Dissemination of information on debris flow hazard areas using GIS technology

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ABSTRACT: The types of debris flow disasters in Japan are diversifying these years. New residential areas developed on the foothill have increasingly been affected by debris flows. Also, the ratio of senior citizens and other disaster-vulnerable people involved in debris flows is increasing. To cope with the situation especially in terms of nonstructural measures, the Sediment-related Disaster Prevention Law was established in 2001. Under this law, various nonstructural measures have been promoted, such as the establishment of a warning and evacuation system and restriction of land development. Presented in this report is our effort to prepare a hazard map using the latest geographic information system (GIS) technology, to be utilized for disseminating information on debris flow hazard areas and for warning and evacuation activities. The hazard map is prepared by overlaying debris flow hazard areas, refuge areas, evacuation routes, etc. over a numerical map and an orthophoto utilizing GIS technology. The prepared hazard map makes it possible to inform local residents about the vulnerability of their areas in an easy-to-see visually manner.

1 INTRODUCTION

About 70% of Japan's land area is mountainous or hilly areas. So, the nation's over 120 million population live in the remaining small land area. Although the high-growth period of national economy has already ended, concentration of the population in large cities is still continuing. As a result, many people are placing their houses in areas at risk of sediment-related disasters, such as below steep slopes, downstream of mountain streams, and the vicinity of landslide sites. According to the results of a nationwide survey in March 2003, the number of sediment-related disaster hazard areas at risk of steep slope failures, debris flows, and landslides was 525,307 across the country. Because of this vulnerability, about 900 sediment-related disasters occurred every year in the past 10 years.

To address the situation, the Japanese Government established the Sediment-related Disaster Prevention Law in 2001 with the intention of promoting nonstructural measures such as establishment of a warning and evacuation system.

Under this law, various nonstructural measures have been implemented. Dangerous areas below steep slopes, downstream of mountain streams, and the vicinity of landslide sites were designated as sediment-related disaster hazard areas. A warning and evacuation system was put in place to protect lives and properties of people from sediment-related disasters. It became also possible to impose a restriction on various activities including private rights, like restriction on building structure and land development.

The authors have engaged in the development and operation of the “Sky View Map” system that can disseminate debris flow hazard areas and related information to local people accurately and efficiently. This system was developed utilizing orthophotos, ordinary road maps available at the shop, and the latest GIS technology.

2 SEDIMENT-RELATED DISASTER HAZARD AREAS

The sediment-related disaster hazard areas prescribed by the Sediment-related Disaster Prevention Law is comprised of two areas. One is the area where hazards may be posed to the lives or bodies of residents (Sediment-related disaster hazard area: Yellow Zone). The other is the area where building damage is likely and serious hazards may be posed to the lives or bodies of residents (Special sediment-related disaster hazard area: Red Zone).

For the setting of these sediment-related disaster hazard areas, a sediment-related disaster hazard area setting support system which uses three-dimensional (3D) numerical maps and orthophotos is utilized. The setting results are outputted as the electronic information.

3 SKY VIEW MAP

The Sky View Map is a system to be utilized for disseminating debris flow hazard areas and related information to local residents. It is displayed on the screen in the form that debris flow hazard areas are overlaid on the road map and aerial photo (orthophoto) which are placed in the background. Information necessary for evacuation such as refuge areas can be inserted. It is also possible to check the location of the nearest refuge area, its route, and the distance to reach it.

Principle functions of the Sky View Map are as follows:

- The map and the orthophoto can be changed or overlaid by one-touch operation. The scale size can be changed randomly in the range of 1:200,000 to 1:10,000.
- A location can be searched from an address, ZIP code, and facility name. So, a target location can be found easily and quickly.
- The target area displayed on the screen can be printed out accurately at a scale of 1:10,000. It is also possible to highlight some range on the screen and paste it into the document file or others. This function is very convenient for the preparation of various materials and for performing analysis.
- As the distance and moving time between two positions can be calculated, it is easy to get the distance and the time necessary for evacuation from a house to a refuge area.

This Sky View Map system has obtained a patent (No. 3779305) as the memory medium storing a program for browsing sabo-related information, and as the browsing system for sabo-related information.

4 PREPARATION OF HAZARD MAP

The preparation method of a hazard map is introduced below. It is prepared by overlaying debris flow hazard areas which are established according to the guidelines prescribed by the Minister of Land, Infrastructure and Transport, over a map or an orthophoto.

