BannaTree: an Information Management System for Banana Contract Farming

ICT4D in the Field Project in Sarawak, Malaysia

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Abstract

The banana contract farming agreement in Sarawak, Malaysia has been developed by the Malaysian government as a means of improving export of banana chips, while increasing the standard of living and income of farmers. The farmers plant and harvest bananas called 'pisang sekaki', which are then sold to the banana factory, before being processed into banana chips for export. However, as a result of lack of information on how much banana each farmer is planting and harvesting, there have been issues in cordinating activities between the farmers and the factory. The farmers sometimes produce too much bananas that exceeds the processing capacity of the factory, or they produce too little bananas. This leads to less income and waste for the farmers, and inconsistencies in the supply of banana chips for export. The BannaTree application has therefore been developed as a means of collecting data from farmers on how much they are planting and harvesting, and making it available to the factory. By having this data, the factory can provide the farmers with information on when to supply, and the factory can make preparations, and match their demand to the expected supply.

Contents

1 Introduction

'Contract Farming' is a term that has been around for the past few decades [8]. It has the potential to involve low-income farmers into the the modern sector where agricultural production can be carried out on the basis of an agreement between buyers and the farm producers. In developing countries it has been a topic of interest since the 1970s. However, there are also some controversy about contract farming. Some concerns about it is that large agribusiness firms use contracts to take advantage of cheap labor and transfer production risk to the farmers, and that smallholders will be marginalized because companies will prefer to work with medium- and large-scale farmers, thus exacerbating rural inequality [8]. Nevertheless, in Malaysia contract farming is one of the projects that have a high-impact on the economic growth of the country. It was developed by the governmental agriculture sector as a mechanism that provide alternative markets for small and medium-scale agricultural production farmers and guarantee consistent supply to the markets [3]. This programme in Malaysia started of with five companies that are based on commercial poultry farm in the 1980s [10]. By 2004, this amount has increased to 29 companies.Because of this programme, the productivity growth of the agriculture went up from 1.9% in 2003 to 2.5% in 2004 [10]. Today, contract farming in Malaysia has expanded with many other farm productions. Under the Ninth Malaysia Plan (9MP), the goal is to focus on production and value-added activities that may increase economic growth and make the agriculture sector as the third engine of economic growth in Malaysia. Especially Sarawak, the largest state of Malaysia, has important contributions to to this programme. Farmers grow multiple crops and fruits here, such as bananas, watermelons, and coconuts. Even Nipah palms for palm sugar and bird nests belong to this growers' production.

The main objectives that have been set for the Malaysian's contract farming programme are: (1) to secure market and increase producers' revenue, (2) to increase the production of fruits and vegetables through systematic production planning and marketing, (3) to ensure quality production and sustainable agriculture as well as to meet market demands through Good Agricultural Practices (GAP), and (4) to accelerate the transfer of technology in the supply chain [3]. The contribution of the ICT4D project described in this paper will be devoted to the last objective, where the banana chips industry will be pushed forward by incorporation of technology that is supposed to support all stakeholders within this industry. The stakeholders that are involved are: (1) the local farmers, (2) the agricultural department, and (3) the factory. The end goal of this cooperation is to export banana chips to China. However currently, the main problems for this industry lay in the the communication between the different stakeholders and the coordination of supply and demand between the farmers and the factory. In this paper we proposed an ICT system, called 'Banna', that could help solve these issues, thus helping this industry to develop in a more mature state where every stakeholders will gain benefit from it. Banna will have web interfaces, on one hand for the farmers as the end users who need to enter data about the banana farming into the system, and on the other hand for the agricultural department and the factory to have an overview of all the collected information. In this manner it is easier to monitor and to predict the amount of harvested

bananas for the factory.

To describe the process from collecting use case information in the field to designing the system and to developing the prototypes, this paper will first start of with some theoretical background information and related literature study about this particular use case of banana contract farming. Secondly, a description of the use case will follow, where the context of the use case and key ideas of the proposed BannaTree system are described in more details. Then the system design will be elaborated. Nevertheless, this happened iteratively, therefore follow-up solution designs will be described here as well. Next, the prototypes will be included in this paper with additional explanations and fidelity description. Subsequently, for the deployment and sustainability plan of the system, a value exchange model is set up to present the the feasibility of the business model of the BannaTree system. An evaluation and discussion of the proposed system follow afterwards. Finally, this paper ends with a conclusion and some suggestions for future works.

2 Theoretical Background

The study of ICT4D is about understanding the basic concept on how to bridge the digital technologies gap in places where technologies are hard to access based on geographic location or demographic groups, and adding economic development so that communication, information and technologies are up-to-date. These technologies can consist of radio, television, cellular phones, computer and network hardware and software, satellite systems which enable various services and applications associated with them based on their needs [9].

ICT4D research has began long ago and has been developing for 3 decades with the uses of new and upcoming digital technologies [11]. Before digital technology was introduce, ICT4D research basically carried out largely in the field where everything is done manually [11]. field. Since technologies such as computer-supported activity is expensive which usually borrowed from the develop country, training the users about cooperative design with the help of computer experts[11]. This method would not be efficient as most of the major projects need to develop indigenously. As times goes, Internet has become a major helping hand as most of the cost can be decrease by having sophisticated search engines which can produce a large interest in using ICT's in developing countries [11].

Information like journals can be shared on-line easily by allowing it to be open access. With the help of the ICT and Internet, technologies has grew significantly [11] with the introduction of mobile phones, laptops, portable network connection, devices and gadgets, software and satellite system. However, not all groups are easily exposed and can adapt with changes. For example, in Africa, the knowledge of technologies is not significantly advance in all parts of the continent which results in using their own tradition and cultural way to live their life. Farming and economic businesses are not greatly advanced, so the challenge to introduce ICT4D towards the people who lack in ICT knowledge is a problem. Book demonstration has been use which has help womens in Africa to get involve in economic activities [11]. In the future, the advancement of technologies will develop and this may or may not be a

difficult task to enhance the impact of their work but it will definitely be an exciting task to look for.

ICT4D is a research involving digital technologies and providing real-time solution to areas that has poor ICT involvement. Based on the project such as improve the technologies aspect in rural areas, the tasks will vary at different location. Some areas may be difficult to access. Therefore, bringing in the computerize technology will be a challenge. With the goal of providing ICT help to people all around the world who were unable to learn ICT, technologies need to be as simple, easy to understand and easy to use. It can be different type of teaching method which can be as simple as providing on-line website for them to share information or allowing Internet access to be accessible. As simple as a task could be, it still can be a big problem, if the current ICT4D research area has lack of Internet access. Information will be hard to get and most learning method need to be off-line or a built-in local Internet connection which only can support limited number of users at a time. This can be similarly apply to this project where data collection is a problem and the lack of ICT knowledge to those farmers can be a difficult task in order to provide software or application to store information. Moreover, some of the information will not be accurate and can be lost. Therefore the challenge is to create a good data collecting system, simple enough for farmers or anyone who will use it. This could result in a good enhancement to the plantation product and could increase the overall output from the current state.

The ICT4D has been developing through the years and every new challenge will have new interest and task to face. Throughout the past decades, ICT4D has evolve and become more and more well known with people sharing and expanding their knowledge to others who are nowhere near capable of getting their hands to the advance technology [11]. The research of this project which is helping the production of banana tree will be the advancement in terms of software usage rather that delivering information through paper.

ICT4D has also began in other areas such as Malaysia, or in more precise will be in Sarawak. Sarawak is a large area where people in Sarawak lives scattered all around Sarawak except the big town such as Kuching. As people stay in various area, the coastal area usually have high living cost compare to other part. The people there lives in groups and mostly work on their own farm as their economic business. Some of the farmer work under a contract , also known as 'Contract Farmer'. These 'Contract Farmer' can be in different based on who the agencies the farmers work on. It can be between Industries, Institute and Farmers or having additional stakeholder where research institute and Financial institute involve [2]. Most farmers in Sarawak usually lives in outskirts therefore Internet connection, computer literacy, technologies and literacy will be a challenging task if projects related to ICT takes place.

3 Related Literature

ICT4D in the field is a project that that has been going for many years all around the world. From poor literacy and lifestyle to developing country, the aim for ICT4D

is to help in international development by bridging the digital divide and providing equitable access to technologies for example helping out people in rural areas. Countries such as Africa as an example where few ICT4D project has taken place. One of which are E-agriculture [6]. This project was to take farming into the future [6]. R-agriculture is an emerging field that sees agricultural services, technologies dissemination, information and communication delivered or enhanced through the Internet of thing (IoT) [6].

This project took place in Sudan and with the help of satellite images, the crop information such as growth, humidity and the nutrient needs of plants can be estimated [6]. The SMS system was used among all farmers where they will be inform when is the best time to irrigate, apply fertilizer and other crop husbandry advice [6]. With the help on this new system, the crop yield has improve to an average of 60 per cent and also help in food sustainability [6].Another ICT4D project took place in Bangladesh in 2011, where their case study would be to use mobile phone based agriculture market information service for farmers in Bangladesh [5]. The study is mainly focus on mobile phones and how they can be used as part of an Agriculture Market Information Service (AMIS) [5]. It is mainly for farmers in order to collect, manage and disseminate agricultural market prices and related information through various process and media [5]. It is a process of understanding on how the use on mobile phone can elevate the ICT use among farmers and the market price information based on implementing AMIS on the mobile phone and evaluating the efficiency and effectiveness of it for the farmers in Bangladesh [5].

