<u>Publication avant LAFMC</u>

Titre	Optimizing Pastoral Mobility Based on Mobile Geographic Information Systems (MGIS)
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Référence	Technologies and Innovations for Development
Editeur	Springer
Pages	185-195
Année	2012
URL	**https://link.springer.com/chapter/10.1007/978-2-8178-0268-8_13**
DOI	https://doi.org/10.1007/978-2-8178-0268-8_13
Index	
ISBN	978-2-8178-0268-8
Encadreur	Non
Extrait d'une thèse	Non

Technologies and Innovations for Development pp 185-195 | Cite as

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Chapter
First Online: 03 January 2012

Abstract

In the agropastoral areas of Eastern Senegal, the goal of pastoral units (PU) is to improve the daily life of breeders and farmers. PUs are characterized by a low population density, and inhabitants are scattered throughout the region. In such cases, it is difficult for breeders and people living in these areas to share information. Many pastoral breeding systems in Africa are conditioned either by the dry season or by the rainy season. This approach incorporates local knowledge covering two complementary strategies: mobility and geographic localization of the resources that should be used.

Keywords

Global Position System   Mobile Phone   Mobile Device   Geographical Information System   Short Message Service

Copyright information

About this chapter

Cite this chapter as:
Niang I., Demanou C., Ndiaye S., Ba P.D. (2012) Optimizing Pastoral Mobility Based on Mobile Geographic Information Systems (MGIS). In: Bolay JC., Schmid M., Tejada G., Hazboun E. (eds) Technologies and Innovations for Development. Springer, Paris

First Online
03 January 2012

DOI
https://doi.org/10.1007/978-2-8178-0268-8_13

Publisher Name
Springer, Paris

Print ISBN
978-2-8178-0267-1

Online ISBN
978-2-8178-0268-8

eBook Packages
Business and Economics

Chapter 13
Optimizing Pastoral Mobility Based on Mobile Geographic Information Systems (MGIS)

Ibrahima Niang, Cyrille Demanou, Samba Ndiaye, and Papa Dame Ba

13.1 Introduction

In the agropastoral areas of Eastern Senegal, the goal of pastoral units (PU) is to improve the daily life of breeders and farmers. PUs are characterized by a low population density, and inhabitants are scattered throughout the region. In such cases, it is difficult for breeders and people living in these areas to share information. Many pastoral breeding systems in Africa are conditioned either by the dry season or by the rainy season. This approach incorporates local knowledge covering two complementary strategies: mobility and geographic localization of the resources that should be used.

In order to mitigate impact of scarcity of resources (e.g., water and grass), breeders move their cattle around. This geographic mobility, known as transhumance, constitutes a strategy for finding resources during both seasons. During the dry season, it is necessary to go toward good pasture areas. Nevertheless, this transhumance still incurs several problems.

First, breeders should avoid crossing farmers' areas, which quite often leads to conflicts between them. Therefore, finding good routes that do not cross farms is mandatory. Second, water point management is crucial. Lack of information, either about water shortage and/or potential overload of water points or the existence of routes that cross farmers' areas should be resolved.

Despite the existence of local knowledge, the endogenous information system is poorly structured and has no traceability (Ancey 2003). Ancey and Astou (2004) have shown that oral communication is the most common way to access or to share information in PUs. The traditional information system used by these populations

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J.-C. Bolay et al. (eds.), *Technologies and Innovations for Development*,
DOI 10.1007/978-2-8178-0268-8_13,

has reached its limits. Indeed, in order to sustain high productivity, breeders should have distributed geographic information systems (DGIS).

Nowadays, solutions based on information and communication technologies (ICTs) can overcome these limitations. In the same way as geographical information systems (GIS), ICT can be used to transmit and keep up-to-date information flows between people that live in pastoral areas. Existing systems, known as PC-based, use global positioning system (GPS) and Internet mapping information. In so doing, they enable pastoral resources to be tracked and managed. The aim is to improve the coordination of breeders' movements and to protect soil and water resources during the dry season. Due to the lack of skills and for economic reasons, this PC-based approach is not appropriate for rural areas.

