

Managing world heritage sites from space: The BEGO project

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ABSTRACT: This paper provides an overview of the project of the European Space Agency “Building Environment for Gorilla” carried out in collaboration with UNESCO in support of the World Heritage Convention. The project aims at demonstrate the capabilities of Earth Observation (EO) technology to provide reliable, synoptic and continuous information to Natural Park managers, Non-Governmental Organizations (NGOs) and local authorities to monitor and manage world heritage natural sites. This pilot project focuses on five different Parks in Central Africa, which correspond with the “Gorilla” habitat

1 INTRODUCTION

The UNESCO General Conference adopted in November 1972, the World Heritage Convention – WHC (<http://www.unesco.org/whc>). WHC aims to define and conserve the world's heritage, by drawing up a list of sites whose outstanding values should be preserved for all humanity and to ensure their protection through a closer co-operation among nations. By signing the Convention, each country pledges to conserve the WHC identified sites situated on its territory. Their preservation for future generations then becomes a responsibility shared by the international community as a whole. Today, the Convention, under administration of UNESCO, is a success: 174 (as per Aug. 2002) State Parties are Parties to the Convention. These State Parties get together at least twice a year in the meetings of the Bureau and the Committee to approve new inscriptions of sites, to review the state of conservation of the inscribed sites and to agree upon on various other actions dedicated to the conservation of the 730 (as per Aug. 2002) World Heritage sites that are inscribed today on the World Heritage list.

To foster this objective, UNESCO and the European Space Agency (ESA) have proposed to undertake a joint initiative demonstrating the application of Earth Observation and other Space Technologies (e.g. Navigation and Positioning, Communication) in support to State Parties signatories of the Convention. At present, the most urgent tasks are to assist developing countries in fulfilling the main goals of the World Heritage Convention, and to establish a framework of cooperation, open to Space Agencies and other organizations.

As a part of this initiative, UNESCO and ESA initiated the BEGO – Build Environment for Gorilla - project [1] aimed at developing user-oriented information products based on EO technology. BEGO, funded in the framework of the ESA's Data User Programme (DUP)

(<http://earth.esa.int/DUP>), will demonstrate the use of such new services for the gorilla habitat in Central Africa.

The effective conservation activity requires continuous monitoring of the environmental evolution of the area and the availability of adequate maps. The situation in Central Africa is such that accurate maps are not available and the several Non Governmental Organizations (NGOs) assisting the local government in conservation activities are responsible to monitor the status of the environment. There is therefore a need to coordinate all currently existing efforts and to produce base maps that can be used by the local government and the whole conservation community to secure the conservation of these invaluable World Heritage sites. The BEGO project focuses on the development of base maps and change-detection maps to support the work of the different national and international organisations involved in the conservation and monitoring of gorillas. This paper highlights the requirements defined by the WHC and the user community and the preliminary procedures established for the generation of the defined geo-information products.

2 THE AREA OF INTEREST

In particular, an area of interest (Figure 1) was defined encompassing south-western Uganda, western Rwanda and parts of the Kivus situated in Eastern DRC. This trans-boundary area has a number of features shared by the three countries. It comprises the central part of the Albertine Rift, which is the western branch of the Great Rift of Africa, a major hotspot in terms of biological diversity at global scale. The altitude of the region ranges from ca. 1,000m to more than 5,000m. Due to the wide range in altitude, the temperatures and rainfalls are quite variable, but the precipitations follow a bi-modal pattern, with two wet seasons and two dry seasons.

The region harbours a wide variety of habitats, ranging from lowland forests to glaciers, including grasslands, mountain forests, wetlands, inactive and active volcanoes. There are numerous species of plants, invertebrates and vertebrates that are endemic to the area, including some “flagship” species such as the gorilla. The mountain gorilla has a population that is estimated to be approximately 650 individuals, to be found only in two forest blocks; the Virunga Volcanoes massif and Bwindi Impenetrable National Park. This population has been relatively stable over the last decade, despite the insecurity prevailing in the region. The eastern-lowland gorilla is found in several sub-populations in DRC only, most of these sub-populations being severely threatened by habitat loss and direct and indirect poaching.

For more than 10 years, the region has been seriously disturbed by unrest and insecurity, and a number of wars have had devastating consequences both on the human populations and on the environment.

