3-5. Internet GIS

3-5-1. Objective

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" consists of "geographical data" and "attribute 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 consists of attributes (name, class, numerical value, etc.) of such feature items. A GIS has various functions that help users to make decisions and to perform environmental or disaster impact assessments. Such functions includes: visualization using selective overlay of spatial data or by legends (classifiers), statistics processing using spatial analyses, 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 special GIS software. This point is a very important in the handling of disaster information, because it helps reduce equipment investment and facilitates information sharing.

The member countries of ADRC still differ greatly in the degree of Internet availability. However, it is certain that Internet user populations will increase in these countries, along with the diffusion of faster and cheaper connection services. Moreover, the problem of unavailability of fixed-telephone lines is steadily diminishing thanks to the ongoing pervasion of the satellite Internet connection technology. Thus, Internet GIS resources can be expected to increase its importance as a disaster risk management system in an emergency.

3-5-2. Development "VENTEN (Vehicle through Electronic Network of disasTer gEographical informatioN)"

3-5-2-1. Background to the Development of "VENTEN"

Recent advancements in image possessing technology have greatly improved the reliability of satellite image data (in terms of accuracy and resolution), laying the groundwork for applying various data, which are extracted using remote sensing technology that eliminates spatio-temporal limitations, to disaster reduction. At present, however, the use of systems having direct applicability 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 social environment data (e.g., population, buildings, and infrastructures). A yet additional and large preventive factor for 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 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 enormous initial costs and the required technical standards presented 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 VENTEN (Vehicle through Electronic Network of disasTer gEographical informatioN), 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).

3-5-2-2. 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 the project.

The two main achievements of the project include:

□ Construction of VENTEN – an internet GIS platform for disaster management information acquisition, and
□ Development of the database on disaster management information

The issues that require further development include:

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

Study papers 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).

3-5-2-3. 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-compliant format to enable an integrated management of these data and the hardware.

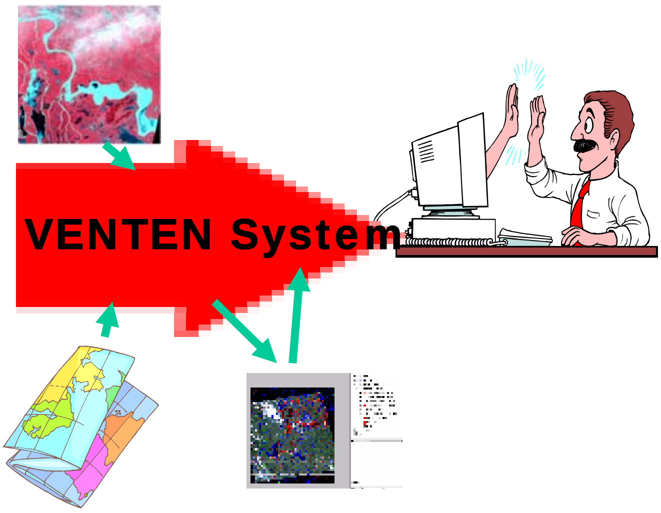


Fig. 3-5-2-1 Function of VENTEN

Fig. 3-5-2-1 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 laboratories, from which the original primary data are provided. In order to extract useful information for disaster reduction from these primary data, a wide range of data processing tasks and data analyses are required. Also necessary are channels to send data thus extracted 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.

3-5-2-4. Overview of "VENTEN"

1) Configuration

The VENTEN system consists of a Web server, a GIS server, and a database server. Fig. 3-5-2-2 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, to 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.

