

DIGITAL REPRESENTATIONS OF THE RHINE RIVER VALLEY BETWEEN BINGEN AND KOBLENZ

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ABSTRACT:

For 65 kilometers, between Bingen and Koblenz, the Rhine River flows through a deep valley. This area, called the Upper Middle Rhine Valley, contains extraordinary historical evidence of art, history, and the interaction between man and nature. The presence of this virtually intact, valuable evidence is the reason why the local authorities have nominated this cultural landscape for inclusion to the UNESCO World Heritage List. The nomination will be examined at a session of the World Heritage Committee in Budapest in June 2002. UNESCO has encouraged the nominants to supply new forms of spatial presentations of potential sites, and in particular geographic information systems. This paper summarises how landscapes can be stored and presented in digital form and shows several pilot systems which are of special value for the digital representation of the Upper Middle Rhine Valley.

1 THE UPPER MIDDLE RHINE VALLEY

1.1 Geology and Valley Dimensions

This part of the Rhine River Valley was formed in the last ten million years by the river cutting its way through the Rhenish Schist Mountains whose formation began about 65 million years ago.

Between Bingen and Koblenz (Coblence) the river flows through a deep valley, losing 16 m in elevation over the 65 kilometer distance (cf. Fig. 1). On average it is 300 to 400 m wide, but the width may reduce to less than 250 m at narrow places. Predominantly, the valley bottom is not much wider than the river itself, giving just enough room for a railway line and a road on either side. Settlements could only develop at places where the valley bottom is wide enough or where side rivers join the Rhine River.

The flanks of the valley, covered with forest or vineyards, are very steep and slope at an angle up to near 45 degrees at heights up to 300 meters.

1.2 History

Human presence along the river is documented well back to the early Iron Times (Hunsrück-Eifel Culture) but the Romans, who occupied the area for five centuries starting around 50 BC, were the first ones to use the river for transportation. They also built a road along the left side of the river and introduced the cultivation of grapes for wine production.

During the Middle Ages, settlements were founded and expanded. Many impressive buildings, especially churches, were erected. In the late Middle Ages, when the area was fragmented among many sovereign states, more churches and most of the more than 40 castles along this stretch of the river were built.

In the 19th Century, a romantic view of this part of the Rhine River developed. The area close to and containing the river was viewed as a typical German landscape. The ancient buildings were considered as cultural heritage monuments and many old castles and ruins were restored. The draw of tourists

began at this time already. The hotels built during this period are still characteristic of the region.

In the 20th Century, 75 percent of the former wine-growing areas were laid fallow, resulting in the gradual progression from low-lying brush to forest land. Since major industrial activity did not significantly develop in this part of the Rhine Valley, settlements did not grow as fast as elsewhere. Thus, with few exceptions, the landscape is still characterised by the patterns developed in the past. Tourism is the main source of income - another reason to protect this cultural landscape and to control its further development.

