THE NEED FOR STANDARDIZATION OF THE TECHNOLOGICAL APPROACHES FOR THE IMPLEMENTATION OF RURAL LAND SECURITY OPERATIONS IN WEST AFRICA: A COMPARATIVE STUDY OF THE CASES OF BENIN, BURKINA-FASO AND SENEGAL.

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INTRODUCTION

The issue of land administration remains a central concern of every country and it is one of the most heated debates. Aware of the political, economic, socio-cultural and environmental stakes involved in the management of land, and very anxious to see real growth, the countries of the world and especially those of Africa are continuing to examine this issue. Throughout the world, numerous decisions have been made, multiple actions taken with several structures and organizations set up to better management of land. And this has reduced the ever-increasing insecurity of land tenure and instability in the confirmation of land rights in urban, pre-urban and rural areas.

With the advent of Geographic Information Systems (GIS), which are powerful tools for data management, we are increasingly seeing the integration of their potential in the organization of land. Thus, various geo-spatial databases are set up at the level of land administrations in order to allow efficient and transparent management of registered land rights.

Although the use of new technologies such as GIS is still lagging behind in developing countries, some countries such as Benin, Burkina Faso and Senegal have already understood their importance and the need to do so. With the support of their Governments and the Technical and Financial Partners (TFP), they have therefore set up GIS, enabling their populations to have quick access to land information and to have a management tool, help with the decision.

However, although the final aim of each country that has opted for the integration of the potentialities of GIS in the organization of their land is to secure land tenure, the methodological and technological approach developed and adopted by each of them Differs from one country to another. While some continue to use traditional methods for collecting socio-land information and property records, others benefit from the many advances in science and technology.

Each of these approaches developed and adopted by these three countries undoubtedly made it possible to achieve the objectives they set themselves, and more specifically to set up an information system that would facilitate access to land for their people. While securing the rights associated with it, It should be noted however, that they all have strengths and weaknesses which reinforces and fills through harmonization of approaches, will not only make
it possible to capitalize on the experiences of accompanying the management and securing of land in the rural territories of West Africa and above all a standardization of topo-cartographic and GIS techniques.

After a brief description of the technological approaches used by the three countries and a critical analysis of these approaches, we will set out how their forces could combine to standardize techniques.

GEOGRAPHICAL CONTEXT OF THE STUDY

Three countries are included in this study: Benin, Burkina Faso and Senegal.

Benin is located in West Africa in the tropical zone between the Equator and the Tropic of Cancer (between latitudes 6°30 'and 12°30 north latitude and meridians 1° and 30°40' longitude East). It is divided into 12 departments subdivided into 77 municipalities.

Burkina Faso is located in West Africa at 13° north latitude and 2° west longitude. It is divided into departments forming 45 provinces, which themselves form 13 administrative regions.

Senegal is situated between 12°8 and 16°41 north latitude and 11°21 and 17°32 west longitudes. It has 14 regions, 44 departments, 133 districts, 115 municipalities and 370 rural communities.
1. PRÉSENTATION OF APPROACHES

1.1. CASE OF BENIN

Benin, in its political will to ensure secure access to land and to promote economic and sustainable agricultural holdings, has launched for decades, through its government and the support of the TFP, a vast undertaking to realize the Rural Land Plans (RLP). Therefore, Several projects for the development of RLP have over time succeeded and 45 municipalities of Benin are now equipped with a Land Information System (LIS) for the securing and management of their land assets.

Although the RLP development process is predefined by existing texts, the methodological and technological approaches adopted by each project vary from one actor to another. Thus, from the implementation of RLP at the village level using the platelet technique in 1992, Benin switched to the use of GPS in post-processing in 2007 and now thinks of implementing a method (5cm accuracy) with a mobile GIS application for the survey of parcels and the registration of rights relating to these plots.

1.1.1. PGRN APPROACH (1992)

The RLP was implemented in Benin from 1992, as part of the Natural Resources Management Project (NRMP), which later became LNRMP (Land and Natural Resource Management Project). On the basis of the experimentation of the RLP approach, the LNRMP had to propose a draft bill on rural land in Benin. The actions were carried out in some thirty villages in six communes in the country. For this pilot phase, the survey of the properties was done using the technique of the board and the land rights were recorded thanks to survey forms carried out in the form of questionnaire. The graphical reports are made directly on the ground and the first graphic documents produced are field minutes carried out by the topographer on surveys on layers of rendered planes, photo plans or ortho-photo plans. Following the netting done at the office, a second layer is made. For a better retention of the information and especially to facilitate the
necesary corrections after the advertisement and the update, the plan is digitized and the information inscribed on the cards is entered in an Excel sheet. The duration of the work was 8 to 12 months for a village and the accuracy of the data was well beyond the meter.