Inside that area, the project focuses on three main World Heritage Sites:

- *Bwindi Impenetrable National Park*, Uganda
- *Virunga National Park*, DRC
- *Kahuzi-Biega National Park*, DRC

In addition to these World Heritage sites, in order to provide a complete coverage of the whole area hosting gorillas, the project also includes two sites that are directly contiguous to the Virunga National Park and that harbour mountain gorillas:

- *Volcanoes National Park*, Rwanda (soon to be nominated as a World Heritage Site)
- *Mgahinga Gorilla National Park*, Uganda



Figure 1. Area of interest of the BEGO project

3 THE USERS AND THE USER REQUIREMENTS

The conservation and preservation of the above natural sites require the involvement of several international and national organisations ranging from the UNESCO and the World Heritage Convention, to the different Protected area authorities and Non-Governmental organisations working in the field.

In April 2002, ESA organized a user workshop in ESRIN (ESA premises in Rome), involving UNESCO and several national and international organizations (World Wildlife Fund, International Gorilla Conservation Program, Dyane Fossey Association, Wildlife Conservation Society, etc) responsible for the conservation of the sites under consideration. The objective of this meeting was to discuss and define a preliminary list of requirements in terms of geo-information products for the proper management of the Parks under consideration. In particular, the following needs were identified, depending on the specific role of the users organizations:

- *UNESCO (World Heritage Centre)*: Regular and updated status reports (level of integrity and threat) for the World Heritage Sites under consideration. In-house capacity to process and analyse EO products.
- *Range states ministries*: Updated and reliable information available for the sites, integrated in a nation-wide development perspective. Digested information to support policy making at decision-making level.
- *Protected area Authorities (national level)*: Reliable and recent base maps for the conservation sites under consideration. Land-use and land cover change detection and analysis. Capacity development at the institutional level.
- *Protected area authorities (senior staff and rangers at the field level)*: Reliable and recent base maps for the conservation sites under consideration. Land-use and land cover change detection and analysis. Training of field staff in data collection of ground-truth.
- *Non-governmental conservation organisations*: Reliable and recent base maps for the conservation sites under consideration. Land-use and land cover change detection and analysis.
- *Aid agencies / Official donors*: Reliable information (pertaining to status and threat) aimed at orienting.

- *Scientific Community*: Capacity development in GIS and remote-sensing techniques. Accurate and recent maps and images in support of studies and scientific activities.

In this context, EO technology may provide a fundamental role to support the user community in carrying out their daily work. In particular, the following EO-based geo-information products were identified and defined by the users as key information for an efficient management and conservation of the above World Heritage Sites:

- *Base maps at medium (1:50,000) scale of the sites under consideration*
- *Small-scale DEM (1:200,000) of the whole geographical area of interest*
- *Medium scale DEM (1:50,000) of the specific sites under consideration*
- *Analysis of the land-cover/land use changes (between 1990 and 2000) at 1:200,000 of the whole geographical area of interest*
- *Analysis of the land-cover/land use at 1:50,000 of the sites under consideration (including the surrounding areas)*

A detailed description of the technical specifications of the above-mentioned products was prepared by UNECO in close collaboration with the user community and ESA during the preparation of the project. These “User Requirements”, were enclosed to the Statement of Work of the project so that they represented the basis for European Industry and Research Centres to prepare their proposal.

It is worth noting that one of the main features of the DUP is the direct and active involvement of users in the projects. In this context, users are required to commit themselves to devote resources to the project: e.g., manpower, technical support or data access. In the context of the BEGO project, the involvement of the user community (represented by the different organisations involved in this initiative) is mandatory.

4 PRELIMINARY RESULTS

From a methodological viewpoint the problems faced are rather complex. This is a direct result of the particular nature of the area of interest (i.e., presence of clouds, high vegetated, inaccessible areas, war, etc.). In this context suitable techniques should be applied being able to overcome the technical drawbacks derived from such a difficult situation.

Concerning the land-cover and change-detection maps to be generated, the significant cloud coverage present during almost all the year over the selected area renders very difficult the availability of cloud-free optical images. In addition, the significant number of vegetation classes and other surface features to be identified renders the problem at hand a very complex one. In this context, a data-fusion approach [2] merging together time-series of optical data and SAR data in order to ensure a complete coverage of the area of interest seems to be the best technical solution to be explored. In particular, the joint use of Landsat data and ASAR data will be explored. In addition, and due to the relationship between the vegetation classes and the height over the sea level, the selected methodology should be able to integrate also data from the DEMs into the classification and change-detection processes.

The preliminary results of the land cover analysis are shown in Figure 2. This figure shows the first version of the land cover map of the Volcanoes Conservation Area derived during the prototyping phase of the project. This product is being validated by the user community (who has a very good knowledge of the area) in order to both improve the thematic accuracy of the final information by allowing local users to participate in the interpretation of the land cover map and to derive a precise estimate of the final thematic accuracy. A final version will be realised at the end of the project in December 2003.

