires a larger area and thus not all farmers are able to grow it. Furthermore, durian and rambutan are heavily exported to China and Japan.

A system would not only assist the farmers, but it would also assist the agents and the state in knowing that the information that farmers are accessing is accurate. It would also assist them in better complying with the quality standards required for international quality certification.

Survey

There were a total of 10 respondents to the survey, 4 female and 6 male, these 10 were a representative of the three racial demographics that can be found in Malaysia (5 Malays, 3 Indians and 2 Chinese) and all were from the state of Perak and conducted their farming activities in the state of Perak.

All farmers own a mobile device; 60% of them are in possession of a smartphone. In terms of operating system, according to their responses, all of them appear to be using Android operated devices. When asked if they were interested in a system to aid them with their decision-making process, they all responded that they would like one and all confirmed their availability for system testing.

The farming experience they possessed was varied and is described in the gender and experience table.

Table 2: Gender and Experience

Gender	Age	Years in Farming	Amount
Female	35-45	5-10	1
Female	35-45	10-15	2
Female	>50	>15	1
Male	<35	5-10	1
Male	35-45	10-15	1
Male	45-50	10-15	3

From the data in gender and experience table it is visible that most female farmers appear start the farming activities at the age of 20 whereas the male farmers seem to start at a later age, around 30 years old. This indicates that the females in the framing industry are generally younger than their male counterparts.

The farming income is generally higher than initially thought of by the author. The income graph illustrates the rage of their income.

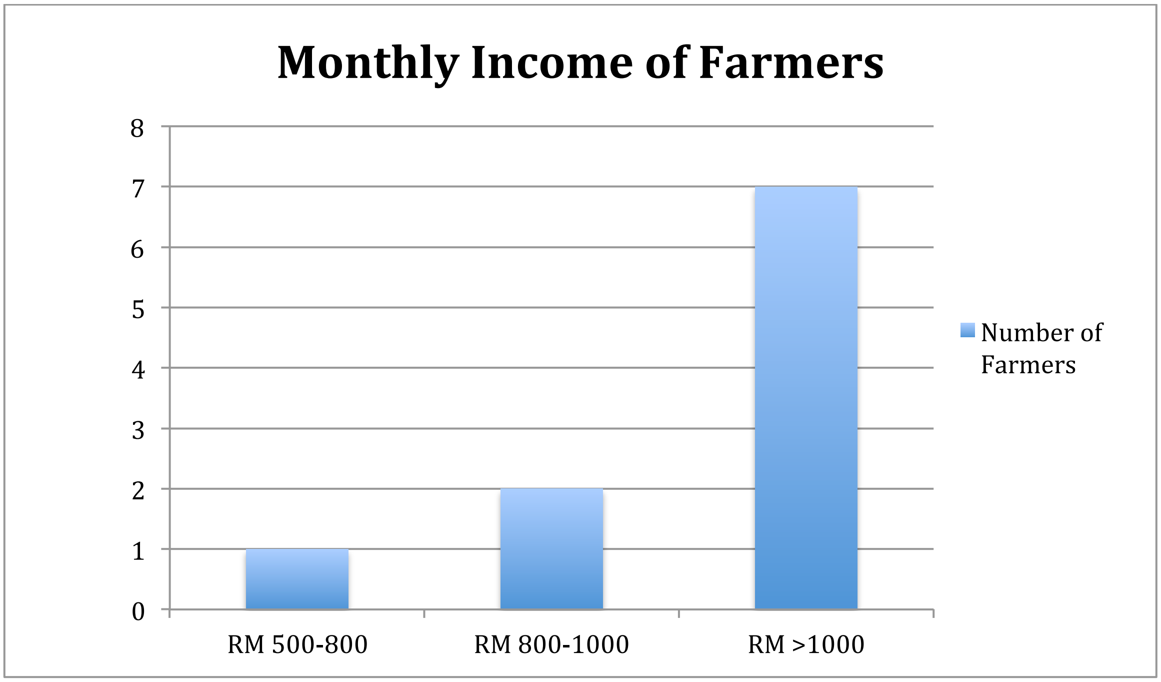


Figure 6: Monthly Income of Farmers

This data indicates that, even without the most advanced technologies, farming is still a lucrative business for most of the farmers. If adequate technologies were to be integrated, these farmers could see their income experience at least a 25% rise in the long run.