These first RLP did not lead to the establishment of a land database or to the development of a LIS.

1.1.2. **MCA-BENIN APPROACH (2006)**

The implementation in Benin of the "Access to Land", Project of the Millennium Challenge Account and above all the installation of the seven permanent stations have revolutionized the world of cartography and topography with the emergence of GPS as the main data collection tools Space. From the technique of the board, Benin switches to the post-processing use of the GPS receiver Trimble GeoXH. The properties are now recorded on the GPS and plot plans are no longer done manually but thanks to the AutoCAD drawing software. On the other hand, the registration of rights continues to be done through land-based survey forms (LSF) filled out manually on the ground. The accuracy of the data becomes isometric with a collection time of around 90 days for a village. Since the RLP work will be completed this time on the implementation of a LIS to be used for the issuance of Rural Land Certificates (RLC), the drawing layers created in AutoCAD (dwg) are converted into form files (shp) and imported into the QGIS GIS software environment; the information in the Sheets is entered in an Access database. For the completeness of village information, the soil structuring elements of the soils are digitized on the basis of the ortho images acquired by the project.

In order to ensure better data archiving and security, all survey forms are scanned along with all other supporting documents (sales agreement, dispute settlement report, gift certificate or any other document submitted by the alleged Owners in topo land surveys). For each parcel,
there is a directory containing these scanned documents, which can be consulted in case of ambiguity. The actions were carried out in 294 villages, separated in 40 municipalities of Benin.

1.1.3. **KFW/FI-AGRI APPROACH (2017)**

In their implementation, as mentioned above, some projects have first reiterated the methodological and technological approach of their predecessor and then improved them for better results.

After experiencing MCA-BENIN’s technological approach for four years, the KFW / FI-AGRI project opts today for the use of new tools for the collection of RLP data and the implementation of the LIS: the use of a mobile GIS application for the survey of parcels and registration of the related rights. These changes are the result of reflections by various actors involved in the land to further reduce the time of development of RLP while further improving the accuracy of the data. The GeoXH GPS is now replaced by the Navcom SF3040 receiver and the previously manually completed survey forms are now replaced by digital datasheets. The topographic data collected in the field are directly managed by the GIS. The intermediate steps
(processing of data via permanent stations, realization of plot plans in AutoCAD, conversion of data into a form file, data entry and scanning of the records) are no longer necessary.

The ortho-images are directly embedded in the mobile GIS application which allows the operator to have an overview of the village territory on the ground. The new RLP database will be modeled and secured using PostgreSQL / PostGIS open source technology. This database will be able to store both the attribute data (owner records) and the spatial data (GPS surveys of the terminals, plots and easements).

1.2.  CASE OF BURKINA-FASO

As in Benin, several initiatives have been made to equip rural areas with tools for securing their land. Among these initiatives, we have the MCA-BF property security project, the National Observatory of Land and the PACOF.

However, it should be noted that the implementation of the RLP in Burkina Faso is the product of the reflections initiated in 1994 by the Ganzourgou Rural Development Project (GRDP), which was involved in a perimeter of agricultural development. In the face of land disputes between indigenous farmers and settler farmers, the authors of the study initiated by the GRDP recommended that the project draw on the experience of the RLP in Côte d’Ivoire (the coast Ivory is the first West African country to have experienced the RLP). The government of Burkina Faso agreed to pilot a rural land tenure scheme in the province of Ganzourgou. The RLP pilot operation did not start till 1999.
1.2.1. THE MCA-BF PROJECT (2009)
With the support of the MCA-BF, forty-seven (47) rural communes have been set up with a SIF to allow the generation of the Certificates of Possession of Rural Land (CPRL). This tool consists of an Access database to manage the literal data related to the issuance of CPRL, and a cartographic module manages under ArcGIS. Unfortunately, with the end of the project in 2014, the space component was not finalized. The LIS installed at the level of the beneficiary communes of the MCA-BF is therefore not very successful and allows only partial management of the rural land.

