SDI FOR DISASTER MANAGEMENT TO SUPPORT SUSTAINABLE DEVELOPMENT

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Abstract

Sustainable development which aims increasing the quality of life is one of the main goals of many countries around the world. Therefore, many national planning and development processes in different countries are based on such achievement. However, disasters would present a major threat to sustainable development or a sign of its failure. Having said that, appropriate disaster management, can contribute to reduction of impacts of disasters and consequently facilitating the achievement of sustainable development. In this respect, considering the crucial nature of spatial data for disaster management, and considering current problems on availability, accessibility and usage of spatial data for disaster management, Spatial Data Infrastructure (SDI) as an infrastructure in spatial data production, management, sharing and access can be an appropriate framework for facilitating disaster management.

This paper aims to discuss the role of SDI in disaster management. It describes an SDI conceptual model and a prototype web-based system for better sharing and usage of spatial data to facilitating disaster management which contributes to achieving sustainable development.

INTRODUCTION

A disaster is defined as a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources (ISDR, 2003). Disasters interrupt the societies by claiming lives, creating victims, and destroying infrastructures and houses. By striking disasters, funds and budgets that have been assigned for development purposes are diverted to responding to disaster and recovering the quality of life to its normal. Disasters have also negative impacts on environment as they affect natural resources. Therefore, considering society, economy and environment as three main components of sustainable development, disasters have negative impacts on them and hence negative impact and delay on sustainable development.

With this in mind, appropriate management on disasters can contribute to reducing its negative impacts on development activities. With other talk by facilitating disaster management, achievement of sustainable development can be facilitated for nations and societies.

The experiences of disaster management activities, particularly responding to the World Trade Center event on September 11, 2001 have proven that spatial data can considerably facilitate disaster management because most of the required information for disaster management has spatial nature (Bruzewicz, 2003 and Donohue, 2002). In this respect, spatial data and related technologies such as Geographical Information System (GIS), Global Positioning System (GPS), remote sensing, and photogrammetry including visible, thermal and LIght Detecting And Ranging (LIDAR) imaging have proven to be crucial for disaster management in such a way that without spatial data, one can not expect effective and efficient disaster management (Cutter et. al, 2003 and Amdahl, 2002).

However, current studies show that although spatial data can facilitate disaster management, there are substantial problems with collection, access, dissemination and usage of required spatial data for disaster management (SNDR, 2002). Considering mitigation, preparedness, response and recovery as four phases of disaster management (FEMA, 1998) such problems become more serious during disaster response which starts after occurrence of disaster for managing emergency situation.

Disaster response is dynamic and decision-makers need to be updated on latest emergency situation by regular collection of information on emergency situation. Disaster response is also time-sensitive with little allowance on delay in decision-making and response operations. Therefore, any problem or delay in data collection, access, usage and dissemination has negative impacts on quality of disaster response.

It is suggested that Spatial Data Infrastructure (SDI) as an initiative in spatial data management can be an appropriate framework and a web-based system can be an appropriate tool for resolving current problems with spatial data. With the other talk, using SDI as a framework and a web-based system as a tool disaster management can be facilitated which contributes to facilitating achievement of sustainable development. With this in mind, this paper aims to describe the development of an SDI conceptual model and a prototype web-based system that facilitate spatial data collection, access, dissemination, management and usage for proper disaster management. This is based on an ongoing research and case study in Iran which investigates the role of SDI in disaster management with emphasize on the response phase.

RESOLVING THE PROBLEM WITH DATA FOR DISASTER MANAGEMENT

Different organizations (such as Fire, Medical and police departments; Red Cross Society; and Utility Companies) collaborate in disaster management activities due to diversity of disaster response operations. Inter-organizational coordination of disaster response operations and controlling the emergency situation is generally conducted through Emergency Operation Center (EOC) where the representatives of involved organizations are gathered.

Considering search, relief, rescue, firefighting, medical service, debate removal, sheltering, and repairing utility network as some examples of disaster response activities, a large number of spatial data layers are required for planning and coordinating such operations. In this respect Road network, closed road, hospital, disaster area, damaged building, location of victims, location of emergency workers, available resources, and utility network are some examples of required spatial data layers for disaster response operations.

Due to dynamic nature of emergency situation, required data for disaster response should be collected regularly in order to be *available* for decision-makers. This is achieved through partnership and collaboration between organizations in production and updating spatial datasets. If each of the involved organizations in disaster management community collects some part of required spatial data for disaster response during their everyday business and emergency situation, required spatial data will be available to all participants (Mansourian et al, 2004 and Rajabifard et al 2004).