In China, the ICT4D team has also work around to study about Internet Adoption and usage among rural users [12]. The aim is to study the effects of Internet use on various aspects of rural development, including economic conditions and education[12]. A qualitative approach was adopted in order to gain an in-depth understanding of the diffusion process plus data-collection methods were use such as in-depth interviews, participant observations, and documentation reviews were use to get its implications for rural development [12]. The finding provide strong empirical evidence in support of the view that society shapes the adoption of technology as the Internet serves as an agent of change, but the extent, duration, and intensity of its impact are primarily determined by the existing socio-economic contexts of the rural settings [12].

The ICT4D project has also influenced the Malaysian team to improve their technology and research for their plantation. One of their success IT implementation is Image Clustering Technique in Oil Palm Fruit [7]. By using digital image of Fresh Fruit Bunch(FFB), the harvest stage can be determine base on the color of the fruit [7].With the help of the high-tech camera, the images of FFB were acquired in autofocus mode, independent of specific weather condition, time of acquisition, and distance from the object of interest and camera or FFB orientation [7]. This approach was considered to ease the image acquisition process where it can be carry out by unskilled worker at any time during day light [7]. This model can promote towards better plantation management and can revolutionize the oil palm industries [7].

4 Use Case Description

In June 2018 the project has started as a collaboration between two universities: the VU Amsterdam and UNIMAS. In the first week of June there was a lot of field work, where information was collected from local communities and different stakeholders. A few use cases were collected. The banana use case amongst others was picked as one of the use cases that have a lot of potential. Stakeholders that are involved in this use case are farmers, the agricultural department, and the banana chips factory. Fortunately, the BannaTree team has the chance to meet and interview all parties. Below, all the interviews are summarized to get an overview of all the information that was collected from the use case.

4.1 Interviews

In order to sufficiently gather enough requirements to build a working application, a number of interviews were held. The interviews were conducted to involve various stakeholders of the system; the farmers, agricultural department of the government, and a representative from the banana chips factory. Preliminary knowledge of the use case was used to develop questions that were asked during the interviews. With more information received during the interview, more questions were asked to get more information and insight into the use case. The next sections will give a brief summary of the various interviews conducted, and the results received.

4.1.1 Interview with Pisang Sekaki Farmers

The first interview conducted was with the banana (pisang sekaki) contract farmers. A total of four farmers were interviewed. Two of them were experienced banana contract farmers who have been planting and harvesting bananas for the factory for at least a year now. While the other two farmers were less experienced in contracting farming, meaning they had just newly bought into the contract farming scheme. These two farmers were yet to make any banana harvests to be sold to the factory, they were still in the planting stages.

The team was split into two. With one team interviewing the experienced farmers, and the other team interviewing the less experienced farmers. The information collected by this two groups allowed us to get some information on the experiences of farmers when they newly join the contract farming scheme, and of what the situation is after they have been in the scheme for a while. We noticed that in terms of the support provided by the government, the new contract formers got more help from the government than the existing contract farmers. In the sense that they provided things such as fertilizers and banana seeds. Once the contract farmers have been established and have made their first banana harvest, the government does not provide as much support in terms of fertilizers and seedlings. Also, the farmers who have been planting the pisang sekaki for longer had more experiences and information to give on diseases and pests that could affect the trees, while the new farmers were yet to encounter such issues.

From the interview, we got information that the farmers in general all planted different types of crop apart from the 'pisang sekaki'. Their crops included watermelon, coconut, and other types of bananas as well. We asked them some general questions about the planting and harvesting of the pisang sekaki. We also collected some information on their experience with selling to the factory, and contacting the agricultural department for issues regarding agricultural subsidies. In respect to technology, and their knowledge of it, we noticed that there was a 50/50 split among the farmers. Two of the farmers were not technology savvy, and had experience with only GSM phones. They had no experience with smartphones, and were not literate in sending messages, only making phone calls. The other two farmers however had android smartphones, and identified as being literate in using smartphone technologies. This gave us two views on the affinity of the farmers to technology.

In general, the farmers provided background information on contracting farming and the processes they employed in planting and harvesting the pisang sekaki. According to the farmers, they were no immediate issues that they felt could be solved by technology. The only issue they seemed to have was with floods, the floods during the rainy seasons could prevent them from planting new bananas, and also affect the banana yield.

4.1.2 Interview with the Agricultural Department

The next interview was conducted with agents from the Agricultural department who represented the government. They are in charge of monitoring the contract farming scheme, interacting with the farmers, and coordinating activities between the farmers and the factory.

The agents provided us with some information on the type of services they provide to the farmer. This information was similar to what was collected from the farmers. They informed us that they provide the farmers with fertilizers, seedlings, as well as some training on the planting and harvesting of the pisang sekaki. Farmers who are interested in joining the program are given support in form of providing fertilizers and seedlings. However, this help is only provided in the first 8 months of planting and harvesting the bananas. The department however still help in providing information on things such as diseases, pests, etc. The also go around to check up on the farmers from time to time.

The interview with the agents was quite brief. They did not seem to have a clear picture of the issues they have, or what they would like to have help with. The only thing pointed out was the fact that they lacked a means of tracking activities between the factory and the farmers. They pointed out the severe lack of information on the current processes.

4.1.3 Interview with an Expert in the Field

The third interview was initially not planned for. However, an expert researcher in the field of contract farming of the pisang sekaki was present and available to provide us with more information, and give more clarity to the use case. The researcher has a lot of experience and knowledge of the use case and the current situation of the

banana contracting farming in Malaysia. From this interview, we were able to get more detailed information on the banana contracting farming process as a whole. It provided us with a more vivid picture of the problem, and how we can help solve it.

From this expert, we were able to get some background information on contract farming and the facts behind it. For instance, the fact that the bananas are planted by the farmers, so they can be harvested and sold to the factory. The factory then processes the bananas into 'creepers' (banana chips), which is then exported and sold outside Malaysia to China, the UK, and the UAE.

Figure 1: Sekaki banana plantation

According to the expert, there are currently 18 contract farmers, however, there are hopes for this number to increase in the near future. Each farmer has a number of hectares of land, and some of this land is allocated by the farmers for planting the bananas. Each plant takes at least 8 months from planting before the bananas can fully be ripe for harvesting. Based on statistics, the experts stated that a plant is able to produce 15 - 20 kg of bananas. If a farmer has one hectare of land, he is able to plant 1000 - 1400 banana trees depending on how he spaces each tree across the hectare of land. According to the expert, the government wishes to have 100,000 banana plants planted by 2020, in order to be able to meet the growing demand of bananas from the banana factory. They wish to add new farmers to the program in order to increase the number of plants and the supply of the bananas to the factory. As mentioned earlier, the Agricultural department as a branch under the government provides some help to the new farmers. They also provide the farmers with seedlings in form of what is called 'suckers' made using the 'tissue culture' method. Which is done by first growing the seeds in a small pot or container, before they transferred into the soil in the farm.

The bananas have to be planted using these suckers, which according to the expert is not so easy to obtain. The agricultural department as a way of support provides the new farmers with these suckers, and subsequent suckers have to be pro-

cured by the farmers. In addition, the type of sucker used affects the amount of bananas that can be produced by the resulting banana tree. If a fresh new sucker is used, the tree is able to produce 15 - 20 kg of bananas. A sucker can also be collected from an existing tree in form of the seeds produced by the tree, then it is re- planted into a new tree. However, each time a new tree is planted from an existing tree, the amount of bananas that can be harvested decreases by 20 percent. The term given by the expert for the amount of bananas that can be harvested from a tree is called 'yield'. This means that the yield decreases by 20 percent each time the suckers are reused, meaning that after the fifth yield, the sucker will not be able to produce any bananas. The farmers are then advised to stop using the sucker from an existing tree after the 4th time, as the yield will the very little.

Most of the essential information were collected from the expert, and in addition to the information given, the expert highlighted the following challenges being faced by the banana contract farming program:

- There is a lack of coordination between the farmer, factory, and the agricultural department, leading to inconsistent supply and demand, and banana waste.
- Lack of knowledge and supply of seedlings using the tissue culture method, as this method ensures consistency in the yield (amount of bananas that can be harvested).
- Lack of knowledge on the types of diseases or pests that can affect the pisang sekaki.
- Lack of knowledge by farmers on how to build proper canals that can regulate floods within the farm.

4.1.4 Interview with Factory Representative

The last interview in the requirements gathering phase was with the banana factory representative. This interview was to provide us with information from the perspective of the factory. The factory as mentioned is in charge of collecting bananas from the farmers, and processing them into banana chips for export, under the name 'BanaBee'. The information collected from this interview gave more details into the contracting farming program, and the problems faced by the factory.

The main problem highlighted by the factory was the issue of inconsistency in supply and demand. The factory is unable to coordinate the supply of the bananas with their demand and processing capacity. The farmers sometimes produce more bananas, but the factory without prior knowledge of the supply is not able to properly prepare, and is unable to handle the supply and the bananas go to waste, or are rejected by the factory. On the other hand, due to lack of planning and information, the supply is sometimes too low, and the factory does not have enough bananas to produce enough banana chips. This thereby affects productivity and makes it quite unstable.

Figure 2: BanaBee factory visit

The second concern they had was with the quality of bananas being provided by the farmers. The factory representative wished for more knowledge and training to be provided to the farmers on how to properly manage their banana farms. If the banana trees are not properly managed, inconsistencies in the size and shapes of the bananas will develop, then they are unable to meet the standards of the factory, and lead to rejection. Therefore, the factory wishes for some sort of knowledge system to also be provided that provides the farmers with information on how to properly manage their banana trees, this will reduce the level of waste and amount of bananas being rejected by the factory, and also help the farmers get more money for their produce.