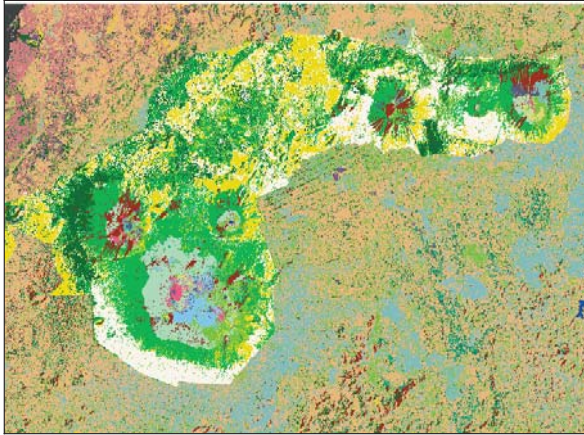


Figure 2. Land cover map of the Volcanoes Conservation Area.

Another important product required by the user community are the Base maps of the different parks under consideration. Figure 3 shows a portion of the Base map generated over the test area of the Volcanoes National Park. The map shows the main geographical features of the area derived from ASAR imagery, Landsat data and the ancillary information made available by the users working on the field. Several GCPs have been collected in the area in order to derive precise geo-locations of the main features in the terrain.

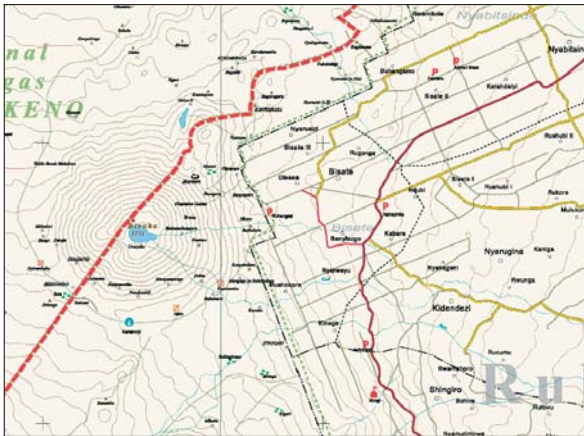


Figure 3. Portion of the Base Map produced during the prototyping phase of the BEGO project.

Concerning the production of the DEMs, we face two main technical drawbacks: the vegetation coverage in the area of interest and the potential lack of suitable ground control points in some areas. In this context, radargrammetry appears as a valid alternative [3]. In particular, the user of ENVISAT-ASARS data will be explored to generate the DEM of the whole area of interest at 1:200,000. In fact, using ENVISAT Narrow Swath beams, horizontal and vertical resolution is suitable for 1:50,000 map production. Expected height resolution will be 15-22m, accuracy approximately 30m.

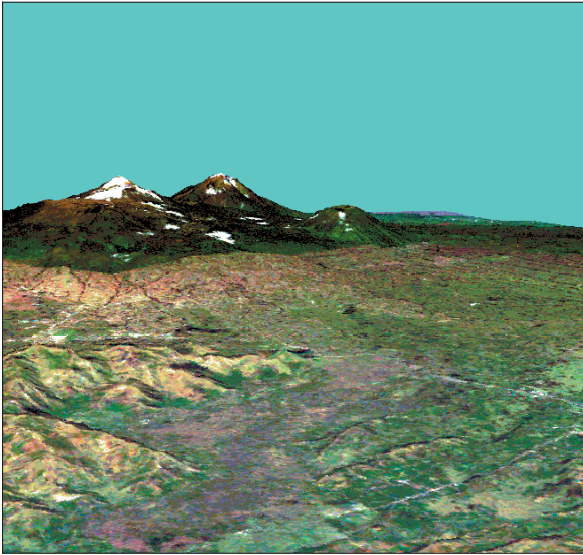


Figure 4. View of the DEM of the Volcanoes Conservation Area derived from ASAR data. A RGB natural color image derived from Landsat data is layered over the DEM.

The first results (Figure 4) derived over the test area demonstrate the validity of the proposed approach. In particular a high accurate DEM were generated at 1:50,000 from ASAR data with a vertical accuracy (RMSE) of 20,7m.

5 CONCLUSIONS

The ESA project BEGO, carried out by an international team led by the Dutch company “Synoptics”, aims at demonstrating the capabilities of EO technology to support the different national and international bodies involved in the implementation of the World Heritage Convention. In particular, the project focuses on the development of DEMs, base maps and change-detection maps on five World Heritage Sites and National Parks in Central Africa, which represent the main habitat of the “Gorilla”.

With this effort ESA and UNESCO aims at demonstrating the value of EO data as a unique source of information for monitoring natural sites and protected areas worldwide on a regular basis.

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