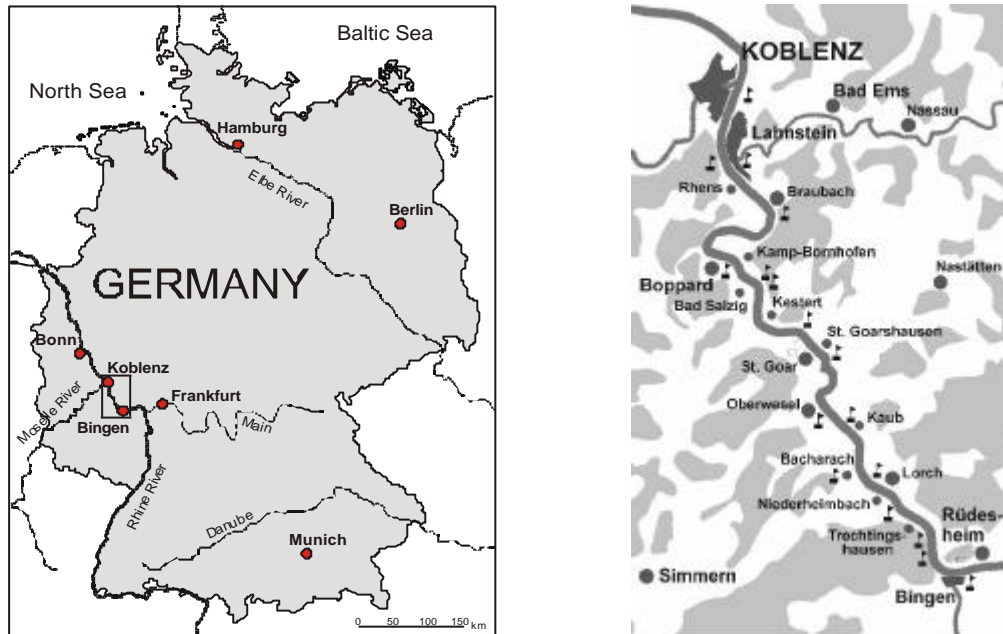


Figure 1: The Upper Middle Rhine Valley is located between Bingen and Koblenz

1.3 Ecology

The climate (dry and warm) and the land cover (bush, wine terraces, groups of historical buildings) distinguish the Upper Middle Rhine Valley significantly from the surrounding landscapes. The flora and fauna are unique. They show a large diversity and include rare and even endemic species. More than 30 percent of the area is under ecological protection.

2 INSCRIPTION ON THE WOLD HERITAGE LIST

2.1 Nomination

The Governments of Hesse and Rhineland-Palatinate have asked UNESCO to inscribe the Upper Middle Rhine Valley on the UNESCO World Heritage List. The nomination has been registered at the World Heritage Center (N/C 1066) and will be examined by the World Heritage Committee at its 26th session in Budapest in June 2002.

2.2 Argumentation

The proponents argue that the Upper Middle Rhine Valley is an outstanding example of a cultural landscape which has, throughout history, experienced steady and slow, yet ongoing, development. It comprises extraordinary evidence of art, history and the interactions between man and nature. Its past is closely associated with the spiritual, and especially the artistic and literary, aspects of life in Europe.

Located in the heart of the Continent, the Rhine Valley exemplarily reflects the history of the Occident, sometimes constituting a borderline, at other times a bridge, between cultures. Esteemed architectural monuments have survived here in a variety and density which cannot be found in any other European cultural landscape. The Romantic era in European history is closely associated with this part of the Rhine

River. The impressive natural appearance and the remarkable ecosystem are also quoted to substantiate the inclusion on the World Heritage List (Proposal, 2001).

3 REASONS FOR DIGITAL REPRESENTATIONS

3.1 Improved Methods for Documentation

Regarding the new category of cultural landscapes, the experts of the World Heritage Committee have expressed appreciation specifically for the subjective elements of landscape perception (de Jong 2000). Poetry and arts play an important role, especially when the associative aspect of a cultural landscape is concerned. A metric and scientific description of a landscape is needed, however, to explain a landscape's development and to understand and manage its present and future conditions. This is especially true for the category of 'continuing landscapes'. An extensive documentation of the heritage is needed for the design of the future development of large and complex landscapes like the Rhine Valley. The opportunities offered by new technologies to simulate the future of a cultural landscape are even more important.

Since a textual description is too abstract to give a clear understanding of topographical features, maps have been used throughout history as an abstraction of the real world. The field of cartography has developed high standards but it cannot overcome certain limitations such as a fixed scale and a limitation to two dimensions which only allow a 2½D-representation, e.g. in the form of contour lines. Since space is restricted on a map sheet, the number of themes has to be limited to one. This limitation makes combining and simultaneously comparing several aspects to come to new conclusions (e.g. topography, soil, and vegetation to predict erosion) relatively difficult. Due to limited space and a fixed scale, only a selection of the information available can be shown, making it necessary to rely on additional sources (books, larger scale maps) if more detailed information is needed.

