Deutscher Tropentag 1999 in Berlin
Session: Information and Communication Technology for Rural Development

An Internet Atlas of Agronomic Resources as a Basis for Data Collection and Communication
An Example from Niger and Benin, West Africa

Ludger Herrmann and Karsten Vennemann

Institute of Soil Science and Land Evaluation (310)
University of Hohenheim, 70593 Stuttgart, Germany
email: herrmann@uni-hohenheim.de, vennema@uni-hohenheim.de

Abstract
Accessibility of scientific data for management purposes, rather than their mere existence, is often a restriction for scientists, decision makers, and extensionists in developing countries since they are scattered in different locations. This is a great obstacle for comprehensive evaluation of natural resources and sustainable development. In order to create a tool for data collection and communication an "Internet-Atlas of Natural and Agronomic Resources" was developed within the Special Research Programme 308 "Adapted Farming in West Africa. Since science develops rather quickly, it requires frequent updates of research results. Therefore, the objective was to create a dynamic atlas which can account for new developments and serve as an open forum for research results of partner organisations and other researchers working on similar subjects. The atlas is designed as a Web site of the University of Hohenheim (preliminary versions of the atlas can be found at URL: http://www.uni-hohenheim.de/~atlas308). In order to make this information available to interested groups who do not have access to the Internet, publishing is also planned via compact disc (CD). The information is partitioned into two main units: (A) the atlas itself with maps based on a Geographical Information System (GIS) and documentation related to the natural and socio-economic environment, and (B) a database. The database provides free access to the data in a standardised format and assures usefulness for a broad range of users. Further development of the maps (e.g. up- and downscaling) will be easily possible as well as adapting and combing existing results for varying future applications. Topics from soil, climate, vegetation, plant and animal production to socio-economics are included in the atlas.

Keywords: information system, natural resources, land use planning, West Africa

Introduction

Sustainable evolution in developing countries is based on a wide variety of factors. Among these are socio-economic settings which are based on the natural resources of the country, and also are dependent on the cultural and historical background and the recent economical and political developments in the region. For example, the task of securing the food supply for rapidly growing populations is a great challenge in many countries, even more so with the goal to ensure sustainability over long time periods. One step towards enhancing sustainable developments in land resources management and agriculture is to provide decision makers such as politicians, non governmental organisations (NGO) and extension agencies with adequate information. Useful information for evaluations of natural and socio-economic topics should be comprehensive and up-to-date. One further step is to provide tools for the evaluation of arising or persisting problems in management of natural resources. Many organisations, such as national and international research institutions, NGOs and extension services, are trying to contribute to this goal. Often, large amounts of data are collected by

these organisations but are usually not stored in ways that make them easily accessible to potential users. Results and data are stored on different media (e.g. printed articles, data sheets, maps, reports, or electronically in spreadsheets, databases or in GIS or Land Information Systems). In addition, the information is stored in different locations. Often it takes great effort, time and persistence to get an approximate idea of what data and information is available. Access is usually limited to a certain group of people. Thus, gathering adequate data on which evaluations can be based is a problem. In some countries, an overwhelming variety of institutions is working on similar projects, sometimes unaware of each other. This illustrates the need for a common database to keep information at one place and freely accessible to all potential users in order to achieve a faster development.

2. Potentials of maps and GIS in land resource management

Questions concerning land resources management mostly involve spatial components. Evaluations are valid only for certain parts of the country. Therefore, maps are a very useful tool for classifying regions, showing the spatial distribution of natural resources, and for planning sustainable land use. Printed maps represent a certain type of interpretation of the land surface or synthesis of data related to the region at a certain point in time. In contrast, GIS-based maps offer the advantage of being dynamic. Once a map set-up is finished, updating is easy and not very time consuming. New data can be simply added to the database (or table) and visualised using the original legend and layout. A further advantage is that additional GIS layers can be added to create new maps. As an example different class intervals of population densities can easily be visualised if the source data are available in the database. But one has to keep in mind that accuracy is limited to the resolution of the underlying data or map geometry.

