An Internet-Geographical Information System for Multidisciplinary Research in Oman

Jutta Häser
Deutsches Archäologisches Institut, Orient-Abteilung
Podbielskiallee 69-71, D-14195 Berlin, Germany

Angelika Schulz
Prenzlauer Allee 32
D-10405 Berlin, Germany

Abstract

Since 1999 a project, entitled "Transformation Processes in Oasis Settlements in Oman", was undertaken by orientalists, ethnologists, architects, urban planners, plant physiologists, and archaeologists from universities in Germany and Oman, as well as from the DAI. The research is focused on processes of transformation throughout history, regarding the architecture and material culture, the economy and ecology of the oasis settlements in a regional and interdisciplinary approach.
An Internet-GIS was developed to provide all involved scientists as well as other researchers in this field with the most recent results of the archaeological investigation. The cartographical data are based on aerial photographs. They were processed with the programs AutoCad Map and AutoCad Overlay to create a georeferenced map. Topographical and archaeological features like tombs, settlements, cultivation terraces, water management systems etc. dated from the third millennium B.C. to sub-recent times were digitised. With the help of the program AutoCad Mapguide these data were transferred to the Internet. Each site is represented by a photograph and a short description. However, the internet users are not only able to look on these data, but they can also evaluate these data with GIS-tools (e.g. distances, puffer) under various aspects without installing a special GIS-System.

Introduction

Co-operation between scientists of different disciplines are standard in modern research projects. When these enterprises take place in a foreign country, usually local scientists are also involved. In many cases special support is granted to those projects, in which various partners from different countries co-operate. This is true not only for the natural sciences but also for the cultural sciences and therefore also for the archaeology.
The work in spatially distributed and specialist groups requires an intensive exchange of information, which is made easier by modern information technology. However, the exchange of documentation, which includes maps, plans, drawings, photographs, reports and databases in their various stages of processing, is still problematic. An Internet-Geographical Information System (Internet-GIS) has been applied to solve this problem in the project "Transformation Processes in Oasis Settlement in Oman", which shall be introduced in the following.

Description of the Project

Against the background of rapid economical and social change in the Sultanate Oman since the 1970s, a German-Oman, interdisciplinary research group has been involved in documenting the traditional way of life in all its material, economical and social aspects and in developing strategies for the preservation of oases in a modern world (Häser 2000).

The research team includes orientalists from the University in Tübingen, architects and urban planners from the University in Stuttgart, agriculturalists from the University in Kassel, archaeologists and agriculturalists from the Sultan Qaboos University of Muscat as well as archaeologists from the Orient-Department of the Deutsches Archäologisches Institut in Berlin.

Initially the project was financed by the Ministry of Research of the State of Baden-Württemberg, the Sultan Qaboos University in Muscat and the Deutsches Archäologisches Institut. Since 2002 the Deutsche Forschungsgemeinschaft has provided financial support for the project.

In the years 1999-2001 a pilot study was conducted in a region of central Oman, which extends along the Wadi Bani Awf, crosses the al-Hajar mountains and ends in the al-Hamra region. The area under investigation is located in the dry belt and encompasses various ecological zones, which are characterized by the northern and southern foothills of the al-Hajar massif and its up to 3,000 m high upland. No archaeological survey had been conducted in the northern foothills of the al-Hajar mountains before; therefore, a broad gap in research could be filled.

The aim of the archaeological project is to determine the chronological dimension of the oasis settlements and to describe the sequence of occupation in the study area. Not only settlements were integrated in the study, but also tombs, irrigation systems, towers, protective walls and rock art.

With reference to historical periods, archaeological findings are a supplement to the knowledge on the history and social structure, which could be gained by the orientalists in the

research group from historical reports and documents in archives (e.g. in al-Hamra).

Agriculturalists participating in the project have investigated the agricultural potential and the bio diversity in the region by studying ecological resources, such as the availability of water and the quality of the soils, further the impact of man on the environment in improving natural conditions, for example, with irrigation systems or manure. The question of the interrelationship between agriculture in the oases and the keeping of animals by semi-nomads is of great importance in this special case.

Architects and urban planners have dealt especially with the development of the architectural structure of the oases in their topographical situation during the last 300 years as well as with the comparison of rural and urban settlements.

Methods of Investigation

Different methods were used in the study of archaeological sites. The survey was prepared with the help of aerial photographs scaled 1:20,000, which were examined in respect to archaeological remains. They were also used in addition to a Global Positioning System (GPS) as a basis for mapping, since the existing topographical map scaled 1:100,000 is not exact enough to map the archaeological remains accurately. The aerial photographs were set in a mosaic for this purpose, which is the map base for the Internet-GIS (see below).

