Remote Sensing in Transition, Goossens (ed.)
© 2004 Millpress, Rotterdam, ISBN 90 5966 007 2

The benefits of remote sensing for conservation and monitoring world heritage sites

Philippe De Maeyer[(1)], Leen De Temmerman[(2)], Peter Bogaert[(3)] Liesbeth Vansteenvoort[(4)] , Rudi Goossens[(5)], Marc Binard[(6)]
[(1,2,3,4,5)] Ghent University, Geography Department, Krijgslaan 281 (S8), B-9000 Gent, Belgium
[(6)] Université de Liège, Labo SURFACES, Allee du 6 aout, 1, B-4000 Liège, Belgium
Philippe.DeMaeyer@UGent.be, Leen.DeTemmerman@UGent.be, Peter.Bogaert@UGent.be
Liesbeth.Vansteenvoort@UGent.be, Rudi.Goossens@UGent.be, Marc.Binard@ulg.ac.be

Keywords: GIS, cartography, world heritage, map serving, website, D.R. Congo

ABSTRACT: Through the joint effort of UNESCO, OSTC Belgium, Geography Dept, Ghent University and SURFACES Laboratory of Geomatics Dept, Liege University, a demo project to conserve five World Heritage sites was launched. For this project an internet site was created. This website aims to demonstrate the usability of remote sensing and GIS for cartography and land cover change studies of World Heritage sites to a wide public audience. Both basic cartography and land cover change studies are needed to support the World Heritage site management and conservation. The five World Heritage sites chosen for this demo project represent a wide variety of natural or cultural/historical characteristics: tropical forest, savannah and coastal area for the natural sites, a European historic centre and an Islamic city for the cultural sites.

1 INTRODUCTION

The Convention Concerning the Protection of the World Cultural and Natural Heritage is an international agreement, adopted by the General Conference of UNESCO (United Nations Educational, Scientific and Cultural Organisation) in 1972. Thus far, more than 175 State Parties have signed the convention. Under the World Heritage Convention, cultural heritage is defined as a monument, group of buildings or site of historical, aesthetic, archaeological, scientific, ethnological or anthropological value. Natural heritage designates outstanding natural features, geological and physiographical formations and natural sites of outstanding value from the point of view of science, conservation or natural beauty. Cultural and natural sites represent a common heritage, to be treasured as a unique testimony to an enduring past.

In 2002, UNESCO celebrated its 30th anniversary. This event coincided with the 30th anniversary of remote sensing – it has been exactly 30 years since the first satellite for earth observation purposes was launched. The concurrence of both these anniversaries has led to a joint initiative of UNESCO and OSTC (Federal Office for Scientific, Technical and Cultural Affairs) Belgium to start up a demo project.

For this demo project, funded by OSTC Belgium and in cooperation with the Geography Department of Ghent University and the SURFACES Laboratory of the Geomatics Department of Liège University, five World Heritage sites were selected and assessed.

The aim of this project is to demonstrate the benefits of remote sensing and GIS for World Heritage Conservation to a broad public. Rapid progress has been made in the development of research techniques and the application of remotely sensed data combined with GIS. The field of cartography is one area that has greatly benefited with the rapid development of remote sensing, with major cuts in map production time and cost inputs of the past era. Remote sensing and GIS have led to recent advances in the production of satellite image maps, which represent the current scenario on the ground and can even be used in emergency situations. Within the field of conservation, remote sensing and GIS can contribute significantly towards establishing the biodiversity status of different habitats on a coarse scale, thus highlighting ecosystems needing higher conservation priority. With this in mind, World Heritage sites have been identified by their respective countries as areas requiring greater conservation efforts, with some needing total preservation. Remote sensing and GIS techniques can therefore be applied to accomplish these goals leading to the sustainable management of these sites through the provision of up-to-date terrain data.

In summary, the objective of this project is to demonstrate to a wide public audience the usefulness of remote sensing and GIS to:

- provide a basic cartography of each site and of its 'buffer zone';
- detect the land use changes in and around the site during the last 10 to 20 years;
- monitor the state of conservation and improve management of World Heritage sites.

