DigiVet: a knowledge-based veterinary system for rural farmers in North-Ghana

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Abstract. Rural communities in several regions in Sub-Saharan Africa are facing environmental and social-economic restrictions and limitations that prevent them from accessing information and sharing knowledge. One of the information needs that subsistence farmers living in these areas have is that they do not have access to animal health information and veterinarians, in case one of their animals falls ill. In order to stimulate them going to a veterinarian, a voice-based veterinary information service named DigiVet has been developed. This paper describes the work done in the previous two development rounds and introduces a telephonic variant of DigiVet, as well as the factors that should be taken into account to guarantee a successful and sustainable deployment in the future.
Keywords: DigiVet, ICT4D, Kasadaka, North-Ghana, Rural farmers, Knowledge-based system, Voice-based information service.

1. Introduction

Inaccessibility of information influences the socio-economic development of subsistence farmers living in rural areas in Sub-Saharan Africa. Poor infrastructure and lack of education are some of the factors that increase communication gaps between experts and rural laymen. W4RA (Web Alliance for Regreening in Africa)[1], which is a mostly VU-based research group, aims to incorporate ICTs in the already existing local communicative infrastructure, in order to help these communities in sharing knowledge and accessing information. Environmental and educational restrictions, such as poor roads and illiteracy, are some of the factors that increase the digital divide between these rural communities and citizens [2]. During previous work of the W4RA group, use cases containing the specific information needs in various domain areas were collected in Ghana. One of the information needs that the farmers have is on animal health.

DigiVet is a voice-based veterinary information service that aims to support rural farmers in making the decision whether or not they should go visit a veterinarian, and bring them into contact with each other. This paper introduces the voice-based, telephonic extension to the already existing visual variant. This version was created to increase the scope of the service and include those that, due to distance, cannot reach the physical Kasadaka.

When developing an ICT system for development countries, there are many contextual issues that have to be taken into account. For example, the users are mostly illiterate, and do not have access to the internet.

Section 2 addresses these issues and some related work. Section 3 describes the use case and the first two prototypical cycles of DigiVet[1]. The prototype is then discussed in section 4, including received feedback which also contained feedback from local people in Mali. Section 5 describes the implementation of the prototype and a guide for installation. Also the scope of the project and its fidelity are discussed. A deployment and sustainability plan is given in section 6. Finally, the conclusion and discussion section sum up the project as a whole and provide suggestions for future work.

2. Background

This chapter describes the theoretical background and the reasoning behind the decision to develop the voice-based version of DigiVet.

2.1. Theoretical background

The previous versions of DigiVet were developed based on a field trip conducted in Zanlerigu, a village in North-Ghana. In addition to the information needs that the farmers had based on education, farming techniques and the weather, there was the one on animal health. These information needs are not met partly because of absence of adequate internet infrastructure and lack of electricity, resulting in a digital divide between the rural poor and citizens [3].

Illiteracy rate

Several countries in Sub-Saharan Africa have to deal with illiteracy and a distribution of different languages spoken by their population. According to UNESCO, 38% of the African population is illiterate. Most of these countries have one or two official languages that are spoken. In fact, in Africa, there exist over 2000 languages [4]. The provided service should support the languages that are spoken by most people in the area, since it is too complex to include all the individual languages.

Lack of internet

While the number of areas that support internet connectivity is growing rapidly, there is still a large gap between the growing rate in rural and urban areas in developing countries. In Sub-Saharan Africa, the internet connectivity opportunities between different areas are distributed unequally, due to lack of governmental support and economic interest from telecommunication companies. Internet traffic in rural African areas is quite different than in the rest of the developed world [5]. Instead of using the internet, the focus should be on using what technical infrastructure they are currently using. Since the construction of new internet wiring is not the aim of this project, the focus should be on the means of communication that are currently available in rural communities.

Lack of resources

Subsistence farmers living in remote, rural areas in Sub-Saharan Africa generally have low incomes. The crops they grow are mainly used for their families consumption. The surplus that is left at the end of the dry season is sold at one of the local markets. When interviewing three veterinarians in Tamale (see Appendix A), North-Ghana, the W4RA asked for the average prices for vaccinations. The vaccinations have different prices, depending on the disease the animal is suffering from and the weight of the animal.

[1] The reports can be found at the Github repository: https://github.com/Rromulus/DigiVet_3.0

On average, a vaccination costs a farmer between 2 and 4 CEDI, which is 0.50 eurocents and 1 euro. Given that the farmers that were interviewed in Zanlerigu village earned an average amount of 500 to 1500 Ghanaian CEDI a year, which is, converted to dollars, in between 125 and 375 US dollar a year, a vaccination is thus quite expensive.

The reason why livestock is so important to subsistence farmers living in these regions, is that they count as savings in case money has run out. Selling their animals on the local markets will provide them the income they need to pay for the education of their children or in case a family member falls ill.

2.2. Related work

Related projects have been conducted and funded by organizations such as the Food and agriculture Organization of the United Nations (FAO). These projects are based on improving the interaction between experts non-experts. iCow, for instance, helps Kenyan farmers to manage their cows' estrus cycle and milk production, by bringing them into contact with veterinarians through an SMS information service [6].

e-Dairy is a mobile service, which uses SMS services and touch screen computers to deliver information on various topics, such as animal health and milk prices, to their customers [17]. This application helped farmers in Sri Lanka to generate more income and to improve production distribution and traceability [18].

Another FAO project uses Digital Pen Technology in Eastern and Southern Africa to collect and manage reports regarding the health and mobility of animals [7].

These projects are great examples of how ICTs can assist smallholder farmers in managing their farms. The disadvantage, however, is the prerequisite that farmers know how to read and write, if they wish to use the ICTs. Voice-based solutions are hard to find, which further marginalizes the very people that are increasingly excluded from society, such as illiterate rural farmers.

3. Use case description

The set use cases of which the one described in this paper is a part, was conducted during a field trip to the village Zanlerigu in Northern Ghana. Interviews that were held with local, subsistence farmers, formed the input for the use cases, which could then be translated into relevant ICT services. Figuring out their information needs through conducting interviews is complex, because of the language barrier and the difficulty of the farmers in expressing the specific information gaps that prevents them from working more efficiently.

