DEMRI: A Web/SMS based Application for Agriculture

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ABSTRACT
Africa is going through a mobile phone-based revolution. The increasing use of mobile phones by the agricultural population in Africa in general and sub-Saharan region in particular offers a favorable ground for the development of new technologies capable for boosting yields of farmers. But, in many parts of Africa, mobile phones are not sufficiently used to support agricultural activities. This work aims to provide a design approach and a mobile application that will help farmers in their daily activities. In order to avoid discriminating users with basic phones, the proposed architecture inspired from M-Kulima considers both web and SMS interfaces. It is implemented using the framework RapidSMS and several backends among which Kannel. The application will provide farmers with relevant information on crop production and market prices.

Keywords
Agriculture, ICT, Mobile Applications, Food Security.

1. INTRODUCTION
Africa, especially sub-Saharan region, is the most vulnerable and most affected area by famine and malnutrition [1]. According to the United Nations, the food crisis that hit Somalia between 2010 and 2012 resulted in the deaths of 260,000 people, half of whom were children [2]. These figures point out the urgent need for African governments to ensure food security for the population. Despite some progress in agriculture over the last decades in several sub-Saharan African countries, the number of poor people suffering from hunger or malnutrition is increasing. This is because the agriculture in Africa remains embryonic and vulnerable to many scourges. These include population growth, low income, inefficiency of the agricultural extension system, difficulties of selling products, unavailability and inaccessibility of agricultural inputs, the poor state of the communication channels, the isolation of production areas or the lack of information on cultural techniques. It becomes imperative to develop the agricultural sector at least to ensure food security, or better, self-sufficiency. To do so, the opportunities offered by ICT can be exploited.

As stated by [3], mobile phone is a platform of choice for digital transformation in Africa. It can help address social challenges and the UN Sustainable Development Goals. This is because the mobile phone is everywhere on the African continent. In 2000, the percentage of mobile cellular subscriptions was less than 2% in sub-Saharan Africa: a telephone for 50 people according to the world bank [4]. At the end of 2011, according to a study by Wireless Intelligence, the number of mobile subscribers in Africa reached 620 million (higher than the one of Europe and becoming the second largest continental market after Asia, and Before America) for a total population heading one billion [5]. That means: a telephone for less than 2 people. A study in rural regions in Cameroon showed that rural population is ready to welcome ICT based solutions to sustain their daily activities [6]. However, although rural regions experiencing a rapid mobile penetration, the bulk of devices are simple telephones which can only make use of SMS service. Notwithstanding actual limitation of devices, a study conducted by McKinsey [7] predicts that half a billion of the African population will have access to the Internet and there will be 360 million smartphones on the continent by 2025. ICTs would thus be able to increase the agricultural productivity of the continent by 3 billion XAF per year. Here comes the dilemma: Using only SMS-based solution will rapidly deprecate the solution since smartphone penetration is growing; using only web-based solution will discriminate the present bulk of potential users. In this paper, a new application named DEMRI is proposed. This web and SMS based solution aim to help farmers before and during and after their agricultural activities.

The rest of the paper is organized as follows: the second section makes a tour of most common application for agriculture in sub-Saharan Africa. The third section deals with the modelling of the proposed mobile application. RapidSMS framework is presented in the fourth section followed by some tests. The work ends with a conclusion and perspectives.

2. RELATED WORK
Several applications have been developed to support agriculture in Africa. The bulk of initiatives have been conducted in East Africa. Among those initiatives:

ICow (Kenya)
ICow is an agricultural information service available in English and Kiswahili with a variety of products. ICow's goal is to increase farmers' productivity through access to expert knowledge. ICow's products are:

- Mashauri-Farmer Tips (paid service): subscribers receive 3 SMS tips per week on cows, chickens, etc.
- Kalenda-Livestock (paid service): users receive personalized advice on registered breeding.
- Vetenari-Find (paid service): this service allows the iCow user to find a nearest veterinarian or AI (Artificial Inseminator).

M-Farm (Kenya)
M-Farm was established in October 2010 due to the difficulty of farmers who were unable to sell their crops in certain areas of Kenya. It aims to increase transparency in the agricultural market by providing information on market prices and facilitating seed procurement and product sales. The M-Farm offers three main services:

- M-Farm: an SMS-based system that allows farmers to know the prices of different crops in different parts of the country (Kenya);
- Group buying: aggregates farmers and connects them to seed suppliers;
- Group selling: allows farmers to sell collectively and connect them to a market.