4.1.5 Observations and Interview Conclusion

The interview process was a bit of a roller coaster and quite different from what was expected. The initial expectations before going into the interview were completely different from the reality when we went into the field. The initial interview with the farmer and agricultural department stakeholders surprisingly did not provide much information or clarity of the use case as expected. The interview with the expert and the factory however was able to provide a much more clearer picture, and understanding of the use case. After the analysis of the information collected from the interview, we were able to conclude on the following requirements for a system: The system should be able to 1) Get and provide information on the amount of banana trees owned by each farmer. 2) Provide information on: Who is planting? Who is fertilizing? (How much fertilizer are they adding?) Who is harvesting? (How much are they harvesting?) 3) Give accurate predictions on when farmers should plant, and when to fertilize. 4) Collect data from farmers to report events e.g. floods (as it can slow down production). 5) Provide a platform for farmers to share knowledge and receive information on various aspects of farming.

Figure 3: Asajaya field visit

4.2 Name and logo

4.2.1 BannaTree

The name of our final application is: BannaTree. This name combines the word "Banana" with "Tree". The application is mostly focusing on collecting data that is related to banana trees (planted trees, harvested trees etc.). Since banana trees are the most important subject of our application, we decided to include this in the name of our app. The initial name of our application was Banna. However, after getting mixed feedback from Malaysian students about the name, we decided to change to name to BannaTree. The feedback was that the name Banna was confusion because it was not clear whether Banna was an existing word or not.

4.2.2 Logo design

The logo for BannaTree has been designed in multiple iterations. For the application, two different logos are designed. The first logo, depicted in figure 4 (a), is the main logo of our application. The name is displayed in the logo, only the letter T, has been replaced by a banana tree. The second logo, shown in figure 4 (b), is a version that is used for the app icon and in the header of the web pages.

(a) Full logo (b) App Icon

Figure 4: BannaTree logos

4.3 Summary Of Key Idea

The main idea of this ICT4D project is to support all stakeholders of the banana chips industry in Sarawak with a computer system that serve them in their communication and coordination for the banana chips production. Therefore BannaTree is set up. It is a data collection system for the contract farmers. Contract farmers get help from the government by ensuring that their harvest is bought for a fixed price by a factory. The government wants to be able to better monitor and control the harvest of banana trees. The government is interested in the following information from farmers: amount of planted trees per yield, amount of KGs harvested bananas per yield, and whether the farmer used fertilizer or not. This data should be recorded every month by the farmers. The government also wants to get information from the banana factory: the amount of KGs bought from the farmers. In the end, our application BannaTree will help the government by providing an application where farmers can enter the requested data every month. The data that is collected might be useful in the future for statistical purposes or extra analysis.

4.4 Actors And Goals

Actors	Role/Responsibilities	Goals
Farmer	- Produce bananas - Provide information	- Providing the factory with sufficient bananas to make banana chips. - Providing information to the agricultural department about amount of trees, amount of harvest, and whether fertilizer is used or not.
Agricultural Department	- Provide banana cultures - Provide fertilizer and pesticides - Find buyers for the farmers - Keep track of statistics - Check on farmers	- Supporting farmers' banana production in order for the factory to produce banana chips and export to China. - Check whether the farmers are using the right fertilizer. - Supporting economic development of the state.
Factory	- Produce banana chips - Keep track of statistics	- Making a profit by producing banana chips for exportation. - Comparing and matching

Table 1: Overview of all stakeholders

4.5 Context And Scope

First of all, we have received information that all farmers have smartphones. Hence, for this project we can focus on developing a mobile application. Also, In general, the internet connection in Sarawak is good. Most of the local people also has access to the internet. However, when doing the field work for the use cases, we have found out that even though their was access to internet in the remote areas, the internet is not always stable or it was only accessible at certain points. Therefore, our first though was to make the application offline as well. However due to the complexity of this requirement and our little time scope, we have decided that a simple web application is sufficient to fulfill the basic needs of a data collection system. Furthermore, there are no non-literate farmers, all farmers are low-literate or literate.

Therefore, collecting information from farmers through data entry by themselves is assumed not to be an issue as well.

The main issue that is encountered within the current work flow between all stakeholders, is that all information that is collected from the farmers, is in paper form. There is no information system yet where all the data can be stored. Moreover, there is a lack in communication between the stakeholders, which could be the main issue that leads to the lack of coordination of the banana production. Also, it seems like both the agricultural department and the factory both try to collect information from the farmers about their harvest and their plantations. This is unnecessary and time consuming. For this we figured that it is best to have all the information that both parties need in one place. BannaTree can serve this purpose. Farmers can then enter data into the system with their smartphone. The BannaTree system will create statistical overviews for the factory and the agricultural department. Moreover it could also make prediction of the amount of bananas for the farmers, so they can see whether their harvest is the same as the prediction. The factory can use the information to boost their business, and the agricultural department can use the information as feedback for their support to the farmers and for the socioeconomic development of the country.

4.6 Use Case Scenario Description

Ali, a 35 years old farmer in Asajaya, is a contract farmer. He has 3 hectares of land where he plants the Sekaki banana crops for the Bannabee factory where they make banana chips. The agricultural department (AD) has selected him amongst a dozen other farmers to be the contract farmers that deliver the Sekaki bananas to the factory. The Banabee factory has the capacity for 3 tons of bananas to make the chips and export them to China. However, currently the factory only receives 1 ton per day, from which 70% comes from their own plantation. The contract farmers need to deliver the other 30%. Right now this does not happen consistently due to lack of communication and coordination between all stakeholders. To be able to deliver good quality of bananas for the factory, Ali needs fertilizers and pesticides from the AD. The AD can provide these products to him and it gives him any support that he needs for his first crop yield. In return the AD asks Ali to report his monthly harvests, the amount of trees that he has per yield, and whether he has used the provided fertilizers. In order to provide the AD with this information Ali can use the mobile application BannaTree on his smartphone to report the data every month. BannaTree will save Ali's data and create an overview of it for the AD to monitor the farmers' work and achievements, but also for Ali himself to keep track of his monthly activities. On the other hand, BannaTree also has a web application for the factory to enter its data about the received amount of bananas per month and the amount of bananas it actually uses to make the chips. In this manner BannaTree can create a comparison overview for the factory. In the long term, the factory can use this information to predict the banana supply and match it with its own resources better. The AD will also have access to this information in the BannaTree web application. In the end, all information is online and accessible for every party, thus the chance of miscommunication is low. Furthermore, coordination between the farmers and

the factory can be improved if the factory can make better predictions of bananas supplies.

4.7 Interaction And Communication

BannaTree will have two kinds of interfaces. One is for the AD and the factory. It is an online web application accessible in an internet browser. The other one is a mobile web application accessible through a mobile browser. For now, BannaTree will not be made for offline usage. Due to the purposes of the farmers' rapportation there is no need to do this offline. Farmers in Asajaya have reported that they have access to internet at home. Therefore the idea is to have the farmers report their data once they are at home. The factory and the AD can access the application whenever and whereever they have a computer with internet connection. Figure 5 shows how the users the interact with the system.

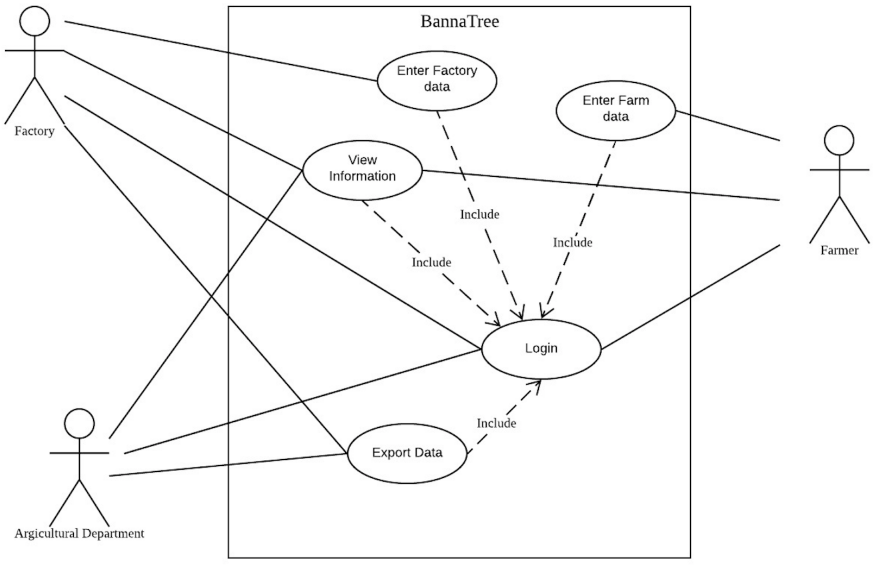


Figure 5: UML use case diagram depicting the user interaction with the system

The AD can create new user accounts for the farmers with their personal information like user name, location (zone), and total amount of banana trees. After having an account, farmers can update their information about amount of trees, amount of harvested bananas, and whether fertilizer is used or not. Within the farmers' user interface, they will have an overview of all these data per month. The farmers will also have the possibilty to edit the information for each month. Moreover they can see the status of the monthly report. If data is still missing for a particular month, this will be visible with an alert icon next to the automatically generated month.

As for the factory, it will have the same web application as the AD, however it will have its own data entry page. Both the factory and the AD will have access to the same data overview pages of both factory and farmers.

4.8 Information Concepts

In Figure 6, a UML activity diagram is presented for different actors who have access to the BannaTree system. First of all, an account need to be created for a farmer. This can be done by the administrator, who could be a person from the agricultural department. However, this is not necessarily, this person could also be an independent actor. After the farmer's account is created, the farmer then has access to BannaTree through his mobile interface. Within this interface he can see an overview of his own entered data. Moreover, in the backend of the system, predictions will also be made for the amount of expected KGs of bananas according to the entered amount of new planted trees in the system. Thus, in the farmer's overview he can see a comparison between the baseline of the prediction and the final harvested amount of KGs bananas.