The subject of the use case described in this paper is animal health care. Some animal diseases spread within and between villages, others can only be cured with the intervention of a veterinarian. The problem that arises in these rural areas is that the expertise is often not locally available and poor infrastructures prevent information and knowledge from being accessible. Some farmers indicated that they would like to receive information on animal diseases, disease patterns, diagnosis and symptoms, to enable them to take preventive action and preclude cattle loss. Gaining information from a local veterinarian could thus be

relevant and useful in these cases. The idea of the elaboration of the use case is to enable veterinarians to enter the up-to-date news and knowledge regarding common diseases verbally into a voice-based system. Figure 1 shows the process flow between the actors involved.

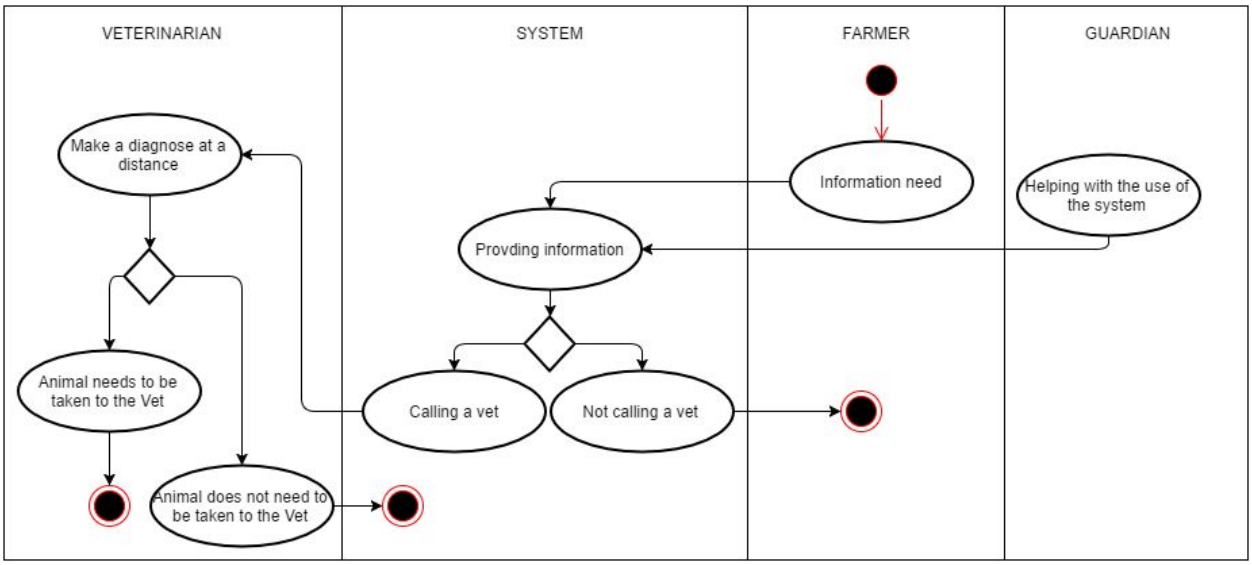

Figure 1. The process flow.

3.1. First prototypical cycle of DigiVet

A first voice-based prototype was built in 2015 that showed a simple interface in which farmers could click through a set of symptom related questions on a touch screen connected to the Kasadaka [8]. The Kasadaka is a rapid-prototyping platform consisting of a Raspberry Pi [9] and a GSM dongle. The main idea behind the Kasadaka is that it is composed of some basic hardware and software requirements that enable the rapid development of new voice-based information services. The first prototype of DigiVet did not yet contain animal disease information that could be used in the real world.

3.2. Second prototypical cycle of DigiVet

In the beginning of 2016, the second prototype of DigiVet was created. This included an improved knowledge base, based on the CommonKADS methodology [10]. In order to develop this new version, interviews were held with a Dutch as well as local, Ghanaian veterinarians. The latter was done by the W4RA group, by interviewing three veterinarians working in rural Northern Ghana. The Dutch veterinarian that we interviewed had stayed in Tamale, Ghana for a couple of months, working in a veterinary clinic. Based on these interviews, the objective of the system was changed from providing a diagnosis to giving an outcome of the decision whether or not a farmer has to go see a veterinarian. This was done in order to prevent that farmers would cure the animals themselves and in order to stimulate them to more proactively visit a veterinarian.

4. Prototype description / System design

As DigiVet aims to make veterinary information more accessible to all farmers living in remote areas, the reach of the service can be increased by creating a telephonic accessible version of it. Therefore, a prototype is developed which elaborates on the already developed visual version of DigiVet by adding a second one that enables local farmers to call to the Kasadaka, and in this way accessing DigiVet.

Figure 2 shows the call-flow diagram of the system. If a farmer calls the system, he/she is primarily welcomed and is asked to indicate the type of animal that he/she would like to obtain information on. Subsequently, the farmer can answer all of the symptom related questions by pressing the corresponding Dual Tone Multiple Frequency (DTMF) number. For instance: "Press 1 if you have a dog" will guide the farmer to more specific questions regarding dog diseases. Once the system knows what kind of animal the farmer has, a general question is asked. If a farmer answers this question with yes, more specific questions will be asked, if not, the next general questions is prompted. Subsequently, if the system has enough information, it will give the output to the farmer regarding the decision whether or not to go see a veterinarian. Finally, the decision is given and an option should be provided to contact a close by veterinarian.

In order to make the system easier to use, improvements were made based on the first prototypical version. Focusing primarily on increasing the usability, the user now receives more feedback when calling to the system. Sentences such as: "We will now list the symptoms, please indicate for each of the symptoms if it is experienced by your animal." were added to improve the flow of the call.

The second extension was made by adding the option to switch between the languages English and French by adding the latter as a possible language. French is one of the main languages spoken in Mali where the application is be tested, which is why this is a logical addition.

