



A tool that provides information on fertilizers

Assignment 3 - Implementation Prototype - Group 3

ICT4D

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PREFACE

*what the farmer does not know, he does not use*¹

If a farmer is not aware of a fertilizer, they will never use it.

This is where our application comes in.

We developed an application that provides information on fertilizers to farmers, which is very important, because the use of fertilizers is key in increasing the yield.

¹ parody on Dutch idiom stating ``what the farmer does not know, he does not eat''

1. INTRODUCTION

The population of Ghana is increasing at a rate of 2.5 percent per year [1]. As a consequence, the country's demand for food is rising each year. Ghana's agricultural production meets only half of domestic cereal and meat needs and 60 percent of domestic fish consumption, according to the Ministry of Food and Agriculture (MOFA) [2]. At the same time, agriculture is major field of employment in Ghana: 42 percent of the (working) population works in agriculture, forestry and fishing [3]. However, to meet the needs of the country, a higher production rate is desirable. The MOFA developed the Medium Term Agriculture Sector Investment Plan (METASIP) to achieve a target agricultural GDP growth of at least 6% annually, halving poverty by 2015 in consonance with Millenium Development Goal (MDG) 1 and based on government expenditure allocation in the national budget of at least 10% within the Plan's period (2011–2015). These targets were in conformity with agricultural performance targets of the Ghana Shared Growth and Development Agenda (GSGDA), the ECOWAP² of ECOWAS³ and the CAADP⁴ of NEPAD⁵ and were expected to contribute significantly to the achievement of the MDGs of the United Nations [4].

A factor that can influence the production rate highly, is the use of fertilizers. Moreover, the Abuja summit on fertilizers from June 2006 declared that Sub Saharan Africa can only increase food production and alleviate poverty when fertilizer use is increased [5]. As a consequence, in 2008, MOFA launched a national fertilizer subsidy programme [6]. Moreover, the government has so called *Farming Officers* (also called: Field Officers) that visit villages to give workshops on fertilizer use and award prizes for the best farmers. This way, farmers can learn about new fertilizers and get stimulated to improve their yield. Ghanaians living in rural areas are dependent on such workshops and information they get from their personal network, since they can not access internet to look up information (as we do here all the time). To reach others, it is common to make a phone call or to pay a visit [7].

We developed a simple voice application called *MaMoisson*, that allows farmers to access information on fertilizers. The application tells which fertilizer should be applied and in what amount, according to the crop. In this report, we introduce *MaMoisson* and elaborate on the use, the context, the technical background and the sustainability of the application.

² ECOWAP is the acronym for the regional agricultural policy used in official languages across the ECOWAS

³ Economic Community of West African States (Benin, Burkina Faso, Cape-Verde, Côte d'Ivoire, the Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Sierra Leone, Senegal and Togo)

⁴ Comprehensive Africa Agriculture Development Programme

⁵ New Partnership for Africa's Development (NEPAD)

2. MOTIVATION

Zalerigu village is a village in rural Ghana (Figure 1), where the idea of this use case comes from. *Farming Officers* are experienced farmers that visit Zalerigu village and other villages every once in a while, to give instructions and to award prizes to the best farmers in the area. With those instructions, farmers have been able to increase their harvest. However, after a while, farmers tend to forget how to properly apply the fertilizers, and the harvest fails. Also, some farmers might not have been able to attend the workshop. Or, they did attend it, but already new and better fertilizers are invented, and they do not know about their existence. Hence, it would help farmers if they could constantly access the information that the Farming Officers provide.

Farmers need to know which fertilizers they should use for a particular crop. Therefore, we decided to develop a system that provides farmers this information.



Figure 1: Ghana. Picture taken from Google Maps [8].

3. CONTEXT USE CASE

Crops

The major food crops of Ghana are cocoa, oil palm, coconut, coffee, cotton, kola, rubber, cashew, shea, soya bean, maize, millet, rice, cassava, cocoyam, yam, plantain, sorghum, cowpea, groundnut, pineapple, citrus, banana, pawpaw, mango, tomato, pepper, okra, eggplant, onion, butternut squash, asian vegetables [9].

Crops can be divided into cash crops and household crops. Cash crops are crops that are used for business, while household crops are meant for own consumption.

Fertilizers

Fertilizers may be thought of as materials used to increase or maintain the yield from the land [7].

The *grade* of a fertilizer refers to the guaranteed minimum percentage(s) of the nutrients it has. For example: Diammonium Phosphate (DAP) contains 18% N (Nitrogen) and 46% P_2O_5 (Phosphorus Pentoxide) so the grade for DAP is 18-46. A compound that contains $\alpha\%$ of N, $\beta\%$ of P (Phosphorus) and $\mu\%$ of K (Potassium) is graded $\alpha\text{-}\beta\text{-}\mu$ [10].

Using an appropriate fertilizer and applying it correctly can increase yield a lot (some fertilizers almost double the yield) [11]. However, one should not use a fertilizer for a crop that is not prescribed, because such wrongful application won't have any impact [11].

The Abuja summit on fertilizers from June 2006 declared that Sub Saharan Africa can only increase food production and alleviate poverty when fertilizer use is increased [5]. As a consequence, in 2008, MOFA launched a national fertilizer subsidy programme [6]. In 2004, already the Ghana Cocoa Board (COCOBOD) initiated a fertilizer intensification program with the purpose of creating fertilizers that raise the fertility of soils [12].

Fertilizer imports in Ghana have seen a significant increase in the last 20 years. The fertilizer application rates are at their highest in cash crops, such as cocoa and cotton [13]. Additionally, to increase the yield of cocoa crops, the Cocoa Research Institute of Ghana introduced "Asasa Wure", a special grade of fertilizer for this purpose [13]. Moreover, the "inoculant", a biological fertilizer currently being adopted by farmers, which was produced by Ghana's Council for Scientific and Industrial Research (GCSIR), promises to increase yields in seven districts of the upper east region of Ghana [11].

Farming Officers

Moreover, the government has so called *Farming Officers* (also called: Field Officers) that visit villages to give workshops on fertilizer use and award prizes for the best farmers. This way, farmers can learn about new fertilizers and get even more stimulated to improve their yield.

4. USE CASE DESCRIPTION

4.0. NAME

The tool we developed is made to help increase crop yields and will be used by farmers that own crops, therefore the name chosen for this use case is *MaMoisson*, which is French for ``my crop''. The logo is given in Figure 2 (and also on the front page).



Figure 2: Logo for *MaMoisson*

4.1. SUMMARY OF KEY IDEA

Being up to date with newly introduced, promising fertilizers, is absolutely critical to the success of a harvest. In the recent years, organisations have created fertilizers that are made for specific crops [13], [14]. Whether a farmer is harvesting cash or household crops, it is necessary to have the information that will produce the optimal yield.

Farmers call *MaMoisson* and select first the category of the crop they are harvesting and, second, the crop itself, and possibly the age or phase of the crop, upon which the system gives an advice on the fertilizers that they should use and in what amount.

The information in the system is to be provided by the Farming Officers, who know about (new) fertilizers. All data is stored in a database and is accessed via a database management system.

A web interface will make it easy for Farming Officers to enter the data.

4.2. ACTORS AND GOALS

The actors that are involved in this use case are shown in Table 1, along with their operational goals.

<i>Actors</i>	<i>Operational goals</i>
Farmers	Easily obtain information about fertilizers using the voice service
Farming Officers	Provide information about appropriate fertilizers.
Hosting organization (ICT business / NGO)	Provide the voice service.
Villagers	Buy more food from the farmers, since there will be an increased yield.

Table 1: The actors that are involved in *MaMoisson*.

