2-7. Disaster Management Internet GIS

2-7-1. Objective of Disaster Management Internet GIS

The objective of the Geographical Information System (GIS) is to make full use of spatial data (data input and output, analyses, storage, and updating) beyond the limits of conventional paper maps. The term "spatial data" refers to data consisting of "geographical data" and "a ttribute data". Geographical data relate to distribution, locations, and configurations of topographic features (elevations, rivers, etc.), and features of human activities and social environments (railroads, roads and streets, buildings, land use, vegetation and population), while attribute data consist of attributes (name, class, numerical value, etc.) of such feature items. A GIS has various functions that help users to take decisions and to perform environmental or disaster impact assessments. Such functions include: visualization using selective overlay of spatial data or by legends (classifiers), statistical processing using spatial analysis, extraction (buffering) of disaster-affected areas, and selection of shortest paths. Usually, to use GIS resources, dedicated hardware, software and databases are necessary. A Web-based GIS has the advantage that it can be devised to enable analysis, display and acquisition of data using the Internet without requiring the user to install any special GIS software. This is a very important point in the handling of disaster information, because it helps reduce equipment investment and facilitates information sharing.

The accessibility to the Internet varies considerably among ADRC member countries. However, it is certain that Internet user populations will increase in these countries, along with easier access to faster and cheaper connection services. Moreover, the problem of unavailability of fixed-telephone lines is steadily diminishing thanks to the steady development of the satellite Internet connection technology. Thus, Internet GIS resources can be expected to be a more important component of a disaster risk management system in an emergency.

2-7-2. Development and Improvement of "VENTEN (Vehicle through Electronic Network of disasTer gEographical informatioN)"

2-7-2-1. Background to the Development of "VENTEN"

Recent advancements in image prossessing technology have greatly improved the reliability of satellite image data (in terms of accuracy and resolution), providing favorable conditions for the use of remote sensing technology that makes it possible to extract various data useful for disaster reduction without spatio-temporal constraints. At present, however, the use of systems directly applicable to disaster reduction is still very limited. One of the main reasons for this is the fact that a disproportionately large emphasis has been placed on technological breakthroughs by satellite image providers while disaster management practitioners have not been actively involved. Another reason is the technical difficulty of direct application of data extracted from satellite images to disaster reduction activities. Such data do not become usable for disaster reduction until they are analyzed in combination with natural environment data (e.g., topography and geology), and socio-environmental data (e.g., population, buildings, and infrastructures). A yet additional and large obstacle to the application of satellite imagery to disaster reduction is the simple fact that it takes huge costs and high technological capabilities to implement a Geographical Information System (GIS) as an analysis platform for such spatial data.

At the First ADRC International Meeting held from February 16 to 18, 1999, a workshop was organized under the theme of "Utilization of Technologies". Discussions at the workshop revolved around the use of GIS and remote sensing technologies for disaster reduction. Conclusions of the workshop are as follows:

- □ Conclusion 1: All member countries recognize the importance and value of GIS and remote sensing technologies, and the advantages of information management.
- □ Conclusion 2: Future tasks include: real-time acquisition of satellite images, cost reduction in satellite data acquisition, technological support for introduction of GIS and remote sensing technologies, and establishment of technologies for extracting disaster management information.

Thus, disaster management agencies of member countries showed strong interests in GIS and remote sensing technologies. At the same time, however, it became clear that the enormous initial costs and the required technical standards are the obstacles to the use of these technologies. Also blamed were the high usage costs for satellite image and map data.

To solve these problems, ADRC developed the VENTEN (Vehicle through Electronic Network of disasTer gEographical informatioN) system, an Internet-based disaster management GIS that can be accessed by anyone from anywhere, using the rapidly expanding Internet. The basic framework of this system was developed as part of the "Asia Disaster Information Network System Development Research" project funded by the Japan Science and Technology Corporation (September 1998 - September 2001).

2-7-2-2. Outline of "Development Research on the Disaster Information Network System in Asian Region"

Granted funds from the Japan Science and Technology Corporation (ACT-JST segment: environment and safety), ADRC conducted a three-year "Asia Disaster Information Network System Development Research" project from September 1998 through September 2001. An Internet-based GIS disaster information system, "VENTEN" (Vehicle through Electronic Network of disasTer gEographical informatioN), was developed as part of this project.

