Development of GIS-Based Information Systems for People Vulnerable to Disaster

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Abstract

How to help people in need of support such as elderly, disabled and sick evacuate promptly and properly in a time of disaster is a big problem for local governments in Japan where huge human damage has been brought by typhoons, heavy rains and tsunamis. In order to cope with this problem we must first list those people who need support and then assign neighbors who can help them evacuate to each of those listed. GIS based disaster management information systems would be a great assistance in this task. However growing consciousness to privacy and collapse of communities prevent local government to develop such support systems. In this paper we present and discuss some possibilities for and problems of GIS based disaster management information systems to support disaster vulnerable people based on our experience of developing a prototype system in Miki City, Japan.

1. Introduction

In Japan, a country known for its frequent natural disasters such as earthquakes and typhoons, progress is being made with disaster damage mitigation actions for the social infrastructure, i.e., increasing earthquake resistance in building design requirements and reinforcing the structures of railways, highways, dams and embankments. However, with an increasingly dwindling birthrate and a rapidly aging society, the proportion of elderly residents, who are easily victimized in a disaster, has become extremely high among the most recent victims. In response, the Japanese Cabinet Office put out a document entitled "Guidelines for Evacuation Support of People Requiring Assistance During a Disaster" in 2006 and is now calling on local governments (especially municipalities) for the prompt development of specific evacuation assistance plans for vulnerable people, particularly the elderly and disabled residents. These plans should, for example, stipulate several supporters for every vulnerable resident in order to provide evacuation assistance during a disaster, such as transferring them to a safe shelter from their high-risk homes. However, local governments are hampered by obstacles such as personal information protection and compartmentalized public administrative organizational structures that hinder intersectional information-sharing activities. The fact is that, at present, the establishment of frameworks for utilizing intersectional information for disaster management and developing systematic support methods for vulnerable residents is not progressing smoothly and promptly.

To support residents requiring assistance during a disaster, the following six major actions

are necessary:

(1) Identification of these residents and their locations.
(2) Preparation of a suitable individual evacuation support plan for each resident.
(3) Notification of the emergency status level to these residents and their supporters in the event of a disaster or when one is about to occur.
(4) Supporting the evacuation activities of these residents and confirmation of their successful evacuation.
(5) Confirmation of the survival status of these residents who are not listed in the shelter sites' reception lists and taking necessary actions to help them.
(6) Preparation and provision of special nursing and medical care for these residents in shelters.

The aim of this paper is to show the development of a disaster management information system, based on ArcGIS 9.3, for residents needing assistance by utilizing data communication technology and infrastructures.

2. System Design for Residents Requiring Assistance During a Disaster

After deliberations, it was considered necessary to incorporate the following functions when designing a disaster management information system to support the six activities listed above.

(1) Database and geographical data handling functions that enable identifying and locating these residents as well as displaying the information necessary to help them instantly on a map. Residents are to be identified through one of the following methods:
   i) Intersectional information sharing (a method whereby information about these residents is obtained by connecting the databases of several departments, including the welfare section and residents' registration section at a municipal office).
   ii) Registration (a method whereby residents are informed of the registration system and information about residents who wish to enroll is collected).
   iii) Consent (a method whereby the authorities contact each resident to collect information).
(2) A matching support function and a promoting or edification function that enables the identification of potential nearby supporters for each resident requiring assistance through a geographical search and helps supporters want to participate.
(3) An emergency status notification function that enables the identification of residents residing in possible damaged districts and notification of their emergency status when a disaster occurs or is about to occur and when the mayor has issued an "evacuation preparation announcement," "evacuation orders" or "evacuation directions" (hereinafter "evacuation announcements").
(4) A safe evacuation securing function that provides both the residents and their supporters a safe evacuation route to the nearest secure shelter and information on any

hazards en route.
(5) A supporters' dispatching function that enables the identification of residents who have not stayed in shelters or communicated with them and allocating/dispatching supporters to those whose safety could not be confirmed.
(6) A shelter management function that enables the prompt admission of residents, identification of their life-support materials and transferring residents to more adequate shelters or hospitals, if necessary.

3. Developing Support Systems for Residents Requiring Assistance During a Disaster

We have experience in developing a prototype disaster management information system for these residents in 2005 in Shingu Town, Ibo County, Hyogo Prefecture (the current Tatsuno City). The system displayed the locations of these residents, as well as information about the assistance they required, using ArcGIS 8.3. Based on this experience and aiming to develop a more advanced system with expanded functions, we started a joint research project to develop a disaster management information system with Miki City, Hyogo Prefecture (population: 84,361, and number of households: 25,112, Census 2005), and with support from Pasco Corporation in 2006.