4.3. CONTEXT AND SCOPE

Scope

The scope of the project is to provide farmers easy access to information about fertilizers by a voice app called *MaMoisson*. The success of the tool can be tested by farmers, namely, if they are able to get the information they want about fertilizers easily, then the tool is a success. Moreover, stakeholders are the Farming Officers, as they might not need to visit the villages anymore to share their knowledge, since their knowledge can be spread via *MaMoisson*. Another evaluation measure is the willingness of the Farming Officers to use this system next to or instead of paying visits. To simplify their task, a web interface is developed.

We will focus on farmers in Ghana and thus the crops and fertilizers that exist in Ghana. However, we want to make it easy to expand the application, so that it can also be used in other countries.

Spoken language

The main language spoken in Ghana is English, followed by French and Ghanaian [15]. In 2010, 28.5 percent of the population was illiterate, and in rural areas (in the North) this percentage is even higher [15]. The voice system that is proposed here takes this into account, by providing the information by voice in multiple languages (English and French) and making it easy in use: the only action that is asked from the user is to press a number, based on their preferences (language, crop, age/phase). Namely, the voice application guides the caller through different menus using Dual Tone Multi Frequency (DTMF). So, illiterate farmers will be able to use the system.

Climate

Ghana has two seasons: wet and dry season. The wet months are different in the North of Ghana than in the South. The temperature is all year the same, from 24-30 degrees [16].

Technology

In rural Ghana, there is no internet and people do not own smartphones. They do have so called “dumb phones”. Therefore, *MaMoisson* is a voice application that can be called by any (working) dumb phone.

4.4. USE CASE SCENARIO SCRIPT

A standard scenario of *MaMoisson* is as follows:

Use case scenario

1. The end-user calls the system.
2. The system offers a choice of languages: English, French.
3. The end-user selects a language.
4. The system offers a choice of crop categories: fruit, vegetable, cash crop.
5. The end-user selects their category of interest.
6. The system offers a selection of crops, depending on the category. For example, for fruit, it gives the options “mango” and “okra”. The end-user selects their crop of interest.
7. The system either gives advice on which fertilizers to use, in what amount and how often, or it asks for more information. For example, when the user chooses “mango”, the system asks

for the age of the mango tree. Then, the end-user selects the age of their tree and gets a fertilizer advice.

Example situation

Agyei is a farmer living in Zalerigu Village, rural Ghana. He has a land full of mango and okra. Last year, the Farming Officers visited his village and gave a workshop on fertilizers and they demonstrated how to apply them. Also, they awarded another farmer a prize for doing such a good job. That year, his okra and mango harvest increased and he made 10% more profit. However, this year, business is not going as well. He is not sure whether the fertilizer still works and he is not sure whether he is using the correct fertilizer. Agyei might be applying it wrong, since he does not remember exactly what the Farming Officers have told him. Agyei decides to call *MaMoisson*.

MaMoisson: Please select your language. Sélectionnez la langue. Press 1 for English. Appuyez 2 pour Français.

Agyei: *Presses 1*

MaMoisson: Welcome to *MaMoisson*. This application costs 0.1 cedi's per minute. A subscription costs 0.5 cedi's per month.

Choose the category of your crop. Press 1 for fruit, press 2 for vegetable, press 3 for cash crop, press 4 to repeat.

Agyei: *Presses 1*

MaMoisson: Select the crop. Press 1 for mango, press 2 for okra, press 3 to repeat, press 4 to go back.

Agyei: *Presses 1*

MaMoisson: Select the age of your mango tree. Press 1 for 1 year, press 2 for 2 years, etc. Press 7 if your tree is 7 years or older.

Agyei: *Presses 2*

MaMoisson: Apply between 1 and 2 kg of NPK 15-15-15 per year. Use a 3 split application.

Would you like to get advice on another crop? Press 1 for yes, press 2 for no.

Agyei: *Presses 1*

MaMoisson: Choose the category of your crop. Press 1 for fruit, press 2 for vegetable, press 3 for cash crop, press 4 to repeat.

Agyei: *Presses 1*

MaMoisson: Select the crop. Press 1 for mango, press 2 for okra, press 3 to repeat, press 4 to go back.

Agyei: *Presses 2*

MaMoisson: Select the phase that you are in. Press 1 for planting, press 2 for flowering.

Agyei: *Presses 2*

MaMoisson: Apply 110-150 kg/ha of Sulphate of Ammonia or 75 kg of Urea.

Would you like to get advice on another crop? Press 1 for yes, press 2 for no.

Agyei: *Presses 2*

MaMoisson: Thank you for using MaMoission. Have a nice day!

After this, he buys the fertilizers he needs, and his mango and okra are doing great again, thanks to the help from *MaMoisson*. The price he paid for the calls, was worth it, since he was able to sell a lot of his crops.

For another example situation, please listen to the recording in Appendix A, where one of our developers pretends to be a farmer and calls *MaMoisson*.

4.5. INTERACTION AND COMMUNICATION

In Figure 3, an activity diagram of the use case is shown. The actors are a farmer and *MaMoisson*.

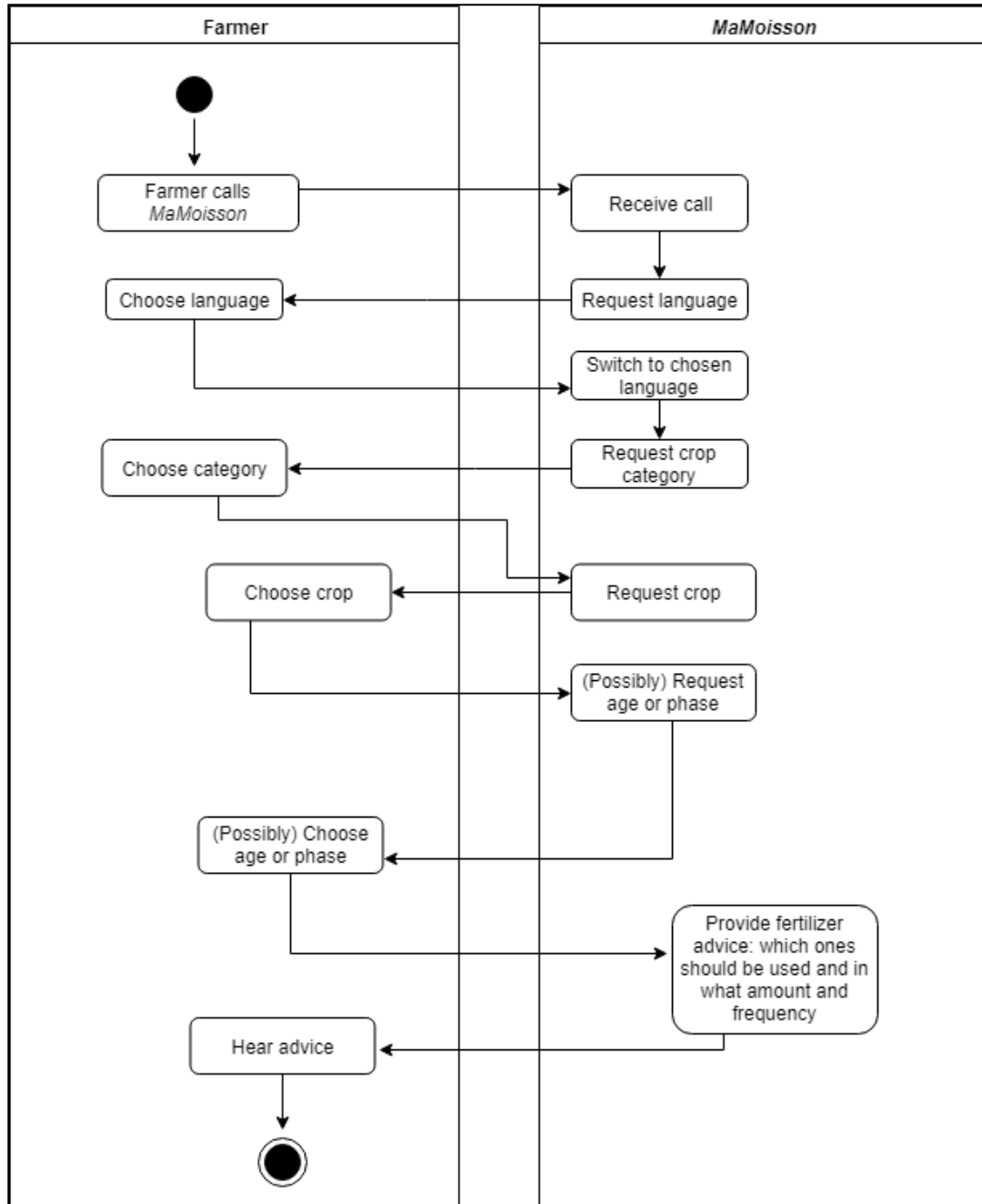


Figure 3: Activity diagram of *MaMoisson*.