4.1 *Background spatial information used for hazard map*

As the background spatial information incorporated into a hazard map, the following two types are mainly used.

1) Road Map. An ordinary road map sold at the shop which contains location names, refuge areas, evacuation routes, etc. is used as the background map. (Fig. 1)

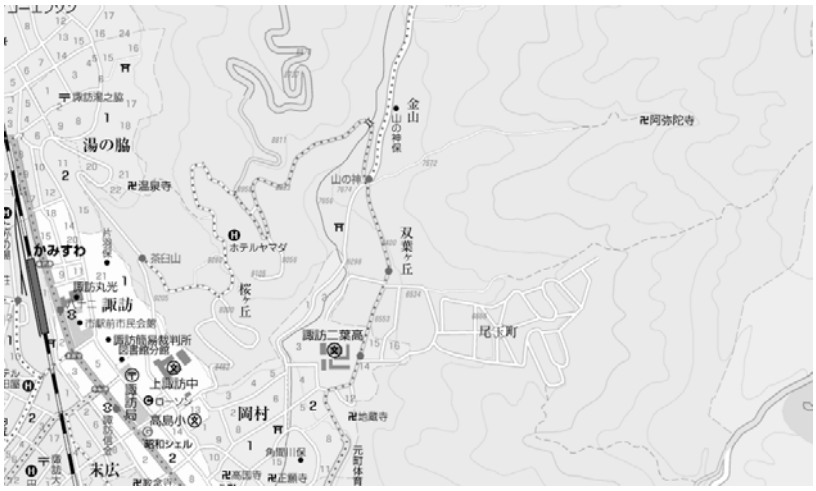

Figure 1. Road map.

2) Orthophoto. An aerial photo showing the area conditions visibly is used as the background map (Fig. 2).

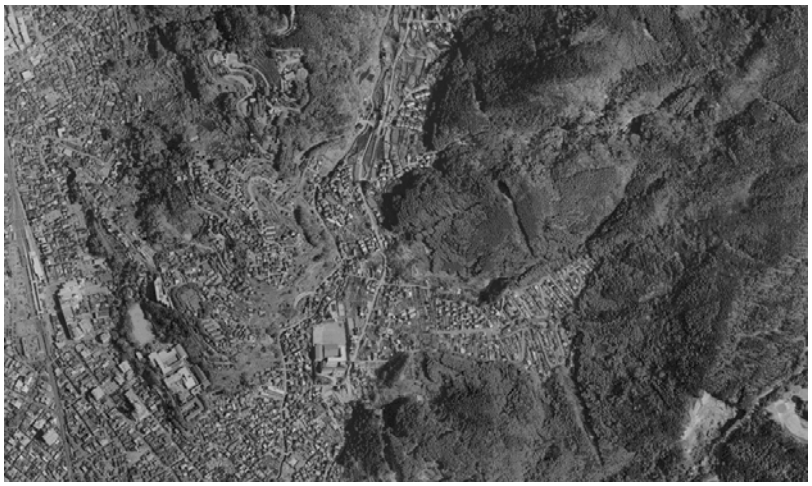

Figure 2. Aerial photo (orthophoto).

4.2 *Main spatial information used for hazard map*

Main spatial information used for a hazard map is the debris flow hazard areas shown in Fig. 3. Fig. 4 shows an example of a hazard map. The Kamisuwa Junior High School seen in the figure is a refuge area.

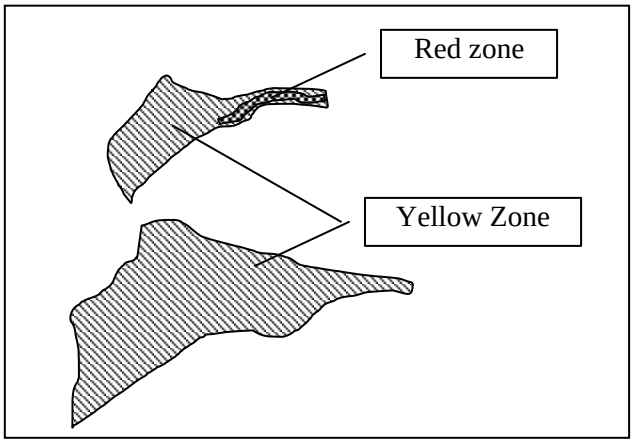

Figure 3. Debris flow hazard (Red Zone, Yellow Zone).