Rural eMarket (Madagascar)
Rural eMarket Rural is a solution for communicating market information, using smartphones, tablets or computers. Rural eMarket is multi-language and affordable for most rural development projects. It aims to improve transparency and access to market information.

mFisheries (Trinity and Tobago)
mFisheries is a suite of open-source web and mobile applications for artisanal fishing. It was developed at the University of the West Indies with the International Development Research Center (IDRC). It supports and includes a virtual market application, which displays market prices using open data. There is also the "Got Fish Need Fish Application" which, in real time, connects agents in the fishery value chain.

Esoko (Ghana)
Esoko is an African popular agriculture platform for tracking and exchanging market intelligence. It connects farmers to markets, informs them about market prices and proposes buyers. It disseminates customized extension messages according to crop and location, and manages extension agents and farmers with SMS messaging. Esoko is a platform designed to transform how to handle information needs in one easy-to-use interface.

M-Shamba (Kenya)
M-Shamba is an interactive platform that provides information to farmers through the use of a mobile phone. M-shamba uses the different functions of a mobile phone, including cross-platform applications accessible in multi-media and low-end phones, and provides SMS-based information on production, harvesting, marketing, credit, Weather and climate. It provides customized information to farmers based on their locations and activities (agricultural). Farmers can also share information on various topics with other farmers.

Mobile Agribiz
Mobile Agribiz is a mobile web and SMS application that allows farmers to decide when and how to plant crops. It helps farmers to be connected to buyers. Farmers can easily connect with customers by sending an SMS with their phone number and receiving information about products, prices and quantities. The initial web site of the application (www.mogribu.com) is no longer reachable.

Agribis
In its website (agribis.org), AGRIBIS is presented as a simple communication tool that facilitates the linking between the different actors in the agricultural sector. It is a platform that also provides easy access to business data by mobile phone, and provides information on meteorological data as well as good crop production and storage practices. Among the services offered by the platform, there are: the publication of offers; the publication of product prices in real time; SMS alerts (prices and offers).

Camagro
CAMAGRO is an information exchange platform that allows producers, buyers, consumers, and other players in the value chain equipped with a computer or a smartphone to send and receive information on agriculture, livestock, fisheries, etc. Concerning agriculture, the services offered by camagro are: The echoes of the market (price by city); information on different agricultural programs; information on agricultural sectors (in particular the palm oil sector).

A summary of most common e-agriculture applications is provided in Table 1.

Table 1. Most common e-agriculture applications.

Application name	Activity area	Country	Architecture
iCow	Agriculture	Kenya	SMS
M-Farm	Agriculture	Kenya	SMS
rural eMarket	Agriculture	Madagascar	SMS
mFisheries	Fisheries	Trinity and Tobago	Web
mobile Agribiz	Agriculture	RDC	Web and SMS
Agribis	Agriculture	Cameroon	-
Camagro	Agriculture	Cameroon	Web
Esoko	Agriculture	Ghana	Web and SMS

As a general remark, most of the above applications are specific to the regions in which they are located and thus solve the specific problems of these regions. This is a major handicap for other regions that do not share same specificities. Available applications have different architectures. But in reality, most are just SMS-based applications offering "SMS alert" services. These are not genuine SMS applications. With the alerts, all the people who have subscribed to the same service receive the same information at a frequency that depends on their subscription. Although interesting, having an alerting service does not allow interaction between the user and the application.

3. DESIGN AND MODELLING

3.1 Presentation of M-kulima

M-kulima comes from the word swahili kulima, which means "Agricultural practices" [8]. It is a specific model for mobile agriculture applications. It is a model that shows how different actors in the agricultural sector can interact on a single platform or through a system allowing for transparent communication and sharing of information. This model shows how the different actors in dairy production can share a mobile platform that meets their different needs. This model took into account the operational and technical requirements of its study environment (Kenya). It provides a platform for interaction between the farmer and other actors in the dairy industry, such as the milk owner, the veterinary doctor, the agricultural agent and the government. Each of the entities involved in the architecture needs to use mobile equipment to communicate with the central system via a mobile

telecommunication network. Thus, the actors access the services of application through their mobile equipment which communicate with the servers using the Internet. The telephone operator is responsible for this communication between the mobile equipment and the application server.