Subsequently, when all information is entered in the forms by the farmer, the data will then be stored in the database and it will be made visible for the agricultural department and the factory on the same webpage. The AD can check on the farmers and see who indeed has made a report and who has not. If data is missing for a particular farmer, the AD can contact him and ask for the reason behind this. The factory on the other hand, sees the same data overview as the AD. Nevertheless, the factory can also enter its own data about the received amount of KGs bananas from the farmers in the the same webpage. This data will then be compared with the farmers' data about the harvested amount of KGs bananas. If these numbers are very different from each other, then both the factory and the AD know that there is something wrong with the banana farms. Finally, it is up to them to do further investigations to find the problem and see if it can be fixed by providing the farmers more support.

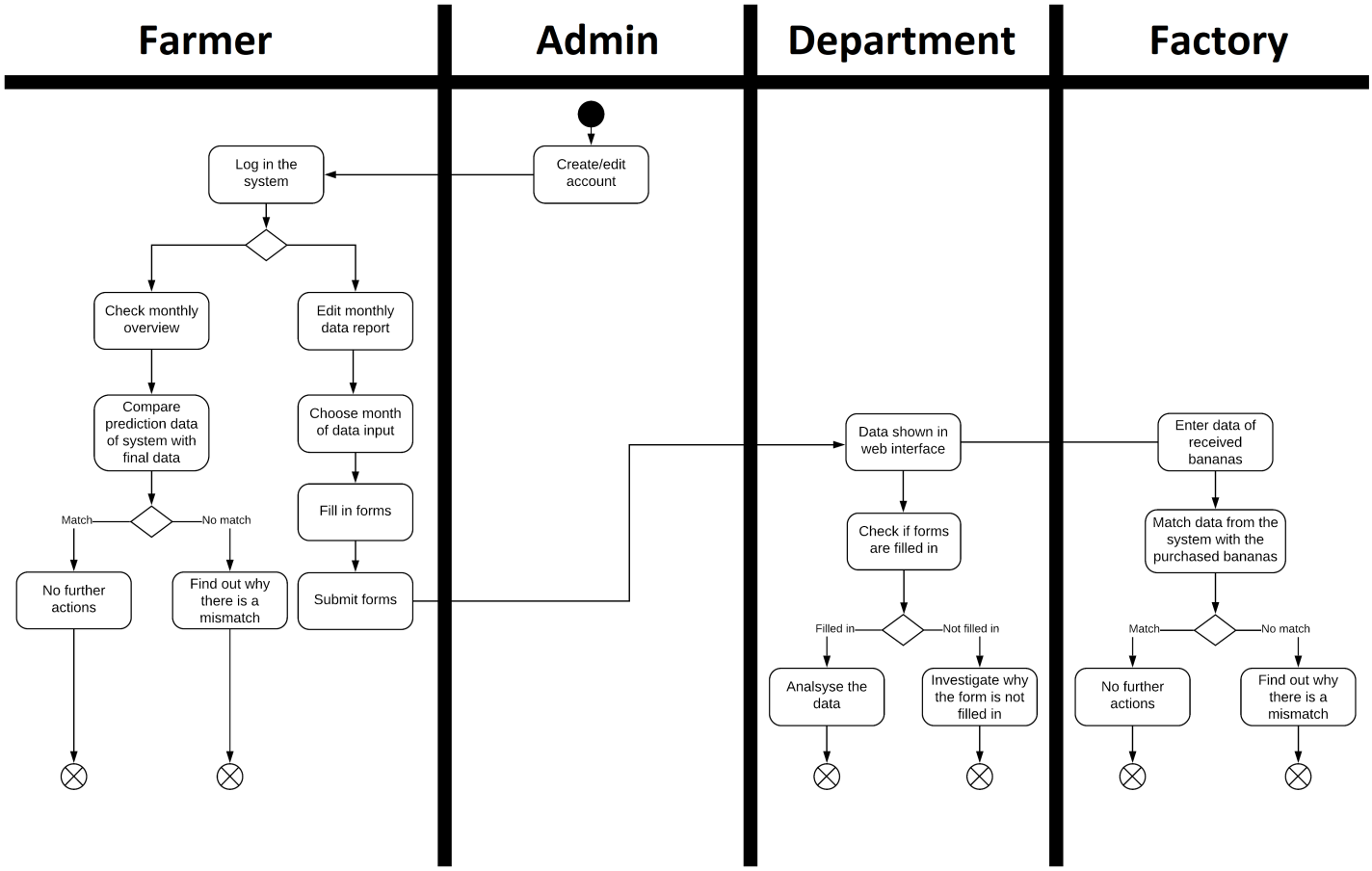


Figure 6: UML activity diagram depicting the user interaction with the system

In Figure 7 the UML class diagram representing the data model of BannaTree is shown. In this diagram there are six classes: a user class, a farm class, a zone class, a report class, a yield class, and lastly a factory data class. The User class provides all the information about a particular user. These user could be a farmer, the person who enters the data into the system for the farmer, the factory owner, a member of the agricultural department, or an administration person. For the farm class, every farm needs a farmer, somebody who enters the data, a particular zone where the farm is in, and the location of the farm (latitude and longitude). It is possible that one farmer has multiple farms. Because the farmer needs to report every month about the amount of planted trees per yield, the amount of harvested trees per yield, the amount of harvested bananas in kg per yield, and whether they used a fertilizer, the report class and yield class will handle that. These classes provides all the needed information for the monthly report. Every report consists of five different yields.

Additionally, there is a zone class, which has also has an ID attribute and a name attribute. Every zone could have multiple farms, but a farm could only be in one zone at a time in the model. Lastly, the factory data class provides information about the kg bananas that the factory has received from the farmers every month. This information is entered by the factory people themselves and it does not have any relation to the other classes in the model.

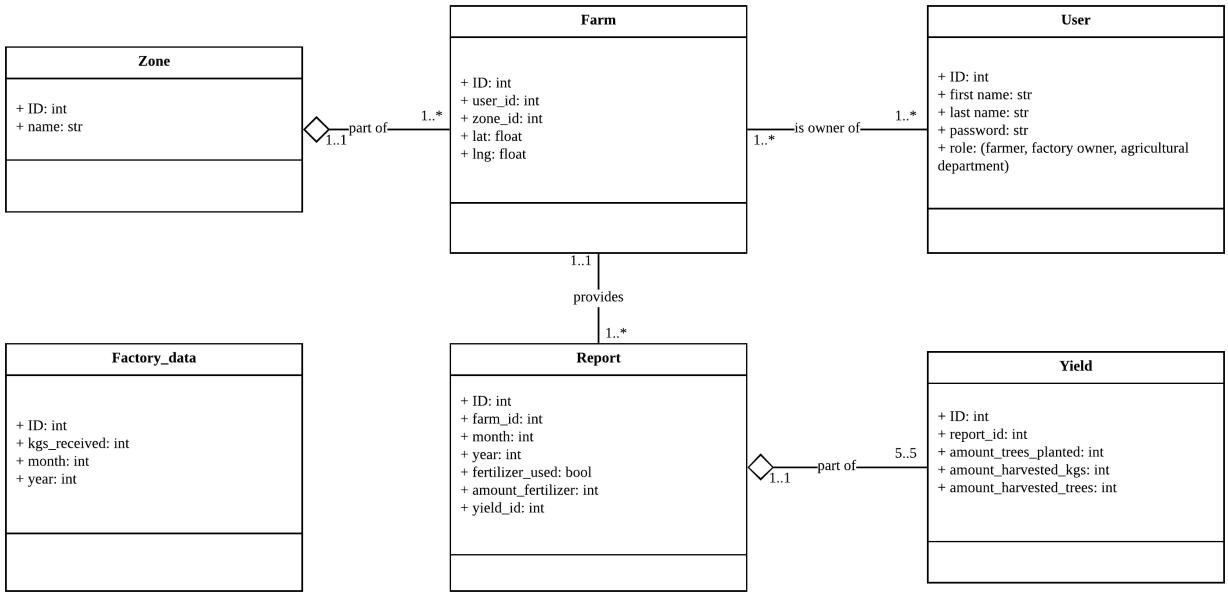


Figure 7: UML class diagram representing the data model of BannaTree

4.9 Technology Infrastructure

In Figure 8, the system architecture is displayed. A web server is the main component that is required for this application. System users (farmers, factory and the agricultural department) need an internet connection to be able to use BannaTree. The farmer interface is designed for smartphone screens. The other interface (for the factory and agricultural department) has been designed for laptop screens. Python in combination with Django is used to generate the web pages. A MySQL database is used to store the data. This database service runs on the same server as the Python code. No decision has been made yet about the actual server platform where BannaTree will be deployed on. An option that we are considering at this moment is Heroku.