2 SITE SELECTION

For this demo project, two cultural and three natural World Heritage sites were selected. These sites were selected based on the following criteria:

- diversity,
- representativeness,
- availability of satellite images and other data on the sites at OSTC.

The three natural sites are Niokolo-Koba National Park (Senegal), Virunga National Park (Democratic Republic of the Congo) en Hay Long Bay (Vietnam).

Niokolo-Koba National Park, situated in south-eastern Senegal, was inscribed in 1981 as a World Heritage Site. The park holds a typical savanna ecosystem with gallery forests along the Gambia River, hosting a remarkable diversity of mammals.

The Virunga National Park is the oldest and most famous park in the Democratic Republic of the Congo. It was established for its spectacular landscapes, including active volcanoes and the Ruwenzori mountains as well as its amazing richness in biodiversity, including one of the remaining populations of the rare mountain gorilla. The park was inscribed on the World Heritage List in 1979.

Ha Long Bay, located in the North of Vietnam, includes approximately 2000 islands and islets forming a spectacular seascape of limestone pillars. Because of their precipitous nature, most of the islands are uninhabited and unaffected by man. The exceptional aesthetic value of this site is complemented by its great biological interest.

The Medina of Marrakesh (Morocco) and the historic center of Warsaw (Poland) were selected as cultural world heritage sites.

Marrakesh, a major city of central Morocco, is a fascinating and very lively city just on the border of the desert. The Medina contains an impressive number of remarkable examples of Islamic architecture: the walls built in 1126-1127, the Kutubiya Mosque with its unsurpassed minaret, the Ben Youssef madrasa, Saadian tombs, palaces and characteristic old houses. The Medina was designated as World Heritage site in 1985.

Warsaw is the capital and largest city of Poland. Its 18th-century historic centre was destroyed for over 85 percent during the Second World War. After the war, a five-year reconstruction campaign resulted in today's meticulous reproduction of the Royal Castle, churches, palaces and the market place, the symbols of Polish culture. This exceptional example of a total reconstruction of a span of history from the 13th to the 20th century was inscribed as a World Heritage site in 1980.

3 METHODOLOGY: CREATION OF THE WEBSITE

In order to reach a large audience and to meet the objectives of this project, the creation of a website was chosen. While creating this website, it has to be considered that the website should be usable all over the world, by as many people as possible. This implies bearing in mind differences in connection speed, computer systems, screen resolutions,... in such a way that all users can easily, quickly and efficiently access the website.

The connection speed to the internet can vary a great deal. People who have a slow connection (e.g. 28.000 bps) might have to wait over half an hour to view a website of one megabyte in size. A user with broadband connection can view the same page in just a few seconds. To minimize the website size and make it more accessible, compressed image files can be used. For thematic maps and figures with few colors, the lossless GIF format is widely used. For illustration and pictures it is better to use the JPEG format. The resolution of the images should also not be bigger then 72dpi, because the computer screen does not show more this resolution. Besides a possible slow internet connection, people sometimes experience very expensive satellite connections, which are often the only available connection in developing countries. These two aspects –slow or expensive connection- require that the website size is as small as possible.

To make sure that the website is user friendly, only horizontally scroll possibilities are acceptable. To prevent vertically scrolling, it has to be made sure that the inserted tables and figures are not wider then the maximum screen resolution of a visitor (e.g. 640x480, 800x600, 1024x738…). Adaptations of the image and table sizes can be made interactive by using script languages (JavaScript, ASP, etc).

Besides the possibility of reaching a broad public, the use of a website offers another major advantage, namely the opportunity to use mapserving technology. Through mapserving maps can become interactive: people can zoom and pan on the images. A dynamic webmap can give a lot more information than a static map by querying information on different map layers. Visitors can also assemble their own map by selecting which information layers they wish to see. In addition the mapserver enables that the

images it produces are optimized for the web. The MapServer used in this project was originally developed by the University of Minnesota (UMN) ForNet project in cooperation with NASA and the Minnesota Department of Natural Resources (MNDNR). The MNDNR and the Minnesota Land Management Information Center (LMIC) made additional enhancements.

