REALIZATION OF EFFECTIVE DISASTER VICTIM SUPPORT THROUGH INFORMATION INTEGRATION AND VISUALIZATION USING GIS

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Abstract: Disaster victims, who cannot make progress in their life recovery by themselves, need to be supported generously by local government. However, there is no information management system for the progress of their life recovery process in order to identify the individual needs of victims. In the first step of this research, we designed and developed Victims Master Database which stored the situation of progress of victims' life recovery process. This master database is developed by the integration of 5 databases; two of those are Residents' Ledger and Fixed Asset Tax Rolls which are used in daily routine business, and the others are databases for granted certification of building damage degree, relief programs management and public temporary housing management which are constructed after the disaster. In this integration, however, it is unable to connect together simply because there is no relational key in each database. Against this issue, we applied GeoWrap method which can connect databases in GIS by the spatial proximity between pieces of information. In the second step, we developed the information management system which can ascertain victims' life recovery status and visualize it in spatial. By using this system, responders developed common operational pictures of victims' status, and provide generous support for victims with special needs effectively.

1 BACKGROUND OF RESEARCH

When risk becomes actualized and a disaster occurs, the greater the degree of damage due the disaster, the larger the number of people whose everyday lives are destroyed, and the longer it takes for those lives to be reconstructed. In order to realize early recovery from disasters, it is vital to effectively support the process of reconstructing the lives of those affected.

Figure 1 shows the work flow of administrative support. Within a process of reconstructing those lives, it is imperative to develop a tool which implements relief efforts within a comprehensive framework as well as effectively supporting such a process.
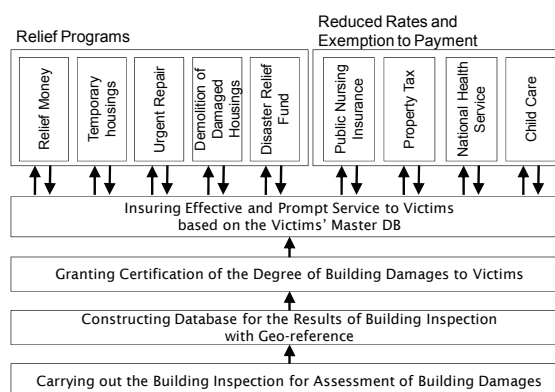

Figure 1: Work Flow of Administrative Support.

2 POTENTIALITY OF VICTIMS MASTER DATABASE

2.1 Basic Framework

When implementing support for reconstructing the lives of disaster victims, it is necessary to make a fundamental decision as to how to allocate the limited amount of human and material resources available for disaster relief. The options can be divided into: 1) allocating support to each disaster victim in equal measure, 2) allocating support depending on attributes of victims (e.g. a higher level of support for the elderly and the poor), and 3) allocating support depending on the extent of damage suffered by victim. In order to make a decision as to which option, or combination of options, to use, it is necessary to establish an environment in which information regarding 1) identity, 2) attributes and 3) extent of damage suffered (e.g. "destruction", "severe damage", "partial damage", or "no damage" to residence) for each victim can be organized and simulations of allocation of resources can be conducted. Such an environment will also enable efficient allocation of resources after such decision has been made.

2.2 Establishment of Victims Master Database using GIS

In order to establish a basic framework for life reconstruction support, it is necessary to work towards creation of a victim register. In this research, this victim register is named "Victims Master Database (VMDB)". In addition to existing registers, such as the Basic Residents Register and taxation registers, that contain various necessary information of citizens for day-to-day civil administration, it is necessary to establish VMDB for life reconstruction support.

VMDB is a database that spatially allocates various information that do not necessarily have primary keys in common, such as: 1) information that shows all disaster victims, including those not originally included in the residents registers for day-to-day administration but surface in the aftermath, 2) existing attribute information already held for day-to-day administration, and 3) extent of damage caused by the disaster, and integrates information from spatial proximities between the pieces of information.

2.3 Use of Victims Master Database

Once VMDB is created and life reconstruction support efforts are underway in accordance with the decision made with regards to resource allocation, disaster victims who have an underlying capability for independent living will eventually be able to reconstruct their lives with the help of life reconstruction support. However, there are also those for whom support on a macro scale is insufficient to enable them to reconstruct their lives; it is therefore necessary to have a system in which individual circumstances not listed in the basic information on VMDB are taken into account in order to concentrate levels of support for such individuals. In addition, information that has been consolidated based on such a system is represented and visualized spatially, thereby allowing planning of support measures and spatial identification of victims requiring priority for support, thus supporting implementation of swift support measures as shown in Figure 2.