The advent of information technology has created new tools, such as digital elevation models and geographic information systems (GIS) where all information about a landscape can be stored and managed in one single data base. Since a common reference system is used, any theme or combination of themes can be retrieved and presented in textual or graphical form. The potential of such a system exceeds by far the limited possibilities of printed documents.

3.2 New Possibilities for Publication

Numerous books have been published about a landscapes like the Rhine Valley. No matter how beautiful (and expensive) they are, each one can only show a limited degree of detail. If more information is needed, additional sources have to be consulted.

If all available information is available in a GIS published on a CD-ROM (or DVD or similar) or in the Internet, the cost of publication, and even more so the cost of access, are much cheaper than the use of printed media. Any user, from an expert to an interested layman, can quickly select and retrieve the data to the level of detail that he or she is interested in. Thus, the valuable information is not hidden in specialist libraries. Such easily accessible data sources will motivate young people and students with good computer knowledge to reflect on the landscape and to develop a sense of responsibility for its future development.

Digital information can be animated to images travelling through space or time. Since videos of this kind are both informative and entertaining, they are ideally suited to attract people to local information centers.

3.3 UNESCO Suggestions

After UNESCO had introduced legal instruments to recognize and protect cultural landscapes of outstanding universal value (UNESCO 1972, 1999), and several cultural landscapes were included in the World Heritage List, it was soon realized, that "the resources management, e.g. the management and protection of the cultural values for which these sites have been inscribed, has to be improved" (Roessler 2000). It is obvious that surveying and mapping procedures, based on sufficiently complete and updated databases, are needed to document and monitor the sites and to allow predictive modeling of future developments. The role of GISs is of special importance in this context (UNESCO 1999), and the parties who made nominations (e.g. the Upper Middle Rhine Valley) which will be examined at the 26th session of the World Heritage Committee (Budapest, June 2002) have been asked to supply new forms of

presentations, particularly geographic information systems, as models for the future revised format of nominations (UNESCO 2001).

Especially in the case of 'continuing landscapes' (UNESCO 1999), where a large number of authorities and private owners may have to co-ordinate their actions, and political decisions have to be prepared and mediated, a GIS is a valuable tool for planning and modeling future developments. Changes within the landscape or in its neighborhood may impair or even destroy its cultural value. This is why UNESCO demands these tools for "reactive monitoring" and "periodic reporting" to ensure that World Heritage Sites remain undestroyed and can remain on the World Heritage List.

4 TYPES OF DIGITAL REPRESENTATIONS

4.1 Geographic Information System

Basic GIS. As a minimum requirement, a basic 2D GIS should be available. For a cultural heritage landscape, the basic topographic, cultural and administrative features within the core and buffer boundaries should be included in this database. All information must be geo-coded in a common reference system. Usually, coordinates will be given in the local land survey system. Since any coordinate transformation can be modeled by mathematical formulas, a GIS can easily provide additional coordinate references such as the geographical coordinates of WGS84 which is used with GPS equipment world-wide.

From the many GIS software products available UNESCO has chosen ESRI's ArcInfo format as a standard for cultural landscapes of the World Heritage List (UNESCO 2001).

Thematic diversity. Numerous research projects have been carried out for a region like the Rhine Valley by different disciplines (geology, fauna, flora, forestry, agriculture, urban development, environmental sciences, etc.). A GIS can have tremendous value, if all this information is retrieved from the archives and input to the system. This can be a very time-consuming process since many studies do not contain a precise spatial reference. Future research projects should be funded on the condition that their results meet the standards for inclusion into the GIS.

4.2 Further Variations

See figure 2 for this section.

2D, 2½D, 3D. Elevation information is essential to document and to understand a landscape. Analogue 2D maps usually use contour lines for this purpose. Digital databases store elevations in the form of digital elevation models (DEM), which allow automatic investigations (elevation zones, drainage, aspect, slope) as well as the creation of contour lines, perspective views and virtual flights.