4 THE WEBSITE: STRUCTURE AND EXAMPLES

4.1 *Structure of the website*

Globally, the website is structured as followed: 'Home','WHP', 'The Project', 'Remote Sensing and GIS', 'Cartography', 'All WHP Sites' and 'About'.

In the component 'The Project', for each of the five World heritage sites, six items were detailed: Brief Description, Location and Cartography, Problems and Risks, Use of Remote Sensing and GIS, Change Detection and Links to other websites.

The 'Brief Description' section gives a brief explanation of the site. In 'Location and Carto-graphy', a description of the location and other cartographic information of the site is given. A detailed map of the site can also be viewed. Some of the maps are interactive with the user simply selecting a preferred layer. The phenomena that threaten the site of its natural or cultural value are described under 'Problems and Risks'. Under the section entitled 'Use of Remote Sensing and GIS' the applications of GIS and remote sensing for the better management and conservation of the site are illustrated. How remote sensing and GIS can also be useful in detecting changes on the site is illustrated in 'Change Detection'. Besides these five major sections, there is also a section entitled 'Links', where a list of interesting websites related to the subject can be found. Examples of the five sites can be found in the fifth section of the paper. On the web pages concerning the selected sites, specific examples of remote sensing and GIS use for the conservation and monitoring of World Heritage sites are given. More general information about the advantages of remote sensing, GIS and cartography is presented in 'Remote Sensing and GIS' and 'Cartography'.

4.2 *Result: Examples from the website*

The results of the project are shown in the form of examples listed below. These are taken from the website and represent the five categories listed in section 4.1. Each subsection covers an example of one of the World Heritage sites. More information is included on the website.

4.2.1 *Location and cartography*

Niokolo-Koba National Park

The Niokolo-Koba National Park is situated in south-eastern Senegal, mainly in the Tambacounda region and a smaller part in the Kolda region. The border of the park is demarcated by an international boundary with Guinea in the south-west, and the river Gambie in the north-west and also to the south-east. The park stretches from 12°30' to 13°20' north latitude and from 12°20' to 13°35' west longitude.

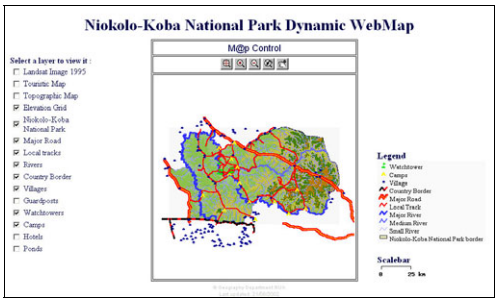


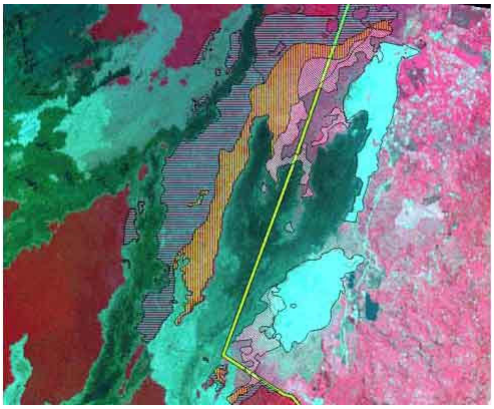
Figure 1. Dynamic webmap of Niokolo-Koba National Park

4.2.2 *Problems and risks*

Virunga National Park

The crisis that has gripped the Great Lakes' region in Africa for about 10 years impacts upon all aspects of society. The region's fauna and flora are no exception. The economy is in a desolate state and the population has become extremely poor, some people survive by poaching animals within protected areas and by unsustainably harvesting the timber resources (e. g. through the production of charcoal, illegal trade in precious timber etc.). Park guards were disarmed in November 1996 and due to lack of operational funds (some guards have not received their salary for several years), poachers and other people whose actions negatively impact on the park's resources are at an advantage and can operate easily.