The two main achievements of the project include:

□ Construction of VENTEN - an internet GIS platform for disaster management information acquisition, and
□ Development of a disaster management information database

Remaining issues identified at the end of the project include:

□ Expansion and enhancement of the database
□ Development of satellite data application technologies, and
□ Interactive transmission of real-time disaster information

Papers based on this project have been compiled into the Final Report on Development Research for Asia Disaster Information Network System 'VENTEN' (ISBN 4-901614-01-0).

2-7-2-3. Objective of the development of "VENTEN"

The objective of the development of the VENTEN system is to provide both a system and data (including analysis results). This system is designed to be readily used with a personal computer connected to the Internet and installed with a WWW browser.

Although various organizations were already providing, free or at cost, not only basic map data including topographic and natural environment information, but also GIS data, it was necessary to convert the data format to the requirements of the GIS software in use in order to view and analyze these data. Therefore, in the development of the VENTEN system, various GIS data were converted into a VENTEN-compatible format to allow integrated management of these data and the hardware.

Fig.2-7-2-1 illustrates the functional position of the VENTEN system in disaster data collection. On the left side of the Figure are data supplier organizations including various space research and development institutes and aerial photograph

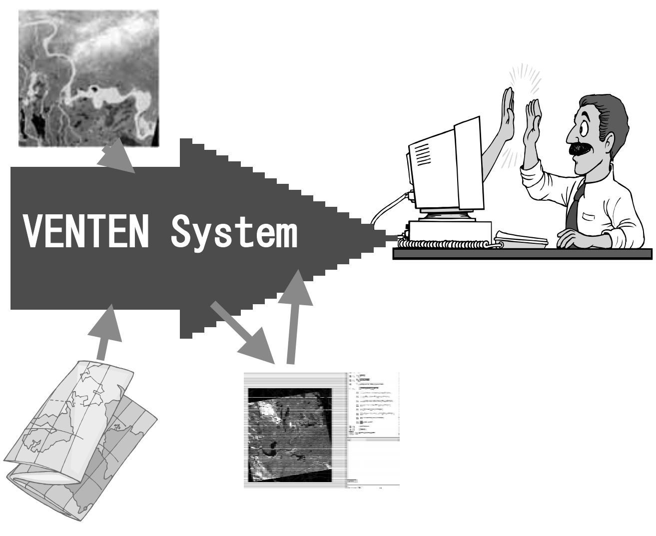

Fig.2-7-2-1 Function of VENTEN

laboratories, from which the original primary data are provided. In order to extract useful information for disaster reduction from these primary data, various data processing tasks and data analyses are required. Also necessary are channels to send extracted data to working-level disaster management personnel. Disaster management researchers can browse and analyze data available from the VENTEN system, as well as feedback the results. The VENTEN system serves as a database and analysis tool for remote sensed disaster data, and provides a communications channel to disaster management personnel. Thus, the VENTEN system allows effective application of disaster-related information obtained using remote-sensing and GIS technologies to the practical aspects of disaster reduction, including disaster reduction planning and support to frontline relief operations.

2-7-2-4. Overview of “VENTEN”

(1) Configuration

The VENTEN system consists of a Web server, a GIS server, and a database server. Fig.2-7-2-2 shows the information processing flow in the VENTEN system. First, an access request from the user is accepted by the Web server. The Web server specifies the necessary information, including the kinds of geographical data and the extents of areas, for the GIS server (multiple geographical data can be specified as required). The GIS server extracts the relevant data from the geographical data it stores (referring to the data server if necessary), and then uploads the data to the Web server in the form of raster images. The Web server adds other elements, such as a country selection menu, disaster management information selection menu, show/-hide toggle button, scale and area management button, and then maps these elements and the raster image data provided by the GIS server onto a hypertext file, which is sent to the user.

Moreover, to make the system so user-friendly that even first-time users can operate it easily, the main page is designed to allow the user to jump to the online manual, tutorials and databases (Fig.2-7-2-3). The system can also display Normalized Difference Vegetation Index (NDVI) images, and land elevation map images. Fig.2-7-2-4 shows the start page of the VENTEN system.