3.2 mDemri approach

With the low but progressively increasing percentage of Internet usage among the agricultural population in sub-Saharan Africa, the M-kulima model have been modified consequently. The proposed model is illustrated in Figure 1. This new model was named mDemri, from the word Demri in fulfulbe (a local language) which means agriculture. With mDemri, communication with the application server is done in two ways:

- Using the Internet. Unlike M-kulima, where the user needs "mobile equipment to communicate with the central system via a mobile telecommunication network", mDemri allows in addition communication via the Internet.
- Using a GSM mobile network. In case there is no Internet connection, communication can rely on GSM network.

As shown in Figure 1, there are several actors that can be classified into two categories: Users and Stakeholders. Users are the main beneficiaries of the system. Users access the platform either via the Internet or through a GSM network using their mobile devices (mobile phones, tablets, PDAs, laptops, etc.). The following actors are considered as users: farmers, buyers of agricultural products and materials (cooperatives, wholesalers, hotels, restaurants, supermarkets, etc.). The stakeholders can be subdivided into 3 categories: donors, local businesses and extension agents. Donors are those who fund agricultural projects. Thus, users will be able to get information about the donors through the platform. The second category related to local businesses encompasses input suppliers, transport / logistics companies, etc. Finally, there are agricultural extension Officers: this category includes government (through ministries), agricultural research institutes, universities, and so on.

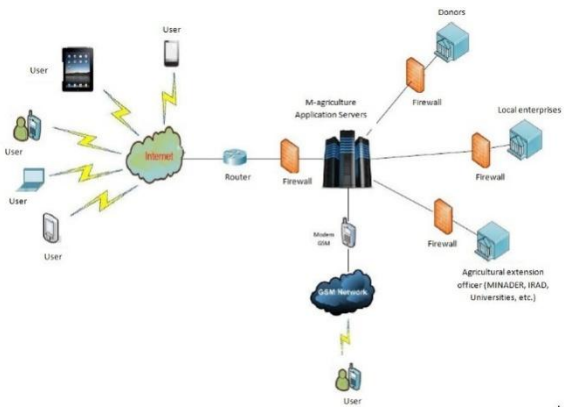

Fig. 1 mDemri: model for mobile applications for agriculture

3.3 Requirements

After the requirement analysis phase, the following functions or services should be provided by the system

- Products marketing;
- Access to information on best practices in crop production;
- Market prices for various products (present price, minimum, maximum, history);
- Demand for various services of agricultural technicians;
- Information on operations before, during and after crop production;
- Information on the nearest market;
- Finding suppliers of seeds;
- Finding clients;
- Finding donors;
- Displaying various statistics (on markets, sellers, etc.).

To be able to realize the above functions, they are classified into two modules which are:

- **Crop production**: allows farmers to decide when and how to plant crops, select the best crops for a given location, what is needed before, during and after a crop production;
- **Marketplace**: it aims to increase transparency in the agricultural market by providing information on market prices and facilitating the sale of products. It allows farmers and buyers to know the prices of different crops of a market from different regions.

3.4 Modelling

Two types of UML diagrams are used for modelling the system: the use case diagram and the class diagram.

A use case diagram represents the interaction between the system and its different users. For each user, the use case diagram presents the different use case in which he is involved. Figure 2 shows the diagram of use cases of the module "Crop production". That of the module "Marketplace" is given in Figure 3.