We have noticed the current use of GIS on mobile phones. This technology, known as Mobile Geographic Information Systems (MGIS) (Tsou 2004; Nyamugama and Qingyun 2005; Noriyuki et al. 2004), is useful for managing geographically distributed databases. In other words, MGIS is the use of geographic data in the field on mobile devices. It should be pointed out that, over the last 7 years, the number of mobile phones has largely exceeded the number of wired phones (ARTP 2008). We have also observed a high penetration rate in rural areas, even if these populations quite often have low incomes. Based on penetration rate of mobile phones in the area studied, we have designed an approach based on short message service (SMS) and which uses GIS. The SMS system is primarily a service that tends to overcome the voice service of mobile telephony, and the price of an SMS is cheaper than a telephone call.

This chapter presents a new approach for information systems management in pastoral areas. The goal is to set up a dynamic platform for water point management. Therefore, at any time, breeders are able to know the status of any given water point. It is worth mentioning that there are three types of status for water points: not available, overloaded, and free. This information is sent to the breeders' mobile phones by SMS from a server which has gathered data from the different collectors (e.g., radio station, selected persons, breeders, etc.) designated in each rural area.

We have therefore designed and implemented MGIS, covering transhumance routes and water points on each mobile phone. Simply put, this platform ensures dynamic management of information on pastoral resources (water points, tides, etc.), and management of transhumance trails by factoring in difficulties that may arise in certain areas (disease, failure of boreholes, etc.). To overcome the language barrier, the output messages for mobile phones are translated into two local languages.

The rest of this chapter is organized as follows: Sect. 13.2 reviews the related work approach-based GIS and information systems in pastoral areas. Section 13.3 presents our approach based on MGIS. Section 13.4 discusses the penetration rate of our approach with respect to the breeders living in the area studied. Finally, Sect. 13.5 presents our conclusions and some research prospects.

13.2 Related Work

At present, mobile GIS, Internet GIS, and wireless web applications are increasingly playing important roles based on the entire geoinformation application. In this chapter, we focus on mobile GIS. Mobile GIS can be defined as an integrated software or hardware framework for access to geospatial data and services using mobile devices via wired or wireless networks (Tsou 2004). Although a lot of research work had been done on the use of mobile GIS technology, not much has been done in the field of environmental monitoring using dynamic information management.

Integration of mobile GIS technologies and wireless telecommunications is the key focus of this chapter (Tsou 2004). Tsou proposes combining mobile GIS application software, GPS, and wireless networking technologies for an application based on mobile GIS and dedicated to natural habitat conservation.

Noriyuki et al. (2004) introduce GIS using a mobile phone that is equipped with a camera and a GPS and displays. The authors aim to provide social information spaces for local communities or towns. Users can add text notes and also photos to physical spaces by sending emails from their mobile phones attaching photos and location information identified by GPS.

Binzhuo and Bin (2005) present a new mobile GIS application, based on mobile scalable vector graphics (SVG) (W3C 2003), known as TinyLine SVG, which is intended for heavily resource constrained handheld devices. This application is a tourism-oriented map application of the Shenzhen territory for mobile phones. This application was designed to perform satisfactorily on devices (mobile phones) with low processor speed and small memory for the GIS application and GIS data. Memory requirements are kept low by using mobile SVG.

Nyamugama and Qingyun (2005) propose a method for constructing an extensive wireless GIS network by utilizing Java cellular phones as GIS terminals for environmental monitoring through dynamic location disaster-emergency notification management of spatial databases. The main purpose of this paper is to assess the use of Java cellular phones as a GIS terminal for environmental monitoring through dynamic location disaster-emergency notification management of spatial databases.