3.1 Creating a Disaster Management Digital Base Map

In Japan, every resident is required to register his or her name, address, gender and birth date at the municipal office where he or she lives. Our first task was to develop a digital map called the Disaster Management Digital Base Map with all residents' location coordinates by utilizing registered addresses in the character-based database managed by the resident registration sections of the municipal offices. This digital base map is designed for identifying the residential location coordinates of residents needing assistance. Adding information, such as clinical history, emergency contact address and detailed descriptions of any disorders, collected from the consenting residents would enable more effective and efficient support by sharing information among supporters and disaster management units under the supervision of the disaster management headquarters organized in the municipal office whenever a disaster is forecast or occurs. The Disaster Management Digital Base Map is also used for estimating the number of potential evacuees for each shelter and making logistics plan for life-aid materials.

In developing the Disaster Management Digital Base Map, the following procedures were taken:

(1) Creation of a new digital topological official address map using both the City Planning Base Map and Land Parcel Map of Miki City. The digitalized City Planning Base Map displays roads and building shapes, but it has no official address information. On the other hand, the digitalized Land Parcel Map contains site index numbers, which are used in official addresses of resident registration, but it has no data about roads and building shapes. We, therefore, overlaid the Land Parcel Map

over the City Planning Base Map and created a new digital topological map that has the full address information for all buildings.

(2) Creation of the Disaster Management Digital Base Map by concatenation of the new digital topological official address map data and resident registration data such as names, gender and birth dates by using residents' addresses as a matching key. This concatenation yields the Disaster Management Digital Base Map, which has roads and building shapes, residential location coordinates and registered attribute data of residents with residential location coordinates.

However, through this procedure, the residential location coordinates for 14,985 (17.7%) of the 84,593 residents registered in resident registration database at the end of February 2008 could not be matched. The reason for the low matching rate was caused by the Japanese zone-based, geo-coding system, which is totally different from the road-based, geo-coding system used in the Western countries. As a result from on-site investigations for each unmatched individual address, there were only 508 (0.7%) resident location coordinates left unidentified in the Disaster Management Digital Base Map.

3.2 Registration and Display of Data from People Who Submitted Written Consent Forms

In October 2007, Miki City changed its administrative policy for preparing a list of residents requiring assistance from an intersectional information sharing method to a consent method, and the emergency management unit in Miki City asked us about the possibility of handling submitted filled-out consent forms from residents on the GIS-based disaster management information system. Based on this policy change, we added functions to enable the officers in the emergency management unit to see at a glance the whereabouts of residents who had submitted the forms to the city and to retrieve digitalized image files instantly to our GIS-based disaster management information system.

3.3 Prototype Support Systems for Residents Requiring Assistance

Using the prototype support system for these residents, Fig. 1 plots the locations of the 3,355 people who had submitted consent forms by end of October 2008. Fig. 2 displays an example of estimating the number of residents within a possible disaster damaged area or an area for which an evacuation announcement could be issued, as well as that of detailed assistance needs for possible residents, which can be shown in our GIS-based disaster management information system.

4. Drawing Up Support Plans for Residents Requiring Assistance

The current GIS-based disaster management information system for these residents fulfills only one of the six functions: the geographical data handling function. In accordance with the directions from the Cabinet Office, local governments are proceeding with making lists of residents who might need assistance; however, creating such lists only results in an

