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GIS IN URBAN DISASTER MANAGEMENT

ABSTRACT
Geographic Information Systems (GIS) are useful tools in disaster management in hazard-prone urban areas. In the future they are expected to have an increased role in the transfer and sharing of data via the World Wide Web (WWW). The case of the Costa Rican city of Cartago highlights the main problems that local governments in developing countries face in terms of geographic information and implementation of GIS.

INTRODUCTION
On January 25th, 1999, an earthquake hit the prosperous Colombian city of Armenia. In a city of 230,000 inhabitants, 800 people were killed, 2300 people were injured, 30,000 houses were damaged, 75% of the educational facilities were damaged. About 1 million cubic meters of rubble was produced. The city was heavily looted and the army had to intervene to protect one section of society from another. Riots followed as a distressed population considered the actions by government agencies to be slow and lacking in co-ordination. Events such as this put the disaster management community to the test, revealing both its strengths and weaknesses.

Disaster management is essentially a dynamic process that includes the traditional management functions of planning, organising, staffing, leading and controlling. Its main objective is the reduction of disaster effects and it involves many organisations working together in one or more of the phases of the “disaster cycle” (see Figure 1). Unfortunately, until very recently, disaster management was seen as the process of co-ordinating relief and reconstruction activities following an event and this proved inadequate as these tasks yield only temporary results at very high costs.

The scope of disaster management can be best understood by means of a tri-dimensional matrix (see Figure 2) describing the three types of elements involved (levels of government, management phase, implementation measure) and the resulting range of possible implementation strategies. In practice, some blocks are more common than others, although all are possible.

The consequences of natural disasters pose a major problem in developing countries; it is estimated that per capita losses of the Gross National Product (GNP) are 20 times greater in developing countries compared to those of developed countries (*Clarke et al., 1994*). Among the main reasons that explain such a difference are:

- Perception of hazards in developing countries tends to be more dependent upon religious views and therefore, natural hazards are seen as “Acts of God” that can not and should not be prevented and only their consequences should be dealt with. This behaviour is characterised by a systematic denial of scientific facts and represents a difficult problem for disaster managers.

- Lack of a general awareness of what good building materials and good construction practices are for each type of natural hazard. In Armenia, even though an adequate building code exists, the general public has little awareness of what constitutes good seismic-resistant practices. A building code is a highly technical document which only people with a background in engineering can comprehend. However, it is remarkable that parallel to this building code, a basic manual has not been produced with the general public in mind, describing in a simple and graphical manner the steps for building, for example, a typical low-income house.

- Lack of enforcement of existing regulations (zonation, building codes, etc.). The Independent Insurance Agents of America (2000) have estimated that the 1992 losses to

Hurricane Andrew in the USA could have been reduced by as much as 30-40% had existing building codes been properly enforced. This allows one to understand the degree of importance that regulation enforcement can play in disaster reduction. This issue is presently high on disaster management agendas as the Armenia and Izmit (Turkey, 1999) earthquakes have highlighted this to be one of the main reasons that explain the catastrophic human and property losses. In Colombia, building inspection is weak due to financial constraints but also due to corruption. In Turkey, it has been widely reported that in return for bigger profits, building contractors deliberately lowered the quality of building materials specified in the approved building plans.

- Disaster management tends to be heavily centralised. Both in Colombia and in Turkey, disaster relief and reconstruction was heavily centralised at the time of the earthquakes. This centralisation caused the speed of disaster relief to be slow and hampered its effectiveness by the lack of local knowledge by central government. In the case of Armenia, the institutional set-up proved weak as there was general confusion regarding the hierarchical structure and the specific tasks of the national, regional and local agencies involved.

- The weak sense of "managerialism" within local government agencies.

URBAN DISASTER GEO-INFORMATION NEEDS

The success of urban strategies depends to a great extent on informed decisions and therefore, on the availability of accurate information presented in a timely and appropriate manner. Unfortunately, supplying decision-makers with raw data is a very common practice which has generally yielded negative results. In the case of Armenia, decision-makers had been provided with maps of hazard zonation, population density, urban growth and land-use, on which to base their decisions. But, as little attempt had been made to integrate the data sets, the implications of the information were not immediately visible, causing confusion and in the worst cases, the formulation of inadequate policies.