4.6. INFORMATION CONCEPTS

In Figure 4 and 5, two UML class diagrams of the tool can be found. It gives an overview of the elements that are used in the web interface and in the admin page, that is used to develop the voice application.

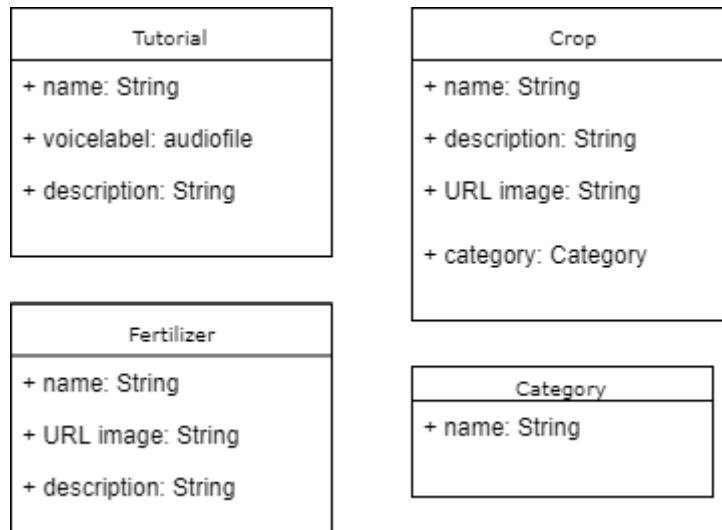


Figure 4: UML class diagram of website elements.

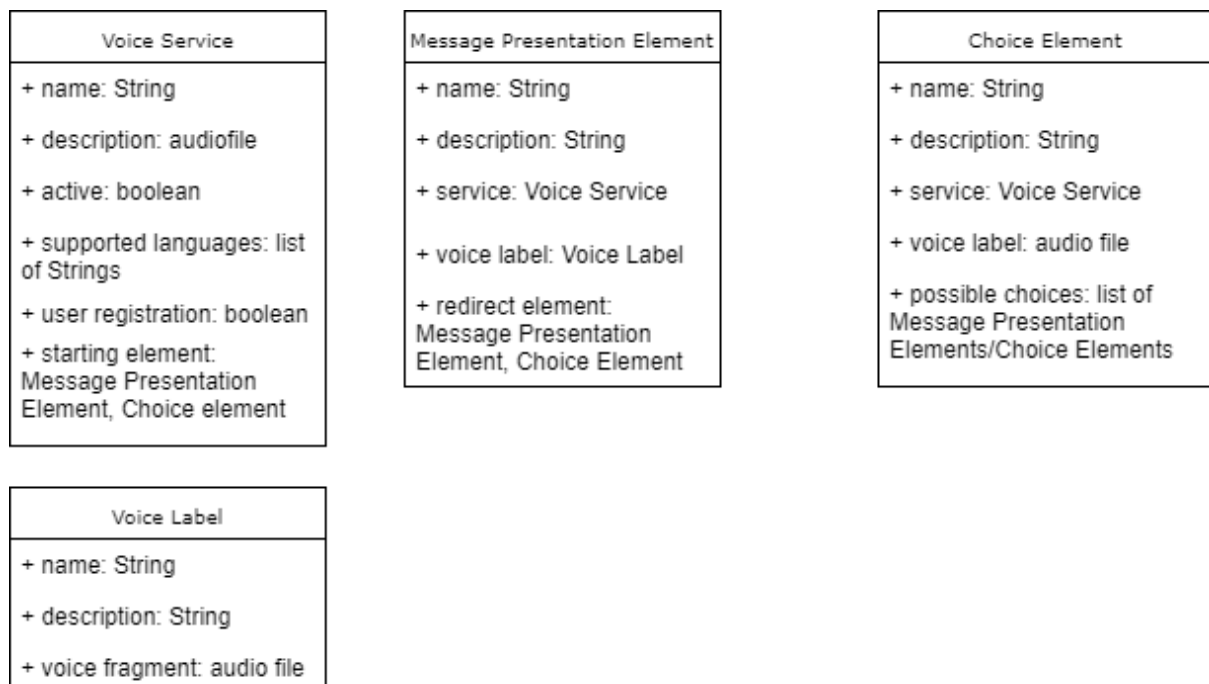


Figure 5: UML class diagram of admin page elements.

4.7. TECHNOLOGY INFRASTRUCTURE

In order to use our tool (i.e. to call for fertilizer advice), one only needs a mobile phone that has a GPRS connection (to call the number of the application). To provide the service, we need a server where we upload the database that interacts with the system.

Farming Officers visit urban areas and, in contrast to the farmers in rural areas, do have access to the Internet, and therefore we decided to make a web interface that is accessible via Internet. Figure 6 shows the technology infrastructure of *MaMoisson* and the Kasadaka system.

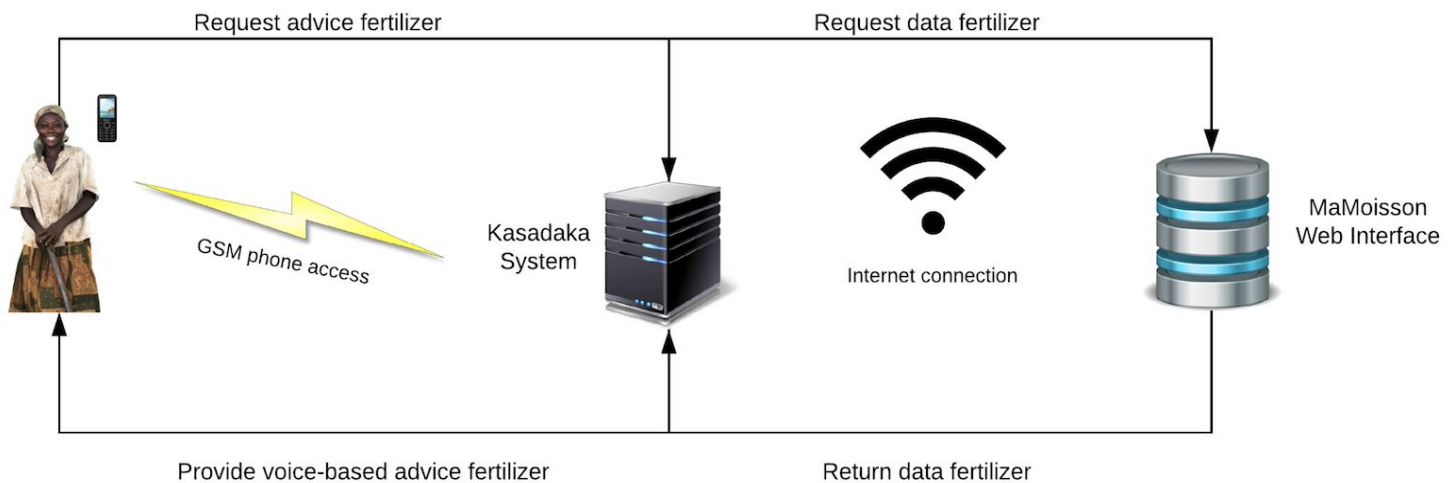


Figure 6: Technology infrastructure - MaMoisson.

