THE APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEM ON DISASTER MITIGATION AND MANAGEMENT

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Abstract: In recent years it has become a trend to use the Geographical Information System (GIS) for disaster mitigation and hazard prevention. The GIS can quickly and efficiently process large amount of spatial data and their attributes. When deployed, it is a valuable tool for decision supports and in-disaster responses, and it can facilitate the operations of disaster mitigation and emergency rescues. When a major disaster strikes, successful rescues depend on the quick arrival at disaster sites and the timely mobilization of personnel, materials, and supplies. Every aspect of the in-disaster response such as reactions, responses, and decisions can be strengthened by the use of GIS.

Keywords: disaster mitigation, geographical information system

1. INTRODUCTION

Because of the economic boom in recent years, the city populations in Taiwan increase, more and more high-rise buildings appear, and an increasing number of large, underground, or multi-purpose building spaces are converted for commercial uses. This results in the higher complexity of urban disasters and fire problems. At the same time, the use of hazardous materials for modern industrial production, energy consumption, and manufacturing such as liquid petroleum, natural gas, and explosive chemicals has made its way into household families, factories, stores, warehouses, and various kinds of vehicles. They have great potentials for hazards. If accidents happen, both property losses and human casualties can be resulted. The recent high casualties caused by a sequence of serious hazards such as building fires, explosions, floods, typhoons, and earthquakes are so alarming that the general public has expressed its concerns on public safety, fire prevention, and emergency responses.

As for the emergency response, the most important tasks are the emergency rescue and the rapid response. If an emergency plan is not developed before disasters, the arrival of emergency supplies after a disaster will not help controlling the chaos but worsen the situations. Therefore, it is very important to implement an emergency response system for disaster rescues. Generally speaking, there are three key elements for successful rescue operations:

1.1 Timely and accurate disaster information

After major disasters, the traffic, residents, and disaster related information in the disaster area will be in a chaotic state. At this time, the continuous supply of emergency goods provided by the rescue operations can easily result in the uneven distribution of supplies and the waste of emergency supplies in the disaster area. To distribute the supplies to the people most-needed, the primary concerns are how to collect and analyze the disaster information quickly, and how to make the best judgements under an emergency condition.

1.2 Sufficient emergency supplies and resources

The sufficient and adequate preparation of emergency supplies is one of the most important tasks in planning an emergency rescue plan. These emergency supplies and resources include specialized rescue organizations, rescue personnel, rescue equipment, emergency supplies, and foods. All of them need to be prepared as early as possible. To be more effective, databases of emergency supplies should also be planned and established for emergency situations.

1.3 Well-trained rescue workers

The well-trained rescue workers refer to the teams of personnel with professional knowledge and skills to participate in a rescue mission. Their specialty should be well designated so that when a disaster occurs, each person in the team knows what to do immediately to avoid delays in the rescue operation.

Also, the team members need to go through routine training exercises in normal times to perfect their skills.

2. THE PLANNING OF INFORMATION SYSTEMS AND DATABASES

To plan for information systems and databases, the following outlines the important issues.

2.1 The basic concepts of Geographical Information Systems (GIS)

A geographical Information System (GIS) is an integrated information system that combines the technologies of computer graphics, database management, image processing, remote sensing, and computer networks. It can be used to retrieve, edit, process, analyze, and display geographical information. Most full-featured GIS includes four functions: the input and editing of geographical data function, the storage and management of geographical data function, the analysis and processing of geographical data function, and the display and querying of geographical data function [1]. One of the features of a GIS is the visualization of spatial and attribute data. That is, the GIS can display spatial and attribute data obtained from analysis or queries with bright colors, drawings, and symbols. It can also send the output to a plotter for better visual displays, and thus enhance the value of the GIS.

Reviewing the recent developments of GIS and computer technologies worldwide, we believe that the GIS will have the following developments in the next few years [2]:

1. Standardization: It is still not easy to share or transfer data between different GIS systems. After a broader acceptance of GIS, we think that the data formats will be standardized to increase the data availability and to reduce the operating cost.
2. Open system architectures: In order to satisfy the users' need, the GIS has moved toward open system architectures so that it will be easier to integrate with other software or development tools. These tools include the computer-aided design software, the global positioning system (GPS), the spreadsheet programs, and the presentation software.
3. Object-oriented developments: The development tools of GIS applications become increasingly sophisticated. The object-oriented approach is believed to be the solution.
4. Distributed processing: The client-and-server architecture is an effective way to reduce the hardware investment and to increase the throughputs. Combined with the distributed database systems, it is the major trend of future GIS development.
5. Multimedia presentations: The GIS can display photos, satellite images, sketches, statistical charts, voices, and animations, and it is gaining popularity on both personal computers and workstations.

