WEB GIS PROTOTYPE FOR INTERNATIONAL COOPERATION PROJECTS SUPPORTING THE REDUCTION OF THE VULNERABILITY TO THE FLOODING RISK

Maria Antonia BROVELLI (*), Diego MAGNI (*), Luca PALAZZOTTO (**)

(*) Politecnico di Milano - Polo Regionale di Como, via Valleggio, 11 – 22100 Como, tel + 39 031 3327517,
fax + 39 031 332 7519, e-mail maria.brovelli@polimi.it, diego@geomatica.como.polimi.it
(**) Ingegneria Senza Frontiere – c/o Presidenza della facoltà di Ingegneria Industriale
Politecnico di Milano campus Bovisa -Via La Masa 34 – 20156 – Milano,
fax: +39 02 2399 8566, e-mail lucapalazzotto@yahoo.it - http://www.isf.polimi.it

Abstract

The goal of this work is to increase the use of the GIS (Geografic Information System) in developing countries that are lacking economic resources and technical skills. In these areas, GIS would be very useful for geospatial data management and analysis, graphics/maps production, spatial modelling and visualisation in help the management of the territory.
This work follows a project to reduce the vulnerability of flood risk in some areas affected by "El Niño".
The project was financed by ECHO (European Community Humanitarian Office) for the Andean Region, and was carried out in Ecuador (Baba and Vinces Cantons) by COOPI (Cooperazione Internazionale) NGO, which developed risk maps of the intervention area and made them public.
Web GIS is proposed to be a tool for the diffusion of geographic information that is gathered.
At present, a demonstrative version has been implemented to raise funds in order to support both the customisation of the web GIS for a specific application, and training activities that would aim to transfer the know-how to developing countries for the autonomous development of web GIS using OpenSource and freeware technologies.

Introduction

International Organisations and Institutions financing International Development programmes are allocating an increasing part of available funds to natural disaster prevention in order to mitigate the effects of climate change in developing countries. Indeed, although the problem affects the entire earth, the poorest countries are the most vulnerable to such catastrophic events.
Funds available for International Development programmes also do not often allow for a long-term perspective in problem solving. For this reason one of the most effective ways to employ these resources is to strengthen local capacity in response to an emergency, limiting damages and deaths during natural disasters events.
NGOs (Non-Governmental Organisations) and International Organisations often support local Rescue Corps during an emergency; a time when it would be very helpful to have access to information about resources and infrastructures available in the affected areas.
In this article three main actions are suggested to be included in International Development and Disaster Prevention projects in order to facilitate operations during the emergency:

- to gather territorial and environmental data

- to process the data and make it widely available and easy to understand for a large number of users
- to guarantee the free access of information through the Internet.

The aim of these actions is to enhance the management of the emergency and the co-ordination between institutions and organisations operating in the same areas.
Web GIS can help to match these objectives: its potential applications are significant and the benefits could be remarkable as long as a GIS map is available, and the easiest way to understand the potential of the web GIS is to show its large applications.

The ease of acquiring access to geographic information through the web GIS can easily convince one of its usefulness in the international co-operation context, where GIS maps are often developed during the projects and used less afterwards. Currently, data and information that are gathered are usually transferred on hard supports, subject to deterioration and loss due to environmental conditions and high personnel turnover that is common in such contexts. Furthermore, high costs and technical skills required for the use of GIS software make it inapplicable at local levels and dramatically limit information sharing and diffusion. Information, where available, is often disorganised and scattered amongst various institutions and organisations. Lack of time and resources during emergencies usually do not give the operators access to the available information and waste time and resources.
A web GIS, however would remain available through the Internet at any time and could benefit operators working in emergency situations, as well as local authorities and institutions in charge of territory monitoring at all levels.
The more difficult the conditions, the larger the application could be.