Kaboret (2003) proposes ICT tools for mapping pastoral movements. The overall objective is to enable Sahelian populations to access pasture resources and use them more effectively during the dry season with the help of new ICTs. The proposed solution is web mapping based on GIS with the use of GPS. Based on the results obtained, effective livestock farming methods incorporating ICTs were identified and validated, not only to help reduce conflicts between growers and breeders and animal pressure on pasture lands, but also to enhance productivity of traditional livestock farming, with the direct consequence of increasing family income.

13.3 An Approach Based on SMS and Mobile GIS for Pastoral Resources Management

13.3.1 Overview of Our GIS Architecture

Figure 13.1 illustrates our two-tier approach and shows the interactions that exist between different poles (sites). It describes the different communication phases that should be established so as to obtain operational GIS. The different sites depicted in Fig. 13.1 are the university area, rural area (pastoral unit), and rural radio station. The university site hosts our GIS server, which embeds an SMS server that is able to handle and process SMS messages sent by the collectors and/or users located in the pastoral unit zone. For instance, these SMS messages are used by breeders to find the geographic location of water points, retrieve the status of water points, or seek the shortest route to any given water point. For the record, the purpose of the radio station in Fig. 13.1 is to send information to the users who do not have mobile phones.

To use our GIS service, the mobile phone customer sends requests to the server, for instance, in order to acquire the URL of target map files. The mobile phone customer also has an SVG (W3C 2003) parser (included in the TinyLine SVG) to parse SGV files, and a TinyLine SVG to display geographic information (Fig. 13.2). In fact, the TinyLine SVG provides virtually all the methods to display and control SVG document objects. It should be pointed out that some SVG files may also be