When it comes to determining the price of their crops, most farmers use more than one method, the most popular ones being:

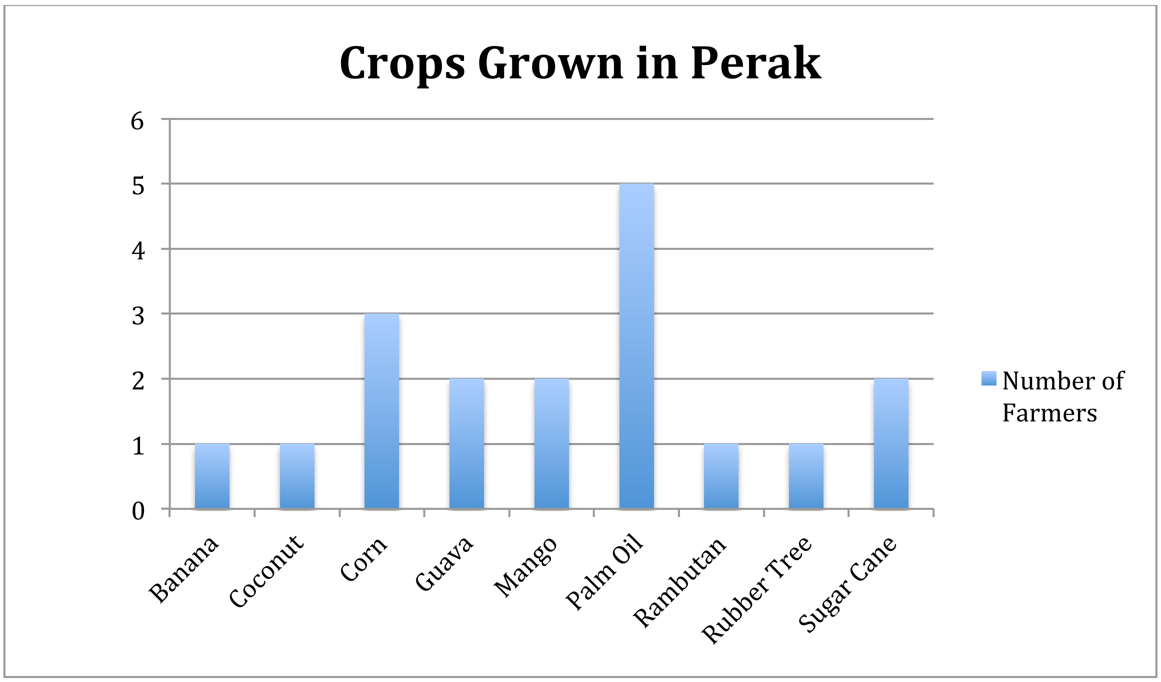
- Negotiation with the buyer
- According to market price
- Using a rate fixed by a board

Providing farmers with daily access to market prices would place them at an advantage when negotiating the price with the buyer. This would ensure that if the farmer were to sell below market price, he or she would have determined the minimum threshold up to wish they are willing to sell in the event that the buyer wanted a relatively low price.

Of the suggestions proposed by the farmers on what they wanted out of the system functionalities was the ability to have buyers and a best price suggested to them.

When asked about the sources of information, which they use, 70% of them use the local agricultural board as their main source. 40% of them admitted to using the Internet as either a primary or secondary source. To illustrate the aforementioned point on the increased level of education of the farmers, one of the farmers said to attend seminars when they are available in order to gain extra knowledge and be kept up to date with modern techniques.

The crops grown throughout the state of Perak are illustrated in the crops chart.



About 50% of the respondents grew more than one crop; from the data it can be seen that the most grown in the state of Perak is palm oil, followed by corm and guava, mango and sugar cane. The growth of more than one crop is also reflected in the rotation of crops that at 40% of them do on a yearly basis. For some of these farmers, their plants are grown on more than one farming site.