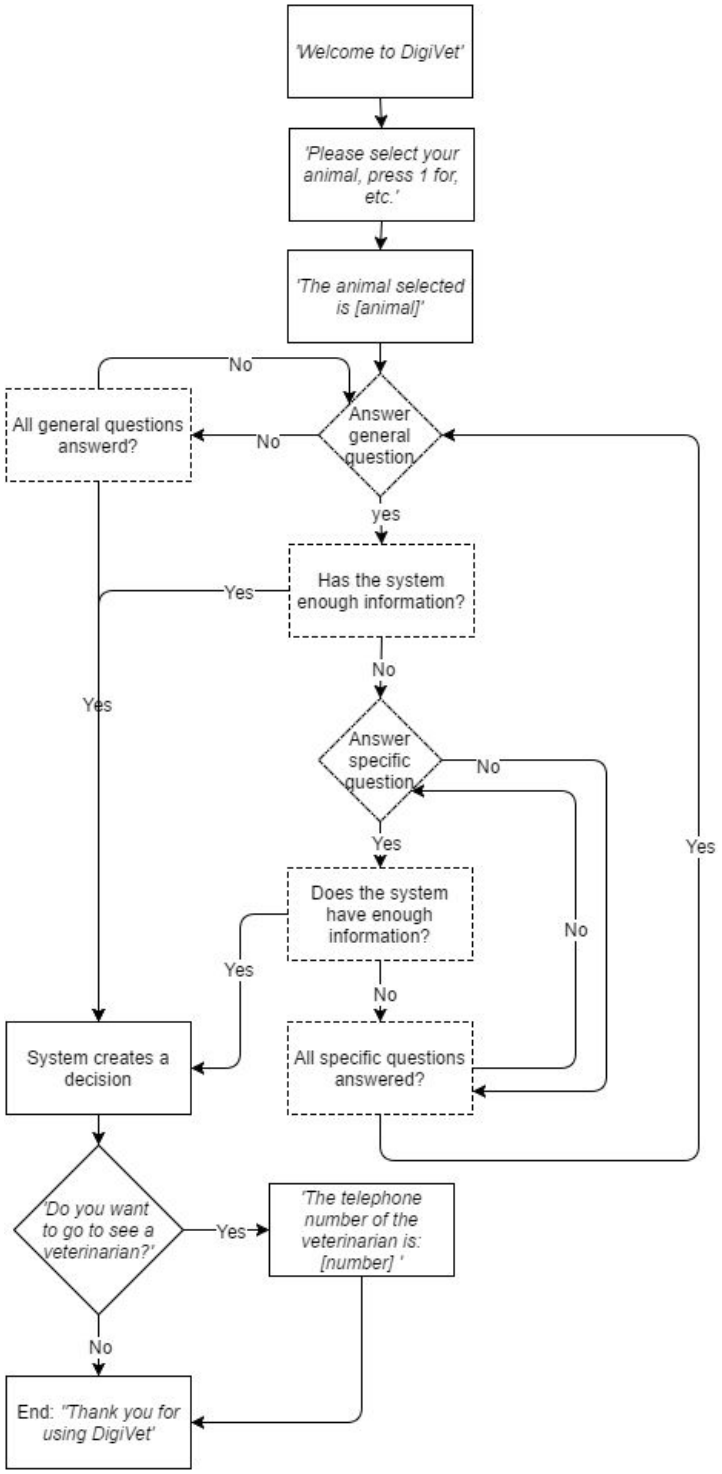

Figure 2. Call-flow diagram. →

4.1. Included feedback from Mali

In the mid of may 2016, a part of the W4RA team went on a field trip to Bamako, Mali. One of the objectives of this trip was to demo the prototypes made by the students to an invited group during a session. During this demo session, 25 men from all over Mali showed up, among whom a local tech entrepreneur.
During previous field trips conducted by the team in both Ghana and Mali, the DTMF (see section 4) was not working properly. This time, however, the DTMF seemed to work properly, which meant that the prototypes could be tested using a mobile phone. Moreover, this means that one challenge of deploying the Kasadaka successfully in at least Mali, but probably in other West-African countries as well, is taken care of.

After the field trip, we were provided with part of the feedback given by the participants of the demo session. Since both the visual and the voice-based version of DigiVet were demonstrated, feedback for both versions was given. The participants of the feedback session indicated that they really liked DigiVet as demonstrated, although they did have some remarks. We will thus make a distinction between feedback applicable to both versions (general feedback), feedback based on the visual version, and feedback based on the voice-based version as introduced in this report.

4.1.1. General feedback

The general feedback is mostly based on the cultural differences between Mali and Ghana. The first two versions of the DigiVet prototype, as described in sections 3.1 and 3.2, had been developed for Ghana. Zanlerigu, the village in North-Ghana where the DigiVet use case was based on, is a Christian village. This means that the animals they hold include pigs and dogs. The feedback given by the Malians, who are Islamic, was that these two animals did not occur in the villages and can be taken out of the application. Instead, and after a lively discussion, they mentioned that the following list of animals would be relevant given their context:

- Cows
- Sheep
- Goats
- Chickens
- Donkeys

This list more or less matches the Ghanaian list, but the differences are important to keep in mind.

The second general feedback we received was to have an optional list of veterinarians to contact. This idea corresponds to our future plans. There are different types of veterinarians, both in Ghana and Mali, and not only their expertise differs, but also their prices. If we were to recommend veterinarians to contact, these different types should be taken into account. The third point of feedback was that the participants would like the end users to be able to copy the telephone number of the veterinarian. In this way, they can choose to call back later if this is more convenient, or if the veterinarian does not return the call.

4.1.2. Feedback based on visual DigiVet

The feedback described in this subsection focuses on the visual version of DigiVet, as mentioned in subsection 3.2. The interface (see figure 3) that shows the questions regarding the symptoms can be answered by the user by tapping either the yellow part of the screen or the blue part. The feedback given in Bamako was that they would rather see a red and green part of the screen, instead of blue and yellow. Red and green were actually chosen in the first prototype of DigiVet, the one mentioned in section 3.1. Blue and yellow were then chosen for the second prototype, since colorblind people can see those colors. We agree with the feedback that red and green fit better, and will add two symbols in the two parts of the screen in the next version of DigiVet, such that colorblind people can still understand what is asked of them.

4.1.3. Feedback based on voice-based DigiVet

The most relevant feedback we received regarding the voice-based version of DigiVet (DigiVet 3.0), was that they would like to see a next version in which farmers can give background information. This information would regard for instance animal food, hygiene and other topics that might correlate with specific symptoms or disease patterns. This sounded like a great addition to our existing prototype. If the farmers indicate what their cow has eaten the week before it fell ill, and the system knows that the specific type of food causes a symptom or disease pattern, this feedback could immediately be given to the farmer. Another option could be that this background information would be sended via SMS to the veterinarian, together with the information regarding the symptoms. This information would be very relevant to the veterinarian and would give a more complete overview of what the animal might be suffering from. Information regarding the amount of animals being held or being ill would also be relevant for organizations working in the region.