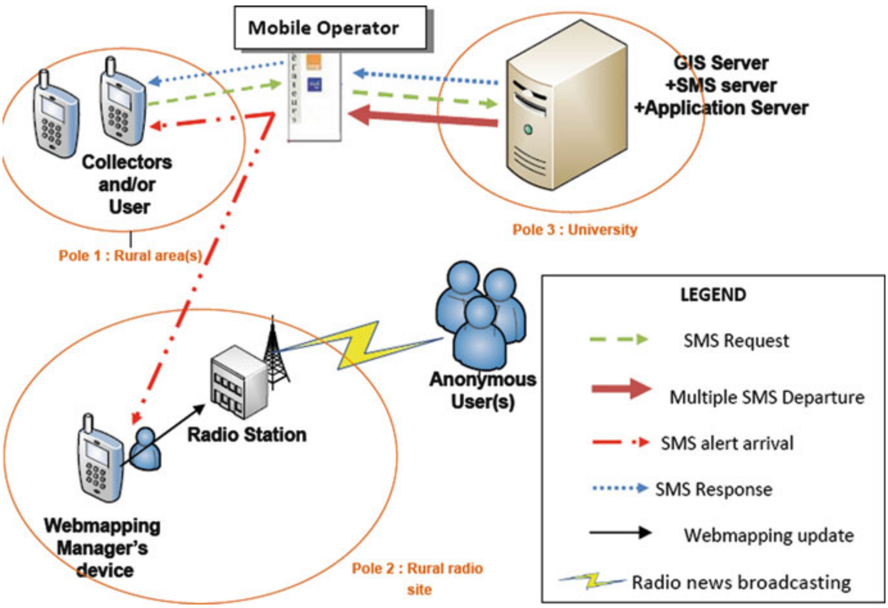


Fig. 13.1 Our mobile GIS middleware

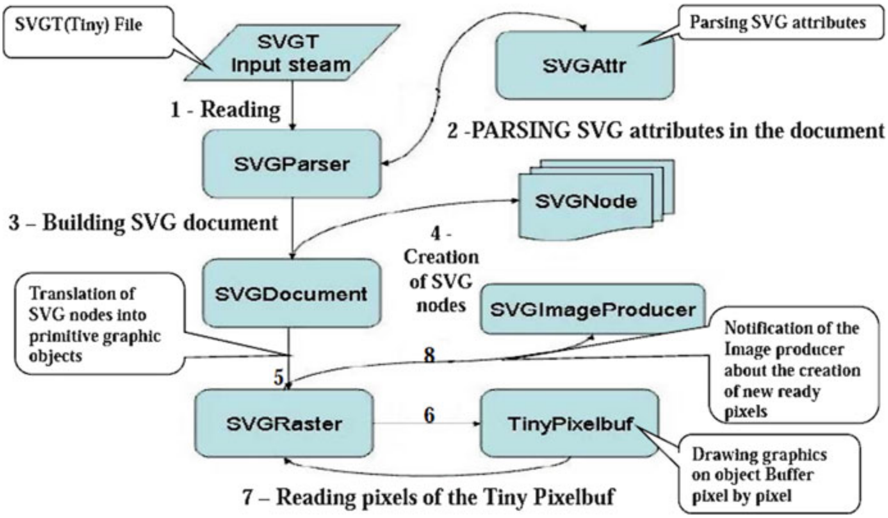


Fig. 13.2 General organization of SVG technology

placed in mobile phones. On the server side, some SVG files are precreated, and Java components are built to generate SVG files forming the database. When a request is received from the mobile phone, the URL specific to the SVG file is transmitted; otherwise, the Java components should generate the SVG file and then transfer the file to the mobile phone. In fact, SVG files or data sources are placed on the web server.

13.3.2 Breeder Use of GIS Applications

The information system implemented is based on SMS and GIS technologies and is freely available. This system consists of two servers and mobile phones as illustrated in Fig. 13.3. One server, located at the university, is used as the SMS server and the other one as a relay through the web mapping application installed at the rural radio station of Koumpentoum, which is a region located 30 km from the study area (Kouthiaba PU). Mobile phones with open-source software (J2ME) are distributed to the 16 breeders participating in the study.

Our experiments used the Nokia N70 for mobile devices as illustrated in Fig. 13.3. For the record, the map of the Kouthiaba PU has been compiled in vector format. Our results show that the breeders have understood the application functionalities during the training and know how to use the mobile device. For instance, two case studies are described here. During the first one, the breeder seeks the status of different water points (Fig. 13.4). For the second case study, the goal is to find the shortest route to a given water point (Fig. 13.5). Figure 13.4 shows the

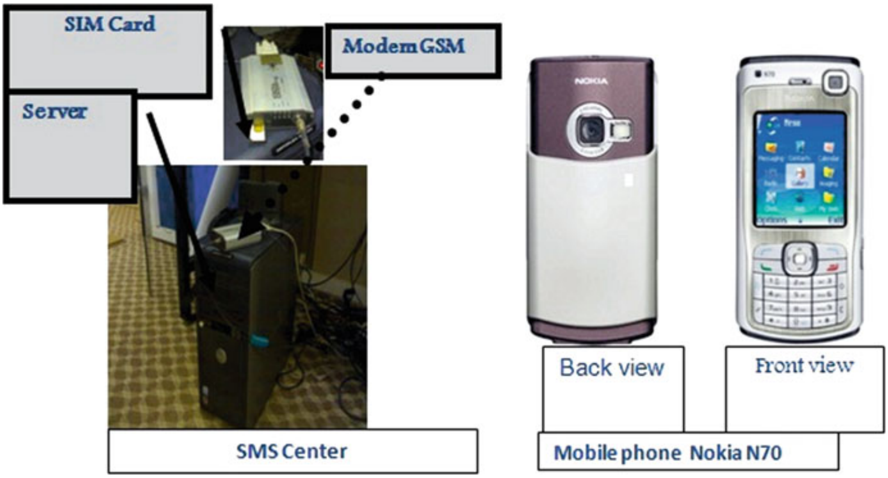
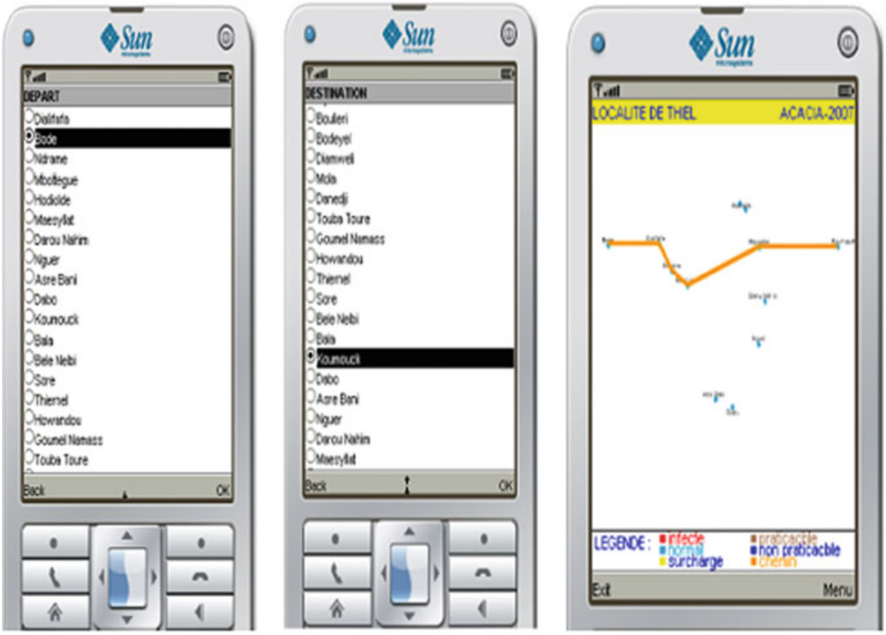