In this research, creation of VMDB is carried out in partnership with Kashiwazaki City which was affected by the Niigataken Chuetsu-oki Earthquake. The situation regarding victim livelihood reconstruction support in Kashiwazaki is established, and a realistically achievable VMDB is created through real-life assessment, leading to a development of a system capable of effective information collection and integration, and creation of a system capable of visualizing such information spatially.
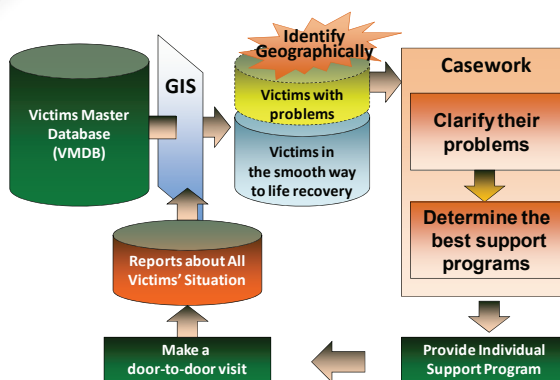

Figure 2: Model for Providing Micro Support.

3 CREATION OF VICTIMS MASTER DATABASE

Kashiwazaki City has a Basic Residents Register which keeps track of residents for day-to-day administration. Those who are not shown on the Basic Residents Register were identified as victims affected by the disaster by the municipal authority based on various documents proving that they were residing in the city at the time of the disaster.

Additionally, there are also tax registers for managing resident tax and fixed asset tax during day-to-day administration. In terms of victim attributes, the income of an affected household can be determined from the resident tax register, and the household's home-owning status can be determined from the fixed asset tax.

In Japan, various types of support are offered based on the Act on Support for Reconstructing Livelihoods of Disaster Victims, and these are based on the level of damage suffered to the homes of the afflicted. After a disaster, the municipal authorities conduct damage assessment on every building, and the level of damage is determined through issue of a disaster damage certificate with the victim's agreement.
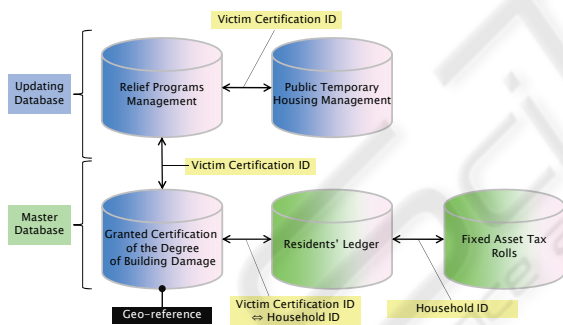

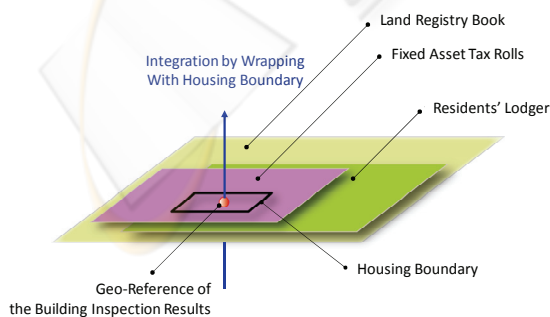Figure 3: Configuration of Victims Master Database.

Figure 4: The Framework of GEOWRAP.

The local authorities then provide livelihood reconstruction benefit payments, temporary housing, disaster relief public housing and other types of support to the disaster victims in accordance with the level of damage suffered. Criteria of eligibility for each type of support vary; information regarding recipients of each type of support are collected individually and managed in the form of registers.

In the case of Kashiwazaki City, a unified information integration was achieved by merging the registers used for day-to-day administration as mentioned above and the registers created after the earthquake, thereby establishing a register that forms a basis of VMDB and that can be used to ascertain individual circumstances of the disaster victims as shown in Figure 3.

4 NEW VISUALIZATION TECHNOLOGY WITH GIS

4.1 Establishment of a Spatial Reference Type VMDB that Uses GEOWRAP

In Kashiwazaki, each of the registers that support the VMDB does not have primary keys in common. Therefore, Yoshitomi et al (2009) conducted information integration based on a system called GEOWRAP that uses space for information integration. In this system, information which do not have primary keys in common are spatially allocated, and spatial proximity between pieces of information is used to integrate information.