The required datasets should also be *accessible* for decision-makers (involved organizations and EOC) to be utilized for planning and decision-making purposes. This is achieved if collected data by each of the participants in data collection to be shared to wider disaster management community.

In addition, the required datasets need to be easily integratable with each other and interoperable with decision-makers' systems for real-time use. This is achieved by utilization of appropriate standards and specifications for data collection and sharing.

Although a partnership model for spatial data collection and sharing can resolve the problem with collection, access and dissemination of required spatial data for disaster response, however there are still different technical and non-technical (such as institutional, cultural, and political) challenges that impede the participation of organizations in data collection and sharing. Therefore, an appropriate framework needs to be utilized in order to facilitate such partnership.

With this in mind, Spatial Data Infrastructure (SDI) can be use as an appropriate framework that facilitates the availability, access and usage of spatial data for disaster management.

SPATIAL DATA INFRASTRUCTURE

Spatial Data Infrastructure (SDI) is an initiative intended to create an environment that will enable a wide variety of users to access, retrieve and disseminate spatial data in an easy and secure way. In principle, SDIs allow the sharing of data, which is extremely useful, as it enables users to save resources, time and effort when trying to acquire new datasets by avoiding duplication of expenses associated with generation and maintenance of data and their integration with other datasets. SDI is also an integrated, multi-leveled hierarchy of interconnected SDIs based on collaboration and partnerships among different stakeholders. With this in mind, many countries are developing SDIs to better manage and utilize their spatial data assets. As a result of these activities different models have been suggested for facilitating SDI development.

Recent studies on SDI initiatives (Rajabifard and Williamson, 2003) have highlighted that development of SDIs is a matter of different challenges such as social, cultural, political and economical challenges beside technical issues.

With respect to core components, an SDI encompasses the policies, access networks and data handling facilities (based on the available technologies), standards, and human resources necessary for the effective collection, management, access, delivery and utilization of spatial data for a specific jurisdiction or community (Rajabifard et al, 2002). Based on these components, Figure 1 illustrates a basic SDI model. According to this model, appropriate accessing network, policies and standards (which are known as technological components) are required for facilitating the relation between people (data providers, value-adders and decision-makers in disaster management community) and data. By clarifying each of these core components, an SDI conceptual model can be developed which can contribute to facilitating the availability, access and usage of spatial data for disaster management and hence facilitation of disaster management.

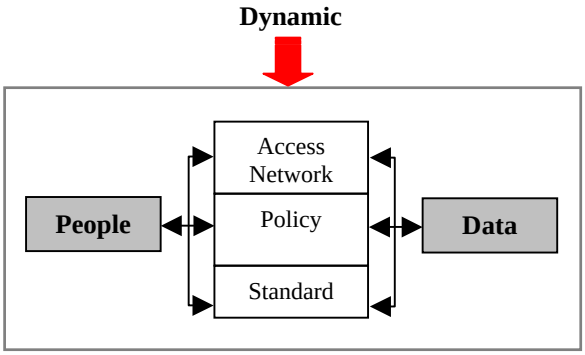

Figure 1: SDI Components (Rajabifard *et al*, 2002)

Considering Geographical Information System (GIS) as underpinning technology for SDI and its role in facilitating data collection and storage as well as facilitating decision-making based on spatial data processing and analysis, GIS is a good tool for improving decision-making for disaster management. In this respect, a web-based GIS can be a good tool for facilitating disaster management due to need to high interaction between decision-makers in disaster management community, particularly during disaster response.

With this in mind, a web-based GIS using SDI can facilitate disaster management by providing a better way of spatial data collection, access, management and usage.

CASE STUDY: DEVELOPING AN SDI CONCEPTUAL MODEL AND A PROTOTYPE WEB-BASED SYSTEM

In order to demonstrate the applicability of SDI and its facilitation role in accessing to data a research project in Iran has been designed and conducted with an aim to develop a system based on SDI through which access and usage of data and consequently disaster management can be facilitated. This research has emphasized on response phase of disaster management.

Two important outputs through this research are:

- an SDI conceptual model as a framework to facilitate partnership of organizations in data collection, dissemination, access and usage; and
- a web-based disaster management system as a tool for data sharing, data exchange and data analysis using an SDI model.