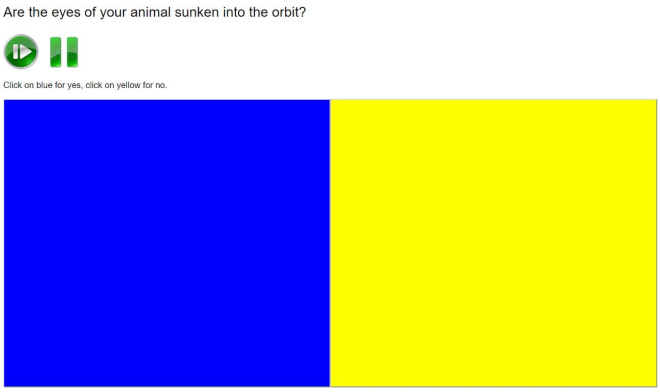

Figure 3. Symptom question interface of DigiVet 2.0.

Other feedback we got for the voice-based DigiVet version was that the participants would like to know where the animals that are sick are situated, this would mean that location based information should be made available to veterinarians or organizations. We understand that this information would be interesting to analyze, but this is of course privacy sensitive. And before we make these kinds of decisions, more discussions and feedback rounds should be held.

The last correlation they would like to be able to make was between the weather (rainy or dry season) and specific illnesses or symptoms. These types of feedback have been taken into account, as we would like our system to be able to indicate certain patterns regarding the diseases and symptoms prevalent in a region or between regions.

5. Implementation and installation

In this section, the data model of the system and its architecture is discussed. How DigiVet can be used in then explained using two possible usage scenarios. Section 5.3 contains an installation guide for the system so everyone can use it. De code for the prototype can be found on the Github page: https://github.com/Rromulus/DigiVet_audio.

5.1. Data model and system architecture

The data, available in the database as well as in the triple store, contains all the information used by the system, such as the symptom questions. These can be found on the DigiVet 3.0 Github repository[2], as well as the earlier version of DigiVet (2.0) and the prototype described in this paper.
Figure 4 shows the domain schema based on the CommonKADS methodology that is used for this prototype and figure 5 displays the system architecture.

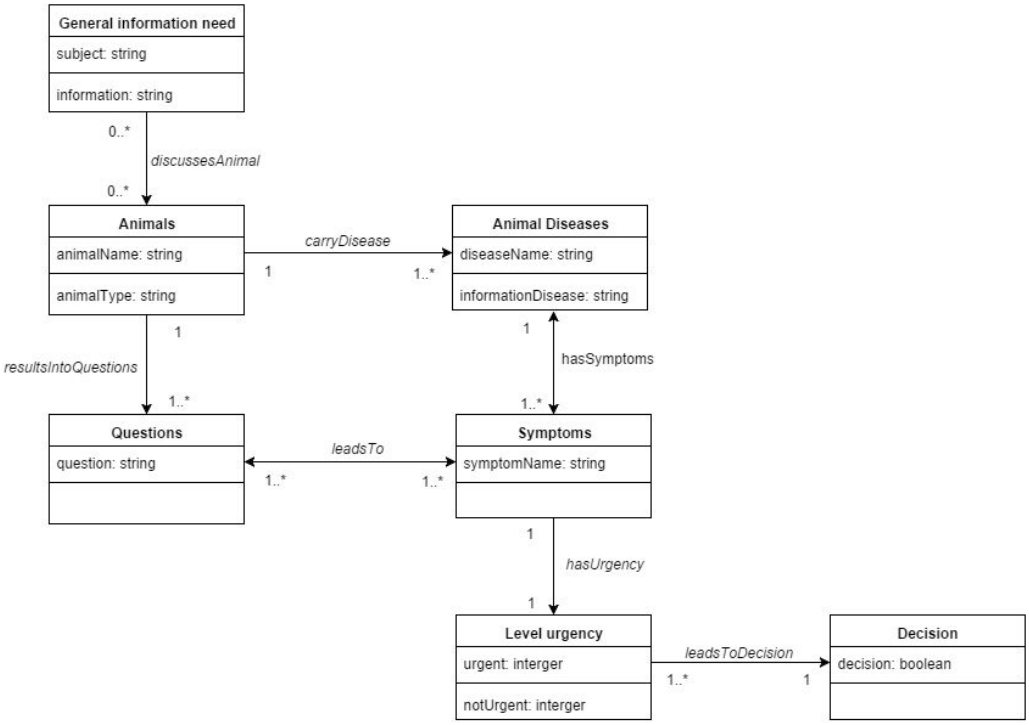

Figure 4. Domain schema.

As can be seen in the domain schema, the symptoms are given a level of urgency, meaning that they are either urgent or nonurgent. The scoring of the urgency of the symptoms taken together eventually lead to the decision whether or not it is recommended to visit a veterinarian. This structure was applied in the visual version of DigiVet that uses a database. The purely voice-based version that is currently being made will eventually follow the same scoring structure. At this point, however, the questions are hard-coded, which means that the specific questions that are answered with yes or no up to the last very last question are leading to the next question in line. The final specific question in given a general question can have two different outcomes based on the input. If the user acknowledges that his/her animal suffers from that specific symptom, the system will recommend this farmer to visit a veterinarian. If this

[2] https://github.com/Rromulus/DigiVet_3.0

specific symptom is not recognized, the decision will be to not visit a veterinarian. In future work the scoring system will be adjusted in order for it to correspond to a real-world situation.

The prototype can be downloaded from the Github Repository. The prototype is made with the use of voiceXML files, which is a document standard for voice dialogs [12]. With the XML files, the described dialog (see figure 2, the call-flow diagram) is programmed. A XML file has been made that enables farmers to call a veterinarian directly if they would like to contact one, based on the decision of the system. Further tests should prove whether this method is sufficient. Audio files were generated in both English and French that were then placed in the XML files. Audacity [13], a software tool for editing and recording sounds, is used to record spoken text from a text-to-speech websites [14, 15].

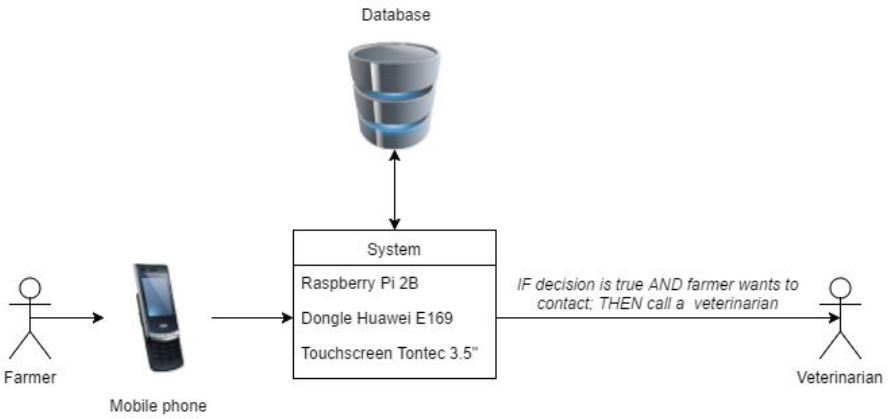

Figure 5. The system architecture.