3. The Atlas of Natural and Agronomic Resources in SW- Niger and Benin

3.1 Scope of the atlas

The "Atlas of Natural and Agronomic Resources" was developed within the Special Research Programme (SFB) 308 "Adapted Farming in West Africa" as a tool for collection and presentation of spatial data. During the first phase, information and results from projects of the Special Research Programme were included. The atlas team tried to incorporate most of the results that have a spatial relevance or to extend the scope of some of the research projects towards a spatial interpretation. Included topics reach from plant and vegetation ecology over soil science and animal production to economics. After the completion of the first phase (which is the set-up of the atlas and the incorporation of the results of the SFB 308) it will be open to contributions from other sources. The use of the atlas is intended towards comprehensive planning and sustainable development in West African countries. The objective was to create a dynamic atlas which can account for new developments and in the future serve as an open forum for research results of partner organisations and other researchers working on similar subjects. These objectives are met by using the Internet as a publishing medium.

The atlas is designed as a Web site of the University of Hohenheim and will be officially presented at the end of 1999. Preliminary versions can be found at URL: http://www. uni-hohenheim.de/~atlas308. In order to make this information available to interested groups which do not have access to the Internet, publishing is also planned via CD and a printed version.

3.2 Structure and content of the atlas

To best serve the potential user community, the atlas will be prepared in English and French. The content is structured into three main parts (compare also Table 1):

1) "General Information" which explains the scope and approach of the atlas and presents the co-operation partners of the project.
2) The main part that features the maps and accompanying comments has three sub-divisions:
   - overview of Niger and Benin (A),
   - country specific parts (Niger (B), and Benin (C))
   - the Appendix (D) with links and publication list of the SFB
3) The database (E) containing the data for download.

The maps in sections A2 "General maps", B1 "Overview Niger" and C1 "Overview Benin" are not original to the SFB308. They were included into the atlas to give an overview and to provide basic maps and GIS layers on which to build new projects. These maps will be linked to short texts explaining the contents of the maps. The maps providing original projects of the SFB will have a more comprehensive documentation. Maps in these sections are displayed together with a comment in form of a short scientific communication. The format of the comment is fixed (Table 2). Also the database provides free access to the data in a standardised format (Table 3) and assures usefulness for a broad range of users.

3.3 Options to provide maps through the internet

The atlas is designed for a broad user community. Some may want to get an overview over a region or an impression of a certain topic, whereas others want to directly use the data and digital GIS layers. Not all of these users are well-trained GIS specialists which makes it necessary to think about the way how to provide them with the information they may need. Two technical approaches are available:

1) The maps can be presented via the internet as graphics (with or without interactive GIS capabilities)
2) The maps can the downloaded as GIS files and viewed with GIS software or free GIS-viewers providing a more simple user interface than regular GIS software.

With the first option users can access data and maps over the web and get an overview of information available on a certain topic. Depending on the set-up of the map server interactive GIS functions may be included. The second option allows the user to view, query and combine the provided data (or to add additional data) according to their needs. Depending on their equipment and skills users are free to use more comprehensive GIS software to perform all kind of analysis.

