INTEGRATED WEBGIS FOR FLOOD RISK MANAGEMENT WITH MOBILE AND GPS TECHNOLOGY WITHIN OPEN SOURCE SYSTEM

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ABSTRACT:

Hydrogeological hazard is one of the most frequent natural risks observed in the city of Messina. In the past, entire populations have been isolated by natural events cause by extreme rains and landslides. Factors regarding geomorphologic characteristics of the river are obviously in charge, but phenomena have been increasing with the deposit of abusive materials inside the bed of the river involving a risk of a coast pollution. Our study has concerned the development of an integrated demonstrator system with advanced data processing technologies that supports the efficient management of decision-making processes. We propose a GIS client/server solution with the use of mobile devices as smartphone or pocket PC in order to monitorate hydrogeological risk areas and to handle event and alarm during crisis. Developed application is based on open source systems. The server is a WebGIS dedicated to the control and management of flood and landslides hazard as well as the environment survey. With the help of hydraulic models, the server application provides expert community with an efficient tool aiding to evaluate risk situation and elaborate hazard maps. Use of mobile devices supplies lack of information in non monitored regions. In the project, a mobile GIS application connected to a GPS system has been developed in order to collect accurate territorial data, handle information and transmit it to the server. Mobiles are used for updating geographic information in both monitoring and event handling phases. For the abusive materials deposit, the system integrates video cameras useful to a continuous control on the vulnerable area. Project finality also concerns the realization of a pertinent database containing models results and elaborated data related to monitored regions assessable via web. Such a database provides responsible deciders with a shared oriented information helping them to a better territorial planning in order to reduce risk effects on economy, infrastructure and population. The work also deals with problem of interoperability of data exchanging between multi-platform cartographical systems. A scalable solution has been constructed to support hydrogeological risk management that can be extended to other kind of risks.

1. INTRODUCTION

The main objective of the research concerns the development of a pilot application through the definition of methodologies and advanced technologies regarding environmental monitoring and risk management helping to handle a timely and accurate information. For this purpose, we implemented a client/server solution with the realization of a GIS server on which run hydraulic models and the development of a spatial information system on a mobile device like a smartphone or a Pocket PC with GPS integration. Regarding this specific area of application, mobile technology permits to carry out a precise, well-timed and complete relief of territorial data in both monitoring and emergency situations.
The study addresses in particular, the problem of implementing GIS solutions based on open source running on mobile platform. In facts, nowadays, many are development tools running on desktop platform diffused in the market of free software but rare are those proposed on mobile one.
The finality of the project is also to create a regional environmental database accessible via Internet to authorities and emergency managers that deal with problem of monitoring and risk management.

2. BACKGROUND STUDY

2.1 Context

Floods are one of the most common disaster phenomena in the Province of Messina (Sicily). Recent tragic flooding and mudslides hit in and around Messina. Torrential rains dumped over 230 mm of water in less than an hour knocking down houses in city districts and nearby towns and leaving hundreds of homeless people. These events already happened in the same area in 2007.
The province of Messina, as the rest of Sicily, is characterized by a particular natural conformation: composed of a long strip of land sheltered by two mountain ranges such as the Nebrodi and Peloritani Mountains.
In addition, the area is characterized by the simultaneous presence of different types of risk related to seismic, volcanic, hydrogeological risk, industrial and transport of hazardous substances and environmental emergencies.
The situation is badly increasing by uncontrolled urbanization and a lack of an accurate knowledge of territory. Moreover the phenomena is amplified by the obstruction of the rivers with wastes of different nature leaning in the flow path causing flooding at the first event of a certain intensity.

2.2 Problematic

In such situation, only a careful management of the area can limit the damage caused by natural events of various kinds.
The principal action to undertake is to establish a proper land management to define correct plans related to civil protection. The main element in this process is the mapping of the area. A clearly understanding of risks is a fundamental aspect on which develop plans should be elaborated in order to determine prevention actions and emergency management.
Moreover the available systems still lack of those tools able to manage risk and address the crisis effectively. For example, there aren't technological support that allow an easy retrieval of the geographic data on the specific area. Nowadays, during an event of crisis the maps of landslides are performed manually by a helicopter or from the ground making it very slow harvesting and processing. An effort has to be done to integrate in a unique system various instruments able to improve the management of the territory against all the principal natural risks.

2.3 Case study

The study site is referred to the basin of the river Santo Stefano di Briga in Messina (Sicily), a basin classified P.A.I. 4, the maximum level in the master plan of flood and landslide risk management. The choice was based on its morphological properties and its level of human activity. The basin is suitable as a reference model of main rivers of southeast Sicily. Like small Mediterranean torrents, it contains rapid and varying flow rates, with floodplain characterized by high flow rates at the peak within limited durations.