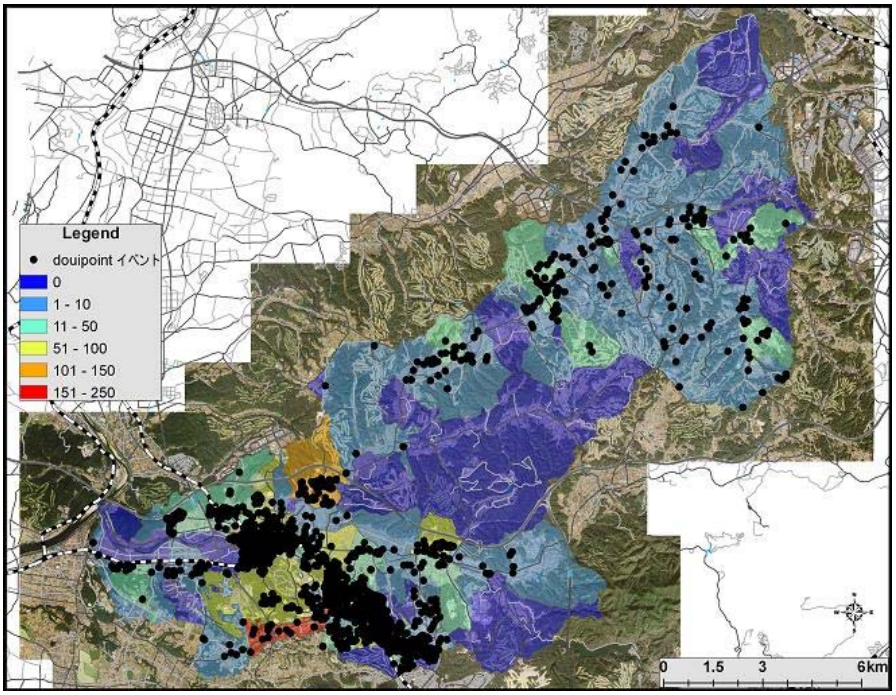

Fig. 1 The residential locations of residents who submitted consent forms, and the numbers of submitters by each residential association

Fig. 2 An example of the use of a prototype system

increased risk of information leaks and will be of no use in actually supporting those requiring assistance. Specific support plans need to be drawn up addressing who will support those listed as requiring assistance and how the supporters will offer help.

Submitters of the consent forms were asked to fill in the contact details of their supporters if they had already asked some of neighbors to be their supporters. However, at the end of October 2008, only 367 (10.9%) of the 3,355 submitters provided the contact details of their supporters. This means the remaining 2,988 people (89.1%) still did not know who would support them during a disaster.

When a trial run of the intersectional database-sharing method was applied at the end of November 2008, 9,995 residents were listed as possibly needing assistance. The standards for inclusion were as follows: residents living in households where there were only elderly people over 65 years of age, according to data from resident registration database; holders of first- and second-level physical disability certificates, according to the welfare department database; artificial dialysis patients; and those requiring nursing care beyond level 3, according to nursing insurance policy database. This trial showed a great difference of 6,640 additional residents who might need assistance compared with the number gained through the method of consent, which was only 3,355. The problem is apparent here that no measures are being taken at present for these other 6,640 people.

Thus, in order to illustrate the current state of residents' awareness of disaster prevention, from December 2008 to January 2009 we conducted a questionnaire survey in Miki City concerning the local attitudes toward disaster prevention and support for residents requiring assistance during a disaster. With the cooperation of Miki City and the Miki City United Residents' Association, the survey was conducted for all households within the city. Other important purposes of this survey were to find out whether or not there were residents who had not submitted the consent forms despite the fact that they were regarded as residents requiring assistance and their reasons for not having done so yet. We also aimed to know the number of potential volunteer supporters in a disaster.

Based on survey reply data from Jiyugaoka District in Miki City where the questionnaire survey sheets had been collected by the end of December, there were as many as 114 respondents who had not submitted the forms but replied, "If a disaster were to occur, I would have difficulty evacuating by myself." The survey details on Jiyugaoka District were as follows:

●Residents' associations	13
●Population	16,912, or 20.4% of the city as of December 2008
●Households	6,459, or 20.5% of all households in the city
●Distributed survey sheets	Two sheets per household were distributed so that partners could reply individually
●Survey sheets collected	7,235, with 7,201 valid replies
●Household reply number	4,303, or 66.7% of all households in Jiyugaoka District