Information such as address managed by the Basic Residents Register, address managed by the fixed asset tax register, or location of buildings from the damage certification assessment are allocated in space as geographical information. Such information all relate to the residence, and are basically included in the same house frame. The various types of information were therefore integrated using GEOWRAP technology, using the house frame as the key. Additionally, the various registers obtained in the course of victim livelihood reconstruction support are merged to create VMDB.

In this VMDB, the location of the disaster victim's house or the location of their temporary accommodation are provided in the form of spatial information, and all information is managed as spatial reference-type information.

4.2 Proposal for 3 Layers for Visualization, Taking into Account the Viewpoint of Responders

In terms of information visualization in order to consolidate the process of assessing the situation, the following three layers were established based on the requirements on the ground.

1) Overall Tasks Layer
This layer allows a panoramic visualization of the overall status across the entire area under the responsibility of the authority. This helps to implement measures that have a large area-wide effect across the area under the jurisdiction of the authority, allowing effective support of a large number of applicable disaster victims.

2) Segmented Victim Groups Tasks Layer
In this layer, the user sets several conditions for which information is amalgamated, thereby allowing segmented groups of victims to be retrieved and their characteristics visualized. This allows appropriate measures to be implemented to each of those segments, resulting in more specific support.

3) Individual Tasks Layer
In this layer, individual circumstances for each disaster victim are ascertained and visualized on an individual level. This allows individual needs to be ascertained and individual support measures to be devised. Therefore, this layer is one that supports detailed support measures which cater to the needs of individual victims which do not get addressed until the end.

Combining these three layers assists disaster victim support on all levels from macro scale to micro scale, thus ensuring that the support schemes cater for requirements on every level.

5 DEVELOPMENT OF A SYSTEM FOR ASCERTAINING INDIVIDUAL NEEDS

5.1 Design of a System for Ascertaining Individual Recovery Status

Information obtained in the course of individual dealings of various departments with each victim are collected and amalgamated using a common application. Information collected can be broadly categorized into visit reports and life reconstruction status.

Items of information collected in order to determine the status of life reconstruction are based on 7 elements of life reconstruction according to Tamura et al (2001). These elements are "housing", "communication", "community", "preparation", "mind and body", "livelihood" and "interaction with the authorities". By organizing individual circumstances into these elements, it is possible to assess the type of expertise required, or the type of support measures which are lacking. Such information is managed on a household level, allowing individual circumstances to be accurately ascertained.

5.2 Development of a System for Ascertaining Individual Recovery Status

An application was developed based on the above-mentioned design. Taking into consideration the situation of the local authority which is to conduct the applicability assessment, the application was to operate on Windows 2000 or higher, with a requirement for .Net Framework 1.0 or higher. Visual Basic .Net 2003 was selected as development environment in order to satisfy this condition; the system was thus developed and installed. The items in the user-interfaces in this developed system were written in Japanese, because local responders were not familiar with English. Some of them are shown in Figure 5 and Figure 6 with English explanation.
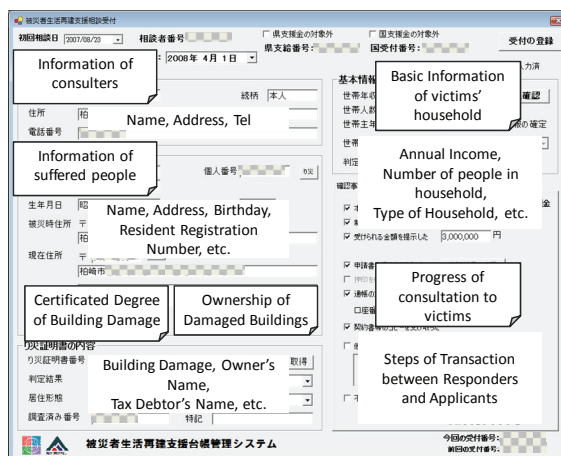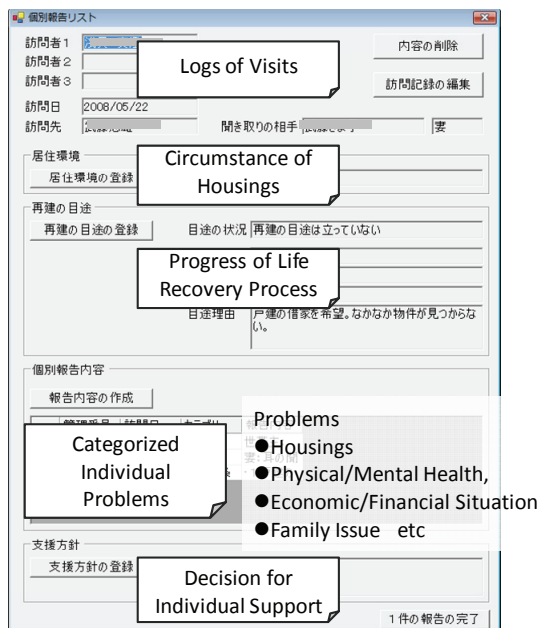

Figure 5: UI for browsing victims' situation.