THE ROLE OF GIS IN URBAN DISASTER MANAGEMENT

Geographic Information Systems (GIS) have considerable potential for improving urban disaster management. Through the use of analogue methods alone (paper files and maps), it was nearly impossible for many local and regional authorities (especially those of fast growing cities typical of developing countries) to collect and update information. Due to the difficulties in retrieving such information from the paper files and maps, planners were also discouraged from attempting data integration and producing "derived" information.

The development of GIS enables attribute data to be linked with spatially geo-referenced data. GIS is a valuable tool for the input, storage, integration, analysis and cartographic visualisation of geo-information. It is very dynamic, not only in terms of its functionality but also in terms of the time saving it involves. It is important to keep in mind, however, that the implementation of GIS does not come without problems and the decision to implement it must be carefully analysed from several points of view:

- The financial investment necessary in terms of software and hardware.
- The financial and also the temporal investment necessary for the training of the staff.
- The necessary acceptance of the tool by decision-makers as GIS somewhat implies decentralisation of functions and a more bottom-up approach to data management.
- Without the existence of appropriate models, GIS remains a tool only suitable for data input, storage and cartographic visualisation. Appropriate models must be produced if it is the intention to integrate data and produced "derived information".

GIS enables a maximisation of the use, potential users and applications of geo-information, and in turn this has very positive effects on the sustainability of geo-information production. The selling of data is crucial in achieving the necessary economic sustainability of data production for all the information providers. It is therefore important to broaden the idea of single producer/single user to that of multiple producers/multiple users of information (see Figure 3). By collecting information at a high resolution, aggregation techniques then allow a wide range of users to manipulate information according to their own needs.

Computer networking makes possible a faster and easier access and transfer of the required data amongst the different users and providers of data and the WWW now provides a platform for setting up a Disaster Information Network (DIN) to further improve disaster management (for details of USA's DIN initiative, see: *FEMA, 1997*). The first step in achieving this objective is to involve all the stakeholders by:

- Identifying potential users and their data needs.
- Identifying potential data providers as well as the characteristics of the data they could provide.
- Identify an entity that will co-ordinate or foster communication among these groups.

The focus of a DIN should be on developing integrative products for decision-makers. Top priority should be given to this area because as mentioned before, the information contained in numerous databases and maps cannot be readily utilised by those who must take action to reduce risks or respond to disaster losses. A few examples, amongst many that could be mentioned, of integrative products of use in the different disaster management phases (see Figure 1) and that could be developed using GIS are:

- Estimates of probability of occurrence of hazardous events in the form of hazard maps (prevention and mitigation phase).
- Local or regional maps showing the potential effects on buildings and the population and depicting the possible changes in space and time (rescue and relief phase, prevention and mitigation phase and preparedness for relief phase).
- Real-time display of what is happening during the course of a disaster (rescue and relief phase).
- Regulations or standards such as zonation mapping and associated documents, building codes and techniques (prevention and mitigating phase, reconstruction phase).

THE CASE OF CARTAGO, COSTA RICA

The city of Cartago is a medium-sized (150,000 inhabitants) highly hazard-prone city. It lies 1,200 meters above sea level in what is known as Costa Rica's "Central Valley". Cartago is located downstream from rivers originating near the Irazú volcano's crater and it has therefore been washed away by lahars (mudflows of volcanic origin) several times throughout its history (see Figure 4). On the path of one of these rivers lies the San Blas landslide, considered the biggest landslide in Central America in terms of volume.

Two active seismic faults, located a few hundred metres from built-up areas, are responsible for earthquakes which devastated the city last in 1841 and 1910. This city therefore requires not only an appropriate disaster management plan, but one which should be of a multi-hazard nature, as a volcanic eruption can trigger a lahar or an earthquake can trigger a landslide. The analysis of the problems in terms of geo-information and GIS highlight the challenges ahead.