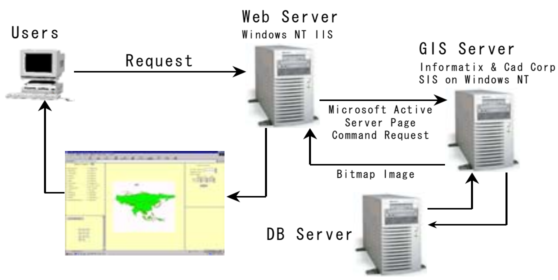


Fig. 3-5-2-2 Process flow of VENTEN

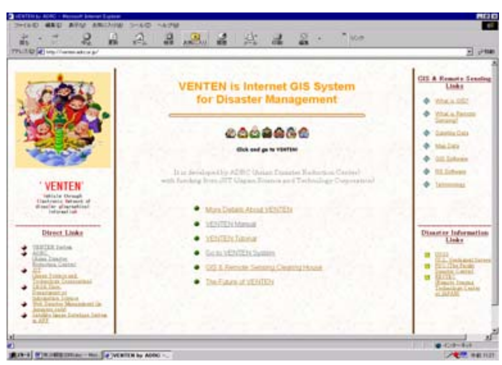


Fig. 3-5-2-3 Top Page of VENTEN

Moreover, to make the system so user-friendly that even first-time users can operate it easily, the main page is so designed that the user can jump from there to the online manual, tutorials and databases (Fig. 3-5-2-3). The system can also display Normalized Difference Vegetation Index (NDVI) images, and land elevation map images. Fig. 3-5-2-4 shows the start page of the VENTEN system.

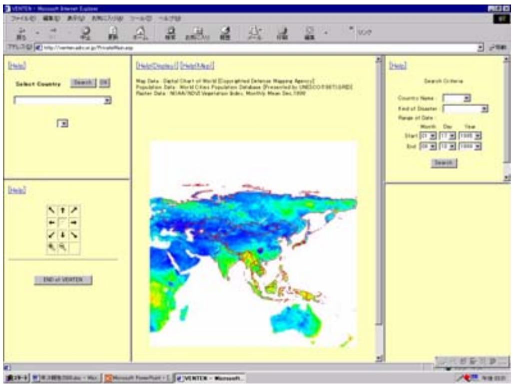


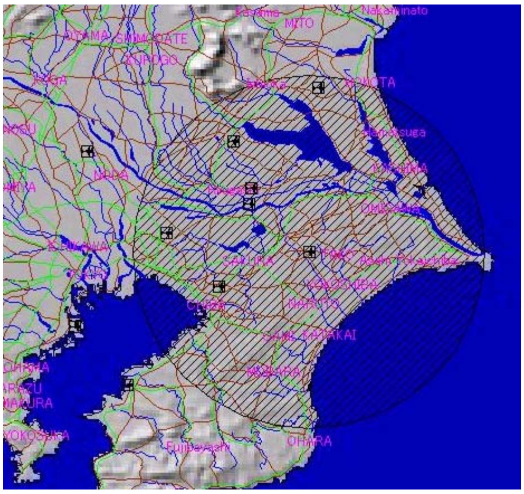
Fig. 3-5-2-4 Start Page of VENTEN

There are several types of Internet GIS systems. Some operate with special application programs downloaded by the user, and others allow only 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 the user in data acquisition, the method allows avoiding the problem of differences in response between different network environments, and the copyright issues of the 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, it is only raster data that reach the user, but the system makes it seem to the user that he is directly manipulating a vector data when it actually is a raster data.

2) Functions

VENTEN has a standard set of GIS functions: "display of selected areas at preferred scales", "buffering", "overlaying," and "search by location and attribute". Fig. 3-5-2-5 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 displayed as extracted data 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 3-5-2-6). This function is useful for searching 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



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

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. 3-5-2-5 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)

3) Data

The VENTEN GIS database covers the member countries of ADRC (24 countries, as of the end of March, 2003). 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 overlain 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. 3-5-2-7).

① Basic 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. 3-5-2-8 and Tables 3-5-2-1 and 3-5-2-2 for the basic map data available as of now.