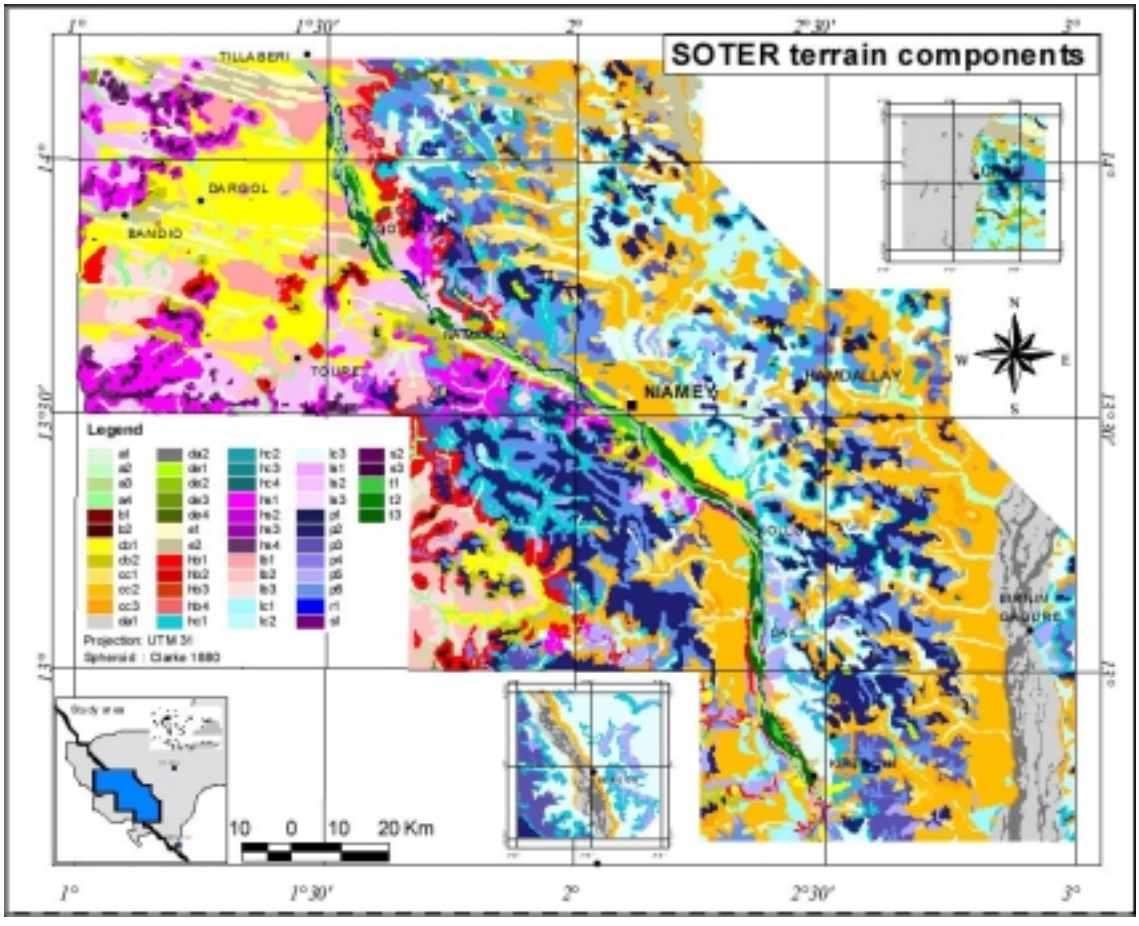
3.4 Using the atlas as a land resources information system: some examples of the contents

Technically the atlas consists of two main units. Part one is the atlas itself with GIS based maps and linked documentation related to the natural and socio-economic environment. Part two are the source data and information which are presented in a database. It was planned to develop a single database for all subjects and projects included in the atlas. However, practical work showed that a single database is uncomfortable for the users, since subjects covered are from many varying disciplines with different data structures. Therefore, a single

database would be difficult to handle. Consequently, the atlas team decided to provide comprehensive databases for individual projects.

One important part of the atlas are the integrated SOTER-maps (SOil and TERrain) for south-western Niger (Figure 2) and southern Benin (Weller and Stahr, 1995) serving as a base for land evaluation and sustainable land use planning. The SOTER approach includes two parts: the digital map geometry (with topology) and the underlying data in a database (ISRIC, 1993). Map units are mainly defined by geology and geomorphology and are considered to uniformly respond to management measures. Each unit is associated with one or more soil types which are represented by a certain number of soil profiles in the database. Thus, information about terrain (slope gradient, elevation, geology, landscape unit) and soils (soil type, horizons, organic matter, CEC, etc.) are combined. Depending on the scale and purpose of the requested evaluation, these data can be combined with additional information (compare Graef and Stahr 1997; Weller et al. 1998). Examples for derived maps are a suitability map for millet production and a map on fallow vegetation management. Difficulties exist to combine natural resource with socio-economic information since i.e. soil and landscape units are delineated by natural borders, whereas socio-economic data are usually related to administrative units. This is not only a question of resolution but also how data of different disciplines can be integrated for evaluation purposes.