4.8. COST CONSIDERATIONS

Stakeholders are farmers, the government (Farming Officers in particular), villagers and the provider of the service. The government might be interested in this use case since it automizes some of the work of the Farming Officers. If the Farming Officers do not have to travel to all villages anymore, they will save time. Therefore, the government is a possible investor. Farmers will make higher profit when using this application and they are probably willing to pay a small amount for this. Villagers benefit from the extra yield that the farmers obtain by using the tool.

We propose two ways of using our service *MaMoisson*. A farmer can take a subscription on the system if they use the system more often. This subscription will be 0.50 Ghanaian cedi's⁶ a month. If the farmer only calls the application once or twice a month, then the farmer could decide to pay per call. To call the application, it will cost 0.10 cedi's per minute, which is cheaper than the cost that MTN, the leading provider of telecommunications services in Africa and the Middle East [17], charges for a local call per minute [18].

The application should be deployed in real, and after this the costs can be changed according to feedback and circumstances.

⁶ cedi is the currency in Ghana, 1EUR equals 5.4 Ghanaian cedi (GHS).

4.9. FEASIBILITY AND SUSTAINABILITY

Whenever new fertilizers are developed, Farming Officers can react on this and enter new data in the web interface whenever they want, so that farmers can very easily and quickly get the new information. There is no third party needed to help Farming Officers enter the information. The sustainability of the application is greatly dependent upon the implementation of the requirements. The requirements are designed to allow the application to be maintainable. Local languages can be added by the administrators of the admin interface, which will allow more people to use the application. New fertilizers, crops, categories and tutorials can also be added, allowing the application to remain up to date. In addition, it will be easy to expand the application with more conditions such as amount of rainfall, the type of soil, etc. The manuals in Appendix B explain how new factors can be added into the system.

Moreover, using subscriptions helps the tool to be sustainable.. If a user is subscribed to our service, they do not have to pay immediately each time they use the application. Instead, they pay a vast amount of money each month. and this provides more certainty for the ones that make business of *MaMoisson*. This guaranteed income of subscriptions gives the owners of *MaMoisson* the opportunity to invest in the application and to improve the quality.

4.10. KEY REQUIREMENTS

The key requirements of *MaMoisson* are listed in a MoSCoW list of requirements below. In addition, Table 2 shows functional requirements and Table 3 shows non-functional requirements.

4.10.1. MoSCoW LIST OF REQUIREMENTS

1. The voice system has to have good audio quality.
2. The system is accessible via web and mobile.
3. The data has to be stored and accessed from a database.
4. The system has to be low cost.
5. The system must be able to be updated.
6. The system should be able to be used offline.

4.10.2. FUNCTIONAL REQUIREMENTS

Requirement ID	Description	Rationale	Originator	Fit Criterion	Created
FR01	The service shall provide the appropriate fertilizer advice based on crop. For okra, the phase in which the crop is in is required as well. For mango, age of tree is required as well.	The crop is required to advise on fertilizer use.	Anastasios Sidiropoulos, Aron Van Groningen, Judith Schermer	After the user has selected their crop type followed by crop name (and possibly age/phase) they will be given advice on which fertilizers to use and in what amount and frequency.	17/5/18
FR02	The voice application service shall be available in English and French, which the user shall be able to choose.	English is the most spoken language in Ghana, while the addition of French will assist	Anastasios Sidiropoulos, Aron Van Groningen, Judith Schermer	After the user selects their language, they will be redirected to the menu implemented in that language.	17/5/18

		in the deployment of the service in neighboring countries.			
FR03	The service shall have an administrator web interface, linked to a database, managed by the Farming Officers. The Farming Officers shall be able to add crops and advice on fertilizers.	Having the ability to maintain and update a database with the newest information is critical to the application's sustainability.	Anastasios Sidiropoulos, Aron Van Groningen, Judith Schermer	After a Farming Officer updates data on the administrator interface, changes shall show up on the next call made.	17/5/18
FR04	The service's admin interface shall allow administrators to add a new language to the voice application service.	Giving the administrators the ability to add new languages to the application will help with sustainability, since more local languages may be added, giving more people the option to use the application.	Anastasios Sidiropoulos, Aron Van Groningen, Judith Schermer	After a Farming Officer adds audio recording on the administrator interface, they shall show up on the next call made.	17/5/18

Table 2: Functional requirements of *MaMoisson*.

4.10.3. NON-FUNCTIONAL REQUIREMENTS

Requirement ID	Description	Rationale	Originator	Fit Criterion	Created
NFR01	Getting the appropriate fertilizer based on the user's input shall not take more than 4 minutes, in a call where "bargain" is not used (prompts not skipped).	Cost consideration of calls has great significance for an application deployed in Ghana, given the economic condition, so allowing the user to get their desired information in a quick manner is a big priority for the usability of our application.	Anastasios Sidiropoulos, Aron van Groningen, Judith Schermer	From the welcome message until the goodbye message, the call flow should be completed in 4 minutes or less.	17/5/2018

NFR02	The voice recordings (prompts) must be clear and concise.	We want to ensure that the user hears the information right and does not have to repeat the message.	Anastasios Sidiropoulos, Aron van Groningen, Judith Schermer	-	22/5/18
NFR03	“Bargein” shall be enabled so experienced users can get to the information they require in the call-flow at a quicker pace.	This requirement satisfies the cost consideration aspect. We do not want users who have already used the application to listen to the same recordings repeatedly.	Anastasios Sidiropoulos, Aron van Groningen, Judith Schermer	When a recording is being heard, a user presses a button and the input is accepted.	23/5/18

Table 3: Non-functional requirements of *MaMoisson*.

5. TECHNICAL BACKGROUND

5.1 VSDK, KASADAKA AND DJANGO

The voice application as well as the web interface are built on the VSDK Kasadaka system. This system connects the interfaces of both applications with a SQL database of Django. 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. Besides models, Django also provides modelforms. Depending on the attributes implemented in the model, forms are generated automatically with the class modelforms [19]. The Django views provide Python functions that take web requests and returns web responses. A response can consist of all sorts of things, such as a web page, a XML document or an image. Thanks to views, the web interface becomes interactive, instead of being a static page. In addition, elements from the database can be retrieved and sent to the templates, so that they can display the required data [20]. 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.

5.2 HEROKU

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.

6. EXPANSION OF PROTOTYPES

Version 1 (Assignment 1)

Version 1 of *MaMoisson*, that was called *MonMoisson*, was a voice system that could be called using Voxeo. Then, three menus were provided: first, one had the option to choose ``Fertilizers'' or ``How to's''. Choosing the first option led to another menu, where a crop had to be chosen: cocoa, corn or cotton. After this, the weather had to be selected: dry or wet. When ``How to's'' was chosen, the next menu gave options for the fertilizer (fertilizer 1, fertilizer 2, fertilizer 3), and afterwards asked for the weather (dry, wet) and then stopped. Instructions still had to be recorded and implemented.

Version 2 (Assignment 2)

The first improvement of Version 1 is that Version 2 complies with the Kasadaka. This makes the application suitable to work in ``the field'' (which is the ultimate goal).

The second improvement is that *MaMoisson* now supports two languages: next to English, the user can choose to use it in French (the second main language spoken in Ghana).