5.2. Usage scenario's

The following scenario indicates how a farmer would use the voice-based version of DigiVet as introduced in this paper.

Farmer Adama, who lives in a little village in the north of Mali, sees that one of his cows is moving abnormally and is eating less than usual. He hesitates whether he should contact a veterinarian or not. Reason of his doubt is that consulting a veterinarian might be expensive, and the harvest was a disappointment this year, he does not want to overspend if not necessary. He remembers DigiVet, about which he had a conversation with his neighbor a couple of days ago. His neighbor Mamadou, also a farmer, had used it to find out whether or not he should consult a veterinarian in response to the spreading of an infectious disease among poultry that was afflicting the neighboring villages.

Adama asked Mamadou what the phone number of DigiVet was, and then dialed the number. A cordial voice welcomes Adama in his local language Bambara to DigiVet, and explains him what he should do. Adama indicates by tapping the right digits what type of animal he has, the types of food his cow eats, how his animals are accommodated and specific questions regarding the symptoms his animal is showing. The voice tells Adama that he did right by contacting DigiVet, and that, based on his answers, the system recommends him to consult a veterinarian to cure the cow. He then is given the option to contact one of the three veterinarians listed by DigiVet, and he taps 2 to consult Ousmane N'diaye, a governmental veterinarian specialized in cattle. Dr. N'diaye answers the call and the two of them make an appointment

the next day to have the cow checked in a neighboring village. Thanks to DigiVet, the sick cow was diagnosed with CBPP disease, was given a vaccination and survived. Adama made sure all the farmers he talked to knew of the benefits of DigiVet.

5.3. Installation guide

This sections describes how the prototype can be installed on a Virtual Machine. The same steps can be used to make the service fully functioning on a Raspberry Pi (Kasadaka), but an additional dongle should then be added to call into the service.

Prerequisites

- A Linux(Debian)-based system, such as a Raspberry Pi (2nd or 3rd generation) [9], or a computer running Debian.
- The Kasadaka image (see next paragraph).
- If preferred, a GSM dongle, such as the Huawei E169.

Install Kasadaka image

Download the Kasadaka image from the following Wiki: https://github.com/abaart/KasaDaka/wiki/Virtual-KasaDaka. Once the download has completed, you may import it in the Debian version that you are using as described in the Wiki.

Logging into the system can be done by entering the username and password, which are both: kasadaka.

Place DigiVet on the Kasadaka

Use the following commands to replace the existing folders and files by the ones needed for DigiVet.

```
kasadaka@kasadaka:~$ cd KasaDaka/html
kasadaka@kasadaka:~/KasaDaka/html$ rm -rf audio
kasadaka@kasadaka:~/KasaDaka/html$ git clone http://github.com/Rromulus/DigiVet_audio.git
```

You should now be able to see the DigiVet subdirectories that are cloned from github[3] to the *html* directory. In the audio directory, the English */html/audio/en/audiofiles_english/* and the French */html/audio/fr/audiofiles_french/* audio files are stored there, as well as the English XML files (*/html/DigiVet/EN/)* and the French versions (*/html/DigiVet/FR/)*.

Adjustment Asterisk extensions file

The last adjustment we should make before testing the application is to replace the extensions.conf file that is used to invoke the XML files.

```
kasadaka@kasadaka:~$ cd KasaDaka/etc/asterisk
kasadaka@kasadaka:~/KasaDaka/etc/asterisk$ sudo nano extensions.conf
[sudo] password for kasadaka: kasadaka
```

After entering the kasadaka sudo password, a screen will pop up that allows you to make changes to the extensions.conf file. Replace the 10th and 14th line in the file such that they match the following two lines respectively:

[3] https://github.com/Rromulus/DigiVet_audio

```
;10th line replacement
exten => _.,n,Vxml(http://127.0.0.1/DigiVet/EN/welcome.xml)

;14th line replacement
exten => kasadaka,n,Vxml,(http://127.0.0.1/DigiVet/En/welcome.xml)
```

Save and exit the file by using *Ctrl + X*, then *Ctrl + Y*, followed by *ENTER*. Since the Asterisk file has been adjusted, we should now reboot the system. This can either be done manually or by typing the *sudo reboot* command in the Terminal.

5.3. Prototype scope and fidelity

The prototype described in this paper merely contains a small part of the system. At this moment, the user can only select a cow, and the system contains only a few questions after which a decision is made and the user can choose whether or not to contact a veterinarian. The reason for keeping this prototype small, is because we want to connect the system to the database that stores all the possible questions. So, the system should be able to retrieve the right question from the database based on the input of the user.

At this moment, if a farmer wants to contact a veterinarian, the user should have the option to immediately call the farmer. In other word, the system transfers the call to the telephone number of the veterinarian. Due to technical errors occurred, this was not possible and now a telephone sound is used as demonstration. See section 7 and 8 for more points of improvement.

6. Deployment and sustainability plan

This section proposes three plans; an implementation, deployment and sustainability plan for DigiVet.

6.1. Implementation plan

As mentioned before, this paper discusses a prototype for the described use case. In order to turn this prototype into a fully worked system, several actions and steps have to be taken. Note that we talk of DigiVet as one overall system, instead of two separate ones (the visual and the telephone system). The main idea is to let DigiVet be physically present in the villages, with the telephone part of the system optional for farmers who are distanced from the physical tool to call the system. First of all, the prototype should be adapted, based on the feedback received and information gained so far. The feedback discussed in section 4.1 should be incorporated into a new prototype. Second, the telephone version of DigiVet as described in this paper, has to be added to the visual version of DigiVet. In this way, there is one system which can be used by the local farmers.

Third, after merging the two systems, the database should be changed. Currently, a PHP MySQL database is used. However, using a triple store would be more suitable in our case. The triple store has already been developed (see the Github page), however, the application should be changed technically in order for it to use the triple store to save and retrieve data instead of the MySQL database.

The final technical improvement is then to develop a back-end for the system. This back-end could be used by (local) developers to improve the system or by allowing updates to solve bugs in the system, but more importantly, it can equally be used by veterinarians to add new data (questions, symptoms and

information) into the system. In this way, the system can be expanded and kept up-to-date with new diseases.