Figure 2: SOTER map of south-western Niger (source: Graef, F. 1998) showing the terrain components



4. Discussion

4.1 Technical set-up of the atlas

The maps are provided as static graphics over the internet instead to use more complex options such as a web map server. The latter software would allow instant automatic update of the maps and databases once new information is added to the GIS. But, until recently this technology was not accessible for a reasonable price. In contrast to the obvious advantage of providing up to date and interactive information it has some disadvantages. First, the set-up and maintenance of such a system is very labour intensive and requires the almost permanent maintenance of highly trained staff. Furthermore, the second important drawback appears when we look at the solutions how maps are served over the web. For serving maps on the internet two main technological options exist: The maps are either served as so called "client side" or "server side" based applications. With client side applications the GIS data are first loaded to the client's computer where browser plug-ins or Java applets provide some GIS functionality. Finally, the map is visualised on the client computer.

In server side applications the already graphically prepared maps are send from the server to the user computer as raster images: A web map server directs the interactive requests to the GIS. The responds of the GIS-system are transferred as readily prepared raster images by the map server to the client. In both cases relatively huge data sets have to be send and received over the net which potentially will cause long waiting periods. Because of this reason, the atlas team decided for a more simple solution that provides maps faster over the net, but does not provide interactive GIS functionality. However, all data used to individually reproduce the maps of the atlas are provided for download. The SOTER data can be selected and down-loaded through a simple query interface. For each of the other projects a single compressed file (Table 2) including all map geometry data, metadata, and text (map documentation) can be downloaded.

GIS layers which are provided as ARC/VIEW shape files can easily be converted or imported to other GIS formats. Thus, users with access to GIS software easily can reproduce maps or add other data and create new maps or layouts. To provide tools for users or organisations that do not have access to GIS software or do not have GIS trained staff, free, easy to use software is available for download from a variety of provided links. Furthermore certain initiatives and projects exist to develop free GIS software that offer more than only basic GIS functionality but also extended analytical tools (i.e. URL: http://www.brc.tamus.edu/char/).

4.2 Future developments

The main future objective is to transfer the project to local organisations in Niger and Benin for further development of the atlas (after the completion of the first phase at the end of 1999). Staff of these organisations will be trained in GIS, database, web design and set-up, and all other necessary software. Maps or results available from many sources will be reviewed and included as projects in the atlas if the development of maps and the preparation of the associated comment can be done with a reasonable amount of work (compare Table 2 and 3). An editorial team will review all comments and maps to ensure quality of the projects and compatibility with the atlas standards. After two years the co-operation partners should be able to operate the atlas and extend it to be a digital national atlas for each of the countries. During the transfer of the atlas, information that is scattered in different locations will be collected and included in the atlas. Many of theses projects will be done in additional co-operation with a wide range of national and international organisations. It is planned to extend

the approach of the atlas towards other West African countries within the framework of the West African Land Resources Information System (WALRIS) initiative by International Soil Reference and Information Centre (ISRIC 1999). The use of the SOTER concept should be extended towards interdisciplinary evaluations of land resource management questions. In order to reach this goal compatibility of data and data structures of the natural resources on one hand and socio-economic research on the other hand will be essential.

5. Conclusions

The atlas will be an open forum to present and communicate scientific results related to the fields of natural resources and agronomy in Niger and Benin. It will provide maps and documentation on a web site and allow the free download of all source data used for production of the maps. Users are free to use the data in their work (however proper citation of the information source should be respected) and to extend or combine the provided information with their own results. The authors of the atlas are aware that the use of the source data may require substantial equipment to further proceed with the work, since premium computer equipment, complex software such as GIS and database software and highly qualified staff are needed. The web presentation of the atlas together with its distribution on CD will already enhance the availability of maps and results. To supply all users with some basic GIS capabilities, free GIS-viewers will be provided for download. Among functions of these programs are the following: query options of the layers, the capability of printing the maps at high quality on different formats , options for changing the legend and map layout, and the option to add additional GIS layers. With the development of appropriate tools (free mini-GIS) the atlas can be extended in the future to serve as a land resources information system. Such initiatives like WALRIS are on the way towards which the presented atlas will contribute. Research towards interdisciplinary compatibility of research data in the fields of natural resources and socio-economics will be essential to reach the goal of comprehensive evaluation capabilities.