Pottery was collected from different archaeological sites during the survey. The sherds were determined in respect to ware, shape and date and statistically processed in a database. Not only prehistoric pottery sherds were registered, but also Islamic material, since this was generally almost neglected in previous research projects.

Architectural remains at selected sites were recorded using large-scale aerial photographs that were taken from a helium-balloon at a height of 300-1,000 m above the ground. The photographs were made with a normal camera. The ground plan of the buildings was drawn with the help of these images, which had been previously rectified. Afterwards the plans were controlled on the ground.

The architecture of the inhabited settlements, al-Hamra and Balad Seet, was measured and drawn by hand to determine the structure of the buildings. The ground plan of these settlements was also mapped and analysed with the help of the rectified photographs. Based on these plans rural and urban structures can now be compared with one another and the development of house types can be observed and defined.

Interviews with the inhabitants of the oasis settlements have provided information on the internal division of the houses, the use of each room as well as the inventory.

Orientalists from Tübingen received permission to study an older archive in al-Hamra, which contains various documents and letters that provide insight into economical and political conditions. The documents were photographed and registered and are now being analysed from different aspects.

The focus of the agriculturalists is the estimation of agricultural production and carrying capacity of oasis settlements and their surroundings. This group produced the large-scale photographs mentioned above and utilized them together with a differential GPS for mapping agriculturally arable land and the radius of grazing grounds for sheep and goats. These spatial data were connected with related attribute data (e.g., the kind of agricultural products) and analysed afterwards.

Results of Archaeological Investigations

Occupation of the region under study started during the early Bronze Age around 3000 B.C. It probably served as grounds for grazing. No settlements were found, but burial tombs were discerned that can be dated to the 3rd and 2nd millennium B.C. (Häser 2003).

The oldest settlement remains are evidenced from the early Iron Age period around 1000 B.C. Settlement activities were probably closely connected with the use of a new irrigation technology. Only this "falaj"-technologie made crop cultivation and planting of date palms possible in that region (Häser, in press).

Settlement occupation was continuous since the early 1st millennium B.C. Diverse ecological conditions led to differences in the regional settlement development. While the settlements in the al-Hamra region shifted - probably due to shifting irrigation systems - the settlement occupation in Wadi Bani Awf remained in one particular place, the Balad Seet, where an abundant and stable outflow of springs ensured a constant water supply until the middle Islamic period between the 11th and 16th century A.D. (Nagieb, Häser, Siebert and Buerkert, in press).

A change in the occupational structure was enforced by investments of the new Ya`ariba dynasty starting in the first half of the 17th century A.D. A new irrigation channel was built in al-Hamra, which made a shift in settlement to an area that was never occupied before possible. Some small oases settlements were also established in the Wadi Bani Awf during the same period, which met the requirements of newly built irrigation channels. It can be assumed, that these investments were also granted by the Ya`ariba dynasty to encourage the tribes in that region.

Only with the oil boom since the 1970s has the settlement structure changed again due to modern roads, different construction techniques of houses, supply of electricity and use of water pumps.

Design and Use of the Internet-GIS

During the investigations outlined above all project partners prepared various material and numerous documents to describe their research results. The primary objective of the Internet-GIS is to support both publication and dissemination

of this documentation, not only for the scientists involved in the project but also for the broader public. Using the Internet, new results can be incorporated without delay, and all information can be retrieved world wide. The user only needs access to the Internet, although display of the interactive map requires an additional browser plug-in, which is available free of charge.

The Internet-GIS and its major component - the dynamic map - is accessible via the project homepage http://www.dainst.org/index.php (search for "Oman" and/or "Oasensiedlungen"). Building an overall structuring frame, the website includes different parts of documentation, e. g., a general project outline, a map, an index of archaeological sites or contact information.

The digital map serves as an orientation base and includes the underlying spatial structure (e. g. surface topography, road and path network, land use) as well as archaeological sites. Further explanatory material such as text documents or photographs are referenced via incorporated hyperlinks (visualized as site number and/or cartographic signatures).

In absence of an appropriate map of the survey area, coloured aerial photographs (scale of 1:20,000, taken in 1985) were used for digitization. Following a graphic rectification (using Autodesk® CAD Overlay® 2000), based on the topographical map "Rustaq 1:100,000", the clearly visible settlement areas, the road and path network and the drainage system were digitized (using AutoCAD Map® 2000). A conventional CAD drawing (*.dwg vector file format) with thematically separated layers was the result.