Figure 2: Time reference, geometrical dimension and abstraction level define different aspects of a GIS

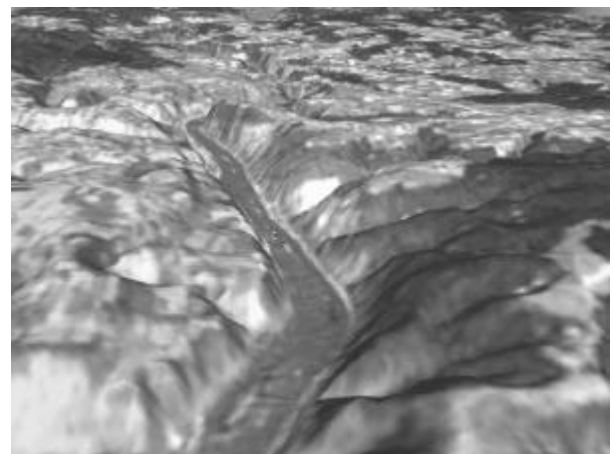


Figure 3: Rhine Valley near Kaub. (Virtual landscape based on a DEM and a LANDSAT TM image)

Since only one elevation is supplied for a point, such a "2½D" DEM system is limited to topography. Buildings, containing many vertical elements, can only be modeled in a true 3D system. 3D systems can be constructed, but it is a tremendous task to model large settlements, e.g. a complete city.

Extent of Abstraction. An information system can only contain a model of the real world. Therefore, rules for the necessary abstraction process have to be defined before the database is created.

If topographic features are documented merely by texts, only a limited perception can be obtained by the reader. This is why maps are used. They also have a high level of abstraction, since small geometric features are omitted, reducing the real-world features to symbols and colors which are explained by short texts inside the map frame or in a legend. The advantage of this approach is the option to show features that are too small to be visible (such as a small monument) or even invisible (such as the classification of a road) on a photo-realistic view. A GIS database uses the same abstraction techniques but can include much more information since it does not have the restriction of a map where only a certain amount of information can be shown in the available map sheet area.

Photo-realistic landscape representations can be obtained as aerial photographs or satellite imagery. Obviously, they have a different and less abstract nature as compared to maps. Semi-realistic presentations can be achieved if map features (symbols, transparent colors) are combined with digital image information.

A GIS can contain and link information of any level of abstraction and offers the possibility of presenting any selection or combination of data in textual or graphical form.

Multi-temporal systems. A landscape represents not a state but a continuous process. Therefore multi-temporal GISs are desirable because they store and present past and future situations and developments over time.

If the geological development is to be modeled, changes to the DEM caused by uprising, eruptions, sedimentation or erosion are required. Software for the modeling of DEM changes has been developed at i3mainz since it is not possible using commercial GIS packages (Böhler et al., 1999).

In landscapes, changes usually materialize in the form of land cover changes due to variations in environmental conditions (mainly climate) and human impact (deforestation, agriculture, settlement, infrastructure). GIS producers have not really solved the problem of time as a fourth dimension of spatial information. However, if historical situations are included in a GIS as additional layers, a satisfactory representation can be achieved.

Changes occurring in landscapes have to be permanently incorporated into the system to keep it updated. Before the system is set up it must be established whether updates will replace current files or if all files have to be maintained to gradually create a multi-temporal system.

Furthermore, future landscape conditions can be simulated and visualized using digital systems. Visualization of alternatives and simulations is a valuable tool for planning and decision-making. Time-dependent changes can also be presented as videos.

5 DIGITAL REPRESENTATIONS OF THE RHINE RIVER VALLEY

Since UNESCO has suggested the delivery of a model nomination for the Upper Middle Rhine Valley (UNESCO 2001), i3mainz proposes solutions which are especially suited to meet the conditions of this area:

5.1 Basic GIS

Basic GIS components, ATKIS and ALKIS, are already available from the local surveying authorities. To prepare the UNESCO proposal this information has already been converted to ArcView shape files. It can be transferred to the ArcInfo format (as suggested by UNESCO), thus giving a basis which can be used for any GIS analyses and presentations.

5.2 GIS Extensions

Thematic extensions (additional layers or coverages) can be created by digitizing and geo-referencing the large variety of available investigation data, especially those concerning flora and fauna. Before this task is started, a meta-data concept should be established.