Background

Before describing the characteristics of the web GIS it is important to briefly illustrate the context where the application has been implemented.
Between April 2004 and July 2005, the NGO COOPI carried out a project for natural disaster preparedness (DIPECHO, Disaster Preparedness European Community Humanitarian Office) in the Rio Vinces catchement (Ecuador).
The project was funded by ECHO, the Department of the European Union for Humanitarian Relief.
Vinces is located in Los Rios province, 80 kilometres from Guayaquil and the Pacific Ocean. It is surrounded by banana trees with small cocoa and rice farms managed by families or cooperatives of local farmers.
Local producers manage banana farms on behalf of the big international brands. Labourers employed in such farms are usually exploited and live in very difficult conditions.
Indeed farmers are generally very wealthy and share local power between them. They are mainly white, and are often from the big cities and have little to do with the local communities. On the other hand, labourers are mainly mestizos and black, and their life expectancy does not pass forthy years.
The area is characterised by a remarkable amount of watercourses flowing in a plain between the Andes and Pacific Ocean and flooding occurs almost every year with catastrophic consequences for the poorest people living in the country.
The largest farms have adequate means and resources to protect their crops and the capacity to manage water for their own needs, although this means they deny the use downstream or irremediably compromise the water quality. Indeed, pesticides and chemicals used for bananas conservation are drained directly into the rivers.

People in the countryside are the most vulnerable because of the long distance from inhabited places and the dispersion on large lands that make rescue operations very difficult. On the other hand, the local rescue corps does not have adequate means and capacities to face the emergencies.

Figures 1 and 2 -Two pictures of Rio Vinces: dry (above) and in flood (below).

What was done and what would be proposed with the web GIS

One of the activities of the project was to develop risk maps of the areas that were most affected by floods using a GIS software. The maps were to offer support to the Rescue Corps, local administrations, National and International Institutions, and other NGOs operating in the area during the emergencies.

The work was put out for tender and a consultant carried out the data gathering and mapping after buying very expensive satellite photos from Military Institutions.
Although at the local level it is often not possible to rely on the capacity to manage a GIS software, it is more realistic to rely on the Internet. In this situation, a web GIS would be a very helpful and reliable tool.
For this reason, a demonstrative web GIS has been implemented using data and information available from the DIPECHO project carried out by COOPI in the 2004-2005.

Data model

The data model of the demonstrative web GIS consists of two different data sources, the database of DIPECHO project (official project name: ECHO/TPS/219/2003/04009 "Plan Integral de Riesgo para la Gestión Hidrológica de las Cuencas de los Ríos Baba y Vinces") and a dataset acquired by *in situ* inspections.
During the DIPECHO project the following maps have been produced:

- "Mapa de la cuenca hidrográfica del Río Vinces" (Map of the Rio Vinces basin, scale 1:250000);
- "Mapas de peligro por inundaciones" (Maps of flooding risk), for these areas:
  - Baba and Vinces cantons (scale 1:50000, both educational and complete version);
  - Baba sector (scale 1:10000, within Baba canton);
  - El Matecito, Clarisa and Versalles (scale 1:10000, within Baba and Vinces cantons);
  - Isla de Bejucal sector (scale 1:10000, within Baba canton);
  - Antonio Sotomayor – San José de Bagatela sector (scale 1:10000, within Vinces canton);
  - San Ramon and Vinces sectors (scale 1:10000, within Vinces canton);
- "Mapa del sistema de alerta temprana para la cuenca del Río Vinces" (Map of early warning system for Río Vinces basin, scale 1:250000).

A data subset was extracted from these maps and loaded into the web GIS after some analyses of data correspondence and consistence.
The *in situ* acquired data contained information about aid centres, escape points and temporary shelters. They have been stored in non-spatial tables (Microsoft Excel tables) during their acquisition, digitalised and saved as ESRI shapefiles with ArcGIS desktop GIS.
Both the DIPECHO data subset and the *in situ* acquired data are loaded by the web GIS as ESRI shapefiles.