2.2 The planning of databases for disaster mitigation & rescues

With the powerful features of a GIS, we not only can search for desired locations on electronic maps, but we can also use the database links to retrieve relevant information for the locations. Therefore, when a disaster strikes, we can quickly search for the needed information on the disaster sites and make the best decisions according to the resulting information. In other words, the purpose of establishing databases is to timely and correctly provide relevant information for the rescue operations and to protect the lives and property of the people involved in the disaster. In fact, the establishment of databases is one of the important tasks to modernize the disaster mitigation effort. The data needed in the databases are as follows:

2.2.1 Base maps

These maps and their acquisition are described below [3]:

1. Maps of municipal districts: These maps are commercially available. Or, they can be purchased from the information center of the Ministry of Interior. These maps come in two scales: 1/50,000 or 1/25,000. They need to be digitized and converted into the proper file formats before use.
2. Arial photos: Arial photos can be purchased from the Forest & Agriculture Arial Surveying Institute of the Taiwan Forestry Bureau. The Arial photos come in one scale: 1/5,000, and need to be digitized.
3. Fire districts and facility maps: The locations of fire departments and fire hydrants are digitized on the base maps.
4. Basic information of fire-fighting equipment, facilities, and fire hydrants: Provided by the local fire departments.
5. Potentially dangerous buildings and facilities: They are marked on base maps according to their coordinates.
6. Basic information of potentially dangerous buildings and facilities: Provided or obtained with the help of local authorities.
7. Street maps: Provided by the Public Work Department of local governments.
8. Basic information of city streets and county roads: Provided by the Public Work Department of local governments.
9. River systems and watershed maps: Can be acquired from the Water Conservancy Agency of Taiwan Provincial Government.

10. Basic information of river systems and watersheds: Can be obtained from the Water Conservancy Agency of Taiwan Provincial Government.
11. Maps of emergency water supplies: They are marked as legends on base maps.
12. Basic information of emergency water supplies: Provided or obtained with the help of local fire departments.
13. Maps of important facilities such as police stations and hospitals: They are marked as legends on base maps.

2.2.2 Establishment of relevant databases

These are the necessary databases:

1. Databases of rescue organizations
2. Databases of other emergency water supplies
3. Databases of traffic networks
4. Databases of positioning
5. Databases of rescue personnel
6. Databases of emergency vehicles
7. Databases of rescue equipment
8. Databases of emergency supplies
9. Databases of emergency shelters
10. Databases of disaster assistance
11. Databases of other and temporary shelters
12. Databases of rescue missions and assignments
13. Databases of disaster reports

The establishment of databases usually starts once the relevant information and maps are collected and digitized. At this stage, the main concern of establishing a database is to ensure the future transferring and storage of data. Therefore, it is preferable to have a standard data format for the databases. In addition to the above mentioned maps and data, the relevant data contained in the databases can also be acquired by surveys. A well-designed survey form should have three key elements: well-defined questions, comprehensive questions, and appropriate layouts. Therefore, the design of the survey forms is also very important.

3. THE DISASTER RESCUE MODULES OF GIS

The disaster rescue modules of a GIS are developed with the object-oriented program language, which can call all of the built-in functions of the ArcView software. Also, it allows the customization of user interfaces such as menus and tool bars. Therefore, it is very easy to learn and use the system. The functions of the disaster rescue modules are [4, 5]:

1. Chinese language Windows environment: In order to provide better learning results and system usage for the domestic users, a localized Chinese language Windows environment is necessary.
2. Modularization of program designs and functions: This allows the users to quickly enter and retrieve data from the system. Also, it is more flexible in future developments of the programs.
3. Overlay of different map layers: The Users can display and overlay different map layers for easy visualization of relevant system information.
4. Linkage of spatial data and attribute data: The users can query relevant spatial data and attribute data in different windows on a monitor and combine the data for special purposes.
5. Fast searches of various databases: Through built-in SQL and statistical analysis ability, common queries can be stored for even faster information retrieval.
6. Display of different theme maps: The theme maps are the maps created by the users to display the spatial and attribute data with different coverage, colors, types, line drawings, and shapes according to the data type and data values. This allows the users to have quick overviews of the distribution of the data.
7. Calculations of effective service radii of rescue units: By inputting the rescue unit and the service radius, the GIS with its capability of route selection and traffic analysis can determine and display the effective coverage area of the rescue unit using different criteria such as simple circles, rectangles, rhombs, and actual street distances. This will allow the identifications of blind spots for future improvements.
8. Effectiveness of rescue routes: Use the disaster simulation software and the spatial analysis capability of GIS to determine the shortest route to reach the disaster area. The simulation results can be used in the assessment of the rescue effort in the event of real disasters.

In summary, the disaster rescue system is divided into the map management module, the disaster reporting and processing module, the positioning module, the emergency supply look-up module (including data on personnel, equipment, supplies, and emergency water sources), the mission assignment and dispatching module, the traffic and information module, the rescue route module, and the fire-fighting power and emergency care analysis module.

4. CONCLUSIONS

In conclusion, to establish a complete GIS system for disaster rescues, we need not only a powerful and adaptable application software system, but also the complete and comprehensive databases. To fully utilize the rescue system, the stored data have to be up-to-date, correct, and useful. Regarding the development of rescue application system, the GIS technology is still under rapid developments. We should monitor the developments and choose the

appropriate software and hardware systems to match the needs of the disaster rescue units. As a result, the GIS can be adapted for disaster rescue uses.

The GIS is a computer software system designed to process large amount of sophisticated spatial and attribute data. By integrating these data and establishing a complete database, the data collected by different rescue organizations can be shared through the use of standard coding, standard data formats, interconnected computer networks, and effective database management. This is the final purpose of applying the GIS to the field of disaster rescues.

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