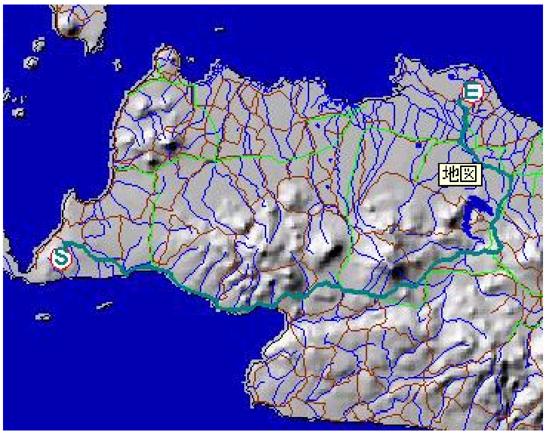


Fig. 3-5-2-6 Result of the Shortest Route Analysis

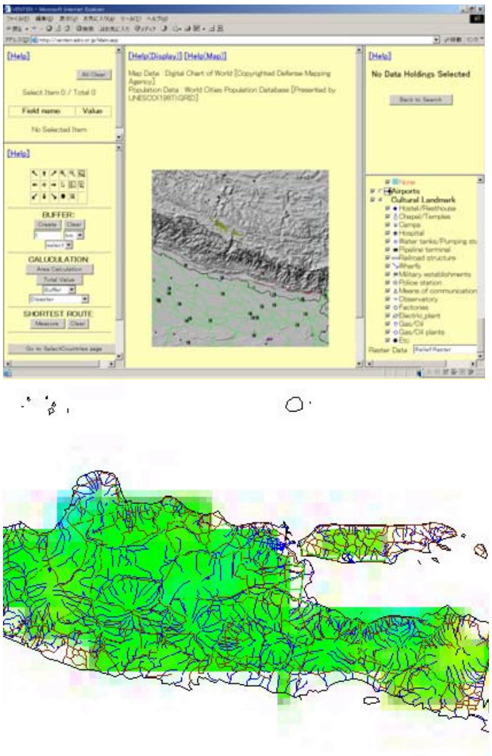


Fig. 3-5-2-7 A screen shot of a basic map data (top), and an enlarged map with Vegetation Index image data overlain on the basic map data (bottom)