The original reference system has been maintained for the maps of the web GIS. It is defined by Instituto Geográfico Militar (IGM, Military Geographic Institute) of Ecuador and adopts the PSAD 1956 (Provisional South American Datum, 1956) system, with Hayford ellipsoid, origin at La Canoa (Venezuela) and mean sea level set at the gauge station of La Libertad (Ecuador).
The coordinate system is UTM / Zone 17 South (central meridian: -81°, latitude of origin: 0°), with false Easting (500 km) and Northing (10000 km) and scale factor of 0,9996.

In this version of the web GIS, all the data has been re-organised in five groups of layers, as shown below:

- *Basin of Rio Vinces* - Layers: Rio Vinces basin boundaries, sub-basins boundaries, hydrographic network, hydrometric stations, meteorological stations, information lines of early warning system, airports, towns;
- *Canton of Baba* - Layers: Baba canton boundaries, settlements (classified in: asentamientos, ciudades, cooperativas, haciendas, haciendas/asentamientos, poblaciones, recintos, sectores);

- *Canton of Vinces* - Layers: Vinces canton boundaries, canals, settlements (classified in: asentamientos, ciudades, haciendas, haciendas/asentamientos, poblaciones, recintos, sectores), buildings;
- *Region of interest* (layers: region of interest boundaries, aid centres, escape points and temporary shelters);
- *Geographic reference* (layers: Equator line, central meridian line of the adopted reference system).

The database is also improved by some pictures provided by the Ecuadorian Civil Defence.

The web GIS: technical features and functionalities

The demonstrative web GIS has been implemented with CGI architecture from the University of Minnesota (UMN) MapServer 4.8.4 and runs on an Apache 2.0.54 web server.
This architecture consists of three parts: the GIS engine, the map configuration and the web interface.
The GIS engine is the CGI (Common Gateway Interface) of MapServer (mapserv.exe), which generates maps and allows for some operations over them using Dynamic Link Libraries (DLLs). Everything is done inside the Apache web server.
The map configuration mainly consists of the *map file*, which contains references to set map properties (e.g. name, units, geographical extension, size, colour, data folder path) and web parameters, to load data, to define layers and to generate objects such as the legend, scalebar or reference map. Other auxiliary configuration files are the *symbolset file* and the *fontset file*, which define and set graphic symbols and TrueType fonts respectively.
At the end, the web interface consists of one or more web pages, named *template files* (see figure 3). They can be simple HTML pages, HTML pages improved by JavaScript functions or other, and manage the interaction between the user and the web GIS.
The demonstrative web GIS being presented by this paper has three versions: Spanish, English, and Italian. Each consist of a specific map file, while the CGI, the symbolset file, the fontset file, JavaScript functions and variables files are unique for all versions. Some template files are specific for a tongue-based version (main template file, pages for attribute-based queries, data attributes description), others are shared (query template file, legend, geographic reference page, reference system information, pictures presentation).

The functionalities implemented in the web GIS, accessible from the main template file, are:
- basic map browsing functions (centre/pan, zoom in, zoom out);
- groups of predefined views (river basins, cantons, towns, region of interest, initial extension);
- zoom factor selection;
- feature queries;
- attribute-based queries (for example, see figure 4);
- on-the-fly function notification;
- selection of the language, choosing among Spanish, Italian and English.

The following objects improve the navigation of the web GIS:
- scalebar;
- actual MBR (Minimum Bounding Rectangle) notification;
- actual predefined view notification;
- last clicked point coordinates notification;
- reference map;

- region of interest geographic location;
- dynamic legend (i.e. table of contents, made by MapServer HTML Legend);
- on-line help.