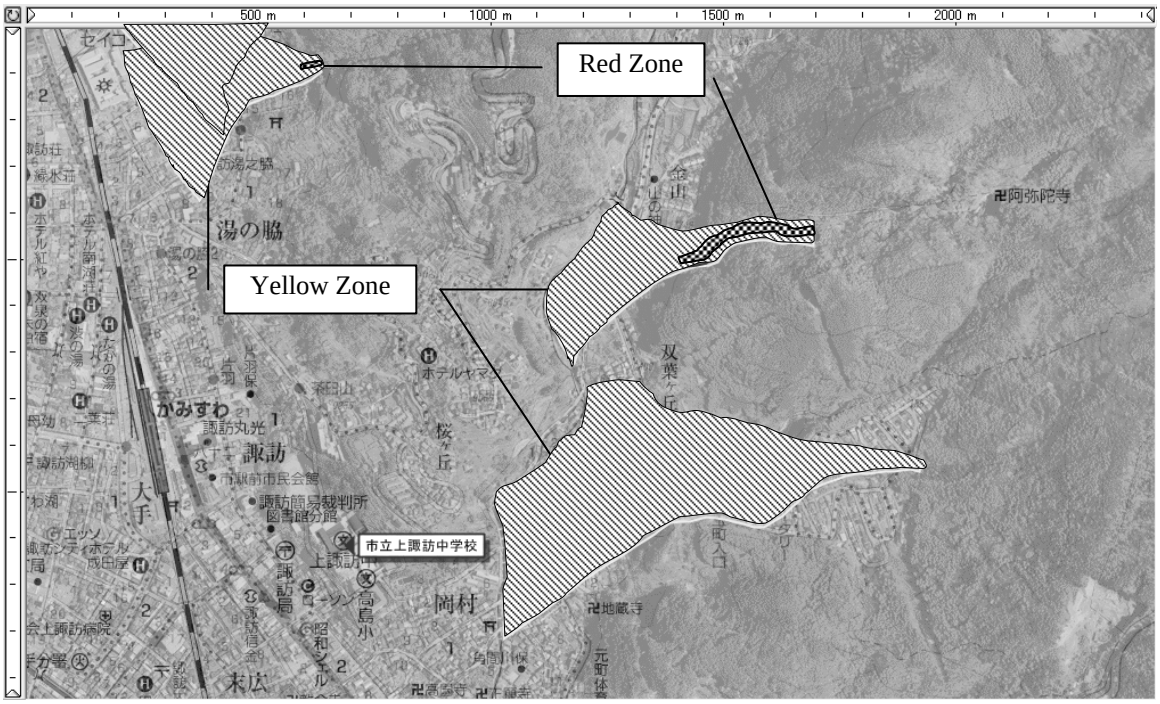

Figure 4. One example of a hazard map.

5 DISSEMINATION OF DEBRIS FLOW HAZARD AREAS

To fully realize the significance of nonstructural measures for protecting lives and bodies of people, information related to debris flow hazard areas should be disseminated to local people exhaustively. For that purpose, a mechanism for providing relevant information to them must be set up at the administrative divisions of municipal governments, prefectural governments, and other organizations. The Sky View Map introduced in this report is readily usable by anyone, because it is offered as an electronic medium, such as DVD or CD-ROM, containing a GIS-based system and informa-

tion for disseminating debris flow hazard areas. The functions that are incorporated into the Sky View Map for information provision are described below.

5.1 *Four-layered background maps*

To describe a location in areas from wide to narrow, four-layered background maps shown in Figs. 5.1 through 5.4 are incorporated. A map on each layer can be displayed on the PC screen without any seams and breaks.

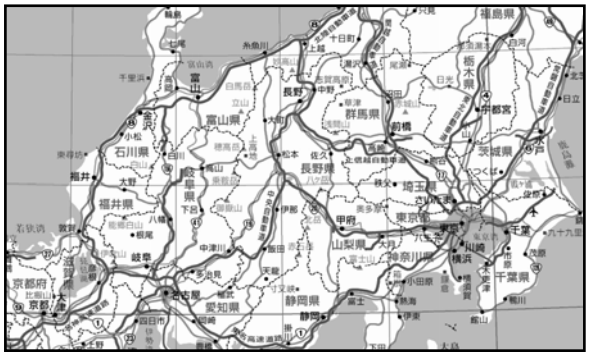

Figure 5.1. Map showing the entire prefecture.