Additional text and photo information should be supplied for the most important natural and cultural features within the GIS, following a suggestion by UNESCO.

5.3 Virtual Landscape



Figure 4: 3D symbol of a castle (Burg Stahleck)

A person on the ground can view only a very limited part of the Rhine Valley at a time. An overall view of this breathtaking canyon can only be observed from locations far above ground surface. The creation of a virtual landscape model based on the DEM (which is currently available) and on recent aerial images will allow one to look at the scene from any virtual observation point (cf. Fig. 3) and to undertake virtual trips along the valley. Significant building structures, such as the numerous castles, can be added as 3D symbols (Holtkamp 2000, cf. Fig. 4) since they are not satisfactorily portrayed in the 2½D model.

Any thematic layer can be draped over the DEM in the same way as is done with the aerial photographs, allowing the judgement and the evaluation of the context of thematic information and terrain relief. A semi-realistic visualization is possible if the thematic information is draped in transparent color over a gray scale aerial photograph (cf. Fig. 5).

5.4 Simulation of Future Development

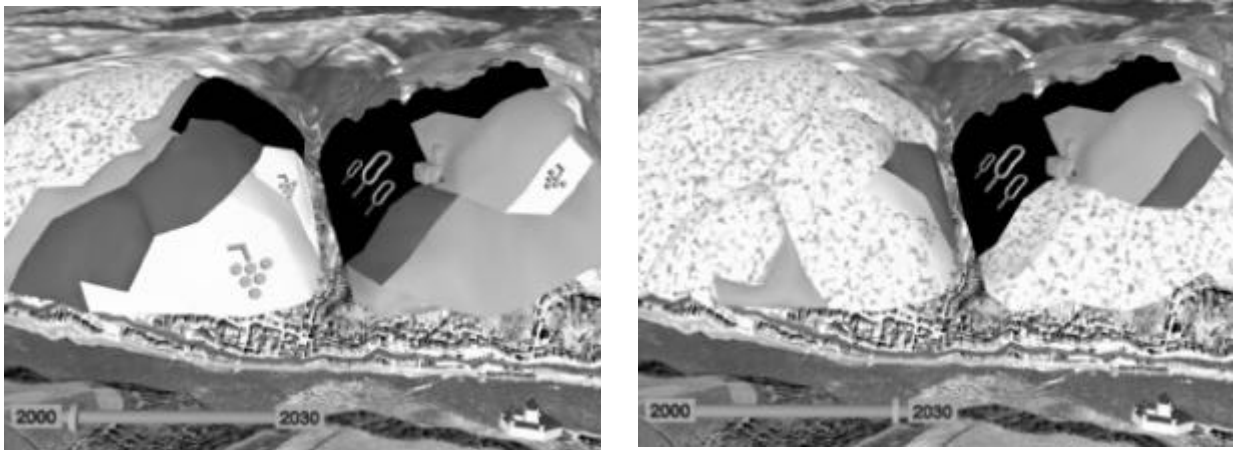


Figure 5: Land cover near Kaub, present situation and one of the planning alternatives for 2030. Original uses transparent colors covering a perspective view based on a digital elevation model and a grayscale aerial photograph.

Predictive modeling should be applied to any region. This is of even greater importance for a complex landscape whose region is inscribed on the World Heritage List. Based on the present geometry, any developmental alternatives can be incorporated into the GIS and displayed as thematic maps or perspective views (cf. Fig. 5).

With appropriate software it is even possible to simulate photo-realistic views of future situations.

5.5 Documentation of Former Development

An interdisciplinary project is recommended to investigate the genesis of this outstanding area. Luckily, all land cover and infrastructure changes can be digitized from historic maps extending in time to nearly 200 years before present. All results of such research should be collected and incorporated into the GIS system. This would help to understand the past processes, and would, in turn, support future planning.

Finally, i3mainz suggests that the geological processes that formed this landscape (uprising, erosion) should be modeled and animated.

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