There are several types of Internet GIS systems. Some operate with special application programs downloaded by the user, and others allow only

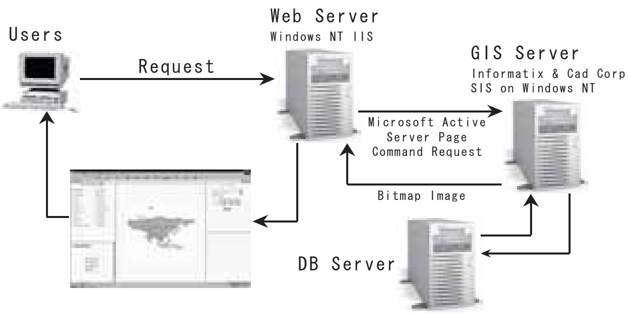

Fig.2-7-2-2 Process flow of VENTEN

Fig.2-7-2-3 Top Page of VENTEN

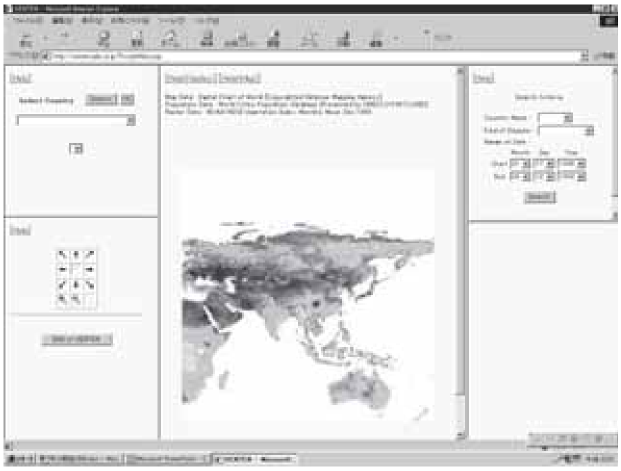

Fig.2-7-2-4 Start Page of VENTEN

viewing of image map-based geographical data. The method adopted for the VENTEN system falls between the two types in terms of functions. In other words, the user can manipulate vector data on the VENTEN system, but can obtain only raster data based on the vector data. Although this restricts data retrieval by the user, the method allows avoidance of the problem of differences in response between different network environments, and the copyright issues of image data. In discussions on Internet GIS systems, the central issue is always the network traffic load of data transmission. As far as the VENTEN system is concerned, this is not so much of a problem.The VENTEN Web server does not do anything more than just transmit fixed scale images of 470 x 470 pixels to the center of the active window of its client machine. This system needs a longer time in calculation on the server side than in data transmission, which means that the network conditions between the VENTEN Web server and the user terminal unit hardly affect the efficiency of the VENTEN system. Of course, only raster data reach the user, but the system makes it seem to the user that he/she is directly manipulating a vector data even though it actually is a raster data.

City	Population
Ichihara	241207
Narashino	137415
Funabashi	507905
Sakura	125069
Yachiyo	142402
Abiko	113239
Tsuchuira	119956
TOTAL	1387193
	1387193

Fig.2-7-2-5 Designation of a 50 km range from Narita Airport as Buffer on VENTEN (top) and Results of the Calculation of Population in the Buffer Area (bottom)

(2) Functions

The VENTEN system has a standard set of GIS functions: “display of selected areas at preferred scales”, “buffering”, “overlayin g,” and “search by location and attribute”. Fig.2-7-2-5 shows a buffer area and the populations of cities in the area. The buffer has a radius of 50 km with Narita International Airport at the center. The names and populations of the cities in the area are extracted and displayed in the table. The shortest route analysis function helps determine the shortest route for evacuation or transportation of supplies. More specifically, when a data extraction process is performed with the source of the supplies specified as the starting point S and the affected zone as the destination E, the shortest route is selected out of many possible routes and displayed as a bold line (Figure 2-7-2-6). This function is useful for determining the shortest route. Used in combination with the buffering function, it also functions as a practical tool for searching detour routes to avoid affected zones.

As described above, the VENTEN system provides only raster data to the user terminal unit, but it accepts requests from the user to perform various processes on the vector data stored in the server.