3. RELATED WORK

Use of GIS has become a generalization in procedures of risk management, especially in flood and landslides applications (Erena, et al. 2005; Zerger, A. & Wealands, S., 2004). Lately, web applications have been increasing to help deciders as well as population to access to the geographical risk information. Moreri, et al. (2008) proposed a web based GIS application that provides timely flood information to emergency managers and citizens. Moreover, Web-GIS permits to share and access available information relative to risk (Frigerio, et al., 2009). Thanks to technology, mobile support is taking a larger place in the geographical work since they permit to retrieve local information to manage crisis more accurately. Zipf and Lehner (2004) present the state of art regarding flood disaster management with the help of mobile devices. However they pointed out that disaster occurrence proved that available warning system do not fully fulfill specific requirements and potentials for mobile disaster management systems.

4. IMPLEMENTATION OF THE WEB-GIS SERVER

4.1 Web-GIS support system

Problem has been dealt with the creation of an efficient central aid decision-making support system able to manage data, assess risk, elaborate hazard scenarios, collect on-line data providing by mobile GIS and produce scientific environmental data to be shared by deciders operating in emergency preparedness and management. The implemented WebGIS is built on the open source UMN Mapserver engine.
The first step of system development has involved the creation of the geo-database through the collection of available spatial information providing by local administration authorities (Region of Sicily, Municipality, Regional Forestry, Province). Data collected regards population, infrastructures, water supply, land use, etc. Spatial data has been organized and processed to be successively easily used and shared between heterogeneous systems.

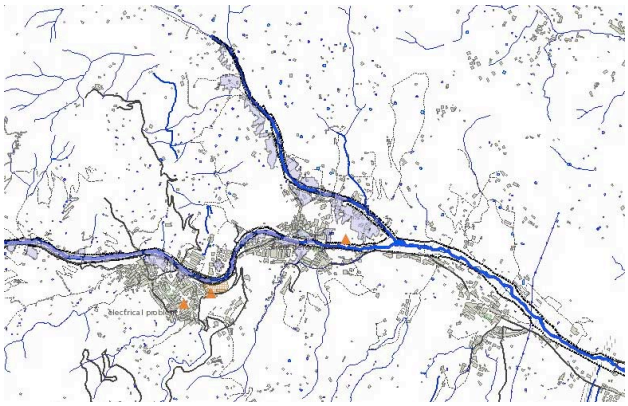

Figure 1. Study area

Then, with the use of hydraulic model simulations as described above, risk scenarios have been elaborated and incorporated to centralized-server.

Server also integrates data transmitted by mobile. In the case of monitoring, created geo-database is updating with information collecting on site. In the case of emergency, all information is received, visualized on the map and stored. Every sent data is date marked. In such a way, deciders have a chronological information of data retrieved during event. That kind of information helps deciders in civil protection to better understand what happened during accident and prepare a post-crisis analysis.

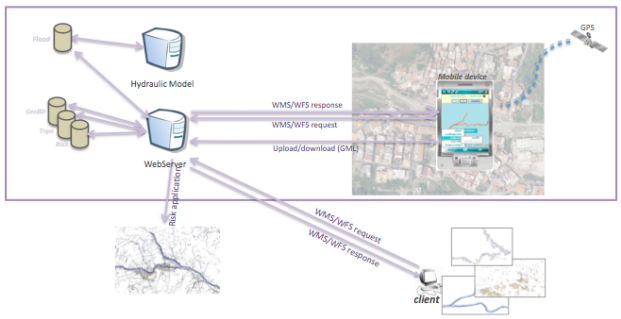

Figure 2. Flood risk client/server architecture

In such a way, central server offers a synthetic view of what happened or could happen concerning flood risk. Such system helps to better manage crisis and, thanks to real information received from mobile device, permits to follow situation assessment for a better save of economic, environment and human factors.

Another point of developing has concerned the control of the area violated by abusive waste discharges in its river's flow path. For the proposal, server integrates a camera system to a better surveillance of sector.

4.2 Integration of hydraulic models

Implemented solution integrates hydraulic simulations, which allows spatial-based visualisation and prediction of flood disaster. HEC-RAS has been employed to simulate flood scenario cases; the dimensional stream channel model was constructed based on geometry obtained from a Digital Elevation Model (DEM) with a 2 meters resolution. The DEM is issued from a LiDAR technology. The application of LiDAR in the flood risk study has proved to be an accurate and practical support for hydraulic modelling and flood mapping. The results of model simulation indicated the spatial extent of flood scenarios and determined flooded areas.