6. References

Graef, F., (1998). Standortnutzungsplanung im semiariden Niger - Ertragsvorhersage und Risikoabschätzung von konventionellen und alternativen Anbauverfahren. Diss. University of Hohenheim, Germany.

Graef, F., Stahr, K., (1997). Applications of SOTER and land use planning in South-West Niger. Mitteilungen der Deutschen Bodenkundlichen Gesellschaft 85, pp. 1143-1146.

ISRIC. 1993: Global and National Soils and Terrain Digital Databases (SOTER). Procedures manual. Wagenningen.

ISRIC. 1999: Regional Implementation Workshop "Establishment of an Integrated Land Resources Information System for the Conservation and Rehabilitation of Land Resources in West Africa" (WALRIS). Workshop report, 23-25 February 1999, Cotonou, Benin.

Weller, U., Igué, M., Stahr, K., (1998). The use of a Land Information System as a management tool in Benin. p. 542 in: Renard, G., Neef, A., Becker, K., von Oppen, M., (eds.). Soil Fertility Management in West African Land use Systems. Proceedings of the regional workshop, University of Hohenheim, ICRISAT Sahelian Center and INRAN, 4-8 March 1997, Niamey, Niger. Margraf Verlag, Weikersheim, Germany.

Weller, U., Stahr, K., (1995). Eine Standortskarte für Südbenin - Erfassung von Geländeeigenschaften und Bodenparametern. Mitteilungen der Deutschen Bodenkundlichen Gesellschaft 76, pp. 1221-1224.

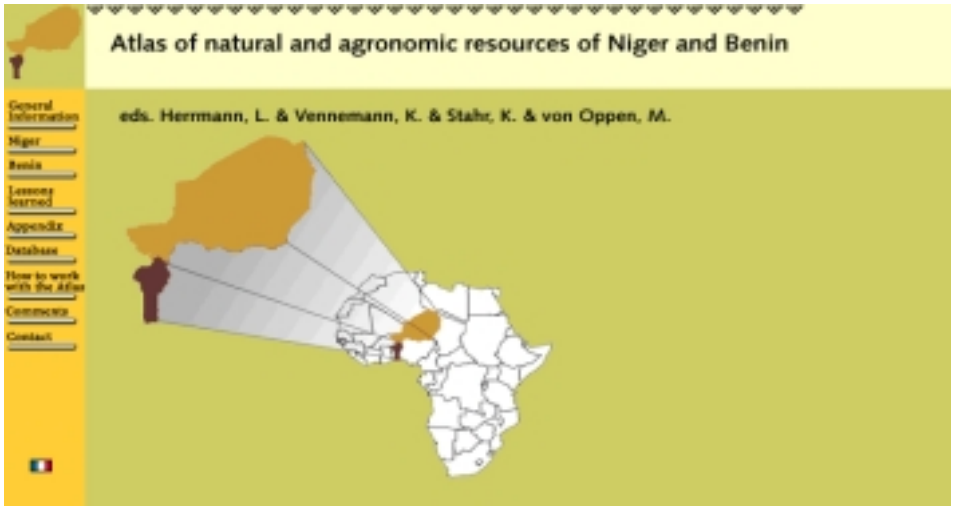


Figure 1: The main navigation page of the internet atlas. The contents are accessible via the navigation bar on the left. Maps and comments are linked from the next page which lists the content in detail

Table 1: Content of the atlas

General Information
Aims of the atlas
Scientific approach
Portraits of research partners:
Germany: University of Hohenheim, SFB308, TROZ
Niger: ICRISAT, Université Abdou Moumouni
Benin: CENAP, CENATEL, INRAB, UNB