A master-plan was produced directly by the Costa Rican national planning authority in 1974 but is now largely obsolete. The document provides little mention as to what were the data themes used for producing the zonation map nor details about the analogue data integration method used. Even though the city is prone to lahars, floods and earthquakes, the only information available within the premises of the Municipality relates to the mapping of faults even though the National Emergency Commission has the information in the form of digital hazard zonation maps describing the areas to be covered by ashes, lahars and flash floods as well as the expected maximum ground motion expected. By using GIS, hazard zonation maps could be combined with traditional urban planning information to produce interactive products that enable decision-makers to understand the impact of particular natural events on the population and their buildings, allowing the formulation of adequate strategies.

In terms of digital data, several problems exist: census data is obsolete as the government diverted the financial resources allocated for the 1994 National Population and Housing Census to relief and reconstruction activities, the metadata (information about the information) is often missing from digital files and data formats of digital files are not homogeneous. There is also no tradition of data sharing. For data exchange amongst ministries, for example, an official “minister to minister” request letter is sometimes necessary.

The analogue to digital conversion of the municipal cadastre data proceeds at a very slow pace due basically to a scarcity of financial resources. In a city of 150,000 inhabitants, a ‘one staff - one computer’ system has been allocated to the task and therefore, the completion of such a task is expected to be in the order of 2.5 years. Since this estimate does not include the time necessary for updating existing digital data, the concept of “think big, start small” has been applied at an extreme level as the completion of the project will probably be of the order of 3-4 years.

SOME GUIDELINES FOR A GIS-BASED URBAN DISASTER MANAGEMENT

The guidelines and recommendations in terms of disaster management and implementation of GIS applications are:

- Planning should be carried out locally and in the form of a strategic plan complemented by action plans. Monitoring change and updating information should be carried out to ensure that plans remain current and can be implemented.
- A straight-forward process of data sharing and transfer amongst government agencies is needed. Obstacles for the sharing and transferring of digital data should be removed and the general public should have access to it as well. Data providers should supply the necessary metadata along with their digital data.
- The concept of “think big, start small” should be re-examined as the allocation of an appropriate number of staff and computer equipment can seriously hamper the success of a project.
- Close co-operation with universities should be achieved to ensure that applied research will assist the needs of local governments.
- Related to the above, a more business orientated approach is needed to ensure the cost recovery of digital data production and the upgrading of computer equipment by selling data to the private sector (i.e. insurers, developers).
- GIS should be used for the production of interactive “loss scenario” products for decision-makers to ensure better disaster management. A first step could be the production of forecasts of possible deaths and building damage by a qualitative method (low, medium, high) and at census tract level.

In summary, the role of GIS in disaster management should focus on the processing of interdisciplinary information to produce interactive products for decision-makers. Two of the biggest challenges ahead relate to cost recovery of data production and its dissemination. It is essential to ensure that data providers recover the costs of data production as well as making it possible to share and transfer both the “raw” and the interactive products amongst urban stakeholders by means of the WWW. GIS is only a tool in the overall process of disaster management, issues such as regulation enforcement should be high on the agenda.

NOTE

This paper is based on a Ph.D. research project that is being carried at the Division of Urban Planning and Management at the International Institute for Aerospace Survey and Earth Sciences (ITC).

REFERENCES

- Clarke, C. and Munasinghe, M. Disaster Prevention for Sustainable Development: Economic and Policy Issues. ESD. USA. 1985
- Federal Emergency Management Agency (FEMA). Harnessing Information and Technology for Disaster Management: the Global Disaster Information Network. Disaster Information Task Force Report. USA. 1997.
- Independent Insurance Agents of America, Natural Disaster Risk Profile, http:/www.independent.com/consumer/disaster/ndcmap.htm. 2000

BIOGRAPHIES

Ian Masser is Professor of Urban Planing at the International Institute for Aerospace Survey and Earth Sciences (ITC) in the Netherlands. He has also published widely in the field of GIT and is co-author (with Heather Campbell) of *"GIS and Organisations: how effective are GIS in practice?" (Taylor and Francis, 1995).*

Lorena Montoya is a GIS adviser at the Project Development Division of the CCSS (Ministry of Health) in Costa Rica. Her work involves the development of a GIS application for monitoring the medical facilities network and the location of suitable sites for future projects. She is presently carrying out a Ph.D. research at the International Institute for Aerospace Survey and Earth Sciences (ITC) in the Netherlands.