After these technical improvements have been processed, the system should be thoroughly evaluated by local farmers and veterinarians. During this phase, it is very important that more available information about diseases and corresponding symptoms are added to the system to complete the information level. Subsequently, the variables used by the system in order to make the decision whether or not a farmer has to go to see a veterinarian should be tuned.

After the first evaluation, the feedback received, again, has to taken into account and be added to the system. Then a user test need to be performed. This test would be to place the DigiVet system in a village, explaining the local farmers and veterinarians how to use this system. This evaluation phase would have to last a specific amount of time (a couple of months) to guarantee the sustainability of the system during the runtime of the project. Close monitoring should be done by both researchers and veterinarians to prevent the animals from dying at the hands of the system and in this way immediate changes can be made where necessary.
Note that an iterative development cycle is used here. After each evaluation and test, feedback received should be taken into consideration. In this way, the system is adapted to its environment and the end-users.

6.2. Deployment plan

Based on the tips provided in Bayer's guide for deploying ICT's in development countries [11] , a first version of a deployment plan is discussed here based on the infrastructure of the environment and the deployment, including training and support.

6.2.1. Infrastructure

As explained earlier, several field trips to Ghana and Mali have been conducted by the W4RA research group of de VU. Based on the information provided by them, we know that the available technical infrastructure often consists of radio and mobile telecom networks. People often do not have access to the internet. These are important factors to take into account and are the reason why DigiVet does not make use of the internet, but instead uses locally generated and available information from the triple store.

DigiVet is running on the Kasadaka which is build on a Raspberry Pi computer. This piece of hardware needs a power source to function. Often, however, there is no grid power available. Research trips to the local environment are necessary to determine how people gain power. Options are to use generators or solar power. The PiJuice Solar is a solar panel can be connected to the Raspberry Pi and can be used to consistently charge the system, which is perfectly suited in these kinds of projects in sunny and remote areas [8].

The Kasadaka should be placed inside a space in such a way that it is dust resistant and does not become overheated. In order to guarantee safety, a guardian of the Kasadaka should be introduced. This could be an important person from the village, such as a village chief, who makes sure that the system is available

and accessible to everyone. By providing access control, the use of the system can be controlled (one farmer at a time for example).

The space in which the system is held, should be kept as cool as possible and should not contain leaks. Even during heavy weather, the system should be kept dry. The system has a case to protect it from dust.

6.2.2. Deployment

Assuming that the system, as described in section 6.1, works as planned before deployment and if the infrastructure as described in the previous section is available, we discuss a first version of a deployment plan in this subsection.

Before deployment, research has to be done on the specific areas in which the systems can be deployed.This means that the number of systems that should be made available before deployment need to be known. Based on this, the necessary hardware should be bought to build the system. This mainly consists of a Raspberry pi, a small (3.5") touch screen and a 3G GSM dongle. Take into account that also gear for power, such as the aforementioned PiJuice Solar, should be bought.

During deployment, when the space in which the system is to be placed is ready and all the necessary components (hardware) are made available, the system needs to be installed and connected. To guarantee a good understanding of the system and improve maintenance, it is important to involve the local population in this process. It would be great if there is a local IT technician, but otherwise local people should be trained to learn how to build, install, use and maintain (update) the system.

User training is really important. Besides a local technician, the guardian of the system needs training in how to use the system, so he or she can assist farmers using the system. Finally, local veterinarians should receive information and training during a workshop about the system, what it does, how to use it, and how to add new data and information into the system. Previous visits showed that most local veterinarians are in possession of a computer. This is enough to be able to add new information into the system, or to allow a larger maintenance of the system (such as software updates).

These deployment steps can be used to deploy the system in multiple villages around different countries. However, changes in software might be necessary based on the location where the system is deployed (as discussed in section 4).

6.3. Sustainability plan

After deployment, the system must become sustainable, meaning that it will survive long after the project runtime. This means that a proper training of the local population (see previous subsection) and a business model should be taken into account.

This first version of the business plan included the farmers, veterinarians and NGO's or involving organizations. The farmers pay for using the system by paying for the telephonic costs of the calls they make. They also pay the cost for sending a SMS (visual DigiVet) or in case the system redirects the call to

a veterinarian. If a farmer goes to a veterinarian, the farmer will, as usual, pay for the consult given by the veterinarian. This includes costs for medicine, vaccinations or necessary surgery.

The background questions that were added based on the feedback given in Bamako, Mali, are very useful for local NGO's and organizations that want to monitor information on animal related subjects such as hygiene and housing. Of course, as discussed in subsection 4.1, this should be done in such a way that the privacy of the users is guaranteed such that the specific information cannot be traced back to a specific user.

As aforementioned, the training of local population increases the probability of success of the project in the long-term. This contributes to the independence of these projects of the West, meaning that high travel costs from here to for example Mali can be prevented. The second benefit of using this participative method is that it adds to the empowerment of the local population, which, in turn, benefits the long-term sustainability of the project.

NGO's or involving organizations are necessary for remuneration of the hardware. They also have the responsibility to replace the hardware when it breaks. In return, the organizations receive information that is collected by the system.

7. Discussion

During the course of this project, some issues occurred while developing the telephonic extension of DigiVet. First of all when we transforming text-to-speech in different languages, often the speech is not as clear as spoken text. The prototype includes the languages French and English, for which there are many text-to-speech services available online. Another problem occurred when local languages were added to the system. Standard services do not contain these languages, since not enough people understand it to be relevant for a text-to-speech service, which means that local people should be recorded in order to use audio in our service. The credibility of the system for the local population is also based on the fact that the accent of the voice is recognizable and derived from a local person. This can be problematic when new information is added to the system.

A second problem occurred during the development of the transfer call function. The idea behind this is that when a farmer decides to directly contact a veterinarian after having used the system, it has to automatically transfer the call to the veterinarian. However, during development, a lot of technical issues occurred. The prototype is developed using VoiceXML files and was tested using a Virtual Machine. VoiceXML has the `<transfer>` function for transferring calls. However, this did not work, and there are two possible explanations for this. First of all, the `<transfer>` function is not widely supported, resulting in the situation that the system does not read this function. Another possibility is that the dongle is not working properly. To test this, three different dongles were tested. Unfortunately, none of the dongles were able to connect to the system.

The visual version of DigiVet is a dynamic system that uses a SQL database. However, a triple store would be more efficient to use. A triple store was already made, but is not yet incorporated. Due to time

limits it was not possible to incorporate the triple store to the telephonic version. We plan to do this in the future.