Fig. 13.3 Study material and equipment for the SMS center

(a) Choice of the task (b) SMS validation (c) Graphic response

Fig. 13.4 Access to status information



(a) Source (b) Destination (c) Shortest path

Fig. 13.5 Finding the shortest path toward a given water point

different steps that the breeder should follow in order to find the status of different water points. The breeder can select a given task from the menu on his mobile device (Fig. 13.4a). He sends a single SMS and then waits for the response according to availability of this task (Fig. 13.4b).

For instance, if the breeder wants to know the status of the available water points, he can receive a map on his mobile phone as illustrated in Fig. 13.4c. It is worth mentioning that the status of the water point is indicated with three colors on the geographic map of the PU displayed on the mobile device. The meaning of these colors is (1) red indicates the presence of a disease; (2) yellow means that the water point is dry; (3) blue illustrates that the water point is usable.

Figure 13.5 illustrates how to find the shortest route between two given water points. In such cases, the first (source) water point (Fig. 13.5a) and the second (destination) water point (Fig. 13.5b) should be selected. After selection, the breeder sends an SMS in order to retrieve the shortest route between the source and the destination. He then receives a response by SMS, which is shown as a map on his mobile device (Fig. 13.5c).

Scalable vector graphics (SVG) (W3C 2003) transcribe the SMS format into a graphical map on the mobile device. The mobile phone GIS based on the mobile SVG can then easily display the map on a phone screen so that simple operations can be carried out on the phone. In our study, this tends to give the breeders too much of an edge.

13.4 Discussion

In this section, we discuss and analyze the penetration rate of our GIS infrastructure with respect to the users located in the village of Kouthiaba. We factor in different parameters, such as the degree of usability, income of the population, and efficiency of the GIS architecture.

13.4.1 Sociogeographical Aspects

The village of Kouthiaba, which is a pastoral unit, hosts telecommunication infrastructures for the use of GSM technology. Since a wireless network covers the village, it is possible to deploy GIS based on ICT. As Kouthiaba is located in the Sahel region, during the dry season, many pools can be infected, spreading disease that may affect cattle. Therefore, the GIS application and web mapping can contribute to reducing the risk of disease in rural areas such as Kouthiaba.

Literacy rate in the Sahel region is very low. Therefore, utilization of mobile devices by these populations is limited despite the fact that mobile screen output is translated into their mother tongue. To overcome the language barrier, we use different menus, such as environmental and sanitary matters, so that users do not need to write an SMS to retrieve such information. Despite this facilitation, it remains difficult to expect full appropriation of mobile GIS based on SMS among illiterate persons.