The main methods used by the farmers to determine what crops to plant are based on the cost of crops and the market needs. The second most commonly used methods are based on past experience and based on the plants grown in the community. All respondents use more than just one decision method, what is important to note is that none of them make these decisions at a random selection; they all think through them one way or another.

CHAPTER 5

Conclusion and Recommendations

The agricultural sector is a critical one for the survival of various global economies, especially the developing ones. Smaller scale farmers aren't able to reap of all the benefits that the available technology and data despite the availability of such tools.

Implementing an information and recommender system that would run on Android powered devices, as these are the lower cost ones in the smartphone market, would assist the farmers in planting the crops that would provide them with the greatest return. Although there are initial infrastructure costs involved and possible difficulties in adaptation of the system, there is a way to overcome this barrier through government subsidies. Through this, governments would be improving their infrastructure while at the same time improving a vital sector of the economy.

The development methodology identified, incremental, is to ensure that the system is not suddenly thrown at the hands of the farmers. Given their demographics, it is very important to introduce technology slowly to them so as to avoid the lack of adherence to the system.

The second phase of the final year project focused mainly on developing the recommender algorithm to combine it to the existing interface for a fully working prototype.

At the completion of the second stage, several conclusions could be drawn. The digitization of any manual system can be of aid to facilitate farmers' as well as local government's agricultural planning. The system has the capability to allow for better interaction between government agents and farmers as well as among farmers in disperse geographical areas. Improved planning will assist in improving the quality of crops to meet global standards and thus increasing market size for smaller scale farmers. The system will also enable for further autonomy from the farmers' side. They would no longer solely be dependent on the agent visits in order to progress with their agricultural planning and activities. They would be able to have their queries answered on a near real-time basis.

One of the main drawbacks stated at the beginning of the research was the lack of availability of low-cost technologies for smaller farmers when compared to the larger corporate farmers. Therefore in order to market the product the criteria of an accessible price still needs to be met. mCrop provides small- to medium-scale farmers with access to improved technology at low cost. Furthermore, the system can initially be introduced for a free trial for one farming period. Upon satisfaction with the product, a yearly low subscription fee is to be charged.

Further studies and development of this project or under the umbrella of agricultural system should include a larger sample for data collection purposes, that would allow for a more varied and more accurate view of the global developing farmers and also the conditions that they are exposed to.

Additionally this system could in itself in the future become an expert system and expert locator for farmers globally. The system could allow farmers to communicate amongst themselves, starting at a national level then expanding it to a regional and global scope. This would allow for knowledge transfer in between them, adding on to a global database of farming methods and advice. At a later date, this would allow farmers to locate the likes of themselves and query with them for advice, rather than only using the agents provided by the government and relying on not always accurate information found online. Furthermore, the system could be extended to allow farmers to connect with potential buyers of their crops, thus removing the need for a middleman and increasing the potential financial rewards of the farmers.

REFERENCES

[1] The World Bank and Agriculture in Africa, World Bank Factsheet, [online] 2010. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/0,,contentMDK:21935583~pagePK:146736~piPK:146830~theSitePK:258644,00.html

[2] J. Stienen, W. Bruinsma and F. Neuman, How ICT Can Make a Difference in Agricultural Livelihoods in The Commonwealth Ministers Reference Book. The Hague, 2007, pp. 2-4

[3] Nokia Life Tools, Wikipedia. http://en.wikipedia.org/wiki/Nokia_Life_Tools

[4] K. Donovan, Mobile Devices and their Impact, in ICT in Agriculture. Washington, D.C., 2012, pp 61-65.