Figure 5.2. Road map: 1:200,000.

Figure 5.3. Road map: 1:30,000.

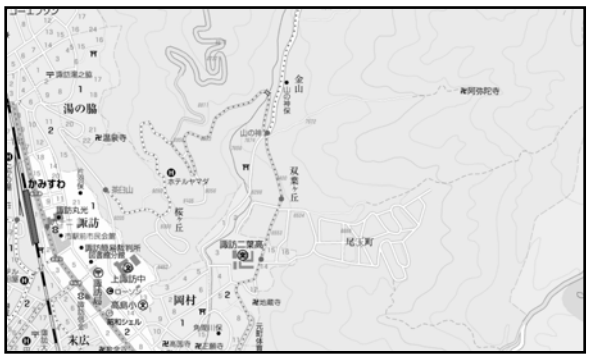

Figure 5.4. Road map: 1:10,000.

5.2 *Overlaying of road map and orthophoto*

The road map provided as the background spatial information is used to indicate a route to a refuge area, name of a specific location, street, facility, etc. On the other hand, the orthophoto also provided as the background spatial information is used to show vicinity conditions around the houses in a visual manner. To display those two types of information by overlaying at a random transmission rate in the Sky View Map, the morphing technique was specifically developed. Figs. 6.1 through 6.4 show examples of screens that are overlain at a random transmission rate just by moving a slide bar on the screen of the system.

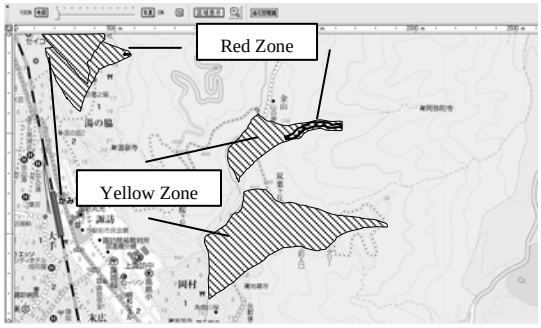

Figure 6.1. Road map 100%.

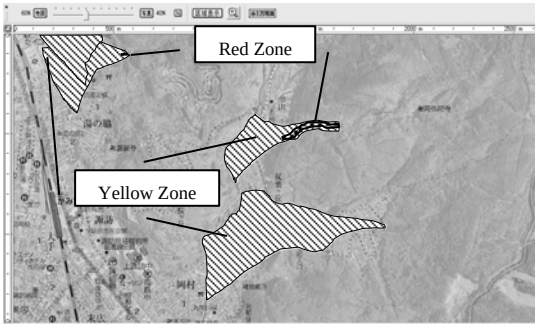

Figure 6.2. Road map 60% + orthophoto 40%.

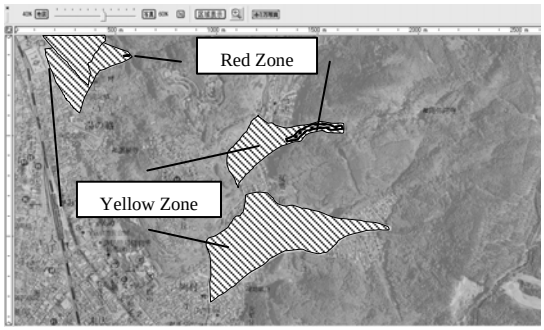

Figure 6.3. Road map 40% + orthophoto 60%.

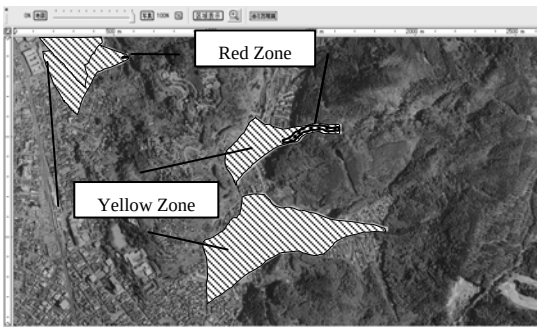

Figure 6.4 Orhtophoto 100%.