Figure 2 illustrates the overall structure of the research. The research began with a literature review on different subjects relevant to the research such as SDI, GIS, and disaster management. At the second stage disaster management community was assessed with respect to spatial data and those technical and non-technical factors that affect development of SDI. Results of organizational assessment showed that development of SDI for disaster management in Iran is a matter of *social, technical and technological, political, institutional* and *economical* challenges.

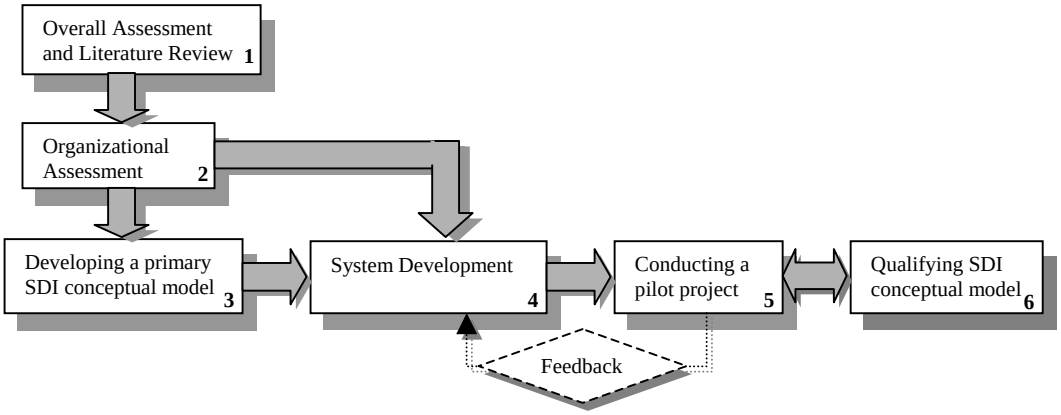

Figure 2: The Overall Structure of Research

Based on the results of organizational assessment, a primary SDI conceptual model was developed by clarifying each of the core components of SDI (including people, standards, policies, accessing network, and data). This model is a framework that can create an appropriate environment for participation of organizations in collection, sharing and usage of spatial data for disaster management.

A prototype web-based system using GIS engine with a user-friendly interface was also developed as a tool for spatial data collection, sharing and analysis. Figure 3 shows the overall structure of this system. As Figure 3 shows the web-based system is based on five core components including user interface for clients to access and analyze data, web server and application server for getting the clients' request and sending it to map server, map server for data analysis and query based on clients' request, data server for retrieving data from a database and serving them to map server for analysis, and database that includes spatial data.

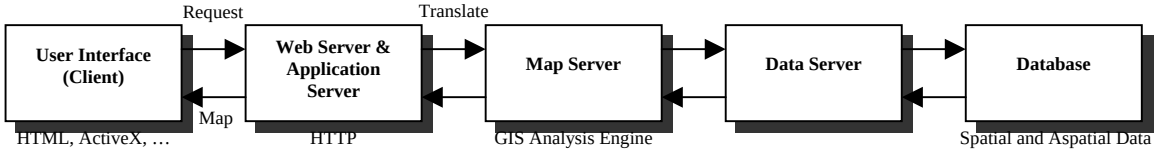

Figure 3: Core Components of Web-Based System and Their Relations

As Figure 2 shows, at the fifth stage, a pilot project was conducted. This pilot was conducted in Tehran, the capital of Iran with collaboration of twelve organizations from disaster management community in order to test the web-based system and developed SDI conceptual model. Considering the important role of awareness for SDI development, increasing the awareness of disaster management community on advantages of developed system that works using SDI, was another aim of this pilot project. This pilot project was about responding to an imagined earthquake in Tehran.

Based on the results of pilot project, primary SDI conceptual model and developed web-based system were qualified. Other pilot projects are planned to be conducted in order to have more qualifications on developed model and system.

CONCLUSION

The results of the case study and its pilot project showed how useful a web-based system that works using SDI can be for effective and efficient disaster response management. Using SDI framework, reliable and up-to-date spatial data for disaster response is always available and accessible for decision-makers. A web-based system is also an appropriate tool which can be used for data analysis and consequently coordinating and controlling emergency situation.

The effectiveness and efficiency of the system can be interpreted by different elements, however, in this research reducing the response time and removing chaos by better management and coordination were considered as two evaluating factors.

It should be noted that such SDI conceptual model and web-based system facilitates and improves not only disaster response, but also other phases of disaster management including mitigation, preparedness and recovery. Facilitating disaster management by providing a better way of spatial data collection, sharing, access, management and usage contributes to facilitation of achieving sustainable development.

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