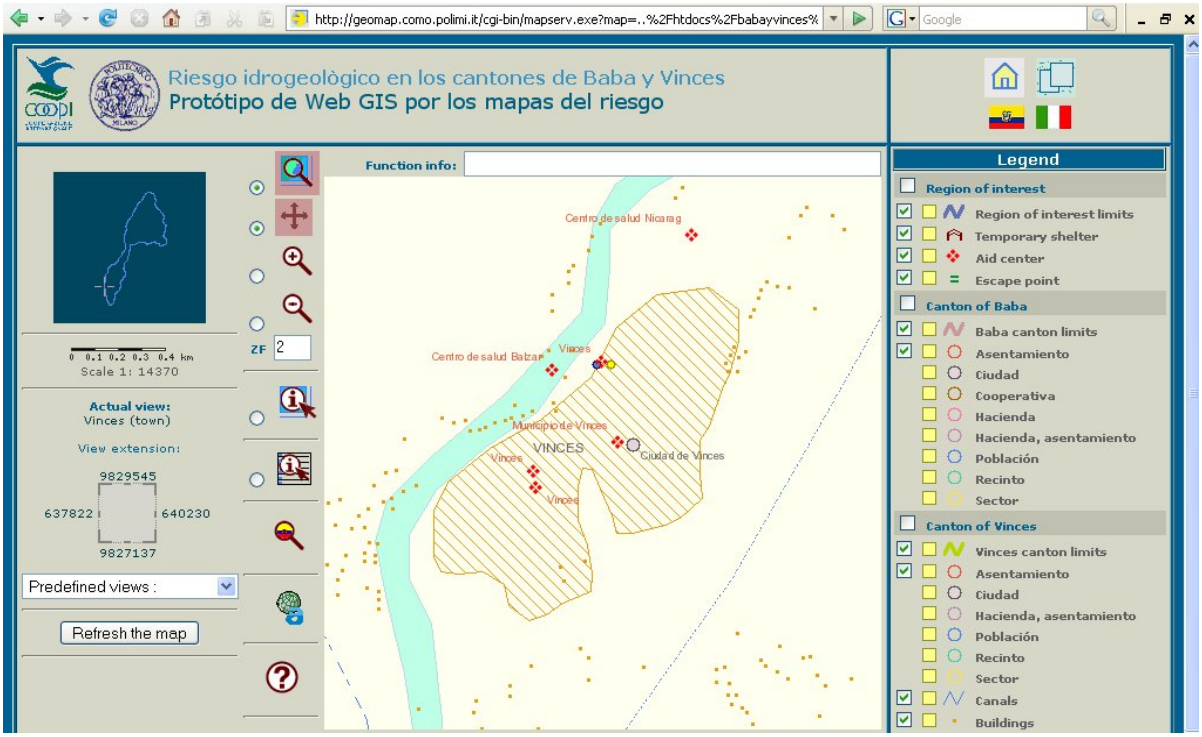

Figure 3 - The main template file of the web GIS (English version).