A. Overview Niger and Benin	
A1.	Research sites
A1.1	Location of Niger and Benin in Africa
A1.2	Location of SFB 308 research sites and partner organisations in West Africa
A2.	General maps
A2.1	Political borders
A2.2	Population
A2.3	Topography
A2.4	Climate: Precipitation
A2.5	Soils
A3.	Applied projects
A3.1	Vegetation zones in Niger and Benin - present and past zonation

B. Niger

B1.	Overview Niger
B1.1	Political borders
B1.2	Population
B1.3	Ethnic groups in Niger
B1.4	History of Niger (text)
B2.	Natural resources and agricultural production
B2.1	Inventory
B2.1.1	Geology of SW-Niger
B2.1.2	SOTER - map of SW-Niger (SOil and TERrain)
B2.1.3	Climate: Precipitation isolines and climate diagrams
B2.2	Agricultural Potentials
B2.2.1	Production risk for pearl millet in SW-Niger
B2.2.2	Yield potentials in SW-Niger
B2.3	Management
B2.3.1	Recommendations for fallow vegetation management in SW-Niger
B2.4	Animal production and herd migration
B2.4.1	Land use and agropastoral systems in the Filingue region
B2.4.2	Seasonal livestock migration and grazing potentials in SE-Niger
B3.	Economics
B3.1	Agricultural production, price distribution and fertilizer use (1990-1997)
B3.2	Marketing patterns of farming systems in SW-Niger
B4.	Development Potentials
B4.1	Potential for mechanised cultivation in SW-Niger

C. BENIN

C1.	Overview Benin
C1.1	Political borders a: current b: planned (not currently used)
C1.2	Population
C2.	Natural resources and agricultural production
C2.1	Inventory
C2.1.1	Geology and geomorphology of southern Benin
C2.1.3	SOTER - map (SOil and TERrain) of southern Benin
C2.1.4	Land use dynamics in the region of Abomey-Bohicon between 1954 and 1982
C2.1.5	Changes of land use and vegetation near the village of Houéto (1981-1995)
C2.2	Agricultural potentials
C2.2.1	Water availability in southern Benin
C2.2.2	Potential maize yield in southern Benin
C2.2.3	Case studies: Potential maize yield on field level on the Allada plateau
C3.	Economics
C3.1	Maize in Benin: Production, Markets and Transport
C3.2	Major crops and their regional distribution in Benin
C3.3	Farming systems and production patterns in southern Benin
C3.4	The origin of "acadja" branches and transport routes in the Province Atlantique

D Appendix

Publications SFB
Links

E Database

Data

Table 2: Structure of the map comments

Title
Keywords
Author(s)/Affiliation

1 Aims of the research
(including brief introduction)

Aims/intentions of the work (concerning map preparation).

2 Approach
Describe tools and the process of the map production (how to reach the goals defined under point 1 ?)
What is new - what is old ?
Which data are used ?
How will the final content of the map(s) be produced (e.g. algorithms, generalisation procedure to get the spatial results) ?

3 Results and Interpretation
Describe and explain the results of the work and the resulting maps.
Give an interpretation of the results found.
Discuss problems and limitations of the maps and results.

4 Conclusions
What is the benefit of the maps produced ?
What are applications for the map ?
What are the final effects or limitations with regard to the maps content ?
What are possible (future) additions to make the map more useful (combination, addition of other data or maps) ?

5 References
Limited to references cited in the text.

6 Further Readings
List of references leading to a broader understanding of the subject (e.g. 10 references).

7 Related Websites
Internet resources.

8 Annotation (optional)
Additional tables, figures and/or text relevant for the subject.

9 Data Links
Source data of the projects.

Table 3: Spatial data available for download (for each project one compressed *.zip file)

Files included in the *.zip file	Format
Gis layers for the map	ArcView shape files (including *.shp, *.dbf, *.shx files)
Metadata for the GIS Layers	Text file (*.txt)
Map	Graphics file (*.gif, *.jpg)
Comments	Rich text format (*.rtf), regular *.txt format
Data	Excel 5.0 spreadsheets (*.xls) and tab delimited text files (*.txt)