Moreover, a web interface has been developed, to support the Farming Officers, who are the sources of information. This website allows Farming Officers to add and maintain fertilizer data.

In addition, the system provides more detailed information: it gives names of real fertilizers (instead of just ``fertilizer 1, fertilizer 2, ...'' etc.) and it gives some additional information on each fertilizer.

However, the ``How to's'' are removed from the system, due to technical complications with the Kasadaka. The ``How to's'' menu will hopefully be implemented again in Version 3.

Another difference from Version 1 is that in Version 1, one could select their options either by pressing numbers or by saying the words out loud. The latter is not possible anymore in Version 2. However, DTMF is the most convenient way to use a voice system in the field, so this does not form a problem. Moreover, DTMF is very robust and easy in use.

Concerning error handling, in Version 2, if the user takes too long to push a button, the message is repeated. If the user presses a button that is not a valid option (so for example, someone presses 5 while there are only 4 options), an error message is provided.

Version 3 (Assignment 3)

After doing more research on fertilizers, we found out that recommendations on fertilizers often consist of multiple fertilizers and the amount of fertilizer that should be used. The type of fertilizer and amount differs per crop and sometimes also depends on the age of the crop. Previously, we assumed that there is one fertilizer that depends only on crop and weather condition. Since it turns out to be different, we decided to change the structure of the application. Namely, now we (after asking for language) ask for the crop and then (for some crops) ask for the age of the crop, and according to this, give an advice on the fertilizer, which looks like ``Apply 110 kg of NPK 15-15-15 per hectare and 150 kg ammonium sulphate per hectare''. So the ``How to's'' and the ``Fertilizer'' menu of Version 1 are merged into a single menu that in the end provides which fertilizers should be used and in what amount.

The Farming Officers, who have the knowledge about fertilizers and should provide the information for the system, can enter this information using the web interface we created. The web interface provides a nice overview of the crops and which fertilizers are recommended. The interface contains a link to the admin page, where they can add fertilizers or crops. Whenever they added a crop or fertilizers here, the voice application will be updated accordingly. This is new with respect to Version 2. To access the admin page, a username and password is needed.

In Version 2, it was not possible to delete a fertilizer or crop from the web interface. For example, when a fertilizer is outdated (out of use), it would be handy that it could be removed from the database. This is possible in Version 3. Moreover, it is possible to edit all elements in the web interface. It is easy to add voice labels in another language, or add more information about a fertilizer (e.g. the price or contact details of the supplier), etc. Farming Officers and users should point out which information is interesting enough to add to web interface and thus the voice application. In the web interface, overviews are added of the categories of crops, fertilizers and tutorials. With these pages it is easier to see which elements have already been added to the database.

Concerning error handling, in Version 3, if the user takes too long to push a button, the message is repeated. If the user presses a button that is not a valid option (so for example, someone presses while there are only 4 options), an error message is provided. Each menu has the option to return to the previous menu (if any) and to repeat the message.

Scope of Version 3

The prototype of Version 3 consists of two languages (English and French), four crops (mango, okra, cassava and cocoa) and several tutorials (that is, several advices on fertilizer use).

This is just for a start, to show the use of the application. If the application would be deployed in the field, then Farming Officers should add more crops and languages to make it a more useful and interesting application.

7. SYSTEM DESIGN AND DESIGN DECISIONS OF VERSION 3

We decided to use DTMF to navigate through the menus in the voice application. DTMF makes use of keys with numbers and the user has to press one of those keys to select an option. We have chosen to represent the information by playing voice recordings. The main advantage of this is that it does not require users to be literate, since the options they have to choose from are spoken out loud.

Some farmers will speak English or French, however some will speak a local language. Since English and French are two of the main languages spoken in Ghana, and we (developers) understand those languages, these two are the ones implemented right now. How other languages can be implemented will be discussed in Future Work.

In our design, we assume that the type of fertilizer depends on the type of crop and on the age/phase of the crop only. However, from the feedback we got on Version 2, we know that it depends on a lot more things, such as type of soil, humidity level, region, amount of rain fallen and the crop that is planted before the current crop. Hence, to give a more accurate advice, we should also take this into account. This is not feasible for Version 3, but could be done in the future.

Between selecting the language and selecting the crop, one has to select the category of crop. We decided to make this extra menu, because it allows for expansion of the application. Now, there are only four crops included. However, with only four crops, the application might not be useful for a lot of farmers. Hence, if the application is deployed in the field, a lot more crops should be added. Thanks to this extra menu, the list of crops does not get too long. This is important, because we use DTMF, which makes it impractical to have more than say, 7 options. Namely, then it will take the user a long time to listen to all options and select the one of their preference.

At last, we decided to allow to go back to the previous many in all steps, and to repeat the message that is spoken. Moreover, once someone got a fertilizer advice, the application asks if they want to get another advice. This makes it easy to get advice on multiple crops in one call and we think that this is desirable, since farmers often have different crops.

The considerations mentioned above led to a voice system with a structure that is shown in Figure 7.

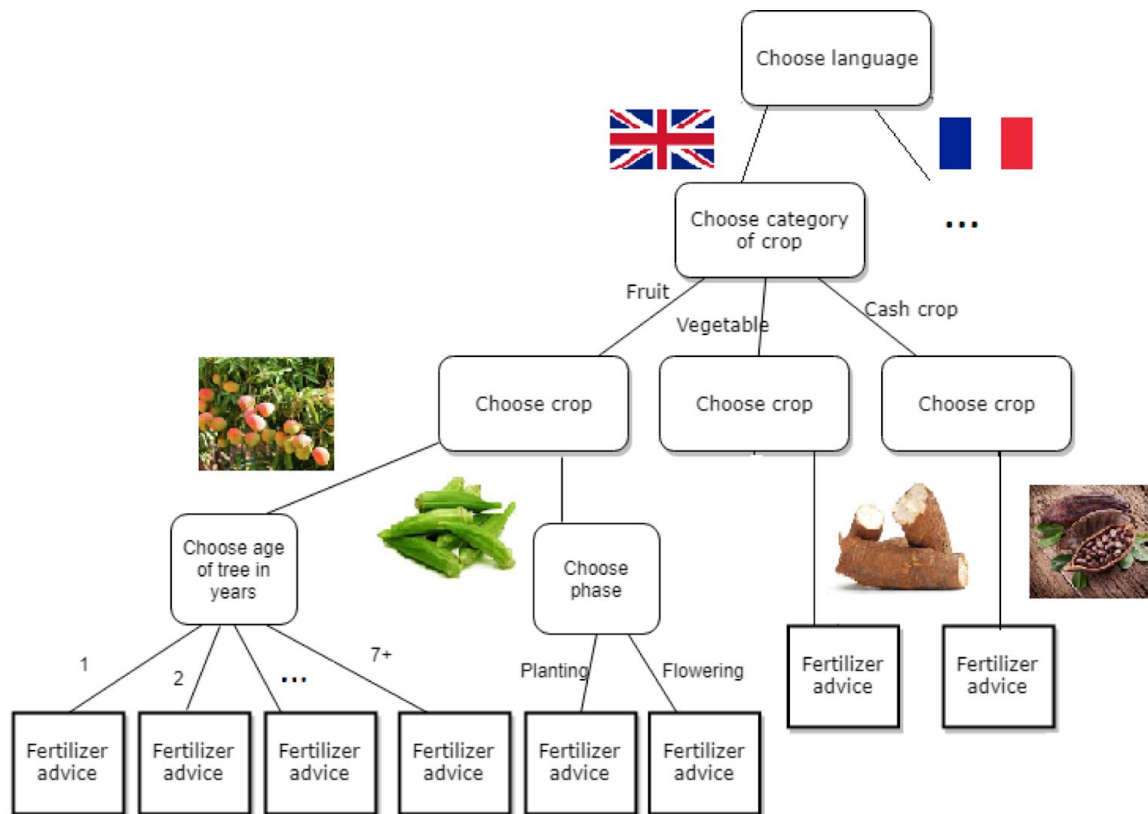


Figure 7: Structure of voice application, represented by a decision tree.