5.3 *Location search*

A location search function has been developed to display a specific location on the screen easily. The location search function consists of three search functions, namely, an address search function, ZIP code search function, and facility search function, as shown below.

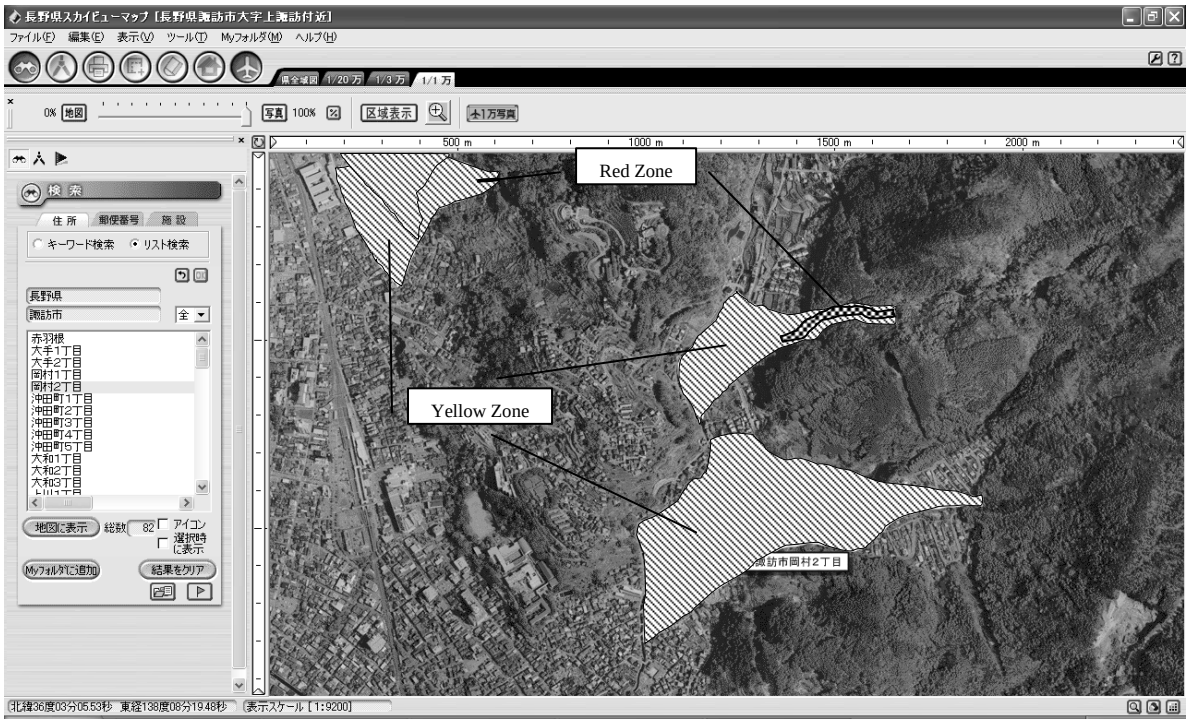

Figure 7.1. Address search (search results of “Okamura 2-chome, Suwa City”).

In the address search function shown in Fig. 7.1, if a specific address is inputted or selected from the search form on the left side of the screen, its location is displayed in the display range on the screen.