An important negative impact on the park's biodiversity has been observed between 1994 and 1996, when Rwandan refugees arrived en masse on Congolese territory (former Zaire), and were settled in the vicinity of Virunga National Park. Several hectares of forest were subsequently cleared within a short period in the park. Village forest plantations (woodlots) were also cut before the trees reached maturity and the wood was sold in the refugee camps. Consequently, the entire region of North Kivu has been virtually deforested. (figure 2)




Total deforestation


Strong deforestation


Weak forestation

Figure 2. Deforestation in 1996 (Two Years after the arrival of the refugees) Image type: SPOT, Credits: I-mage

The negative impact political events in the region have had on the fauna are enormous. This is illustrated by the numbers of hippopotamuses that decreased from 10 000 in 1990 to fewer than 4 000 in 1996. For these reasons, Virunga National Park was inscribed on the List of World Heritage in Danger at the 18th session of the World Heritage Committee (1994).

Through the war, the park lost almost its entire infrastructure and does not have any means of generating its own revenue. Tourism activities in the central part of the park ceased since 1996. Gorilla tourism, which generated a considerable income for the park has been discontinued since August 1998. The rationale for tourist visits is to assist gorilla conservation by generating revenue from them. The money spent by tourists is used to pay the wages for the park guards and is invested in the management and protection of the park. Many other people profit from the tourism business. Tourism can generate important resources for gorilla conservation on the condition that it is organized in a careful way. Approaching the gorillas too closely, for example, increases the risk of transmitting diseases. Another risk has become evident over the last few years: gorillas habituated to people can be tracked down and killed by poachers much more easily. Therefore, it is often the habituated groups that are killed first.

4.2.3 *Use of Remote Sensing and GIS*

Virunga National Park

The satellite image (figure 3) shows three volcanoes in the southern part of the Virunga Massif. Notice the white spots, with a black border on the right side of the image. These are clouds, and the black is the cloud shadow. On this image, the abrupt change of dense vegetation (reddish brown) to sparse vegetation (blue) is clearly noticeable. This is an example of how by using remote sensing images, the boundary of the park can be detected and mapped. The green line indicates the Virunga National park boundary.

Figure 3. Virunga National Park Boundary

The satellite image in figure 4 is taken by ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) in the Goma region. The image covers the Nyiragongo volcano, which is situated in Virunga National Park and is one of Africa's most active volcanoes. The town of Goma is at the bottom of the picture, visualised in blue. Blue symbolises habitation, green, vegetation and white are clouds (the black borders are the shadows of the clouds). The image was taken shortly after the eruption of the Nyiragongo volcano in January 2001. At the bottom of the image we can clearly see the stream of lava (symbolised by red), which goes straight through the city of Goma.

Figure 4. Aster Image Nyiragongo volcano (source: Aster website)

A 3D-model of the volcano can be made based on the ASTER image. These 3D models are easy to understand and interpret.

4.2.4 *Change Detection*

Medina of Marrakesh

Satellite imageries are useful to assess the growth of the city of Marrakesh. The comparison of the Corona space photograph acquired in 1965 (figure 5) and the QuickBird image acquired in 2002 (figure 6) highlights the change occurred during the last 37 years.

Figure 5. Corona 28/05/1965

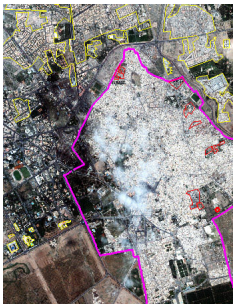


Figure 6. QuickBird 21/04/2002

The "medina" is delimited by ramparts (purple line), while new buildings are shown in yellow outside of the "medina" and in red inside.

New constructions are mainly limited inside of the medina, Marrakesh mainly grows to the North. A lot of new luxurious hotels are located just outside of the buffer zone at the south west of the medina along the road to the "Menara".

The growth of the city occurred mainly at the expense of gardens and orchards.

5 CONCLUSION

The website created for this demo project presents a snapshot of the possible applications of remote sensing and GIS for World Heritage Sites. It serves the purpose of this project, namely to demonstrate to a wide public audience the usefulness of remote sensing and GIS for providing a basic cartography of each site in order to be able to monitor the state of conservation and improve management of World Heritage sites. The potential though is unlimited; sustainable management and monitoring of threatened environments and monuments can be accomplished through the combined efforts of the countries concerned working together with research organizations.

Website: http://telsat.belspo.be/whp/