8. PROTOTYPE DESCRIPTION OF VERSION 3

8.1. VOICE APPLICATION DESCRIPTION

The prototype includes a main menu where the user is asked their preferred language: English or French. After choosing the language, the user is asked to select the crop category. After the user has chosen the crop type, they have to choose the crop of interest. Depending on the crop, there are three different options. The first option is that the user needs to tell the system how old the crop is. The second option is that the user needs to tell the system in which phase the crop is. This phase could be the planting phase or the flowering phase. After the system gets this information, the user gets advice on how to use fertilizers for this specific phase or age. The third option is that the system does not need more information from the user and gives the fertilizer advice immediately. In addition, during the call the farmer always has the choice to play the message again or to go back to the previous menu.

Appendix A contains information on how to call the voice application and also contains examples of calls in both languages.

The necessary information about fertilizers will be provided by Farming Officers via a web interface.

8.2. WEBSITE DESCRIPTION

The web interface of *MaMoisson* allows Farming Officers to share their knowledge about fertilizers. Appendix A provides the url to visit the website.

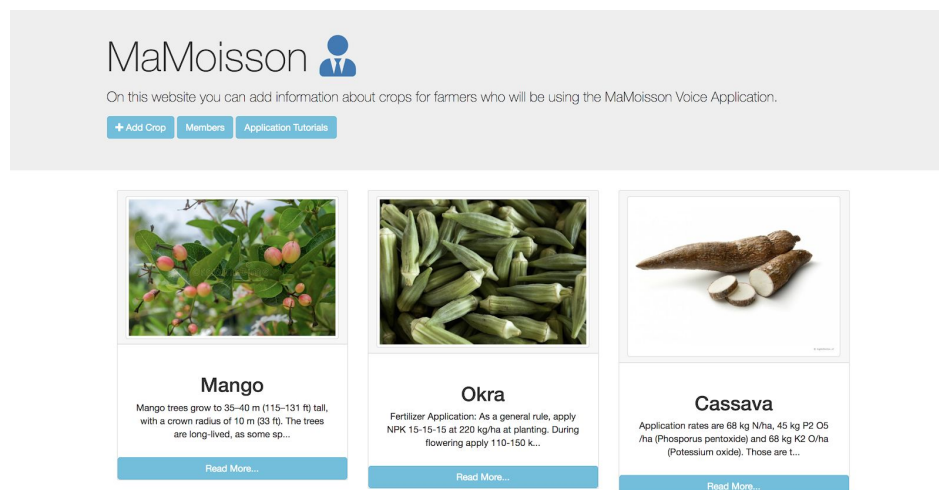



Figure 8: Main page with three crops: cassava, okra and mango.

Figure 8 shows the the main page of the *MaMoisson* website. This page provides an overview of all crops. Every crop is shown as a card item which contains the crop name, a picture and a small description. If the user wants more information about a specific crop, they can click on the *read more* button to go to a more detailed page. If the user wants to add a new crop, they can click on ``add more`` to add more crops to the main page. If the user wants to implement new crops into the voice application, the user clicks on the  to go to the admin panel, that allows you to add crops of the

web interface into the voice application. A manual with more information for the Farming Officers can be found in Appendix B.

Figure 9 shows the detailed page, which provides more information about a crop. On this page, the user can find the name, a description and multiple images of the crop and recommended fertilizers. The page shows also the advised fertilizers in a list. Moreover, the detailed page contains the audio that are used in the voice application. The user can edit and delete crops here.

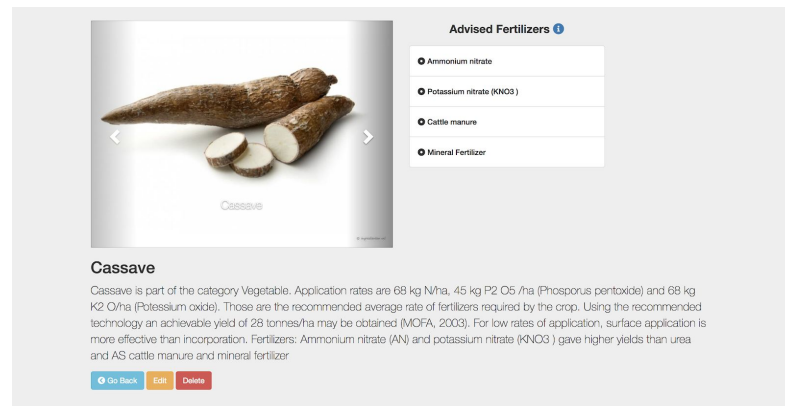


Figure 9: Detailed page of cassava.

Figure 10 shows one of the four forms that are used in the web application. Forms are used to add a crop, a fertilizer, a category or a tutorial into the database.

Figure 10: Crop form of web interface.

9. QUESTIONS TO EVALUATE *MaMoisson*

To evaluate *MaMoisson* (Version 3), we would like to ask the end-users (farmers) the following questions:

1. What is often the reason for a less optimal or failed crop? Do you think it has to do with the fertilizer?
2. What is your experience with Farming Officers?
3. Would you be interested in sharing your experience with other farmers? (we might want to make the tool interactive, so that users can upload their own recording, see Future Work).
4. Do you feel as if you have your own techniques, or choices when it comes to fertilizers, which are different than what is commonly advised for your crops?
5. What is more important - the fertilizer you use, or how you apply it or prepare it?

10. BUSINESS PLAN AND SUSTAINABILITY ANALYSIS

We propose two business models, one is with government funding, and the other with organisational funding.

10.1 Government Funding

Figure 11 shows the Value Web of *MaMoisson* with funding provided by the government. The incentive that the government has to invest is market and economic growth. In this business model, the government funds *MaMoisson*, and assigns Farming Officers to maintain it and update the information it provides. In turn, *MaMoisson* advises farmers on the information they require. Revenue is also generated from payments by telecommunications providers, which will pay *MaMoisson* for the customers that call the service. An expense that *MaMoisson* has, is the hosting fee paid to the hosting provider. With this business model, the end-users are able to get government recommended advice through the Farming Officers, however sustainability may be questionable, as other government funded projects have failed in the past.