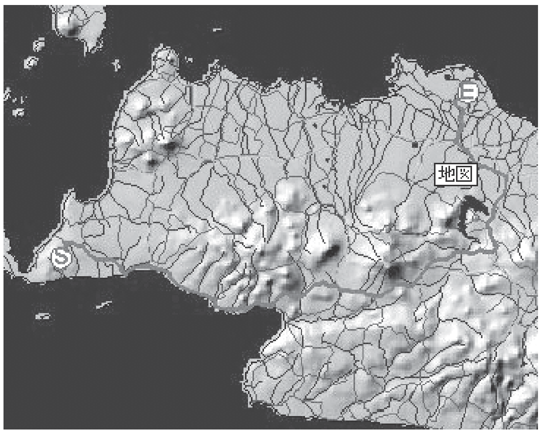

Fig.2-7-2-6 Result of the Shortest Route Analysis

(3) Data

The VENTEN GIS database covers the ADRC member countries (25 countries, as of the end of March, 2006). These data are divided into two main categories: general basic map data (e.g. topography and natural conditions), which are not specifically collected for disaster management purposes, and disaster management-related geographical data containing maps overlayed with disaster information..

In 2002, basic map data of non-member Asian countries were incorporated into the VENTEN database, because it is undesirable that there are areas left with no basic map data, when considering the possibility that a natural disaster may occur at a border area between a member country and a non-member country (see Fig.2-7-2-7).

①Basic map data

A fixed menu box is provided at the right bottom of the VENTEN screen to select the Show/Hide option for basic map data.

See Fig.2-7-2-8 and Tables2-7-2-1 and 2-7-2-2 for the basic map data available as of now.

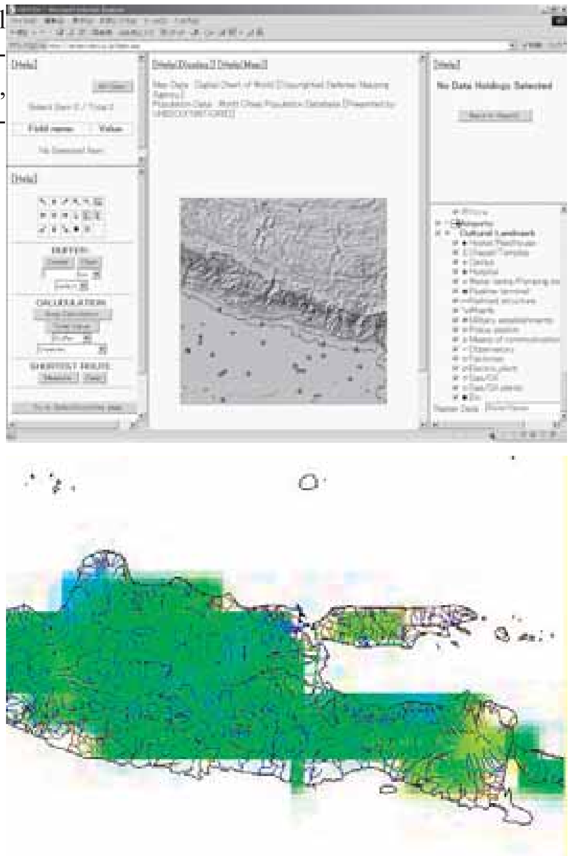

Fig.2-7-2-7 A screen shot of a basic map data (top), and an enlarged map with Vegetation Index image data overlain on the basic map data (bottom)

Fig.2-7-2-8 Area Covered by VENTEN Basic MAP Data (Dark Areas)

Table2-7-2-1 Basic Geographical Data (Vector Data)

File name	Description	Data structure
AEPOINT	Airports	Point
CLPOINT	Cultural facilities	Point
DNAREA	Rivers (polygon)	Polygon
DNLINE	Rivers (line)	Line
LCAREA	Land coverage	Polygon
POAREA	Shorelines	Polygon
PPPOINT	City names	Point
RDLINE	Roads and streets	Line
RRLINE	Railroads	Line
TSLINE	Transportation facilities (line)	Line
TSPOINT	Transportation facilities (point)	Point

Table2-7-2-2 Basic Geographical Data (Image Data)