During the project, a discovery was made that veterinarians can be categorized into three categories:

- Private veterinarian: full veterinary education.
- Government veterinarian: short veterinary education.
- Local veterinarian: veterinary training lasting a couple of weeks. Are not trained to perform surgery or make life/death decisions.

This is, of course, very relevant information that should be taken into account. The division of veterinarians differs per country, but the general hierarchy is more or less the same between Ghana and Mali. The educational background as well as their specific experience, but also costs attached to the services they provide are crucial factors that should be made transparent to the farmers who opt to contact one of these veterinary workers. As described in subsection 4.1, the farmers should have the option to choose between the veterinary workers to receive help best fitting to their financial situation. It would be a shame, however, if this means that the poorest farmers would not receive proper health care for their animals, and if they would die because of this. The individual veterinary workers that participate in this project should be scanned and evaluated before hand.
The problem of animal health care being too expensive for some farmers could be fixed by introducing a micro financing-like structure, as was the case in the very successful M-Pesa project first conducted in Kenya and later extended to other countries [16]. Just like in this project, farmers could open a bank account and use their mobile phones to transfer small amounts of money when they can miss it. This money can then be directly used to pay a proper veterinarian, in case the animal needs a vaccination, medication or surgery. This idea of using micro financing should be further devised in the future, but sounds like a possible payment solution that can be incorporated in our business plan.

Based on the feedback received so far and general properties of the system, some technical improvements have to be made before deployment. However, these technical improvement should be tested. So a thorough user test/deployment experiment should be conducted in order to evaluate these improvements.

One of the biggest issues is the guarantee that the decision made is ‘good’. The system makes a decision based on the answers given by the farmers on the questions. However, due to the fact that there is no 1-to-1 mapping between diseases and symptoms, it is difficult to make a final decision or diagnosis. This is also the reason why we decided that the system should not provide the diagnosis to the farmers. The problem stand that the decision could be wrong and that this affects the trust of the farmers in the system, is prevented. Veterinarians in Tamale, Ghana, have already indicated that they are willing to test the service. This evaluation, as well as future ones, will help us fine tune the symptom/disease mapping, based on their feedback. In collaboration with these veterinarians, we could work on a functioning version of DigiVet, both visually and purely voice-based.

8. Conclusion and Future work

This paper provides an overall description of the development of DigiVet, and in particular the addition of the telephonic variant of the system. First, theoretical background is given, highlighting the the environmental and social issues that occur when developing ICTs in development countries. These issues

are the high illiteracy rate, lack of resources and a specific lack of internet connection and an overall technical infrastructure. Related work shows that some projects have already been done, but that a project like DigiVet, that really takes into account the socio-economic and environmental background of its users, is not yet conducted.

Next, the use-case description is given and the earlier prototypical cycles of DigiVet are discussed. This shows the improvements that have already been done over the past projects. During this third development cycle, relevant feedback has been collected which was partly used to improve the system. With the use of the CommonKADS methodology, the data model and system architecture are described. Followed by an installation guide on how to install the voice version of DigiVet.

The next step for this project is to deploy DigiVet in rural areas in Sub-Saharan Africa. In order to do this properly, deployment and sustainability plans have to be made, of which the first versions were included in this paper. These plans show that, based inter alia on the feedback received so far, some technical improvements need to be made before deploying the system. However, these are clear and duable improvements which can be added in the future.

Besides some technical improvements, a thorough user test and experiment should be conducted in a specific testing area to further improve the DigiVet system. User experiences provided by both the local population and the veterinarians should be included in the future versions of the system. This involves adding more information about diseases and their symptoms, as well as adjusting the variables used by the system to make the final decision whether or not a farmers has to go to see a veterinarian.

In order to make DigiVet sustainable, training of the involved people is necessary. Additionally, a good business plan should be developed. This paper introduces a first version, which displays the main idea on how to finance DigiVet and make its use affordable to the farmers.

To summarize, future work includes:

- Technical improvement of DigiVet:
    - Combining the two DigiVet systems into one system
    - Replacement of the SQL database by a triple store
    - Developing a user-friendly back-end for veterinarians so information can be added easily
    - Integrate SMS and transfer calls into the system
    - Choosing of the relevant veterinarians based on location, skills and price range
- Steps for deployment:
    - Training of the (local) users
    - First test deployment to tune DigiVet
    - Adding more information about diseases and their symptoms
    - Adding more information on animal health related topics (background questions)
    - Involvement of NGOs or local organizations
    - Further development of the infrastructure plan
    - Further development of the deployment plan
    - Further development of the sustainability / business plan

In conclusion, this paper has shown which context-related challenges have yet to be overcome in order for DigiVet to be deployed successfully. The extension of the telephonic variant has clear benefits that have been confirmed by feedback received during the field trip to Mali. These have given us a further indication of where the weaknesses and strengths of DigiVet lie, given the aforementioned challenges, and have given us food-for-thought on how to proceed in future prototypical cycles of the system's development.

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Appendix A: Interviews Tamale

Medior vet:
Abubakar Zibuila,
Technical officer
Tamale Metro Veterinary Clinic
026586919

Junior vet:
Dr. Amoro Nelson Ajanga,
Tamale Metro Veterinary Clinic

The following interview was held by Hans Akkermans, Anna Bon and Chris van Aart, with veterinarians in Tamale in December 2015. The questions were provided by Romy Blankendaal and Gossa Lô.

What is a veterinarian's working day like in Ghana?
Cattle. If a farmer has a problem, he calls you. Then you go there, to the community. Most of the time it has to do with difficulty in giving birth. This can be done from mondays to saturdays, I'm visiting all the villages.

How many veterinarians does each region have on average?
There are around 14 veterinarians in Tamale. Tamale Metro has 11 vets and Zanleru has 3. They are divided over the region.

Which types of animals are taken to the veterinarian?
All the species that you can think of. Cows, goats, sheep, dogs, birds (fowls, guinea fowls), donkeys, horses?, cats, some people even have snakes as animals.

What are the most common diseases that farmers bring their animals in for?
They are not that varied. In the food, Foot and mouth disease is attacking the cattle. A bacteria takes charge of the system. Farmers sometimes do not have money to treat them. Three streaks: SAT I to III. SAT I can be okay, will sometimes heal by itself, others will suffer and die. If you treat your animal with antibiotics, it will survive. But others who refuse to treat their animals (because of lack of money) will return and they will become carriers. In three or four months, the disease will return. SAT III does not really occur in Ghana. If the animal is sick, it cannot eat, because the mouth is full of sores the feet is full of sores. If it is rainy season, it can spread fast, because of the water.