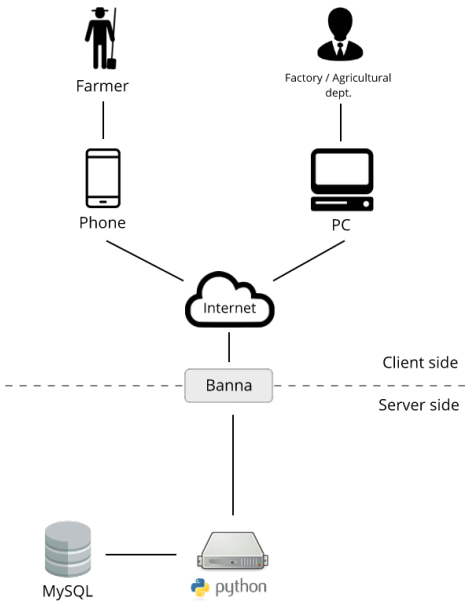


Figure 8: System architecture

4.10 Cost Considerations

The stakeholders who have the most interest for BannaTree are the factory and the AD. Farmers will benefit the least from all the stakeholders. However they will still have an incentive to use the application if the AD makes it mandatory as a conditional statement for contract farmers. Therefore, the consideration is that BannaTree will receive funding from the government. Additionally, the factory could financial the other part of BannaTree. However, this can also be seen as a future scenario. Another scenario for the future could be that the government retreats and that the factory will takeover the entire financial part for BannaTree as the factory can use the BannaTree information service to improve their business. Thus, multiple scenarios can be made up for the cost considerations of the BannaTree service. In section 9, 'Deployment and Sustainability Plan', the scenarios for the sustainability plans for BannaTree are further elaborated.

4.11 Feasibility And Sustainability

For the government to confirm the effectivity of the contract farming programme, the agricultural department need to collect information from the farmers. Currently, all data that is collected from the farmers are in paper forms. Moreover, the AD is not the only party that is collecting data from the farmers. The factory is also sending their own staff to check on the farmers and collect data about the plantation. Because of this, information can easily be lost and unorganized. This could probably also be the reason for the lack of communication and coordination between all

stakeholders. To make it less intrusive for the factory and the AD to monitor and analyze the farmers' data, an information system can be set up for this where all data can be stored in one place and is accessible for all users. In this manner, no confusions between multiple information sources can occur and information is transparent between stakeholders. Good administration can therefore be very crucial to improve the communication and coordination that are required to boost the industry. To develop an information collecting system, it is not difficult. However, many factors play a role when it comes to the usefulness of the data.

Potential conflicts can happen when farmers are not entering data into the system due to difficulties that they might experience while using the system. For this reason it is important to make sure that the threshold is low for the farmers to use the system. The system should be user friendly first of all. Therefore, user requirements are very important to take into account when developing the BannaTree system. To assure the usefulness and sustainability of BannaTree, user feedback is needed for every iteration of the development of the system. At first we will design the user interface intuitively with the end users in mind. This mean that we will start off with the basic information that we have collected from end users. For instance we know after the first meeting with the farmers and the department that most of them are literate and in possession of smartphones. However not all of them are computer literate. Moreover, there is also no internet issues most of the time. Therefore, we figured that a mobile application is highly feasible. Nevertheless, it must not ask too much effort from the farmers while entering data into the interface otherwise they might not use it in the end. For now the incentive for the farmers to use the system is not high, because they are not the one that will benefit directly from the information in the system. Although, there is a general benefit for the entire banana chips industry when the information can help the industry to grow, the farmers need to see this too. However, right now this is not obvious for them. For this reason, we need to think of a solution that makes them want to use BannaTree. In the section system design, a proposed solution for this issue will be elaborated. When we are further in the project user testing is definitely also required to improve our interfaces according to the users' feedback. Furthermore, it is also crucial to do more research for the business model of BannaTree. In the section deployment and sustainaility plan we will describe this in more details and set up different scenarios with E3-value models for the business model. All these aspects are part of the goal to keep BannaTree sustainable even after the current project has ended.

4.12 Key Requirements

As a starting point for further architecture design, and system and component development, the so-called MoSCoW list of requirements is used in this sections to present the key requirements for the BannaTree system (see Table 2 and Table 3). A distinction has been made between functional and non-functional requirements. This because especially the non-functional requirements had a considerable impact on the final system design. The "won't have" in the non-functional requirements list, is about whether the app can work without internet connection. During the first requirements engineering interview session, there was indicated that the app should

be able to work without internet connection. However, at a later stage, it became clear that the data only needed to be added once a month by the farmer. Since this is not very often, the requirement of working offline became less important and was eventually not implemented in our final prototype.

Must have	- Smartphone web interface for farmers - Computer web interface for factory and agricultural department - Get and provide information on the amount of planted banana trees, amount of harvested trees, and amount of KGs bananas (all per yield) - Get and provide information on fertilizer usage - Statistical overviews for the factory and the agricultural department
Should have	- Overview of harvest prediction compared to final harvested KGs bananas for each farmer - Print/export option of overviews for the factory and agricultural department - A statistics page for the farmer, so basic information about the harvests can be viewed
Could have	- Overview of farm updates submitted by farmers for the dashboard - Map overview of all the zones where the farms are in - Overview of harvest prediction compared to final harvested KGs bananas for all stakeholders - Monthly calculation of total amount of tree per farm - An option to see the banana prediction per yield - A way to enter advanced fertilizer information (the type of fertilizer, when it is used etc.) - Smartphone notifications in order to alert farmers that have not entered their monthly report
Won't have	- Guidelines on how to grow bananas for farmers - Collect data from farmers to report events e.g. floods, diseases, etc. (as it can slow down production) - Provide a platform for farmers to share knowledge and receive information on various aspects of farming - Provide advice on what fertilizer to use - A system to detect fertilizer fraud

Table 2: Overview of all the functional requirements according to the MoSCoW ordering of requirements

Must have	- Farmer interface is working on a smartphone screen - The system is easy to use - Loading times for pages do not exceed two seconds - Farmer interface works on both Android as iOS devices
Should have	- Language options: English and Malay - Authorization dependent on user role - Easy extendability of the system for future work
Could have	- An option to ensure the farmers privacy - Easy configurable data inputs, for future adjustments
Won't have	- The ability to work without internet connection

Table 3: High-level overview of non-functional requirements according to the MoSCoW ordering of requirements

5 Final System Design

Quite a number of changes were made in the designs of the system due to the changing requirements (details on this can be found in the Evaluation and Discussion section) however, the final designs of the system, and the reasoning behind each design decision are discussed in this section. The interfaces to be implemented in the system will first be discussed, followed by the architecture of the system.

5.1 BannaTree Interfaces

The BannaTree application will have three interfaces for the different stakeholders, all of which will be web-based. The farmers will have their own interface for inputting data, the factory will have an interface for inputting some data and getting an overview of all data collected, while the agricultural department will have an interface for viewing all data collected in the system.

5.1.1 Farmer Interface

The farmer's interface will serve as the main data collection interface for the system. All data collected from the farmer interface will be slightly analyzed and made visible in the agricultural department and factory's interface. The initial idea was to have a mobile application for the farmers that will make it easier for them to access the application on a regular basis, and input data as needed. However, due to the time constraint, and the requirements that farmers only need to input data once a month, a web-based app has been designed instead. On the other hand, since the farmers will mostly access the app using their mobile phones, the app has been designed to fit a mobile phone screen. The app has been designed similar to a mobile phone app so that when the farmers open it via their web browser, the user experience and interface design can be compared to that of a mobile application. In addition, by

designing the app this way, one is given an idea of how the app should look and function if a mobile app will be developed in the future.

5.1.2 Factory Interface

This interface has been designed to be very similar to that of the Agricultural department because they both wish to see the same type of data. The factory interface is designed as a web application with a dashboard that shows an overview of all data collected in the application. This data will be essential for the factory in knowing how much is being produced by all farmers, and in the future, after all the data have been collated and analyzed, it can help in making calculations and predictions on supply from the farmers. In addition to the dashboard, an additional functionality will be included for the factory, which also collects data from the factory on how much bananas they receive on a monthly basis. This data will provide the factory and agricultural department with information on the differences between the amount harvested by the farmers, and the amount that is actually received by the factory. If there are great differences between these two numbers, then the factory and agricultural department can take measures to reduce the difference.

5.1.3 Agricultural Department Interface

The interface for the agricultural department as mentioned above will be web-based. They will share a similar interface with the factory, without the data collection functionality. Based on the prioritized requirements for the system, the agricultural department is not currently required to provide any information for the system. The department is mostly interested in getting information on how many trees have been planted, how much is being harvested, and how much has been received by the factory. All these data will be collected from the farmer's and factory's interface, and made visible to the department. By providing the department with these data, most of their requirements for the system will fulfilled.

5.2 BannaTree Architecture

In Figure 8, the system architecture is displayed. A web server is the main component that is required for this application. System users (farmers, factory and the agricultural department) need an internet connection to be able to use BannaTree. The farmer interface is designed for smartphone screens. The other interface (for the factory and agricultural department) has been designed for laptop screens. Python in combination with Django is used to generate the web pages. A MySQL(SQLite for Django) database is used to store the data, which runs on the same server as the Python code. At the moment, the BannaTree app has been deployed on Heroku for testing and viewing purposes, however, it is possible to migrate when needed.

6 Prototype Description

The final prototype consists of three different interfaces. One for the farmer, one for the agricultural department (or government) and one for the factory owner. The prototype has been deployed online, and can be accessed via: `www.bannatree.herokuapp.com`. In this section, each individual part of the different user interfaces will be discussed. The login page for all interfaces is the same. Based on which account is used to login, the user is redirected to the correct interface. In table 4 the credentials for all the different accounts (and interfaces) are displayed. These credentials can be used to test the system.