Image file name	Description	Data structure
Relief	Shadow image data (Switchable between the two scale levels)	Raster (approx. 10km resolution)
		Raster (approx. 1km resolution)
DEM	Elevation image data	Raster (approx. 10km resolution)
Vegetation July, 1998	Vegetation index image data (Summer)	Raster (approx. 15km resolution)
Vegetation Dec., 1998	Vegetation index image data (Winter)	Raster (approx. 15km resolution)

②Disaster management geographical data

- Status of Nishinomiya Station and the surrounding blocks affected by the 1995 Great Hanshin-Awaji Earthquake
- Status of affected blocks according to a survey conducted after the 1995 Great Hanshin-Awaji Earthquake (source: Building Research Institute, Ministry of Construction, Japan)
- Areas affected by Chang Jiang Flood in 1998
- Distribution of active faults (Japan, Eastern region of Nepal, and Sakhalin (Russia))

2-7-2-5. "VENTEN"-related Future Development Plans

(1) Basic Map Data

In principle, basic map data currently integrated into the VENTEN system are based on source maps with a scale of 1:1,000,000. However, the desirable scales for the Geographical Survey Institute's national basic maps would be 1:50,000 to 1:25,000. To enable practical application of maps to city planning (including disaster preparedness plans), disaster management or emergency response activities, their scales should fall within the range between 1:5,000 and 1:2,500, at least. At present, however, it is impossible to integrate map data into the VENTEN system at these scales (Few Asian countries have such detailed digital map data, and, from the perspective of disaster reduction, it is impractical to create such map data for uninhabited regions.). When geodetic satellite technology makes it possible to create, update, and disseminate high-resolution GIS data, the VENTEN system should incorporate such data. The ADRC will continue to upgrade and update geographical data as required.

(2) Disaster Management Geographical Data

In Asian countries, data on active fault distribution are extremely important in earthquake disaster reduction. However, there are many obstacles, such as severe natural environmental conditions, or economic and technical limitations, to collection of actual data. In cooperation with researchers of active faults in Japan, ADRC has been promoting an aerial photographic database project to realize stereoscopic detection of exposed active faults in some member countries highly prone to earthquake disasters. This method has the advantage of allowing detection of potential active faults without the need of on-site geological investigations. Such a macroscopic approach to geological structures helps to avoid local disturbances and detect active faults that could be left unnoticed in field surveys. The ADRC is investigating how to incorporate data thus collected into the VENTEN system.

It is also necessary to extend GIS data coverage to other kinds of natural disasters such as tidal waves, floods, volcanoes, landslides and droughts, in addition to earthquakes, with a view to integrating data ADRC possesses into databases created by external organizations.

It is also important to incorporate disaster management-related and damage-related information, such as hazard maps, early warnings, and actual damage data, into public domain GIS databases accessible through the VENTEN system. There are various maps publicly available today, but few of them are available in the form of GIS data. ADRC will launch a pilot program to collect data for the integration of hazard maps and other disaster management data into the VENTEN system.

(3) Cooperation with Satellite Data Providers

ADRC is currently conducting a research project on the construction of a disaster management information network utilizing high-speed Internet satellite (WINDS: Wideband InterNetworking engineering test and Demonstration Satellite), remote sensing and mobile technologies, in cooperation with Japan Aerospace Exploration Agency (JAXA), National Institute of Information and Communications Technology (NICT) and Diamond Air Service Inc. (DAS). The purpose of this project is to make it possible to transmit real-time image data from aircraft equipped with high resolution cameras to ADRC (or the disaster management headquarters) when a severe disaster occurs in Asia and other regions, so that ADRC can disseminate the information from its Website to facilitate sharing of the information of the disaster and promotion of international emergency response activities. It is also considered possible to transmit photographic images captured on-site real-time to distant locations for assessment of building collapse hazards.

Needless to say, all these visual data should be incorporated into GIS databases, and further research is necessary to investigate how to incorporate these data into the VENTEN system.

The launch of WINDS is planned for fiscal 2007, and another land observation satellite "DAICHI" (Advanced Land Observing Satellite (ALOS)) has been launched at Jan. 2006. ADRC concerts to JAXA for using DAICHI data for the VENTEN system. DAICHI project has been promoted with a view to making contributions to the Global Mapping Project (http://www.iscgm.org). DAICHI is expected to facilitate global sharing of high-resolution map data.