Black leg is a bacterial disease, the upper thigh, the hymen. In a shorter period, per acute. It happens really fast, in the morning you can become sick, and if you don't take care of it, by the evening, you will lose the animal. You might think that it is bitten by a snake or a scorpion, and by the time you have it checked out, it dies.

The third disease is CBPP, it is very common in the Northern region. There is no vaccination for CBPP. The fourth one is Anthrax, but that occurs more in other regions. The last time it occurred in Tamale was in 2001/2002. Due to vaccination, this occurs less.

When veterinary care was first introduced in the Northern region in Ghana, it was given for free. So the current people heard from their parents and grandparents that the care was free, which is no longer the case. Before, it was founded by the government. Due to economical hardships, this is no longer the case.

How are these diseases treated in general?
How much does a veterinary consult/ surgery cost on average?
The cost of the vaccination of one cow for Anthrax is 2 Ghanaian cedis.
CBPP is 4 cedis.
Black leg is 2 cedis.
Foot and mouth disease we don't have vaccin for it right now. It spreads by contact. The treatment with antibiotics depends on the weight of the cow and on the antibiotics used. It can range between 5 - 20 cedis.

What are the diseases that are characteristic of the rainy season/the dry season?
Most of the diseases happen in the rainy season, for example the foot and mouth disease. Ticks occur in the rainy season and they bring diseases into the system of the animal, parasites. Breaking down their system.
Anthrax and foot and mouth are very contagious, they can affect other four legged animals. Dry season, mostly in the time when we are in the peak of the heat, we have Anthrax and Blackleg. Tetanus happens during the dry season, they graze closer to the ground, and bacteria can live there for 20-30 years. The animals graze closer to the ground, and get the bacteria in their systems. We vaccinate these animals for all these diseases, except for Foot and Mouth disease. We do not have a vaccination for that disease. The animals are thus protected.

Do you use ICTs, such as computers or cell phones, in order to complete your daily tasks?
We use them on our mobile phones to get particular information, for example pictures. You can snap the picture with your phone. There is a need to get pictures from animals. Our system is so porous, even providing notebooks by the state is difficult. Farmers don't use the devices to snap pictures, they can only call. They call to ask the veterinarian to take a look at their sick animal. "Can you come, my animal is dead, it died suddenly.". They want you to drop everything you're doing and come fly to them immediately.

Do you use the internet for consulting about veterinary information?
When I use the net, I go on it for my own personal issues. It is not used for professional purposes.

People have a lot of goats here, do they also vaccinate them?
They vaccinate goats and sheep here. Groups can get infected by similar diseases, so the most common disease that affects them is PPR. There are other diseases, such as black leg or foot rot.

Is it easy to recognize the disease?
No, we have certain meetings and workshops. A serious farmer is one who is concerned about his animal, and that when there is a need for him to call a vet, he will do it. %serious farmers is the whole community.

Do the farmers keep the cattle for meat or to sell it?
They keep them for economical benefit. They do not slaughter themselves. All the cattle farmers keep them for business, the whole year, to get medium size animals, to get some small money out of them. They also keep them to carry heavy things or to plow to get maximum results of their yields. Now, the illiterate and literate farmers know why they keep their animals. The housing might be a problem, the hygienic aspect, some of them know, but not all of them. They can take a workshop for two or three hours, to learn this stuff, so then they know.

What kind of things do you teach farmers?
How to identify diseases, typical diseases for their particular animals. You let them know when a particular animal is healthy. Some diseases are due to nutritional factors.

So there are also some diseases that the animals can get, because they don't get the good food. What kind of symptoms do cows have when they do not get good food?
During the rainy season, the weight of the cow will change. We ask the farmers to give the cows supplementary feeding. It does not eat, and it walks in a wobbly way. There are certain situations where we have to give calcium, dextro(...) or put them on multivitamin. We need to tell them that where they live is a problem. So we tell them to take them off that particular place, and they heal automatically. Cause sometimes this disease is due to bacteria that are in the place where they eat.

Is that expensive for the farmers?
All things are expensive to the farmers. They always say that they do not have the money. They live in poverty. The rain has reduced. It comes somewhere may/june, sometimes june/july. Before it would sometimes come in march, but this is no longer so, sometimes it arrives beginning of august.

Do you also give advice on cropping or harvest?
We do, we go to the communities and tell them that because of certain techniques, their animals are suffering. We call it a training, we train them.

How often do you go to the village and give training?
You want to give a vaccination, so you go there. You try to talk to them, cause you see this or that. We have to come together.

So you make advantage of the fact that they have called you for a vaccination to give training?
Yes, exactly.

Did you experience any difficulties while using ICTs in your job?
We are developing a knowledge based system to enable farmers in rural Ghana to obtain veterinary information. Through the system, they can indicate what the symptoms of their sick animal are, and the system will output whether or not the farmer should visit a veterinarian. In this way, we hope to reduce the time farmers take to find a cure for their sick animals. In case of a disease, we hope to establish communication between the vet and the farmer.

What do you think of our system?
Yes that is useful, it might give them a push. If you give them the tablet, and let them physically diagnose the disease, and tell them this is how it's supposed to be done, then tomorrow, they will go beyond. Farmers often come to us and tell us what the condition of their sick animal is, and they will not even tell you the truth. If they don't tell you the right condition, you will never fight it. So most of the times you even have to go there specifically. There should be veterinary officer around.

It would be difficult to diagnose for them, but it would be nice to repeat what we have told in the training/meeting. There are some communities or members that could test it out.

Before they distribute it, we should talk to the students about the diseases, the signs. Then, prior to that, the very day that the tablet will be issued at, this should be repeated.

It would be made for illiterates as well, such that everything would be in pictures, and they can see what they do. It is a gradual process, if you say that we should change it, we will change it.
The illiterates will not even be able to tell you what the signs are. If you don't have a proper explanation, then it will not go well.

Do they keep their animals in their own field, or combine them?
Some do, they release them to graze. Some lock them up inside and don't allow them to go outside. They are protected from bad water and weather.
They supplement them in the morning. Put water with it. Then they go out until the evening.

Do they buy the food or do they take it from their fields?
Almost all buy food for their animals now, almost all the animals within Tamale. Virtually nothing is free when it comes to animal feeding.

Do they milk the cows and sell the milk?
Yes they do, and sell it as well. They do not do that for the goats or sheep. They produce cheese from the milk in the cattles. Those who know how to make cheese will do that.