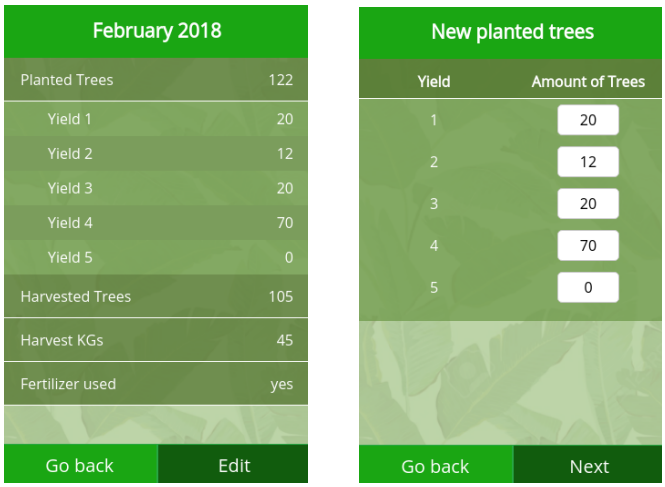
Role	**Username**	**Password**
Farmer	farmer1	123456!!
Agricultural department	agridept	123456!!
Banana factory	factory	123456!!

Table 4: Credentials for the online prototype

6.1 Farmer interface

The farmer interface is the main data entry point in the system. Here the farmers are able to enter their data on a monthly basis. This data consists of: entering the amount of newly planted trees, the amount of harvested trees, the amount of harvested KGs of bananas, whether fertilizer is used or not and lastly how much fertilizer is used. Every month a new report is automatically being created, so the farmers only has to enter the data for that specific month. The data overview of one month has been displayed in figure 9 (a). The data entry and data edit screens are the same, they are displayed in figure 9 (b). The data entry screens consist of multiple pages that are similar to that page displayed in this figure.

During one of the interview sessions, it was proposed that the farmers needed some statistical data in order to make it more attractive for them to use the system. With this statistical data, they are able to compare their banana harvest, to the average harvest over a certain period of time. If they find out that their harvest is below average, they can ask for help to increase the harvest.



(a) Monthly overview (b) Data editing

Figure 9: BannaTree farmer interface

6.2 Agricultural department interface

The agricultural department interface shows multiple stats and graphs to provide the department with information about the farmers. The dashboard page is the page that is displayed immediately after the user has logged in. This dashboard displays a variety of different data, like: the total amounts of bananas, harvest and farms. This is displayed in colored boxes. The user can click on the colored boxes in order to view more data about this statistic. Among other things, the monthly statistic is showing the amount of harvested KGs, compared to the amount that the factory receives. This is interesting information, since it can be used to find out how much bananas are not accepted by the factory. Reasons for not accepting bananas can be: low quality or that the bananas are not needed at the time (the full capacity of the factory is being used). Another table is displayed on the dashboard that shows which farmers have entered their report data for the previous month. This is an important table for the agricultural department. With this information they are able to find out which farmers are actually using the system, and which are not. Farmers that are not using the system can be contacted to find out why they are not entering their data into the system.

Since the dashboard has a lot of different pages, we will not discuss all the individual pages in this section. Most pages have a similar setup: a graph displaying the data and a table for a more detailed overview. All tables also have an option to export the data to: excel or csv. It also possible to copy the data to the clipboard using a button. These export options were proposed during a focus group session with the stakeholders.

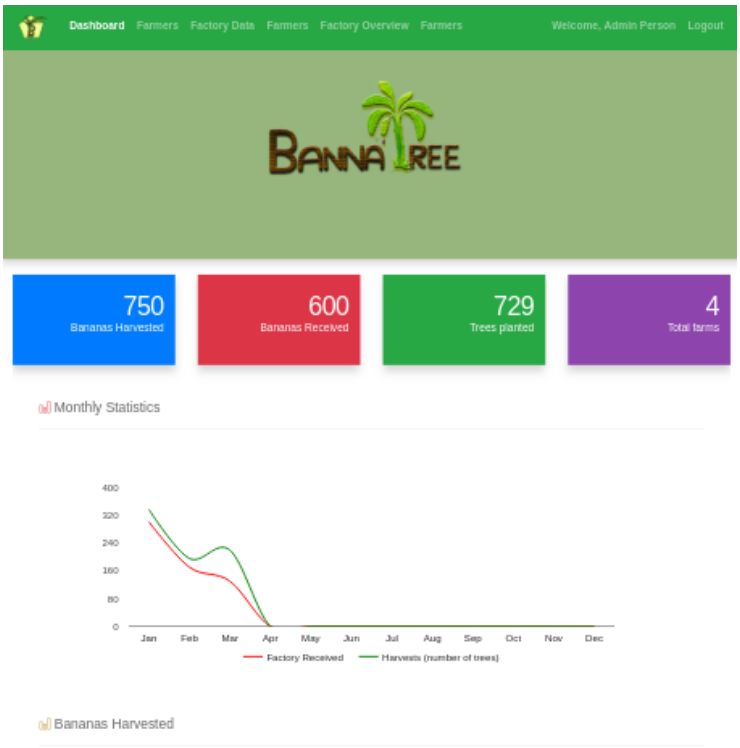


Figure 10: Dashboard for agricultural department

6.3 Factory interface

The factory interface is very similar to the interface of the agricultural department. The most important distinction is that the factory interface has an extra page, called: "Factory data". The factory can add information about how much KGs bananas they bough from the farmers per month. As mentioned before, this data can be used to calculate the amount of banana waste (by comparing this amount to the harvested KGs of the farmers). Apart from this "factory data entry page", the interface is the same as for the agricultural department.

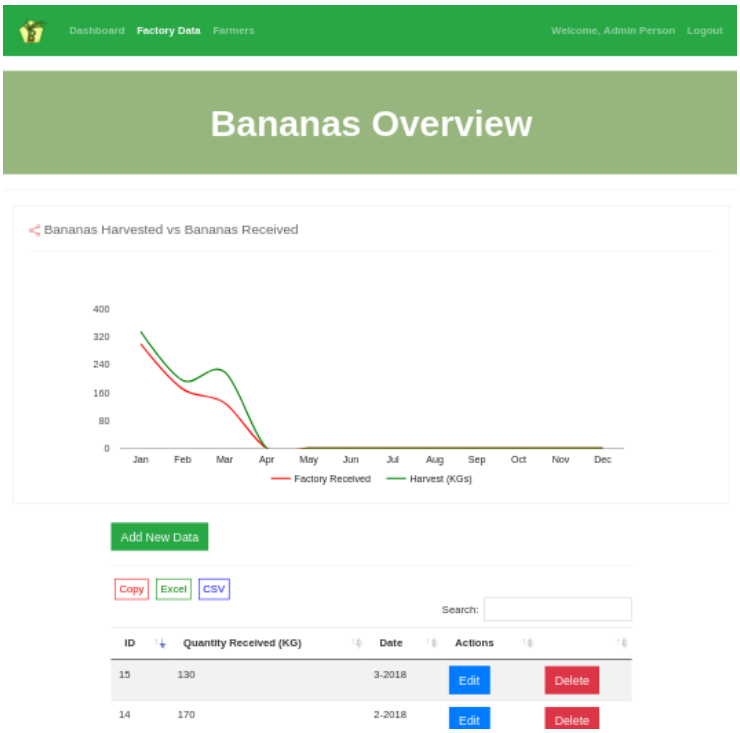


Figure 11: Dashboard for agricultural department

7 Implementation and Usage Scenario

7.1 Usage Scenario

BannaTree is built on a Django framework. Django is a free and open source high-level Python web framework, which takes care of much of the hassle of web development. This means that the developer only needs to focus on writing their app without setting up the same framework every time the developer wants to create a web interface. The Django framework follows the model-view-template architectural pattern so that different components of a web application are clearly separated. The Django models are subclasses of the Python framework Django. The models contains the fields and behaviors of the stored data. Every single database table is mapped to a model. Figure 7 shows the models which we are using in BannaTree. The Django views provide Python functions which uses web resquests and return a response to a particular templates. The Django templates are used to show all data from the web application. The view functions tell the template what they need to show or how to redirect to another webpage. With this framework the user can add multiple applications in the same project. In the BannaTree application we made use of that function. We created two applications: a mobile web interface for the farmers and a dashboard for the factory and the government. Both applications are

hosted on heruko, but can also be hosted on another hosting service which python supports. Heroku is a container-based cloud Platform as a Service (PaaS) which is used to deploy, manage or scale modern apps. On Heroku, developers have the freedom to focus on their core product without distractions that are needed to host a application. Problems can arise when developers do not have the knowledge about the servers, hardware or the infrastructure of the application.

When the application needs to be expanded then only new models or attributes could be added into the app. After implementation of the new models or attributes, Django will create new tables for the database. When the new models are built then only the views and templates must be adjusted to be able to show the latest information on the interfaces. For example, if more information about farms is needed then the application can be expand with more questions about the information which is needed from the farmer. These data can easily be added into the mobile interface as well as the dashboard. Also this BannaTree could be used in multiple countries. At the moment, BannaTree supports only English and Malay, but it is effortless to expand the application in multiple languages. To extend the application with various languages, new languages need to be added into the 'locale folder' with the translation of the words in the new language and button to select this new language. When this information is inserted into the application, then BannaTree will automatically generate the new language into the app.

7.2 Installation instructions

In this section the installation instruction for BannaTree are listed. Using these instruction, BannaTree can be installed locally on a PC or server. These instruction are only needed for the initial launch of the application. A more extensive readme file can be found at the Github page [1]

- git clone https://github.com/aoelen/banna
- (Optionally create a virtual environment using: $ virtualenv venv)
- (Optionally activate the environment: $ source venv/bin/activate)
- Install the required packages: $ pip install -r requirements.txt
- Change the database settings in: banna/banna/settings.py
- (Import sample data: python manage.py loaddata db.json)
- Run the server: $ python banna/manage.py runserver
- Visit Banna at: http://localhost:8000

[1] https://github.com/aoelen/banna/blob/master/README.md

7.3 Usage Scenario

At the moment, BannaTree provides two interfaces. These interfaces are used by the Agricultural Department, the BannaBee factory, and the banana farmers. Farmers use the mobile interface. They upload every month a report with information about their banana trees. After they filled in the report, they can view these data in tables or graphs views gives them information about if they are on target. This information is also used by the dashboard interface which is used by the Agricultural Department and the BannaBee factory. Both stakeholders have access to the same dashboard which gives an overview of information about which zone a farm is located, which farmer has uploaded their report and different graphs about information about the banana trees and harvested or received bananas. The only difference between the government and the factory is that the factory can add data into the dashboard to get a clear overview of the number of bananas received in kg from the farmers and how many bananas the farmer has harvested from the banana trees. This comparison must be the same in a perfect world, however the discussions with the factory director and the government showed that there is a gap between the harvested bananas and the usefull bananas to create banana chips.