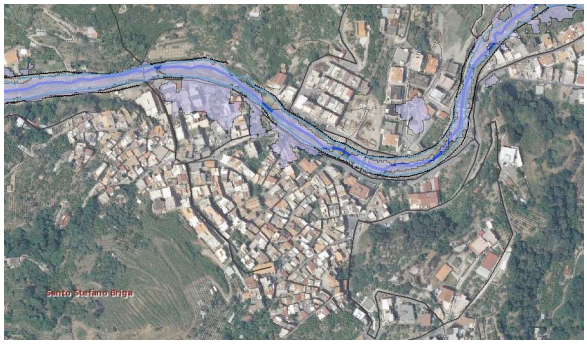

Figure 3. details of risk area in study

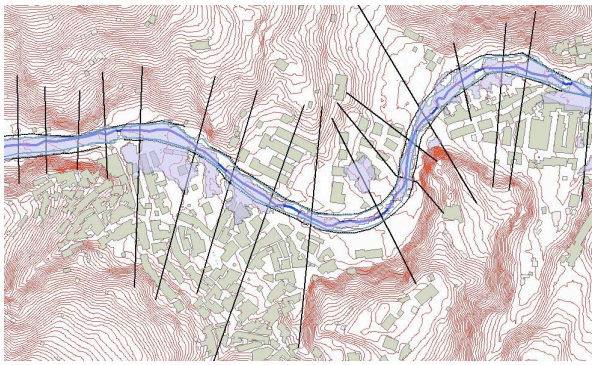

Figure 4. spatial elements used in hydraulic models simulation

5. MOBILE-GIS AND GPS INTEGRATION

In main risk situations, much attention is focused on providing more and better data and information to decision makers. During an event response phase, the real-time tracking of events and response resources is critical. In such cases, desktop GIS are not sufficient to handle information and manage crisis. Mobile solution helps to supply this problem in collecting local information in order to get a more accurate data. Principal focus of our research is to make information available especially during crisis event where communication about updated situation between decisional crisis centre and operational groups located in the involved area is fundamental. Centralized servers need a real time updated situation to handle event, organize rescue and improve the decision process.

The coupling with GPS system permits to retrieve geographical data in location less monitored or with no existing geo-database reference.

For the proposal, an embedded GIS has been developed in order to manage local data, retrieve pertinent information, add semantic and transmit it to the server.

The mobile client GIS communicates with the server through the exchange standard GML message sending using web services protocol for the download of data and FTP protocol for the upload.

Coordinate system reference is Gauss-Boaga, the one applied in the Region of Sicily.

The mobile device can operate during crisis and monitoring situation. During an event, managed information concerns event evolution, implicated areas, damages and population involved; during monitoring the hand-held helps to easily update geo-database on site. System is used either to signal abusive dumping in the bed of river. Waste discharge on the river is claimed to be a serious factor of risk effects increasing and the principal one for pollution.

Work pointed out the lack of open source development tools for mobile GIS applications, which is not the case of desktop platform.

Besides, because of physical constraints of mobile devices, such as small screen, small memory storage, and low frequency of CPU, some critical issues have been taken into account. Implemented hand-held client application integrates these limits in regards to type, format and dimension of spatial data managed.

6. CONSTITUTION OF THE MAP RISK GEODATABASE

The Web-GIS realized runs also as a map service server. Cartographical data and elaborated hazard maps are available on the Web through Web Services protocols. A particular awareness has been reserved to data format to guaranty interoperability between heterogeneous systems and improve data sharing.

The pilot implementation has indentified methodologies and techniques to undertake in order to handle risk planning and give rise to the constitution of the first local risk geo-bank. In the future, the Web-GIS server should give access to any data treating local risk information.

7. CONCLUSIONS

The implemented client/server application pointed up the efficiency of a multi-platform integrated solution used to manage flood risk.

Even if mobile solutions still suffer of limits due to their own characteristics and a lack of dedicated open source development tools respect to desktop, coupling with GPS, they demonstrate to be necessary in situation where time and accurate local information retrieval is critical. Real time data exchanged between mobile client and server helps to follow, during the crisis, the evolution of the situation.

The application is scalable. Methodologies and informatics techniques used can be adopted to any other kind of risk.

Pilot implementation gave rise to the creation of the first local geo-database of risk to be accessed by any deciders operating in the risk management.

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