(4) Improvement of User Interfaces and Functions

The current VENTEN system still has some points to be improved in terms of user-friendliness: help pages, instruction manuals, and tutorials need further improvements. It is also necessary to use questionnaires and opportunities such as workshops in order to systematically identify and incorporate the needs of end-users into the improvement of the VENTEN system. ADRC is developing a new VENTEN system in cooperation with JAXA and Keio University, so new VENTEN system will be released in 2006.

2-7-3. Toward Wider Use of Disaster Management Internet GIS

ADRC will closely observe current and future developments in the relevant fields, and seize opportunities to further promote the use of its disaster management Internet GIS in Asia.

2-7-3-1. Creation, Distribution and Use of Hazard Maps

It seems that cities around the world have been becoming more vulnerable to disasters because of rapid development, urbanization, and population growth since the second half of the 20th century. Municipal governments of capitals and major cities of countries in Asia, including Teheran, Istanbul, Kathmandu, Manila, Ulan Bator, Tokyo, and Yokohama, have prepared estimates of earthquake damage. Flood hazard maps have also been prepared in Asian countries. As for forest fires, the ASEAN countries, for example, have developed an Internet GIS network to share hazard data collected using satellite imagery and observation.

It is important to study and implement the methods of integration of hazard maps into city planning (disaster preparedness), zoning, building standards, and public disaster awareness raising campaigns from various perspectives including international cooperation, central government policies, and local community activities. It is not enough that the government provides hazard maps to citizens. A mechanism should be devised in order to incorporate citizens' view points into updated data. Equally important are cross-organizational information exchange among relevant ministries and agencies, cooperation among the public, private, academic and NGO sectors, and disaster education curricula for schools. A disaster management Internet GIS open to anyone is indispensable for all these purposes.

2-7-3-2. Integration of Mobile Telecommunications with Disaster Management Internet GIS

Mobile phone networks can be developed with a smaller initial investment than fixed telephone networks. Therefore, mobile phone networks are rapidly expanding in Asian countries, developing countries in particular. According to some estimates, the world's mobile phone user population will exceed two billion persons in 2005. There are already many successful cases of transmission of early warnings and disaster emergency information using wireless telecommunications technologies such as cell-phone short mail services. The ongoing diffusion of broadband connections will influence the way mobile phones are used. It will become more common than it is today to use mobile phones for interactive transmission of image data in addition to text and voice data.

To display GIS data on the small screen of a mobile phone, it will be necessary to develop a new data format different from the existing Internet GIS data formats, as well as a whole new set of data. Therefore, it is likely that mobile phone-based GIS data will first become available for major cities and surrounding areas. It is also important, in terms of cost effectiveness, to develop cell phone-based GIS networks as a useful multi-purpose urban IT infrastructure not only for disaster reduction, but also for daily social life and tourism.

Once they become widely used, cell phones bundled with sophisticated digital camera and GPS functions will provide a powerful Internet tool for semi-realtime GIS data sharing between affected areas and disaster management headquarters in disaster emergencies. It is also considered that cell phones will become a useful ubiquitous communications tool for raising disaster preparedness awareness among local populations and promoting "participatory disaster-resistant city planning."

2-7-3-3. Utilization of Satellite Imagery and Aerial Photography

Satellite image data and aerial photographic data are useful to enable the user to associate map data with physical geography. The problems are: that these data are expensive, that raw data need reformatting for integration into GIS databases (data conversion and management), and that satellite image or aerial photograph data for areas or times of interest are often unavailable at preferred resolutions.

Recently, there is an increasing number of satellite image and aerial photograph databases being created and released as part of international cooperation or as national policies. As of

March 2006, there were 163 countries and regions participating in the “Global Mapping” project, and the number of countries releasing data reached 22. Though the Project has various limitations such as small scale maps, vector map data as well as satellite image data are already made available on the Internet. Moreover, the Geographical Survey Institute of Japan has released a chronological collection of aerial photograph data of the three Japanese metropolitan areas (Tokyo, Osaka, and Nagoya) (available in Japanese only. http://mapbrowse.gsi.go.jp/airphoto/indexmap_japan.html). A national spatial database created primarily with taxpayer’s money is a common property of the nation. The Japanese government should continue taking the initiative in the development of this kind of databases.