All relevant data associated with archaeological sites, such as geographic coordinates and further information regarding type and date, are stored in a relational data base (Microsoft® Access 97).

The linkage between spatial objects (e. g., archaeological sites) and the related attribute data (e. g., site names) was realized within the CAD drawing file, which had to be connected with the relational database. The linked objects were exported and saved in a specific spatial data file format (*.sdf), which in turn was used as input for the dynamic map.

The software package Autodesk® MapGuide® is a Geographical Information System, which supports the compilation of complex, static or dynamic maps to be used via Internet. The exported spatial files, connected with attribute data, were put together in a so-called map window file (*.mwf). Each source file (*.sdf) already corresponds to a thematic map layer in the map window file and may be configured static or dynamic.

According to user requirements each layer can be switched on or off. If a layer is configured as a dynamic layer, each request will initiate an update based on the current state of the connected data base.

Different zoom levels and navigation tools allow selective views showing either an overview or details. Further tools are available to calculate area sizes or distances. Buffers can be created to define specific catchment areas, for example, to determine the range within tombs are located around settlements. These buffers can be saved automatically on a separate layer for further analysis.

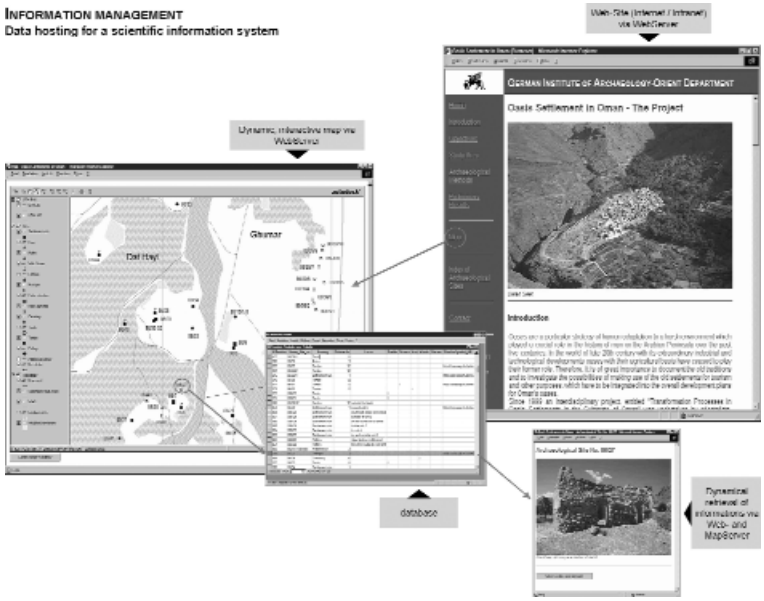

Figure 1 Information Management, Data Hosting for a Scientific Information System

Additional information such as site descriptions, charts and photographs can be prepared as separate HTML documents, which will facilitate easy updating. Photographs were scanned from slides and saved in the graphical *.jpg format. The resolution was optimized for screen display (72 dpi), which also minimized memory capacity. Access to these additional documents is provided via hyperlinks incorporated in the dynamic map.

The development of an Internet-GIS and all its components requires appropriate software. In this case the following software packages were used: the CAD program AutoCAD Map®, the database Microsoft® Access, the GIS system Autodesk® MapGuide® (including MapGuide Server, MapGuide Raster Workshop, MapGuide Author), the web server Microsoft® Internet Information Service, and the image-editing software Adobe® Photoshop. To host all data an adequate server with sufficient working and storage memory capacity is required.

On the client's side a common web browser (e.g., Microsoft® Internet Explorer, Netscape® Navigator) and a browser specific plug-in or ActiveX® control is needed; java script must be enabled.

The Internet-GIS described above is accessible for everyone without any restriction. However, if necessary, single parts of the documentation can be protected so that access is limited to authorized persons, e. g., project participants. Browsing through the Internet-GIS, the user can retrieve the documen-

ted results of the whole archaeological survey in terms of type of site and date.

Conclusion

An Internet-Geographical Information System was established for the interdisciplinary project "Transformation processes in Oasis Settlements in Oman", which enables the various working groups to retrieve interactively the results and the latest state of processing of the archaeological survey via Internet. It is planned to integrate the results of the other project partners in a future stage of work.

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