7.4 User testing

During the project, we showed the BannaTree application several times to our stakeholders. Together we reflected on the system to improve the application. Main requirements of the mobile interface where that the system must be easy to use for the farmers and that the system do not overload the farmers with questions about their farm, but the dashboard needs to give enough information to be able to advice the farmers to imrpve their harvested. Also, it was important that the application is accesable with a smartphone for the farmers. The dashboard must be accesable by a computer, which has export functions to convert the data into Excel or CSV. To solve these problems we made our system easy to use. The mobile interface only ask a couple of questions to the farmer which gave which gives enough information to create an interesting dashboard for the government and the BannaBee factory. They can use the information in the system and give advice to farmers to improve their banana harvest or make their harvest more consistent. Also we implemented several export and search functions into the system to export the data into Excel.

At the end of the project, we tried to test our application with real banana farmers. Using real users would give us accurate information about how they use the app. With these data, we could improve our system, so that the farmers correctly understand how the system works. Unfortunately, we could not test our final working application on real banana farmers. For this reason, we tested our final application with students from Unimas University and the Vrije Universiteit. The user testing gave us various interesting information about our system. First of all, users found our application easy to use. the users thought the application looked great and displayed the right information that they were looking for we hardly had to explain what the user had to do. The error handling in the forms was very nice for different

users, because they did not know that they had to enter a certain value everywhere in the form. With this notification they knew immediately that all fields had to be filled in to continue to the next question. Secondly, we experienced that our mobile application is not entirely responsive. The main problem was that on small smartphones the statistics page does not display correctly. The total trees harvested will be displayed under the go back button which makes this information invisible for the user. Also, the user did not know when he could enter his report. The button at the bottom was not so clear that the user immediately knew that he could add data into the system by using the edit button of the month report overview.

8 Scope and Fidelity of Prototype

The prototype that has been developed, is designed to be a fully functional application. All the requirements that were listed in table 2, from the "Must have" and "Should have" sections are included in the final prototype. The scope of our application was limited to an information collecting system. The main functionality is collecting basic data from banana farmers. In addition to the data collection, our application also provides the ability to view basic statical data about the farms. Limiting the application for basic data collection only was an important requirement. Since entering farm data in a system is something completely new for the banana farmers, it should be easy to enter this data. When it takes too much time to enter data (because of the amount of data, or the difficulty of the questions), changes that BannaTree will not be used by the farmers are higher.

The BannaTree application has been scoped to be a simple information management system. Some features that were initially proposed by the interviewees (like the banana information exchange, fertilizer advisor and fertilizer fraud prevention) were intentionally left out. This includes the banana information exchange system that was proposed by Dr. Ibrahim. The idea of this system was that farmers can exchange knowledge that they learned over the years. The idea of knowledge sharing is a good idea according to us, however during other interviews we found out that banana farmers are competitors to each other, and that sharing knowledge might not be done because of this reason. An other feature that was proposed during an focus group with the fertilizer experts, was an advisory system for using fertilizer. Finally, the fertilizer fraud detection system was not implemented as well. The previously mentioned features can be helpful for farmers and the agricultural department, however these functionalities differ too much from the functionalities of a data collection system. Since these functionalities are so different we consider this out of scope for this project. In the end, we suggest that these functions are implemented in a different app.

As mentioned earlier, the goal of our prototype was to make a fully functional application. The final prototype that has been created is indeed a functional application. In this project, there was no time to conduct the user testing with the actual system users (for example the farmers and the agricultural employees). As has been de-

scribed in this document, the users testing was done with VU students. Since these VU all has an ICT background, this test group might not be a good representation of the actual system users. However, as described before, we did made some interesting findings during the user testing. In the end, we have created a high fidelity prototype that can be implemented in a real-world setting relatively easily.

9 Deployment and Sustainability Plan

In this section, business sustainability plans and a technical sustainability plan for BannaTree is described. First we start off with the business models for which the E3-value model will be used to describe the value exchanges. Subsequently, a description of the technical sustainability of the system will follow.

9.1 Business Sustainability

To deploy and maintain the BannaTree service after implementation, it is crucial to think ahead about the sustainability of the service after this project has ended. For this, we have set up multiple scenarios as sustainability plans for the BannaTree service. In order to show the value objects between the different actors, we made use of E3-value models [1] for different scenarios (see Fig. 12,13,14). As for the current situation without BannaTree, the main path for producing banana chips starts with the end customers who want to buy the banana chips from the factory. In our use case this is China. In Figure 12 the exchange value for the banana chips between the customers and the factory is defined as money, which means that the factory earns money from the customers in exchange for delivering banana chips to them. On the other side, the factory gets bananas from the farmers and in exchange the farmers received money from the factory. In the current situation there is no information management system yet. Information about the farmers production is there, however it is in paper forms as mentioned before. To make analyses of banana production easier in order to improve the entire industry, an information management system can be useful. This is where BannaTree comes in and offers a service for information management and statistical analyses.

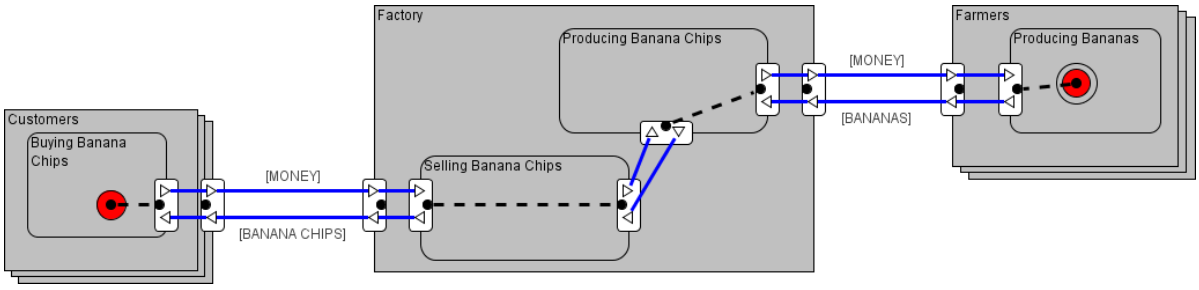


Figure 12: E3-value model for the current situation without the BannaTree service

In Figure 13, the scenario with the BannaTree service is presented. To maintain the service in the beginning it can be helpful if the government (the agricultural department), is responsible for the funding of this service while the government is also the one that would like to monitor the statistics of the farmers. In this scenario multiple start points for the value model can be seen. First of all the path that starts with the customers stays the same. Additionally, a second start point can be found at the government and it ends at the farmers, while the government would like the farmers to deliver a monthly report through the BannaTree application. In exchange the government gives the farmers support in form of fertilizers, pesticides and other informative support for growing bananas for the contract farming. A third start point can be found again at the government's side, however this path goes from the government and ends at the BannaTree service, because in this scenario the government is the one who pays for the existence of the BannaTree service, although both the government and the factory receive information from BannaTree.

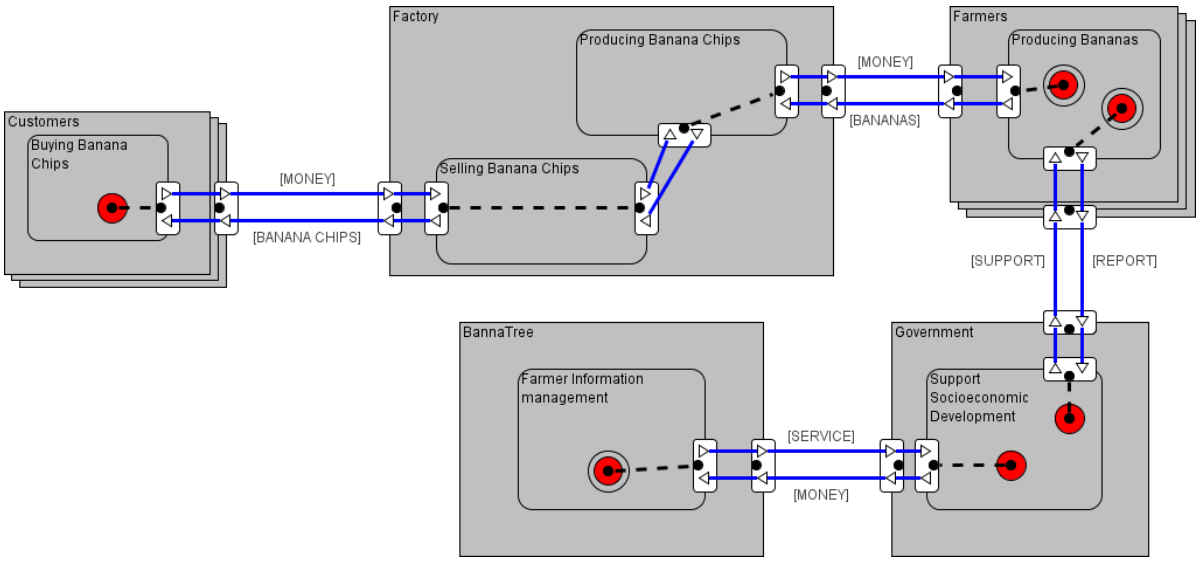


Figure 13: E3-value model when the BannaTree service is deployed with funding from the government

For the third and last scenario which can be found in Figure 14, we are sketching the future for BannaTree. Here, we imagine that the factory will benefit the most in the future from the BannaTree service, because the factory can make use of the BannaTree statistics to improve its business. Therefore, the consideration is that the factory will take full credits for the payment of BannaTree and the government will stop sponsoring. Though the government is still able to see the statistical overviews, the government is not responsible for the support for the farmers anymore. It is possible that the banana chips factory could take this over and give guidelines and support to the farmers for how to grow qualitative bananas for itself. For this scenario it is also

crucial that farmers realize that they need to be cooperative and that their role in delivering qualitative bananas for the factory is an important factor for the industry to make a profit, thus their income for growing bananas will sustain. This last scenario is consider the most sustainable scenario, because the banana chips industry is not relying on support from the government anymore and thus the entire business can operate independently.