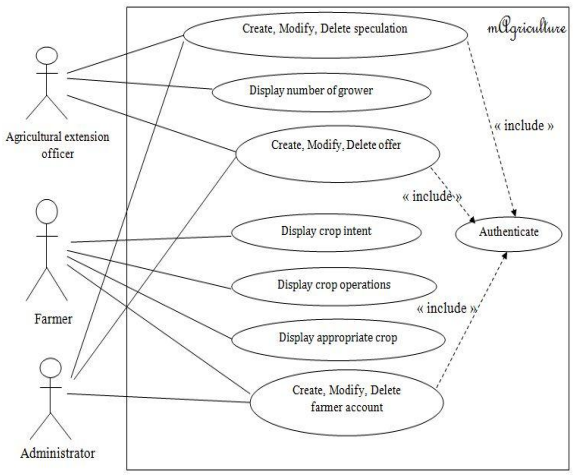

Fig. 2 Use case diagram of the "Crop Production" module

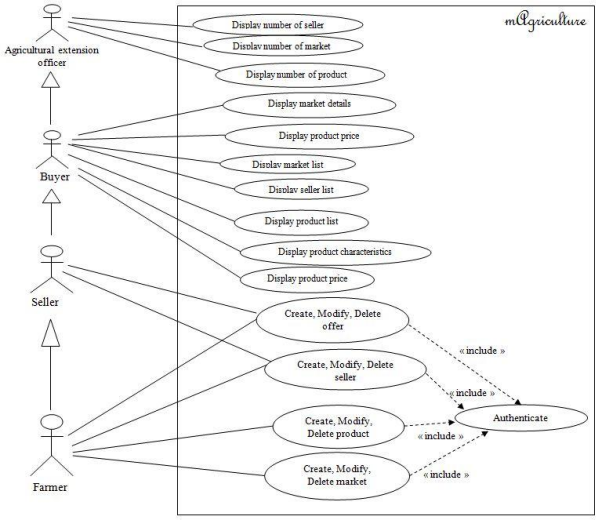

Fig. 3 Use case diagram of the "Marketplace" module

While the use case diagram represents the system from the point of view of actors, the class diagram describes its internal structure. It allows to provide an abstract representation of the objects of the system that will interact together to realize the use cases. Figure 4 shows the class diagram of the "Crop Production" module and Figure 5 shows that of the "Marketplace" module.

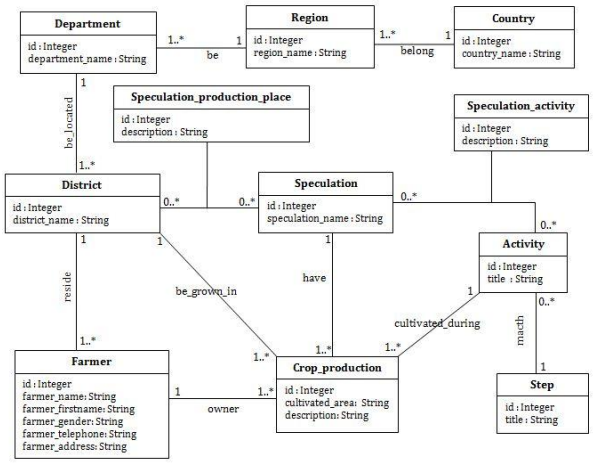

Fig. 4 Class diagram of the "Crop Production" module

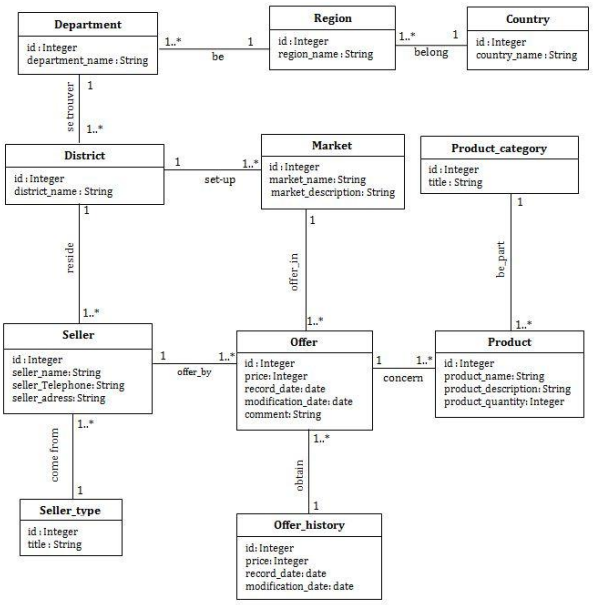

Fig. 5 Class diagram of the "Marketplace" module

4. RAPIDSMS FRAMEWORK

RapidSMS is an open source framework for application development using SMS. It is the rapid penetration of GSM networks that seems to have motivated UNICEF. Its objective is to develop data collection applications, whether quantitative or qualitative. It is done through SMS form type adapted to each situation. All kinds of information can be collected in real time. Thanks to its web-based interface, users can access the system from anywhere in the world to access data as they arrive. RapidSMS is written in Python and integrates Django, a web development platform also written in Python

As shown in Figure 6, RapidSMS is divided into three major parts which are:

RAPIDSMS Apps

This part of the architecture represents applications created within RapidSMS. RapidSMS applications are Django applications that contain logic in the custom processing of incoming and outgoing messages. When the router receives a message, it triggers a series of phases by which its associated applications can process the message. The order in which the router chooses the applications to process is extremely important because each application will have the ability to block other applications according to their positions in "INSTALLED_APPS" settings.py configuration file and according to the processing method of the application.

Backends

The role of Backends is to receive messages from external sources and deliver messages from applications to external sources. Thus, Backends define how RapidSMS communicates with the outside world. The router uses the backends to send and receive messages and all text messages pass through a backend. They manage a two-way messaging protocol: Incoming messages and Outgoing messages.