Figure 6: UI for browsing individual problems.

6 CONSOLIDATION OF STATUS ASSESSMENT OF THE RECOVERY PROCESS

6.1 Visualization of Temporary Housing Status using Deformed Maps

This research aims to consolidate the process of status assessment based on the 3 layers shown in the previous section. Here, the aim is to amalgamate the three layers within one map. Because the 3 layers each differ in scale, it is difficult to visualize on one piece of paper.

Therefore, it was decided to create a deformed map in which each temporary housing is expanded so that individual rooms can be visualized, while maintaining the relative positional relationships between each temporary housing as shown in Figure 7. This map thus assisted in consolidation of status assessment which maintains a continuous viewpoint from a general level to an individual level. In this research, we visualized the status of victims' life recovery progress based on this map-template.
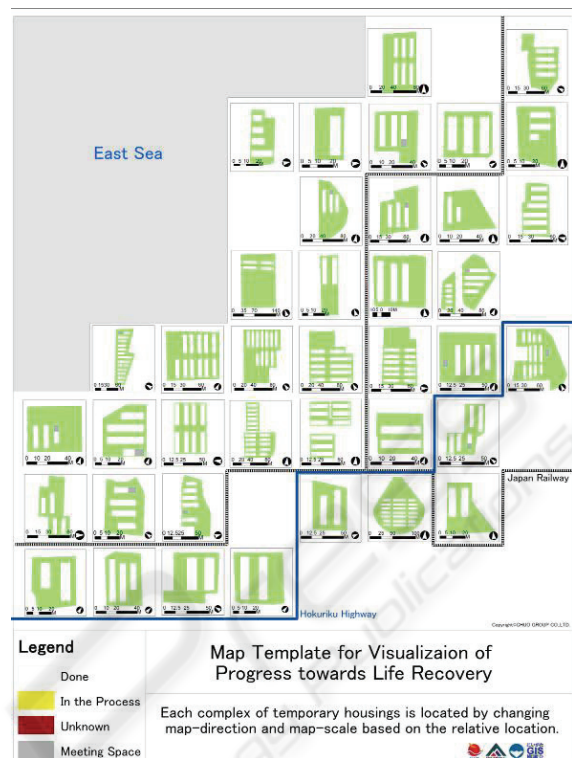

Figure 7: Map Template to Visualize Progress of Life Recovery in Temporary Housings.

6.2 Realization of a COP Relating to Status of Temporary Housing Residents

1) Visualization of Overall Recovery Status for Temporarily Housing

This map spatially visualizes information which shows the overall progress towards reconstruction and any issues which are outstanding. This allows the user to gain an overall understanding of the progress of various reconstruction support measures being carried out. This also became the basic information source for policy decisions in terms of merging of temporary housing facilities with small numbers of occupants.

2) Visualization of Temporary Housing Recovery Schedule on a Housing Complex Scale

In this map, one temporary housing complex was considered as one unit, and the occupancy statuses of temporary housing were visualized according to expectations of reconstruction progress. This allowed measures relating to issues such as snow removal operations and control of quality of water in water tanks in each housing complex to be planned in advance.

3) Visualization of Reconstruction Policy on a Household Basis

This map visualizes outstanding issues and reconstruction progress statuses on a household-by-household basis. Discussion was carried out in terms of resolving issues for each individual household, based on a map showing a visual representation of information on an individual basis for each household. Figure 8 shows the victims who had family issues in the way of life recovery with red colour symbol, and Figure 9 shows the victims who had physical or mental health issues with red colour symbol.

7 FUTURE DEVELOPMENT OF THIS RESEARCH

Temporary housings in Kashiwazaki City are expected to be taken down within this year. Disaster victims who still have difficulty in reconstructing their homes at that time will then be moved to disaster relief public housing. We aim to continue assisting such victims, taking their individual circumstances into account, using the system described in this research. We also believe that continued assessment in other future cases will lead to the system described in this research becoming standard, and contributing significantly to implementation of effective life reconstruction support for disaster victims.

Figure 8: Visualization Map of Victims with Family Issues.

Figure 9: Visualization Map of Victims with Physical/Mental Health Issues.

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