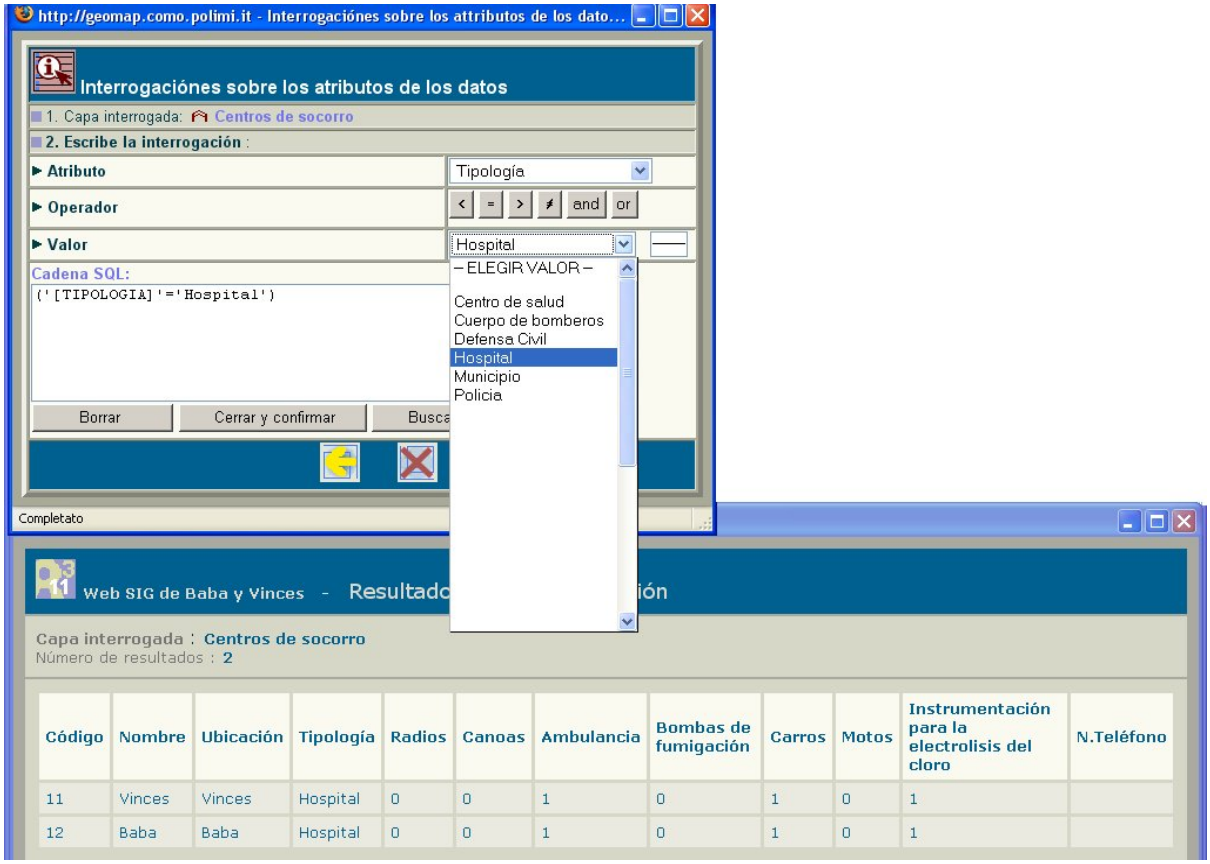

Figure 4 – Example of attribute-based queries (Spanish version).

Future developments

The project is currently in the presentation and submission step. As said above, the idea is to present project to organisations dealing with international cooperation, both by a specific proposal submission and the web GIS publication on the web site of Laboratorio di Geomatica (http://geomatica.como.polimi.it/).
The goal is to propose the web GIS as a tool for publishing cartographic data and other information in regards to environmental risks and civil protection.
Moreover, this project aims to promote educational activities in transferring the know-how required to implement web GIS based on OpenSource and/or freeware technologies to beneficiary countries.

Acknowledgements

The authors would like to thank:
- Defensa Civil del Ecuador, COOPI (Cooperazione Internazionale), and ECHO (European Community Humanitarian Office), for supplying the DIPECHO project data and maps;
- Magno Rivera, Mario Cruz, and Carlos Gutierrez, for the development of the risk maps;
- Gabriela Chiriboga, Ivonne Vinacuña, and ESPE (Escuela Politecnica del Ejercito, Ecuador), for gathering data and writing project reports;
- Riccardo Bianchi, for processing the initial web GIS data;
- Lora Forsythe (Research Assistant at CESI, Centre for Economic and Social Inclusion, London, http://www.cesi.org.uk), for proofreading the English version of the article.
- Roberto Antolín Sánchez (PhD student at Politecnico di Milano, Polo Regionale di Como, http://geomatica.como.polimi.it), for supporting the implementation of the Spanish version of the web GIS.

References

ECHO, Defensa Civil Ecuador, COOPI (2004), "*Proyecto DIPECHO (ECHO/TPS/219/2003/04009), Reducción de la vulnerabilidad por las amenazas naturales en los cantons de Baba y Vinces, provincia Los Ríos, Ecuador*", Quito.
University of Minnesota (2006), *MapServer*, http://mapserver.gis.umn.edu/.