Many backends exist in the RapidSMS community and can be installed for use in a personal project: Kannel backend, Vumi backend, HTTP Backend, Database backend.

-Router

The router is the RapidSMS message processing component. It provides the infrastructure and defines the workflow to receive, process, and send messages. RapidSMS includes

several built-in routers to use depending on the needs of the application, including:

- BlockingRouter: Default router that processes messages synchronously in the HTTP thread;
- CeleryRouter: Processes messages asynchronously;
- DatabaseRouter: which uses the message queues in the database for asynchronous processing;

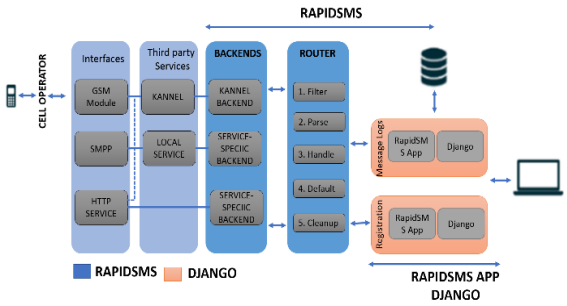

Fig. 6 RapidSMS architecture

5. RESULTS AND COMMENTS

The proposed mobile farming platform was designed to be adapted to agricultural stakeholders. The application provides a platform for interaction between the farmer and other stakeholders in the agricultural sector (agricultural extension agents, agricultural enterprises, donors, etc.). Each of the entities involved in the architecture can use mobile equipment (mobile phones, tablets, PDAs, laptops, etc.) to communicate with the system. This communication takes place in two ways: through the Internet or through a GSM network.

5.1 Communication through a GSM network

Tests in this first section is performed using the SMS simulator of RapidSMS. French has been used as the main language in the application, since it is the common language at the national level.

An important feature of the application is to provide an insight on ongoing crop production. This can be useful for anyone who is intending to invest into agriculture for a commercial purpose to know which crop is not currently produce in enough quantity. This can help avoiding people to cultivate the same crops and by the way making other crops being rare on the market. The farmer can inquire about the number of farmers and the cultivated area of any crop, at the national level, in a city and according to the growing season. For example, it can send an SMS to application with the text "crop intent rice" to obtain the number and area of the rice crop at the national level (Figure 7). He can send a request to the application to know, according to his city, the growing season, and the characteristics of his land, the appropriate crop (Figure 8). It can also obtain information on the different operations concerning a particular crop and carry out several other operations (Figure 9).

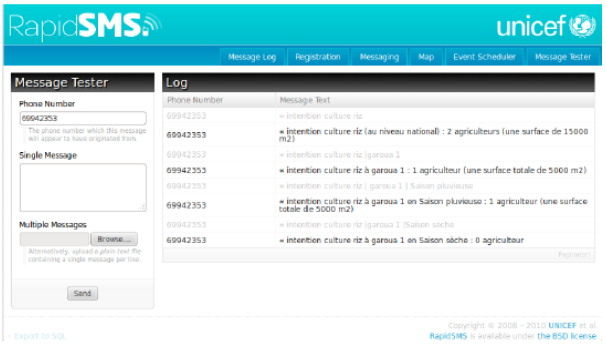

Fig. 7 Tests on "intent of culture"

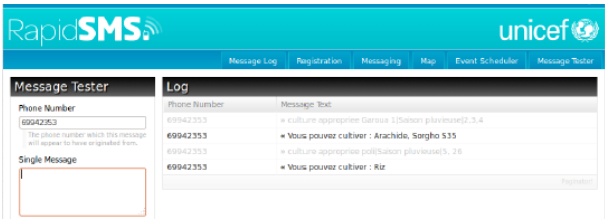

Fig. 8 Tests "Appropriate Culture"

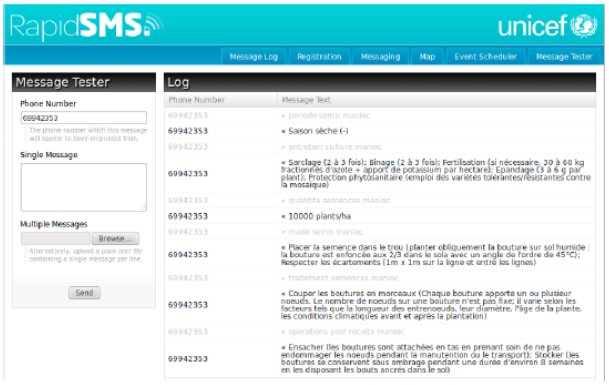

Fig. 9 Tests of some operations on speculation

The seller is responsible for creating an offer. Using its mobile equipment, it sends just "Create Offer" with other information such as the market, the product, and the price (Figure 10).