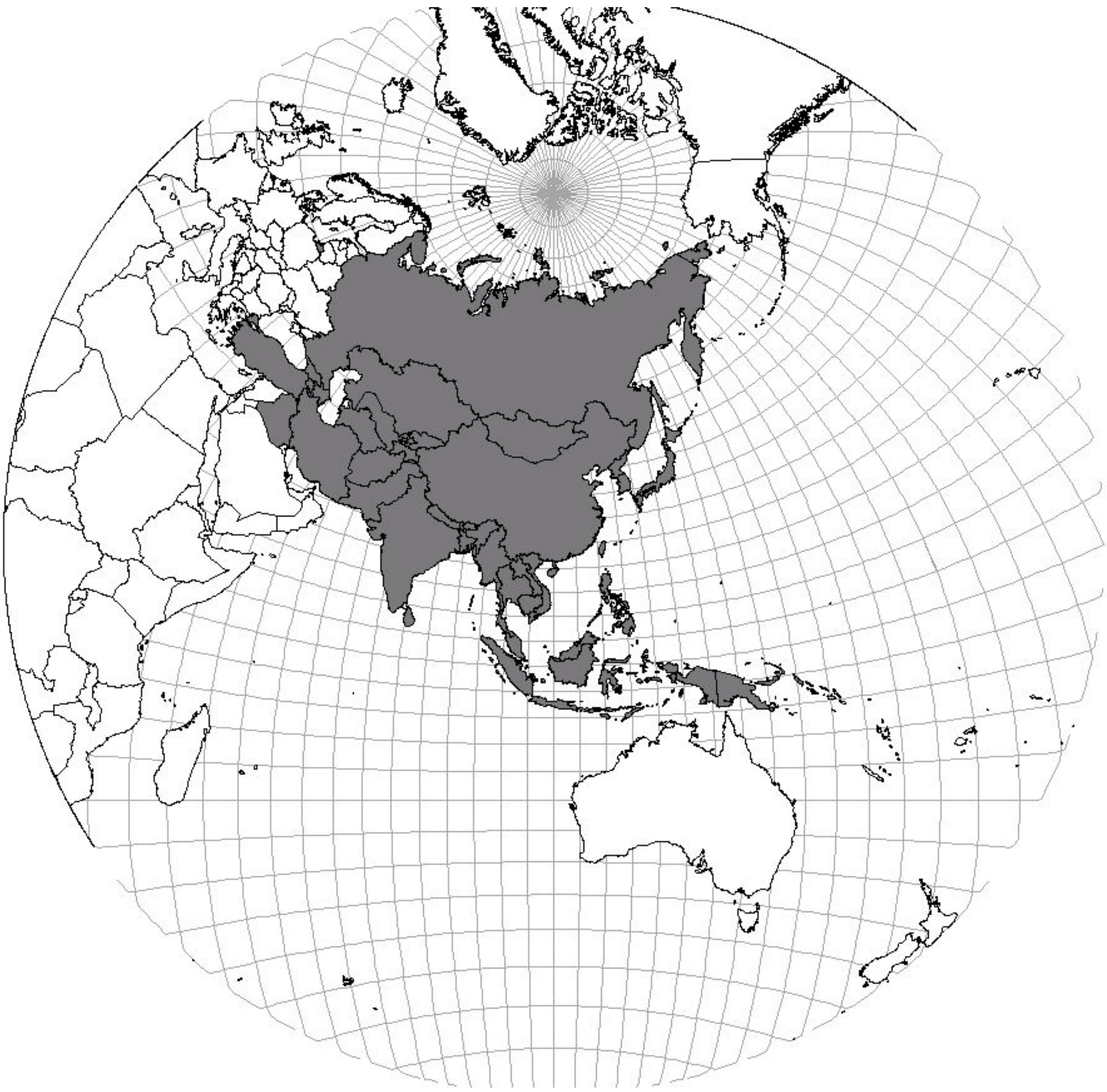


Fig. 3-5-2-8 Area Covered with VENTEN Basic MAP Data (Dark Areas)

Table 3-5-2-1 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

Table. 3-5-2-2 Basic Geographical Data (Image Data)

<table>
<tr><th>Image file name</th><th>Description</th><th>Data structure</th></tr>
<tr><td rowspan="2">Relief</td><td>Shadow image data</td><td>Raster (approx. 10km resolution)</td></tr>
<tr><td>(Switchable between the two scale levels)</td><td>Raster (approx. 1km resolution)</td></tr>
<tr><td>DEM</td><td>Elevation image data</td><td>Raster (approx. 10km resolution)</td></tr>
<tr><td>Vegetation July, 1998</td><td>Vegetation index image data (Summer)</td><td>Raster (approx. 15km resolution)</td></tr>
<tr><td>Vegetation Dec., 1998</td><td>Vegetation index image data (Winter)</td><td>Raster (approx. 15km resolution)</td></tr>
</table>

② Disaster management geographical data

- Damages to housing around Nishinomiya Station by the Great Hanshin-Awaji Earthquake in 1995
- Damages to housing in each district analyzed on the basis of survey results of the Great Hanshin-Awaji Earthquake in 1995 (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))

3-5-2-5. "VENTEN"-related Future Development Plans

1) Basic Map Data

In principle, basic map data currently integrated into VENTEN 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. For maps to serve practical purposes in city planning (including disaster preparedness plans) or in disaster management and emergency response activities, their scales should fall within the range of 1:5,000 to 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. 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 difficulties associated with collection of actual data due to severe natural environment conditions, or economic and technical limitations. 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 conducting on-site geological investigations. Such a macroscopic approach to geological structures helps to avoid local disturbances and detect active faults that field surveys alone could leave unnoticed. ADRC is investigating how to incorporate data thus collected into the VENTEN system.

It is also necessary to extend GIS data collection to other kinds of natural disasters such as tidal waves, floods, volcanoes, landslides and droughts, in addition to earthquakes. ADRC will consider doing so with a view to integrating data it 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), the Communications Research Laboratory (CRL) 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 disaster information 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 assessing 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 2005, and another land observation satellite (Advanced Land Observing Satellite (ALOS)) is scheduled to be launched in 2004. ADRC is studying methods of using data from ALOS for the VENTEN system. The ALOS project has been promoted with a view to making contributions to the Global Mapping Project (http://www.iscgm.org). ALOS 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 to be improved. 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.

3-5-3 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.

3-5-3-1 Creation, Distribution and Use of Hazard Maps

It seems that cities around the world have been increasing their vulnerability to disasters because of rapid development, urbanization, and population growth since the second half of the 20th century. As for earthquakes, capitals and major cities of countries in Asia, including Teheran, Istanbul, Kathmandu, Manila, Ulan Bator, Tokyo, and Yokohama, have conducted damage assessments. Asian countries have also been committed to creating flood hazard maps. 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 disaster awareness raising activities targeting citizenry 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 that can incorporate citizens' view points into data updating. Equally important are multilateral 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 that anyone can readily access is indispensable for all these purposes.

3-5-3-2 Integration of Mobile Telecommunications with Disaster Management Internet GIS

Mobile phone networks can be developed with 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 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 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 near real-time 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 residents and promoting "participatory disaster-resistant city planning."

3-5-3-3 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 photographs data for areas or time of interest are often unavailable in the user's 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 2004, there were 132 countries and regions participating in the "Global Mapping" project, and the number of countries releasing data reached 18. 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). National spatial data primarily created with taxpayer's money are a common property of the nation. The Japanese government should continue taking the initiative in the development of this kind of databases.