13.4.2 Training and Testing of Usability

Each breeder has been trained for 28 h in using mobile phones and related applications. However, training duration cannot be considered as a probable cause of lack of appropriation of the applications. In fact, at the end of the training, feedback received from the breeders shows that they have profound understanding of how to use SMS technology, start applications, and consult the various interfaces.

13.4.3 Content Distributed in Applications

Our mobile GIS architecture takes into account two key elements in the pastoral area: the status of pools (drinkable or not) and the routes that lead to these pools.

- First, breeders in the Ferlo region consider the status of pools as strategic. Ancey and Astou (2004) have shown that breeders in the Ferlo region travel following the geographic location of weekly markets. The mobile GIS is therefore

designed as a structural element for accessibility and availability of information in pastoral areas. However, both in the endogenous system and in modern information systems, information has a limited lifetime. Knowledge of the status of pools in the Kouthiaba PU has temporal validity spread over 2 or 3 months of the rainy season, but draining of the pools in 7 months makes the tools obsolete.
- Second, finding the shortest route between two pools can benefit the breeders living in the pastoral unit. The shortest route means a given route that avoids sanitary obstacles (infected areas and drained pools) and crossing the farmers' areas. This information secures breeder mobility. It is worth mentioning that during our test with the breeders, this functionality was not used enough – perhaps due to the innovative feature of this application.

13.4.4 Usability of Our GIS-Based Applications

ICT is considered appropriated by a given population when the following conditions are fulfilled: (1) low cognitive control of ICT by users; (2) significant social integration of the use of this technology in daily human life; and (3) the possibility of building innovative solutions using ICT.

- The satisfaction survey conducted after training did not reveal any major complexity of the mobile GIS according to the users. No personal investment has in fact been made by the breeders to acquire mobile GIS. This factor excludes the hypothesis that the cost of innovation would work in favor of compliance. As the PU power grid is not totally operational, sometimes farmers painfully continue to walk 8 km to reach the solar panel of some individuals in the PU to recharge their phones. However, we realized that the farmers are deprived of ensuring permanent autonomy of their phones, as multimedia features tend to run down the battery.
- While the use of mobile phones and SMS can cope with local practices of communication as pointed out, the fact remains that this is hardly noticeable when innovation is not a service whose value does not provide direct economic profitability. The successful example of Grameenphone in Bangladesh (Adam 2005) for economic profitability of the phones stemmed from the fact that women could buy minutes of communication at wholesale prices which they could then resell at retail prices so that they were able to repay the loan and generate income.

13.4.5 Analysis of Quantitative Indicators

Two quantitative elements enabled us to characterize appropriation in this study: efficiency and intensity of use.

- Penetration rate: 12 months after system deployment and training of the breeders, the results show that more than 50% of the breeders have used the system.
- Mobile GIS efficiency: the mobile phone is nowadays one of the most accessible ICTs for the base population, and the project has enabled people to receive free phones that cost on average 200 euros per unit for the Nokia N70. Applications built from free and open-source software do not require upgrades, and thereby purchase of a license. These factors have undoubtedly contributed to reducing the digital divide for some of the breeders in the Kouthiaba PU.

13.5 Conclusion

We have proposed two-tier architecture based on MGIS in order to overcome the lack of information in the Sahel region. In fact, breeders are confronted with many problems, such as finding water points and routes that do not cross farms. We have designed an application based on mobile GIS and have conducted real experiments with the breeders located in the village of Kouthiaba.

The results obtained show that more than 50% of breeders have used our application despite the low literacy rate observed in this village. This percentage can be explained by the apprehension that some breeders may feel about this new technology. This study also shows that the process of appropriation of ICT is not linear. It can take a long time for a given population to adopt innovation based on the use of SMS to access information according to their needs.

We are investigating the possibility of providing the amount of water usable in a given water point. It may be useful for cattle breeders to know if it is necessary to reach a water point depending on the size of his herd. We plan to use sensor technologies to monitor the different water points in order to update our database dynamically.

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