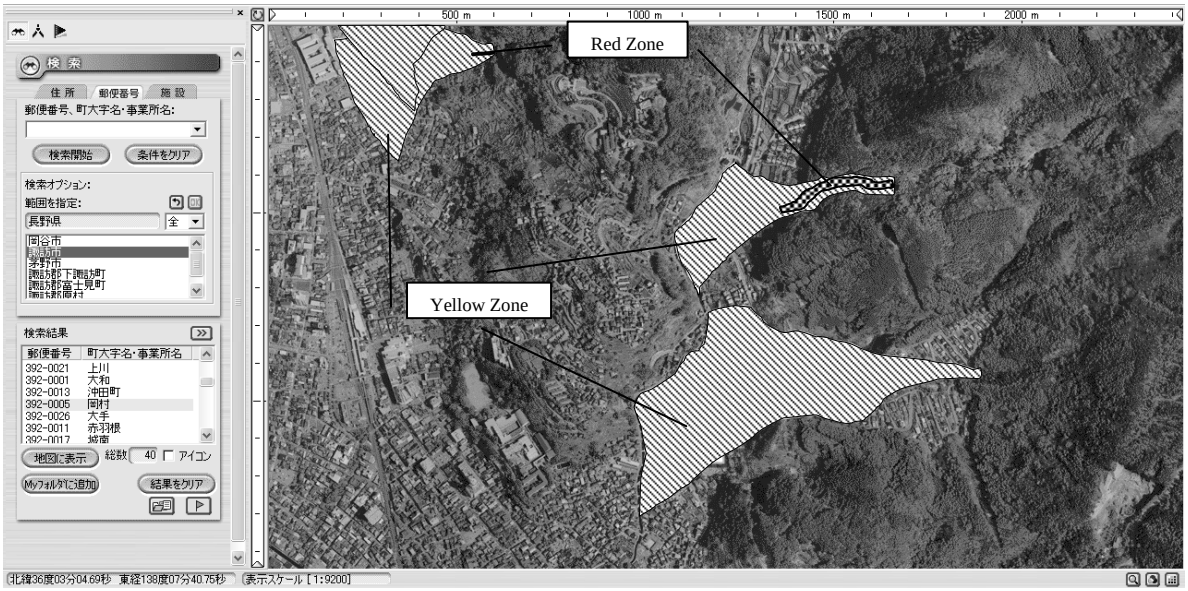

Figure 7.2. ZIP code search (search results of “392-0005”).

In the ZIP code search function shown in Fig. 7.2, if a specific ZIP code is inputted or selected from the search form on the left side of the screen, its location is displayed in the display range on the screen.

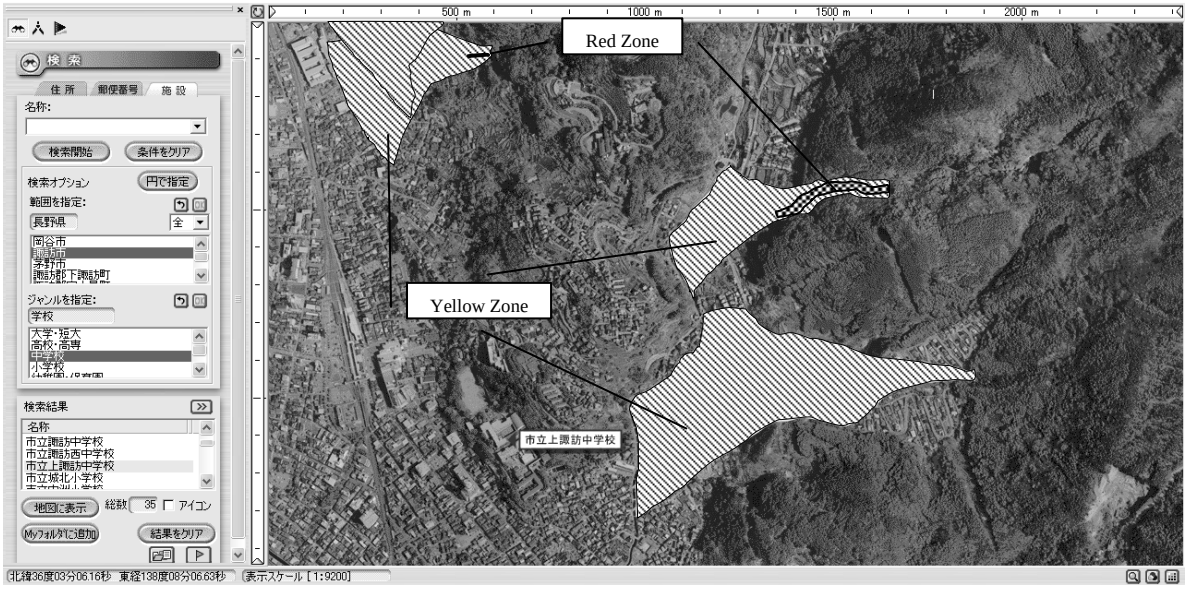

Figure 7.3. Facility search (search results of the refuge area “Kamisuwa Junior High School”).

In the facility search function shown in Fig. 7.3, if some specific facility name like a refuge area is inputted or selected from the search form on the left side of the screen, its location is displayed in the display range on the screen.