1.2.2. THE NATIONAL OBSERVATORY OF LAND
One of the National functions Observatory of Land in Burkina Faso (ONF-BF) is the production, collection, processing and capitalization of land information in order to help decision-making at national and local. Several initiatives in the area of land security have therefore been undertaken by the ONF-BF.

The initiative currently underway to equip rural areas with adequate security tools is experimenting with the technological approach developed in Tanzania using an application called MAST (Mobile Application to Secure Tenure) to secure land. This online application is used to record land data and GNSS / GPS points of the parcel using a mobile phone or a tablet. It is open source and accessible to all. This technological approach combines information sources such as satellite images with GNSS / GPS data to remain within the required 3 m accuracy as required by law. Recording the collected data requires an Internet connection. Once implemented, the application will allow the automatic editing of field sketches, the output of statistics, and the cartographic visualization (with GeoServer).

However, reflections are under way within the ONF to see how to contextualize this application on the realities of Burkina Faso with for example, the question of hosting basic data, the availability in ortho-images of the municipalities concerned.
The PACOF Project for its component 1 initiates the design and implementation of an LIS capable of enabling rural land management with the issuance of CPRL and the digital archiving of land documentation in fifteen (15) municipalities Pilots of Burkina Faso. The system will be developed with open source applications such as PostgreSQL / PostGIS and QGIS. The collection of socio-land data will be done through pre-established forms and plots will be taken to the navigation GPS. The idea of using the cartographic supports ortho images is considered from the experience of Benin.

1.3. CASE OF SENEGAL

Unlike Benin and Burkina-Faso, the RLP has not been experienced in Senegal. However, cartographic experiments were conducted in rural areas to enable communities to better manage rural land with technological and modern means.

1.3.1. Project of Support to the Rural Communities in Senegal River Valley

The PSRC was implemented in 2008 with the assistance of the "Agence Française de Développement (AFD)". The objective of this project was to equip rural councils with tools, procedures and know-how to enable them to manage their area of competence in a more effective and transparent manner. Its implementation has enabled the establishment of a Land Information System (LIS) designed as a set of principles governing the collection, processing, use and conservation of data on the occupation of the national domain and to inform decision-
making. It answers the fundamental questions of land tenure: who occupies what space and how from the realization of socio-land surveys; Where this occupation is located on the basis of a mapping and a strategy of identification of the plots. From a functional point of view, the LIS is a set of tools enabling the RC to have a facilitated and transparent management of rural land. It constitutes the basis from which a land register is established in each rural community.

1.3.2. MCA-SENEGAL

A LIS is also operational in the municipalities of intervention of the MCA (until the end of 2015). The database management system used is postgresql / postGIS with a Chinook platform. Topographic surveys are made by the national commission to the GPS Garmin 62s with a precision of 3m. The forms are entered manually. The satellite images are used to enrich the database. The application has the following features: new request, search, land register and mapping. It is fed by direct input and generates the extracts parcels and the duplicates of all the documentation real estate attached to the land procedure.

The map data is updated by Quantum GIS. The FME is also used for the massive integration of data into the LIS database.

Each of the approaches developed and adopted by these three countries undoubtedly made it possible to achieve the objectives they set themselves, and more specifically to set up an information system that would facilitate access to land for their people while securing the rights
associated with it. However, they all have strengths and weaknesses that can be strengthened and addressed through harmonization of approaches.

2. CRITICAL ANALYSIS OF APPROACHES

The methodological and technological approaches to the implementation of the land security tools adopted by each of the three countries enabled them to achieve the desired objectives. However, each of them has strengths and weaknesses that need to be analyzed in order to standardize the approaches and technological orientation of future land security projects. Comments will focus on the latest technological approaches in Benin, Burkina Faso and Senegal.

2.1. CARTOGRAPHIC SUPPORTS

From a purely cartographical point of view, the integral coverage of rural areas in satellite imagery, ortho photo or ortho image is a prerequisite and precondition for the start of land surveys. These supports are in fact excellent tools of communication with the population and allow the extraction of structuring elements or land use. In the implementation of each of the approaches developed, satellite imagery, ortho-images and ortho-photography have been used. This is already an advance or a plus to be taken into account by future projects.