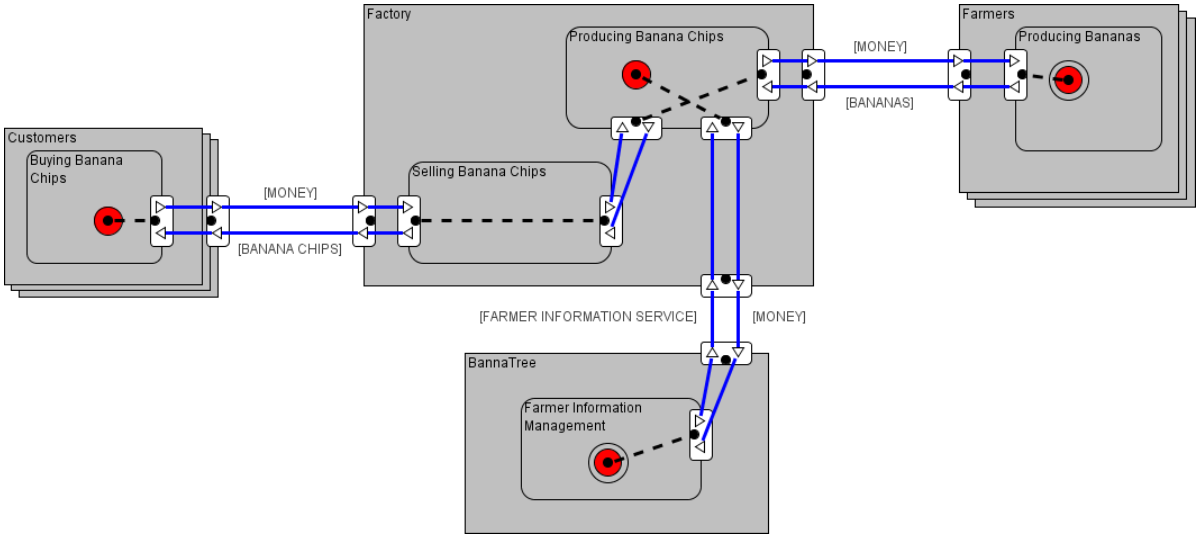


Figure 14: E3-value model for the future of the BannaTree service without funding from the government

9.2 Technical Sustainability

A lot of times projects in ICT4D fail after the project period has ended. This could be due to multiple reasons. A well set up business plan is just one part of the intentions to keep the ICT4D service alive. It is also important in ICT4D to build on other people's works and sharing knowledge could be very beneficial to this field too as it is also mentioned in the paper of Ho and colleagues [4]. Therefore, BannaTree is set up as an open source which can be found on GitHub. For the BannaTree system we made use of standardized frameworks like Django with Python and Heroku to set up the BannaTree web application. As for the time scope of this project, there was only a few weeks to collect all the requirements and develop a system that could be useful. However, this does not imply that the BannaTree application cannot be improved and new functionalities can be added. Hence, the fact that BannaTree is open source is crucial as we want this project to be able to go on if there is still interest for it. Therefore, standardized frameworks have advantages. Thus, for the technical side of the BannaTree service, it is definitely sustainable.

10 Evaluation and Discussion

This ICT4D project has two main results, firstly the description and the development of the application and secondly the extensive context analysis that has been conducted in order to develop the application. The full source code of the application can be found online on Github[2]

10.1 Multiple stakeholder demands

During this project, a lot of different stakeholders were involved. A distinction can be made for the following stakeholders: the banana farmers, the banana factory, the fertilizer experts, the agricultural department and Dr. Ibrahim. Although Dr. Ibrahim is not directly involved in the banana stakeholder analysis, a lot of ideas and knowledge came from him. At the start of the project, it was known that multiple stakeholders were involved in this case. Less clear was the actual problems of these stakeholders. While the farmers indicated that they did not have any problems at all, Dr. Ibrahim explained that they needed help on multiple aspects. There were also a lot of conflicting requirements and demands between the stakeholders. For example: the agricultural department wants to collect as much information as possible from the farmers, while the farmers do not want to spend too much effort in filling out the information forms. The factory had as main goal: knowing the amount of banana for the coming months, so that they can prepare for that. In the end, a decision had to be made about what stakeholder demands to include in the system. We tried to make an trade-off between the interests for the farmer and the agricultural department. This trade-off means that the collection information consists of a few forms, that should be filled in monthly. Because the forms need to be filled in on a monthly basis, this does not require a lot of effort from the farmer. But it is still possible to collect useful information from the farms.

10.2 Changing requirements

From the initial requirements gathering, a lot a changed. From the first interview sessions, it became clear that farmer data needed to be collected and managed by a system. The initial purpose of this system was preventing fraud in receiving fertilizer. However in a later stage, preventing fraud with fertilizer became less important. On of the reasons for this was because fertilizer was only provided to the farmer when he is starting with his farm (so the impact of fraud detection would be not very high). After that, the focus of the application was to create a system for banana factories in order to predict banana harvest. This requirements also became less important, the main reason for this was that this system would be too complex to start with. Therefore, we decided to create a simple information management system, that can easily be implemented in the real-world. Because of the changing requirements, the first two weeks (of the four week project) were spend on requirements engineering and modeling. After this time, we are able to start with the actual development of the application. Since we were using an agile development approach,

[2] https://github.com/aoelen/banna

the requirements gathering continued during the development. Some focus groups were planned to demonstrate the prototype of the application to the stakeholders. This also results in requirements changes, mostly about what kind of information should be collected.

10.3 Planning and communication

When conducting projects in an ICT4D environment, communication is known to be a factor that can cause difficulties. Especially the different understandings of farm related terms caused trouble. For example, farmers are not splitting up their land in different areas. They only think about individual trees, and in which yield this tree is. Completely understanding the local methods of farming is time consuming, but crucial in order to develop a system that fulfills the needs of the stakeholders.

10.4 Missing user testing

As has been described previously, the user testing parts were not conducted with the actual system users. This because a meeting at the agricultural department (with the employees and farmers) was canceled. Therefore the system was testing using VU students. Although useful feedback about the interface was provided, this is no guarantee that farmers are able to work with the system. However, the system has been designed in close cooperation with the stakeholders, therefore chances that the system suits their demands high. The system has been designed while keeping the ICT literacy in mind of the farmers. This means that the interface is very simple and intuitive. By using for validation, we ensure that the farmers cannot enter wrong data in the system. In the end, user testing would be been helpful, but not critical for the project.

11 Conclusion and Future Work

At the completion of this project, we have developed a fully functional information collection and management system. The system is able to collect data from the farmers using a separate interface, and make it available to the factory and the farmers on a different interface. The factory and the department with the use of the system will be able to get more tangible information on the productivity of the farmers. The data collected can be used to solve the issue of inconsistency of supply and demand once the factory is able to monitor the trends in the supply of bananas from the farmers. Looking at the project as whole, there was a lot of difference in what was expected and the reality. It was quite a challenge to keep up with the changing requirements, while meeting up with the user's expectations given the short period of time. The requirements for the system had changed completely from the initial information provided at the beginning of the project however, with more interviews and questions asked to the stakeholders, clearer picture for the system could be developed, and finally a full functioning system is created after making a series of trade-offs in the system requirements.

11.1 Future work

11.1.1 Improving the information provisioning

Future work can focus on different aspects of helping banana contract farmers. In the first place, BannaTree should be implemented in the real world. When the app is actually being used, the next development iteration can start. More information is needed to give useful advice to farmers. Factors such as the weather condition, the type of soil and diseases are important factors which affects the harvest of bananas. Additionally, some of the functionalities that we intentionally left out of this project can be implemented. Especially the banana harvest prediction system can be helpful for the factories in order to handle more bananas. The basics of such a system are already present in BannaTree, so banana KG prediction would be an extension of the current app.

To have a sustainable system the system must not only depend on the subsidy from the government. Since it is important for BannaBee that they receive good quality of bananas from the farmers. In the future it is very useful for the farmers to integrate a manual of how to maintain a banana tree in the application. With this manual, the farmer always knows what he needs to do in a particular situation, which will increase the quality of the banana harvest. Also, it is important to implement more data into the system.

11.1.2 Extending use case

The application that has been developed in focused on banana contract farmers. However, the government has multiple programs for contract farmers including other types of crops, for example: coconuts and pineapples. BannaTree could be used for similar contract farming programs as well. Although some of the questions are focused on bananas only (for example about the yield of the tree), the system can be adjusted relatively easy to be suitable for other crops. More research is needed in order to find out how this system can be implemented for other contract farming programs.

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