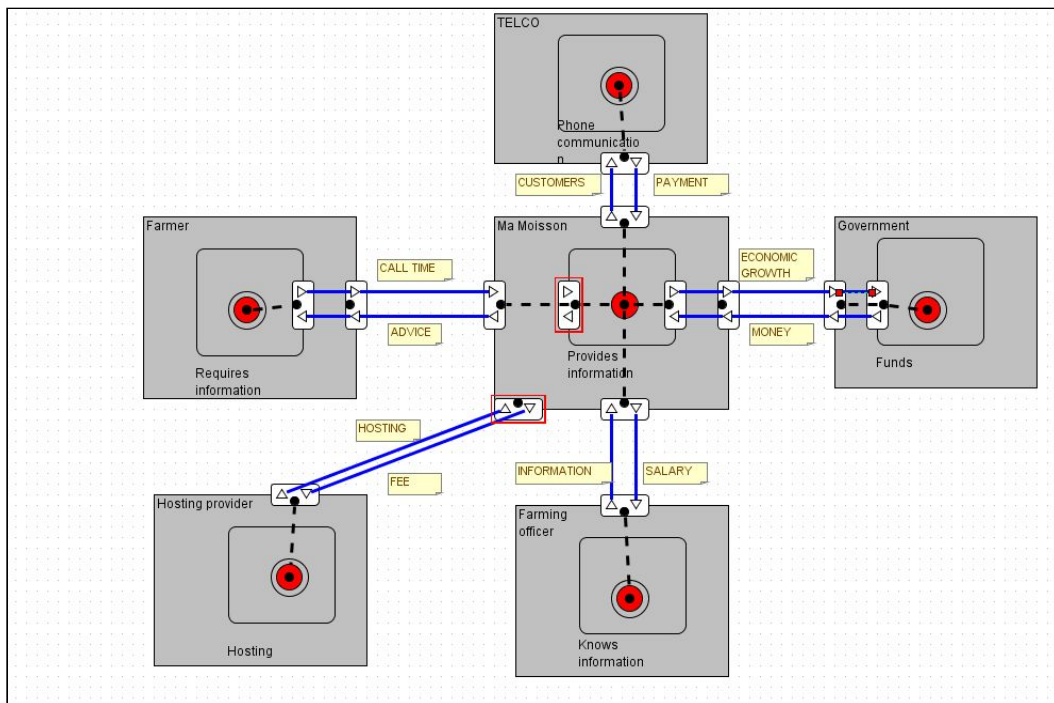


Figure 11: Value Web of *MaMoisson* with government funding. The actors are *MaMoisson*, Farmers, Telecom Providers, Farming Officers, Hosting provider, Government.

10.2 Organizational funding

Figure 12 shows the Value Web of *MaMoisson* with funding provided by organisations that develop or want to market their fertilizer. The business model remains similar to the one in Figure 11, however, the main idea behind this model is that fertilizers can be developed by organisations for certain crops, and there exist different brands of fertilizers with the same nutrients. Therefore, *MaMoisson* could serve as a platform of advertisement, where the organization that pays a fee to *MaMoisson*, will benefit from our service as the brand will get exposure. An undesired outcome of this is having a low-quality fertilizer listed in the app that does not produce good results, or does not produce results at all, causing the inverse of the goal of *MaMoisson*.

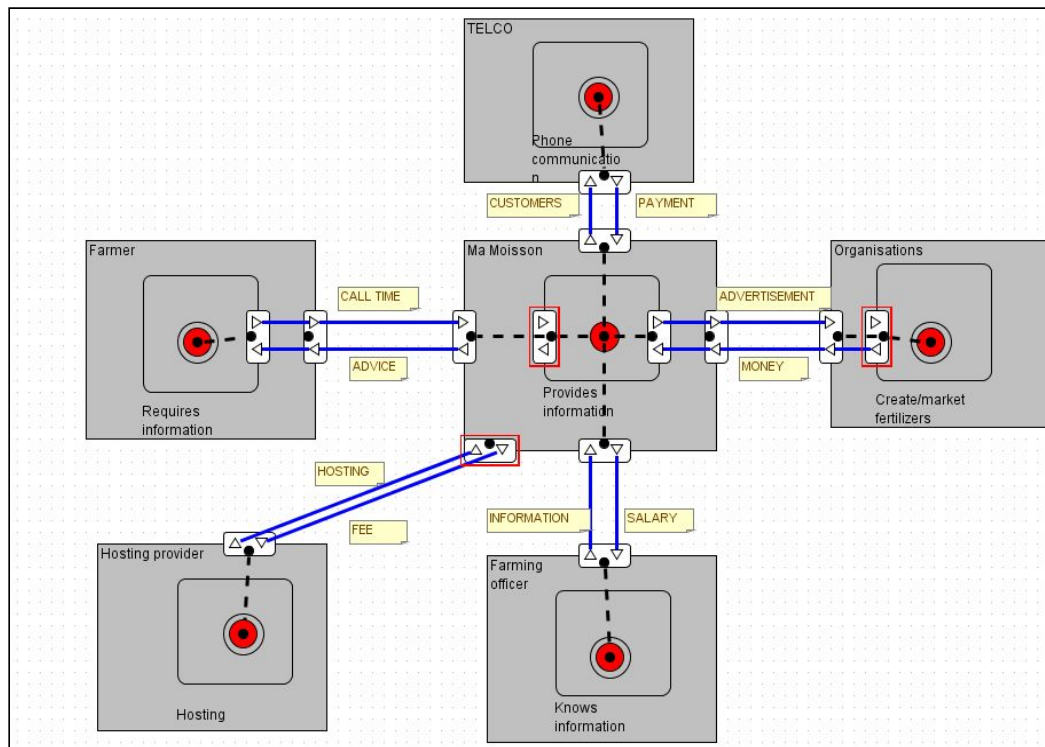


Figure 12: Value Web of *MaMoisson* with organizational funding. The actors are *MaMoisson*, Farmers, Telecom Providers, Farming Officers, Hosting provider, Organisations.

11. DATA MODEL

With *MaMoisson*, farmers in Ghana provide us with information about their crops. They select the crops they have and possibly the age of the crops, and if other factors will be implemented in the future, even more data is provided. This data could be used to give more insight in farming in Ghana. For example, one could make an overview of the crops harvested in different parts of Ghana (if they also provide their region). How this can be done, is by retrieving the caller ID of each caller and then saving the choices they made in a database. See also Future Work.

12. CONCLUSION (SUMMARY OF PROJECT)

We developed a voice service called *MaMoisson* that provides Ghanaian farmers with information on crop fertilization. The fertilizer advice is based on the crop and on the age or phase (flowering or planting) that the crop is in. The advice consists of one or more fertilizers, the amounts that should be used and the amount of times a year that a farmer should use this fertilizer. The application supports English and French and it gives advice on four crops (mango, okra, cassava, cocoa). However, the tool can be easily edited, and should be edited, by Farming Officers, who know all about the correct fertilizers. The idea is that the Farming Officers provide the information for the voice service, using a web interface that we developed next to the voice app. Whenever they update the web interface, the voice application is updated accordingly. Farming Officers can add a language by recording the crops and the advice in their own language and uploading the recordings to the web interface. The application could be supported financially by the government, that employs the Farming Officers, or by suppliers of fertilizers, who can then more easily sell their products.

13. DISCUSSION AND EVALUATION

Throughout the three iterations of *MaMoisson*, a lot has been discovered. As a general note regarding the use case, it is apparent that the complexities of agriculture are greater than it was initially thought. Nevertheless, it can be said that the development of an application made for farmers has reached a deployable state. A farmer is now able to acquire the optimal fertilizer advice for their crop. However, there are many factors that can influence the effectiveness of a fertilizer, and the same information may not hold true in a separate region. That is why, through the development of a web interface made to complement the *MaMoisson* voice service, we have created a system that can be updated with new factors, advice, crops, fertilizers and even languages, so that to a great extent, we achieve sustainability.

We have great aspiration that our application will be successfully deployed and used by farmers, so that they increase the yield of their crops. We are also optimistic about the promise of longevity and impact of our system.