5.4 *Search of evacuation route information*

This search function was developed as the support function to help residents when they move to a designated refuge area. As shown in Fig. 8, if a route from a house to a refuge area is specified on the screen, the moving distance, the necessary moving time, etc. are calculated and displayed on the screen instantly.

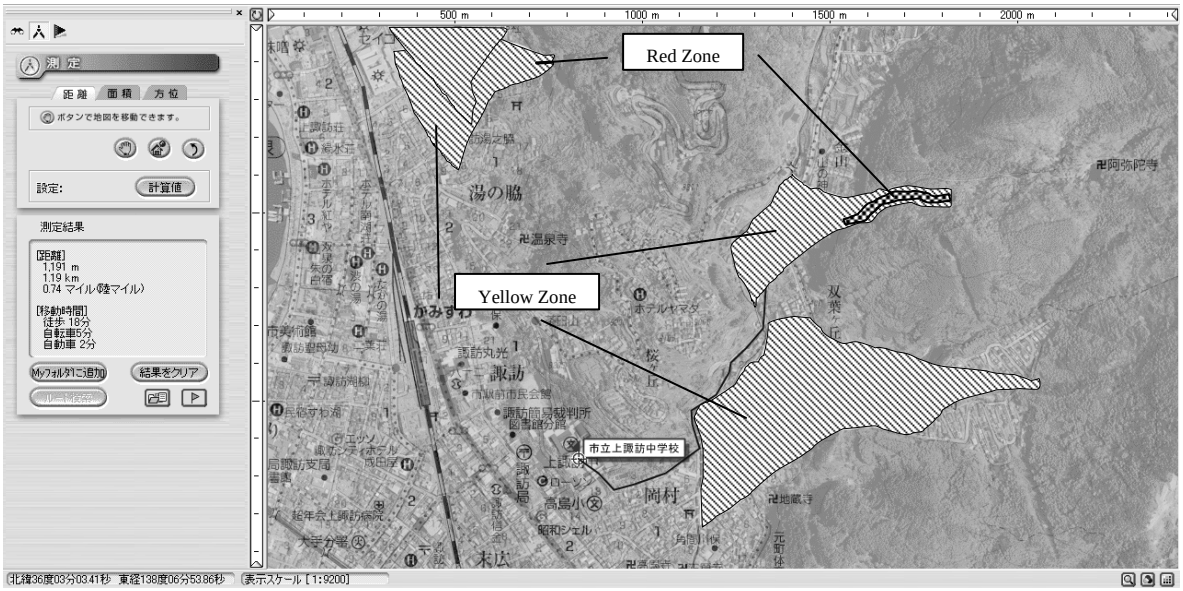

Figure 8. Search of evacuation route information. (Search results of the route from a house to the refuge area "Kamisuwa Junior High School".)

6 UTILIZATION FOR WARNING AND EVACUATION

Debris flow disasters occur abruptly with a strong destructive force, however the time and place of their occurrence are difficult to predict. Therefore, to protect people from such disasters, it is necessary to improve the disaster prevention capability of local regions through the sharing of sediment-related disaster information via "conveying efforts" on the administrative side and "receiving efforts" of the resident side. The following are considered as the utilization methods of the Sky View Map for warning and evacuation:

- To disseminate disaster prevention information such as the debris flow hazard areas to local residents and relevant organizations during normal non-disaster times utilizing hazard maps, and to make it known that they are living in a dangerous area (people who encounter disasters often say that they did not know their region was dangerous).
- To utilize the Sky View Map as a tool for developing an effective evacuation system during disasters by providing useful information on refuge areas and evacuation routes to local people during normal non-disaster times.
- To encourage local people to prepare a warning and evacuation manual and conduct drills on their own initiative to ensure safe evacuation. The Sky View Map is used as a tool for reviewing the warning and evacuation system/procedures and for enhancing disaster prevention awareness.

7 CONCLUSIONS

In this report, the Sky View Map which was developed utilizing the GIS technology was introduced together with its application examples. This system was specifically developed to disseminate information related to debris flow hazard areas to local residents to enable smooth warning and evacuation activities. This system is still being improved to refine its functions. We are also intending to enrich support menus for possible utilization by prefectural governments.

As the future effort, we are considering to integrate into the system the needs and opinions of both administrators and residents, which are the information managing side and the information receiving side, to make the system further serviceable. It is also necessary to develop a mechanism of information disclosure to increase information dissemination to residents.