[5] APSIM Initiative, http://www.apsim.info/

[6] Systems Development Life Cycle, Wikipedia. http://en.wikipedia.org/wiki/Systems_development_life-cycle

[7] Software Development Life Cycle Incremental Model, Simplicity through Breadth. http://faisalsikder.wordpress.com/2009/12/19/software-development-life-cyclesdlc-incremental-model/

[8] What is Incremental model- advantages, disadvantages and when to use it? STQB Exam Certification http://istqbexamcertification.com/what-is-incremental-model-advantages-disadvantages-and-when-to-use-it/

[9] Wikipedia. Android Operating System. Retrieved from http://en.wikipedia.org/wiki/Android_(operating_system)

[10] Wikipedia. MIT App Inventor Rehttp://en.wikipedia.org/wiki/App_Inventor_for_Android

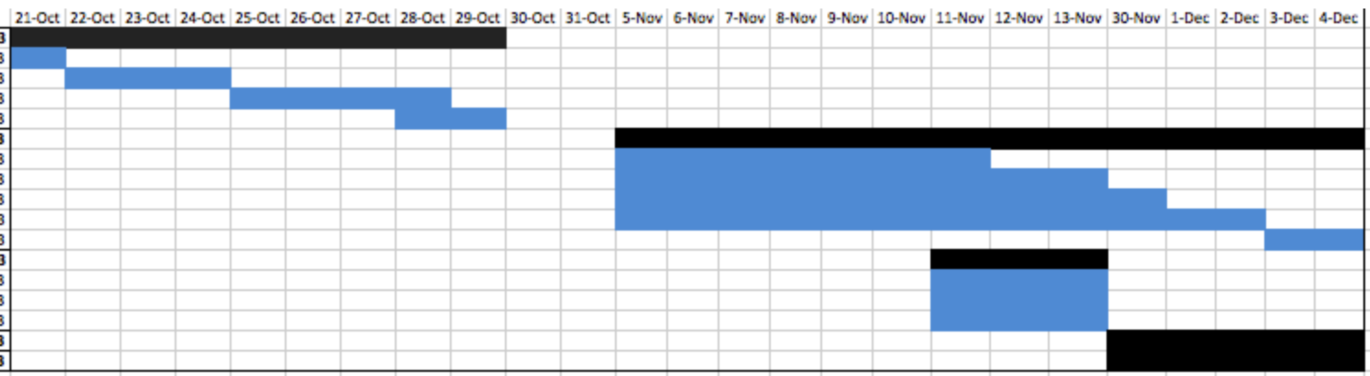
[11] Wikipedia. Collaborative Filtering. Retrieved from http://en.wikipedia.org/wiki/Collaborative_filtering

[12] An Overview of the Malaysian Agricultural Sector. http://www.slideshare.net/ranzcdadavao/overview-of-agriculture-sector-in-malaysia-presentation