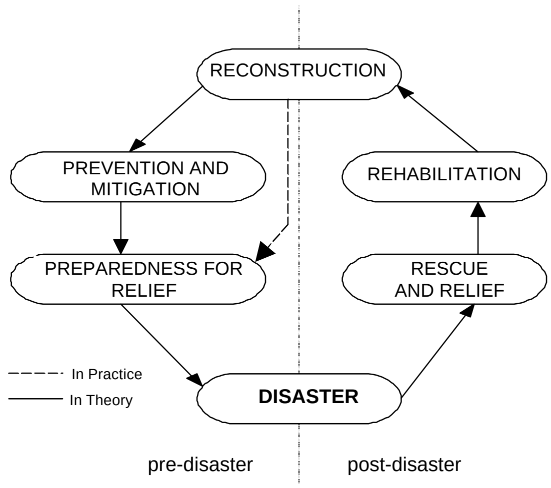

Figure 1: The Disaster Cycle

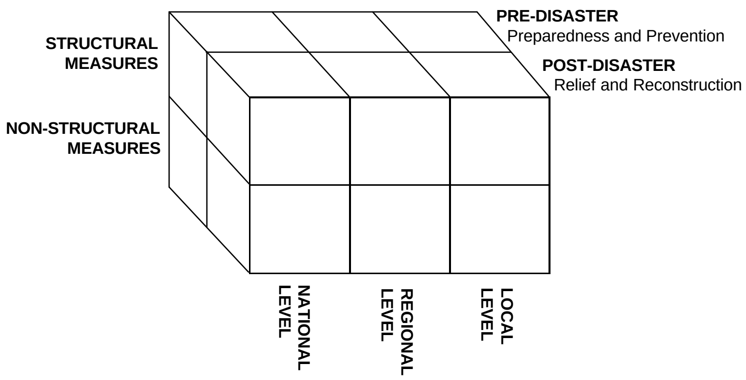

Figure 2: Disaster Management

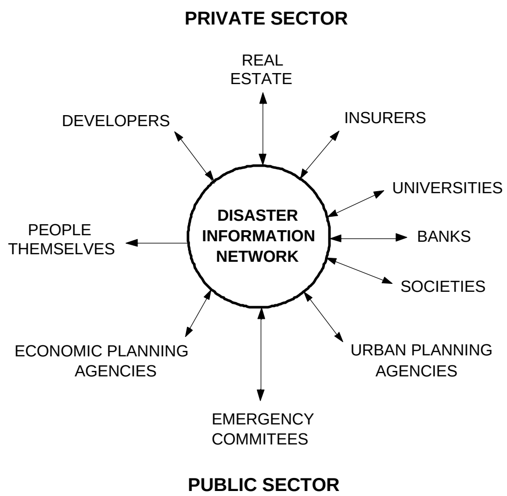

Figure 3: Potential Users and Providers of Disaster Geo-Information

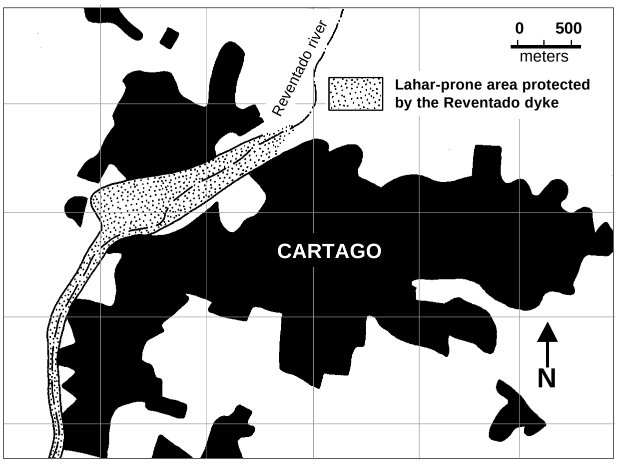

Figure 4: The City of Cartago in 1981

Immediately after the lahar of 1965, the Municipality relocated the victims, banned further development in the lahar-prone area and built a dyke to protect the city. The story is not a fully successful one as there are nowadays some squatter settlements inside the perimeter of the dyke and little work has been done on the estimation of possible property and human damage to a future lahar.

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