14. FUTURE WORK

We have the following suggestions to improve *MaMoisson*:

1. To provide a fertilizer advice that is, next to crop and age/phase, also based on region, type of soil, humidity level, amount of rain fallen and the crop that is planted before the current crop. New menus that allow to choose the region, type of soil, humidity level, amount of rain fallen and crop that was previously planted can be easily added to the system. However, humidity level and amount of rain fallen may be difficult to provide for the farmers, because there is a dependency on a tool/sensor, or weather report that provides that information. So if we would want to incorporate those factors into the application, we also need to use sensors or weather information on the internet. Appendix B provides a manual how developers can implement these factors into the system.
2. Provide more information about the fertilizers, e.g. the price of a fertilizer, or the name of the supplier. After receiving fertilizer advice, it might be nice to get additional information about the recommended fertilizers, such as the price or contact details of a supplier. This information can be easily added by recording the information and then adding it using the admin page. In the web interface the developer can easily add more attributes to the existing models(forms) by using the manual in Appendix B.
3. Add local languages. To do this, it is first required to let the locals know of the existence of the app, which is part of the deployment. After that, the locals and administrators can cooperate to make the addition through the admin interface and by making voice recordings. These voice recordings can be easily added to the voice labels in the admin panel.
4. Allow users to upload a message, so that they can contribute to added information. To allow users to record feedback and personal experiences, the structure of the voice application should change. After asking for the language, the user should be asked whether they want to get information or provide information. If they select ``provide'', then they should be able to speak a message into their phone. The feedback they record will be evaluated by the Farming Officers and used to update the advice that is given by the voice app.
5. Give users the option to call a Farming Officer for more information, after they got the fertilizer advice. This can be easily implemented in the voice application by adding an extra menu in the admin page (see Appendix B for more detailed instructions), but the question of feasibility remains, since a Farming Officers is needed to answer their phone at all times, which is costly.
6. Save caller IDs and store the data that users provide (the crops they have and information about those crops), to get more insight in the crops that are harvested in Ghana. With the Kasadaka, caller IDs can be retrieved easily.

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APPENDIX A - CODE & EXAMPLES

Code of website and voice application: <https://github.com/AVG-Apps/KasaDaka-VSDK>

Website: <https://pacific-plateau-36688.herokuapp.com/vxml/mamoisson/>

(Please use the website within a Google Chrome browser, since other browsers do not show the UI nicely, due to some UI bugs. The website is optimized to be used on mobile phones, tablets, laptops and personal computers.)

To get access to the admin panel, login with:

- **Username:** koji
- **Password:** ict4dcourse

Voice application:

Kasadaka login data

Heroku: <http://serene-woodland-76686.herokuapp.com/vxml/start/2>

The phone number: 020-3697664

Examples of all versions of our applications can be found on:

https://pacific-plateau-36688.herokuapp.com/vxml/mamoisson/tutorials_app/

APPENDIX B - MANUALS

How to expand the information forms into the system? (Manual for administrator)

To expand the web application with more data, such as the amount of rainfall or the humidity of the soil, follow these steps:

1. Add model(s)

To add a new model class you need to create a new class into the model.py file. This model needs a class name and specific attributes for the form. Attributes that could be added are fields such as a charfield, a textfield or a urlfield. A charfield is used to add a name or a single line of text, when you want to add more text to the system then use a textfield. In a textfield you can add as much as text as you want. An url field checks if the file of text is an url. This makes it impossible to add anything other than a URL. In addition, you could add constraints in the brackets of the field. For example, the amount of maximum characters of a field or whether the field is required or not.

2. Add modelform(s)

To add a new modelform you need to create a new class with attributes into forms.py. With this form Django will create a form automatically depending on the attributes given in the model. If all attributes of the generated model are needed you can use this code:

```
class YourClassForm(ModelForm):
    class Meta:
        model = YourClass
        fields = '__all__'
```

However, if you do not want to have all the fields of the generated class then you add only the attributes you want as fields = 'your attribute'.

3. Add view(s)

After you have implemented the models and modelforms you need to add a new Python file in the views folder. In this folder you add a function for how you want to show the data, what data needs to be added, how the data needs to be edited and if necessary a function about how the data needs to be deleted from the database. Also, make sure that you refer to the correct template with the information you want to show into the template. This information must be sent into an object to the template. This information are we going to use in step five.

*Tip: it is important to add **from** .yourfilename **import** * into the init python file so that the system understands that you have created a new python view file.*

4. Add url(s)

Next, add important urls you want to use into the urls.py file from the service_development folder. A url consists of a url path, a function which is provided in the views python files and a name of the function. To have more security on the url, if you add the \$ after your url, then it is not possible to add more characters after the url to go to the same webpage.

5. Add template(s)

After you implemented step 1 until 4 you can create a new template for the form or edit the form with the information you would like to add. If you want to create a new template, then you need to add a new python file in the templates folder mamaison. To create a form automatically then you need to add a form, a div for the form row and a submit button. Such as this code:

```
<form method="POST" action="">
    {% csrf_token %}
    {{ form.non_field_errors }}
    {% load widget_tweaks %}

    <div class="form-group row">
        {{ category.name.errors }}
        <label for="{{ category.name.id_for_label }}">Category name</label>
        {{ category.name|add_class:"form-control" }}
    </div>

    <div class="form-group row">
        <input type="submit" class="btn btn-success" value="Submit">
    </div>
</form>
```

You need add to form the the method POST, `{% csrf_token %}` and `{{ form.non_field_errors }}` to let Django know that you want to use the automatically generated. After you created the form you need to add every row of the form in a div. It is important that you add the error handling, attribute id and the attribute itself. To handle the errors on the form you need to add `{{ category.name.errors }}`. To handle the label you need to add a label tag with a for method which refers to the id label. Optionally you could add a name of into the label. To show the form you need to add the object and the attribute. In this example form the category is the object and the name is the attribute of the object. To improve the UI of the form you could use the load widget_tweaks and add a class to the form rows. Also you can improve the UI to use bootstrap classes like 'form-group row' or 'btn btn-success'.

Tip: You can optionally create different forms to add and edit the forms you created.

6. Align forms into the crop form

If you created your form and you want to add this information to the crop form, then you need to add a ForeignKey or a ManyToManyField into the Crop model. With a ForeignKey, the user can only add one specific value to the crop from, whereas the ManyToManyField can add more then one value into the crop form. In addition, it is also important to add a form field into the crop form template with the attribute which is used in the Crop model. Otherwise, the field will not be shown in the crop form.

How to expand the voice application? (Manual for Farming Officers)

If you want to add a new crop to the voice application, for example tomato, then you need to record ``tomato`` in the language(s) of your choice, you need to record the fertilizer advice, and possibly also other information, depending on the factors that influence the fertilizer of tomato (e.g. the age of the tomato plant). Once you have made your recordings, you can implement them in the system.

The voice application can be edited and expanded on the admin page:

<https://pacific-plateau-36688.herokuapp.com/vxml/mamoisson/> → .

Then login with username ``kodi`` and password ``ict4dcourse``.

1. Add voice labels

You will upload your voice recordings in *Voice labels*. A voice label consists of a recording and a name. To add a voice label, click ``Voice labels`` → ``Add``. Then, add a name, description (optional) and per language an audio file. Then click ``Save``. After you saved the voice label, you can listen to the audiofile if you open the voice label again to check whether it is correct.

2. Voice application tree

After you have uploaded the audio files into the voice labels you will use them in a message representation element or a choice element. They represent different kind of elements of the voice application.

2.1 Message presentation element

The message presentation element represents a message that will be played in the voice application. After this message is played, the user will be redirected to another element. Hence, to add a message presentation element you need to add a name, description (optional), the voice service you use, a voice label and the element where the message needs to be redirected to.

2.2 Choice element

The choice element is used to create a choice for the user. Adding a choice element requires a name, the voice service, a voice label (for example: voice label with audiofile ``Please select your crop``) and all the options. For each choice you need to specify the voice service, a name and description (optional), a voice label and an element where the choice redirects to.

How to add a crop to the main webpage? (Manual for Farming Officers)

Click ``add crop``.

Fill in the whole form.

Click ``save``.

Note: it is important that you fill in all the information that is asked for. If categories, fertilizers or the tutorial are not yet available, then these need to be filled in before adding the crop. After all the forms are filled in and submitted, then the system automatically generates a new crop into the system.

How to use the voice application? (Manual for farmers)

Please call 020-3697664 (it costs 0.1 cedi per minute and 0.5 cedi per month). Then select your language, the category of your crop, the crop, perhaps the age or phase of your crop, and then you get your advice.

In the figure below, the structure of the voice application is shown.