APPENDICES

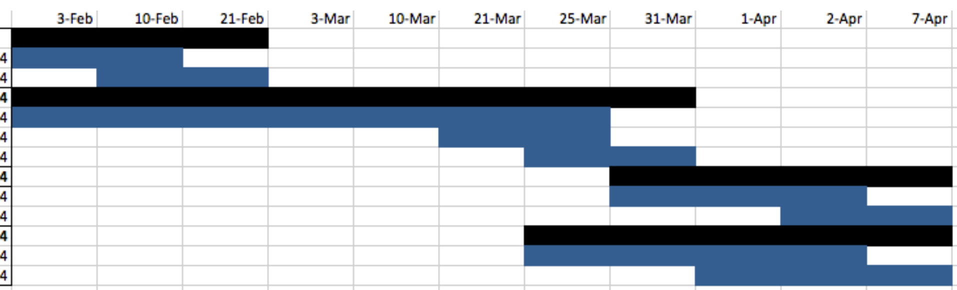
Appendix I: Gantt Chart FYP 1

Name	Duration	Start	Finish
Crop Identification	**7 days**	**21/10/2013**	**29/10/2013**
Identify expert systems	1 day	21/10/2013	21/10/2013
Search for existing crop databases	3 days	22/10/2013	24/10/2013
Compile database of crops	2 days	25/10/2013	28/10/2013
Select crops to be used for the system	2 days	28/10/2013	29/10/2013
Technology Identification	**22 days**	**5/11/13**	**4/12/13**
Identify cost-effective hardware an software	5 days	5/11/13	11/11/13
Identify existing agricultural technology	3 days	5/11/13	13/11/2013
Carry out desk and fielld research	19 days	5/11/13	30/11/2013
Identify functionality needs	20 days	5/11/13	2/12/13
Define user and system requirements	2 days	3/12/13	4/12/13
Feasibility Analysis	**3 days**	**11/11/13**	**13/11/2013**
Identify technical feasibility	3 days	**11/11/13**	13/11/2013
Identify economic feasibility	3 days	**11/11/13**	13/11/2013
Determine product marketability	3 days	**11/11/13**	13/11/2013
Develop System Architecture	**3 days**	**30/11/2013**	**4/12/13**
Develop User Interface	**8 days**	**30/11/2013**	**4/12/13**



Appendix II: Gantt Chart FYP 2

Name	Duration	Start	Finish
Data Collection		**3/2/14**	**21/2/14**
Collect Crop Data for Perak		3/2/14	10/2/14
Collect Zoning Data		10/2/14	21/2/14
System Development		**3/2/14**	**31/3/14**
Develop Crop Determining Algorithm		3/2/14	25/3/14
Develop and Populate Crop Location Database		21/3/14	25/3/14
Develop Additional Information Screen		25/3/14	31/3/14
Check Code for Mobile Functionality		**31/3/14**	**7/4/14**
Migrate Code into Mobile Device		31/3/14	2/4/14
Debug		2/4/14	7/4/14
Undergo Phase 1 Testing		**25/3/14**	**7/4/14**
Perform Unit Testing		25/3/14	1/4/14
Perform System Testing		1/4/14	7/4/14



Appendix III: Questionnaire

Questionnaire

The purpose of this questionnaire is to gather information regarding the farming environment in order to assist with the development of mCrop, which is a mobile information system that aims to assist small- to medium-scale farmers in improved decision making. Your cooperation is highly appreciated.

Instructions: For the close-ended questions please, highlight or tick the relevant answers. For the open-ended questions, please provide your input on the lines provided.

---

1. Gender
   a. Female
   b. Male

2. Age
   a. <35
   b. 35 – 45
   c. 45 – 50
   d. >50

3. Race
   a. Malay
   b. Chinese
   c. Indian
   d. Other, please specify _______________

4. Number of years in the farming industry
   a. <2
   b. 2 – 5
   c. 5 – 10
   d. 10 – 15
   e. >15

5. Resident State

   ____

6. Farming State

____

7. Monthly farming revenue
    a. < RM 200
    b. RM 200 – RM 500
    c. RM 500 – RM 800
    d. RM 800 – RM 1000
    e. > RM 1000

8. Cellular device used
    a. Basic black and white phone
    b. Smartphone

9. If smartphone; which operating system is used?
    a. Android
    b. iOS
    c. Other, please specify ____________

10. How do you decide which crops to plant? *(Select all that apply)*
    a. Past experience
    b. Based on the plants grown in the community
    c. At random selection
    d. Depending on cost of crops
    e. Personal preference
    f. Depending on the market needs

11. List the top 4 crops you grow

    a. ________________

    b. ________________

    c. ________________

    d. ________________

12. How many times a year do you rotate/change the crops grown?

    ____

13. What source(s) of information do you use for crop related enquiries? *(Select all that apply)*
    a. Local agriculture board
    b. Books/Newspaper/Magazines

c. Internet
d. Other, please specify ______________

14. How do you determine the price of your crops? *(Select all that apply)*
    a. Fixed rate by a board
    b. Depending on the market price
    c. At random
    d. By negotiating with the buyer
    e. Other, please specify __________________

15. Do you sell your crops outside your community/neighbourhood?
    a. Yes
    b. No

16. If yes to q15, how far do you reach out? *(Name the cities/states)*

    ____

17. If no to q15, please provide a reason.

    ____

18. Would you be interested in a system that aids you in making planting decisions?
    a. Yes
    b. No
19. Please provide any functionalities you would like to see on the system.
    ____
    ____
    ____
    ____
    ____

20. Would you be available for testing the system once it is ready?
    a. Yes
    b. No