2.2. TOOLS FOR LAND DATA COLLECTING

The identification of local land rights is the essential phase of land security operations. The knowledge of local land rights is obtained through the achievement of local land surveys to:

- identify the different plots of exploitation;
- identify their exploitants and holders;
- specify the nature of the rights exercised by the operators on these lands and register them.

Collection tools differ from one approach to another, we have:

<table>
<thead>
<tr>
<th>Approach</th>
<th>Identification and plot surveys</th>
<th>Registration of Land Rights</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>Receiver Namco SF-3040 in conjunction with the Starfire + SIG mobile</td>
<td>Mobile Application (digital files)</td>
<td>- data accuracy 5cm</td>
</tr>
<tr>
<td>Burkin-Faso</td>
<td></td>
<td></td>
<td>- data directly reserved in the SIF</td>
</tr>
</tbody>
</table>
Approach | Identification and plot surveys | Registration of Land Rights | Observations
---|---|---|---
MAST | Mobile phone or tablet (GPS integrated) | Mobile phone or tablet | - requires internet connexion for data logging  
- sharing information via a web application
PACOF | GPS navigation | Pre-established form | - accuracy of data 3m
Senegal | GPS Garmin 62s | manually filled forms | - accuracy of data 3m  
- requires the digitization of informations on the forms for data better archiving

2.3. **THE LAND MANAGEMENT SYSTEM**

In the implementation of LIS, the technological approaches developed have all opted for an open-source database management system: the PostgreSQL / PostGIS. The map pane for the most part is also managed by the software GIS QGIS which is also a free application.

2.4. **SYNTHESIS OF FORCES AND WEAKNESSES**

<table>
<thead>
<tr>
<th>Approach</th>
<th>Forces</th>
<th>Weaknesses</th>
</tr>
</thead>
</table>
| Bénin | - Accuracy of data ;  
- Integral coverage of the village terroir ;  
- Imagery embedded in the possibilities for the photographer to have an overview of the village terroir ;  
- The properties are directly drawn on the ground ;  
- The data collected in the field are directly accepted by the LIS  
- The time for the collect and treatment of the data is reduced / limited  
- Complete data base at the scale of the village terroir ;  
- Fixe Data update time ; | - Density of socio-land information ;  
- Too long preparatory phase (precisely the ortho’ realization time) ; |
### Approach | Forces | Weaknesses
--- | --- | ---
**MAST** | - Application smartphone open-source;  
- Easy to use;  
- cheaper;  
- it is sustainable over time;  
- uploading of data;  
- automatic processing of recordings | - Data less accurate comparing to Benin;  
- Requires internet connection for data logging;  
- Requires contextualization compared to the socio-land realities of Burkina-faso

**PACOF** | - cheaper;  
- fast data collection;  
- Complete database adapted to the socio-land realities of Burkina-Faso’ rural municipalities. | - Less accurate/ precise than Benin;  
- Update of deferred data per levy of plot;  
- Topographic survey that is not systematic for the whole village;  
- Incomplete data base on the scale of the terroir

**Senegal** | - Cheaper  
- fast data collection;  
- Complete database adapted to the socio-land realities of Burkina-Faso’ rural municipalities. | - Less accurate/ precise than Benin

### 3. UNIFORMIZATION OF APPROACHES
Taking into account the strengths and weaknesses of each country approach, it is necessary to harmonize the solutions proposed within the framework of rural land management. To achieve this, it is essential to establish criteria that will facilitate the coherence of technological approaches:

- Accuracy / Precision
- Duration
- Reduced cost

#### 3.1. ACCURACY / PRÉCISION
The precision criterion depends on the national policy of each country to a large extent, therefore on existing and existing topographic and cartographic standards. While rural land legislation in Burkina Faso and Senegal requires three meters for the accuracy of topographic
and cartographic data, in Benin it requires a much finer sub-metric accuracy. The precision of the graphic plans is conditioned primarily by the hardware and the measurement tools used.

Burkina Faso and Senegal with the 3m sought use the Garmin 62 handheld GPS that gives them great satisfaction while in Benin; technicians are led to use for example GPS Trimble GeoXH and most recently the receiver NAVCOM SF-3040 the details of which make it possible to meet the requirements of the technical standards. We are therefore faced with two different situations and each of them has its advantages and disadvantages.