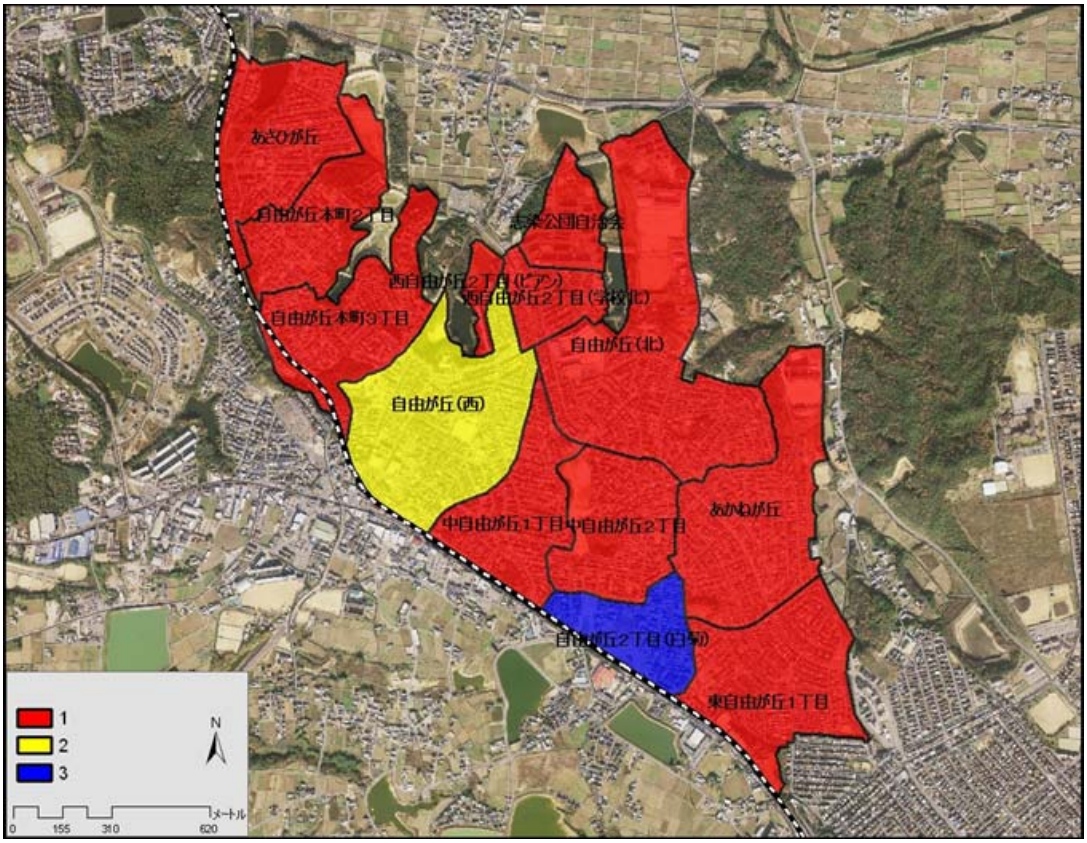

Fig. 3. A comparison of the number of potential supporters and the number of people requiring assistance, according to the survey of residents' attitudes

While a more thorough analysis is required, the fact that not all people requiring assistance have submitted the forms suggests the need of further notification campaigns to encourage submission, as well as some measures to supplement the method of consent.

While 848 people in the district submitted the forms, the survey showed the number of residents who are willing to be supporters was only 1,557. Fig. 3 is a choropleth map that displays the surplus and shortage of local supporters for each of the 13 communities, based on the number of potential supporters and the number of possible residents needing help in these areas. In Fig. 3, red indicates that the availability ratio of potential supporters to one vulnerable resident is below 1 or it is difficult to assign one supporter to each resident; green indicates that the availability ratio is more than 1 and less than 2; and blue indicates that the availability ratio is more than 2. This data allows the disaster management unit and residents in the communities to consider whether the region can support those requiring assistance and, if not, what steps the region should take. By creating the choropleth map showing the availability ratio for potential supporters to one resident in need for all areas of Miki City, and by giving the information back to communities by means of community meetings and disaster prevention drills, function (2), one of the required functions for support systems for those requiring assistance, can most likely be achieved.

5. Conclusion and Issues for Consideration

In this study, we have discussed the desired functions of a GIS-based disaster management information system for residents requiring assistance and introduced the prototype system developed in Miki City, Hyogo Prefecture, Japan. We are still working on the expansion of this disaster management information system for further development in Miki City.

However, there remain many issues to be addressed. First, the lack of a synchronized and automated data updating system for related databases is the major deficit of the current disaster management information system. Whenever a data update occurs in one of the related databases due to the birth or death or moving in/out or status change of these residents, the data on the related databases must be updated at the same time in order to keep the disaster management information system effective. Legal restrictions on the intersectional data exchange are obstacles to the synchronized data updating. Just how smoothly data updates could be performed, and whether a paradigm shift for the intersectional data exchange could be established (or whether Business Process Reengineering could be pushed through), are key factors for the successful implementation of our disaster management information system.

In addition, with regard to securing evacuees' successful reception at shelter sites, we carried out a drill of handing over students in the lower grades to their caregivers by utilizing IC cards at Miki City's Hirono Elementary School on January 17, 2009, the memorial day of Hanshin-Awaji Earthquake disaster in which more than 5,500 people were killed. Through this drill, we confirmed the effectiveness of the IC card base reception system. Individual identification, through use of Radio Frequency Identification IC chip cards and QR Code, under an adequate personal information protection rule, enables quick reception and residential coordinate identification of evacuees by our GIS-based disaster management information system. This result shows the accomplishment of functions (4) and (5) is almost at hand.

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