The buyer of a product may have information on offers, the list of markets where he can find any agricultural product (Figure 11), and many other features such as "Products Prices" (Figure 12).

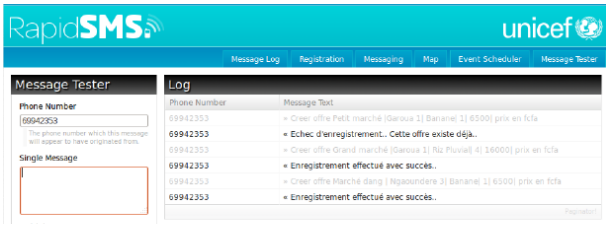

Fig. 10 Tests "Create offer"

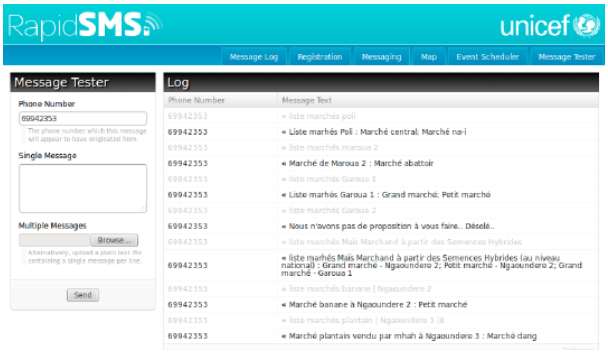

Fig. 11 Tests "Market list"

Fig. 12 Tests "Products Prices"

5.2 Communication through the Internet

All the application features available through the SMS service are also available through the web. The home page describes the application and also explains its use. It includes the navigation area and the body (see Figure 13). A responsive design has been used to adapt the display according to the screen size of devices. The navigation area contains four menus: Home, Display, Information and Statistics.

- "Home" menu allows the user to return to the home page at any time;
- "Display" menu allows the user to display the list of countries covered by the application, the regions of each country, the list of speculation and the list of registered products;
- "Information" menu allows the user to have information on the characteristics of the soil, the technical itinerary of speculation, the list of markets, products, prices of products, etc.;
- "Statistics" menu allows the user to obtain the number (and area) of farmers intending to cultivate speculation, the number of people who sell any product and the number of markets in a town;

To obtain the (appropriate) characteristics of the soil for a particular crop, you have to go to the "information" menu and then click on "terrain characteristics". One obtains a page (Figure 14) where one must choose the speculation and then click on the button "Show the characteristics of the terrain". For example, if soybean is selected as crop, soil characteristics for its production are obtained as shown in Figure 15.

Fig. 13 Agricultural Home Page

Fig. 14 Soil characteristics depending on crop choice

Fig. 15 Soil characteristic for soy

The "Statistics" menu contains a feature "Crop Intent" which is composed of three sub-menus as presented in Figure 16. The first submenu allows us to know the number of people who cultivate a special crop at the national level according to the season. The second submenu provides the same information but at the department level and the third at the level of a city. If the example of rice is considered, one can decide to display the number of rice farmers at the national level. Figure 17 presents the result of such a request.

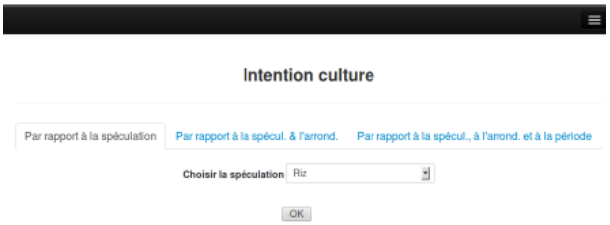

Fig. 16 Select submenu page intent culture

Fig. 17 Result of "Crop Intention" for rice at the national level.

6. CONCLUSION

This paper has presented a model of application for agriculture in Africa. This platform can help by providing relevant information before, during and after crop production. Difficulties such as products selling, isolation of the production basins, lack of information on cultivation techniques, can easily be mitigated. By allowing users to access relevant information via basic telephones by using SMS or via smartphone by passing through the Internet, this platform can play a crucial role in the productivity of farmers and the national food security policy.

As future work, an optimization approach will be integrated to the system for maximizing the net revenue of farmers. The system will also consider other languages, mainly English.

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