3.2. DURATION

The time required for the development of rural land security tools varies from one approach to another and depends not only on the duration of topo-land surveys but also on the processing of the data collected. The method and technique of collection and processing developed by each approach therefore depends largely on the time taken to complete the work. While the Garmin 62 allows Burkina Faso and Senegal to work in real time with a position of less than one minute per parcel’ top, the GeoXH Trimble used in post-processing in Benin requires a much longer positioning time (at least three Minutes per top of parcel/plot). The GPS coordinates recorded by the Garmin 62 are used directly for graphic drawings, while those of the GeoXH Trimble must first be corrected and processed via the permanent stations before being used for the drawing of the plots plans. The use of the Garmin 62 for the realization of topo-land surveys therefore has the advantage of being much faster than the Trimble GeoXH. Data collection by the MAST or the NAVCOM SF-3040 receiver displaces the Garmin 62 in terms of rapidity. In fact, With the MAST or the NAVCOM SF-3040 receiver, the integrated GIS applications allow the operator to automatically record fields on the ground as polygons by connecting the different GPS points representing their vertices. From the tablet or mobile phone, the progress of the work is monitored in real time and the data collected are directly usable by the GIS.

3.3. REDUCED COST

Several elements make it possible to evaluate the cost of developing land security tools: the price of equipment, the fees of the service providers, etc. But in the present study, only the price of the material will be taken into account.

A classification in ascending order gives:
- The Garmin 62 GPS
- The MAST
- The Trimble GeoXH
- The NAVCOM SF-3040 receiver

The technology considered by Benin for the development of its future RLP is therefore much more expensive than other countries.

### 3.4. SYNTHESIS

<table>
<thead>
<tr>
<th>APPROCHE</th>
<th>PRECISION</th>
<th>RAPIDITE</th>
<th>COUT</th>
<th>SYNTHESE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOXH- BENIN</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>Specific/Precise, slower and expensive</td>
</tr>
<tr>
<td>NAVCOM SF 3040</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>More precise, faster and more expensive</td>
</tr>
<tr>
<td>MAST BURKINA-FASO</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>Less precise, faster and cheaper</td>
</tr>
<tr>
<td>PACOF BURKINA-FASO</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>Less precise, fast and cheaper</td>
</tr>
<tr>
<td>SENEGAL</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>Less precise, fast and cheaper</td>
</tr>
</tbody>
</table>

An analysis of the approaches in the synthesis on the basis of criteria, allows us to notice that the Navcom SF-3040 envisaged to be used by FI-AGI in Benin and the GeoXH already experienced are more clearly accurate/precise than the collection tools of Burkina-Faso and Senegal. In addition to the precision that the Navcom SF-3040 offered, the latter shows the advantage of being as fast as the MAST of Burkina-Faso and even more than the GPS Garmin 62s. From a financial point of view, it seems a little more expensive than the other tools. But in reality, this high cost is not one when the security works are realized at the scale of the village terroir and for a large number of villages. The acquisition cost of the equipment gets amortized over time with a large coverage of secured land properties since the equipment under warranty of a few years will be used for the completion of several rural land surveys. The Starfire differential correction solution offered by the equipment is a lifetime subscription once the equipment is functional. Then a judicious choice has to be made both at the national and regional level by considering the socio-land realities of each country.

Finally, it should be noted that Benin is opting for the establishment of a single Cadastre at the national level. The content of this technological option remains to be specified.
4. TOWARD A REGIONAL LAND INFORMATION SYSTEM

The objective is to collect and gather in a unique system, various regional’ land information produced during the implementation of different tools of land security and to facilitate their consultation and diffusion through an online GIS. This gathering of data, with the importance of land information will require the definition of a certain management rules also the standardization of some cartographic and topographic standards, in order to avoid an overlap of data: what precision seems appropriate for data collection of land? Of the three meters required for instance by the land legislation of Burkina-Faso, Senegal and the isometric precision of Benin, which one allows a better registration of land information and, an effective securing of land rights without encroachment ? Which format is more appropriate for the pooling of data and how to secure their access and diffusion/dissemination?

The standardization of approaches and standards is therefore a very important step for the implementation of a regional LIS.

CONCLUSION

The harmonization of the approaches will make possible to capitalize on the experiences of accompanying the management and securing land in the rural territories of West Africa, also and above all, a standardization of topo-cartographic technics and SIG based on the forces of approaches already developed and tested. It should be remembered that this harmonization is already at the scale of UEMOA, ECOWAS in fields such as economic, transport and monetary systems.