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A METHOD FOR EVALUATING THE DIFFICULTY POSED ON RESIDENTS' DAILY LIVING ACTIVITIES BY THE INTERRUPTION OF LIFELINE SERVICES

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SUMMARY

A method to investigate the difficulty on the residents' daily lives caused by the suspension of electricity, water, and natural gas was developed. A household-by-household questionnaire survey was conducted to evaluate the difficulty in a numerical way. The questionnarire was designed so as to determine to what extent daily living was restricted and how long this condition continued. Questions were asked about five essential living activities at home, namely; cooking meals, using the toilet, using a washbasin, taking a bath, and washing clothes. Results of a household-by-household survey were processed statistically to obtain any regional indexes. A pilot study with approximately 1,000 samples was conducted in Noshiro, Japan, where the lifeline systems were severely affected in the 1983 Nihonkai-Chubu earthquake.

INTRODUCTION

As compared with the research regarding the material losses in lifeline systems, less investigations were conducted into residents' lives affected by the interruption of lifeline services. Although a considerable number of case studies on the effects of lost services have been carried out, the results were largely descriptive rather than analytical, and, therefore, the findings have been accumulated randomly rather than systematically.

In this paper, we have established a numerical scale that defines the degree of residents' hardship in the interruption of lifeline services. The procedure to measure the difficulty can be used in any investigation conducted in any society suffering from a disruption of utility services. The scale is expected to work as a tool not only for analysis of a disaster but also for systematic accumulation of research data.

OUTLINE OF METHOD

Subject The difficulty on residents' daily living at home is investigated. We examine only the effects of the suspension of utility services, namely, electricity, water, and natural gas supplies. We do not include the effects of the suspension of other lifelines such as transportation and communications. Our intention is to keep the survey as simple as possible, as we are still at the outset of development in this area.

Residents who did not lose their lives or dwellings in a disaster are investigated. For residents whose dwelling was destroyed, suspension of lifeline services is obviously not a problem.

Contents The following two subjects are surveyed to evaluate the difficulty: (1) degree to which daily living was restricted and (2) period for which daily living was restricted. An index to evaluate the difficulty is derived based on these two components.

The restriction is investigated concerning five essential living activities, such as (1) cooking meals, (2) using the toilet, (3) using a washbasin, (4) taking a bath, and (5) washing clothes. These activities are ordinarily carried out with a great dependency on utility services. These are essential for maintaining daily living at home even in the aftermath of a destructive earthquake as long as a family desires or has to live in their own place.

Additional questions are asked to analyze the way in which the residents live; namely, how each household depends on lifeline services. The following questions are included: (1) what heat-source is used for cooking, (2) what heat-source is used to make hot water for bathing, and (3) whether or not a flash toilet is used. Another important question concerns the alternative for the water supply: (4) whether or not they have a well. Questions are also asked about the basic characteristics of a household, such as family size and dwelling type.

Procedure The survey is conducted by means of a household-by-household questionnaire. This is reasonable, because each household has its own ways (1) how it ordinarily depends on utility services and (2) how it deals with the interruption of services.

A mail survey is relevant, because the method must be applicable to a large-scale investigation. When we like to determine a representative measure for an area such as a community, a district, and an entire city, sampling on a large scale is the most essential and effective means.

Results of the survey must be a set of a few numerical indexes processed from the questionnaire responses. Such indexes will allow a numerically analytical examination of a disaster and, when accumulated, the development of systematic knowledge. It is not appropriate to apply the conventional techniques of statistics directly to the questionnaire responses. Although histograms, scattergrams, and so on are useful for description of a disaster, such diagrams cannot be applied to a further systematic analysis.

DIFFICULTY INDEX

We use the model shown in Fig. 1 for post-earthquake living associated with the disruption and recovery of utilities. The living activity suddenly goes down when affected by the disruption of services, and then it goes up by stages in accordance with the recovery of services. The living activity is determined in terms of the degree to what extent it is restricted. We determine the level of living activity giving a score designated as the Degree of Restriction. The way to define the score is mentioned in the next section.

The numerical evaluate of difficulty, which is called the Difficulty Index (DI), is defined as

$$DI = \int_t (\text{Degree of Restriction}) dt.$$

The shaded area in Fig. 1 is a schematic idealization of the Difficulty Index (DI). The DI increases as, first, living activities are restricted more severely, and,

second, the restriction continues longer.

While the DI's for each of the five living activities are DI elements, the weighted sum of the five DI elements is called the total DI:

$$(\text{Total DI}) = \sum (c_i \cdot (\text{DI Element})_i)$$

where c_i (i=1 through 5) is a weighting coefficient that indicates the significance of the i-th living activity. In this study, a weight of 1.0 is used tentatively for every living activity. We have to consider and determine how relatively important each of the five activities is, particularly, in the post-earthquake society.

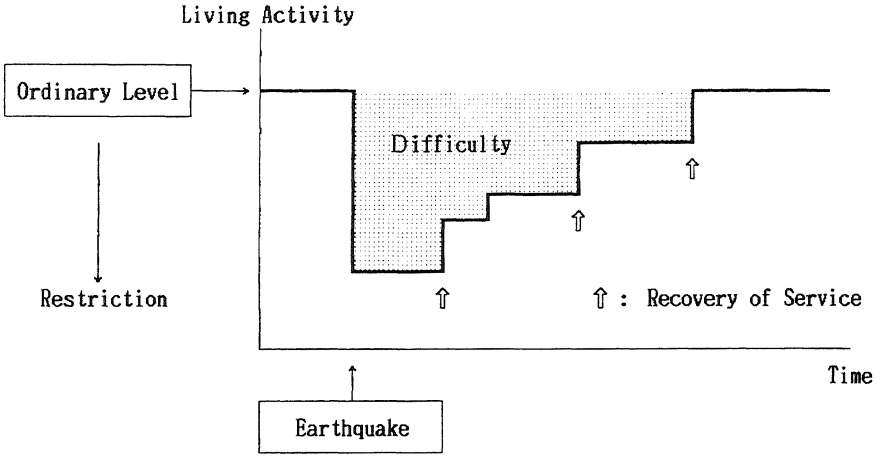


Fig. 1. A model for post-earthquake recovery process of living activities in the interruption of lifeline services.

DEGREE OF RESTRICTION

The Degree of Restriction (DOR) is assigned with a score between 0 and 10. A score of 0 is given in case no effect occurs in residents' living activities; A score of 10 is given in case their living activities are entirely halted. A few intermediate scores are assigned between 0 and 10 in accordance with the seriousness of restriction.

A DOR for cooking meals is assigned as follows: A score of 10 is given in case cooking is entirely restricted at home; namely, residents can eat only food that has been cooked somewhere else or food that does not need to be cooked like canned food. The only in-between score, 5, is assigned for a situation where cooking is possible but still limited. Two terms of restriction are accordingly investigated; how long cooking was suspended entirely and how long cooking was not carried out in the normal way.

In order to assign DOR's for other activities, the frequency of using the toilet, using a washbasin, and taking a bath, and amount of washed clothes are investigated. As the difficulty on using the toilet, using a washbasin, and washing clothes is substantially related to the suspension of water supply, the period of water interruption can be used for the term of restriction. As the difficulty on bathing is posed, in general, by the suspension of water or heat-source, the period of restriction can be substituted by the longer of the two disruption periods.

PILOT SURVEY

Background Noshiro, with approximately 18,000 households, suffered from major lifeline disruption in the 1983 Nihonkai-Chubu (Central Japan Sea) earthquake. The water supply was suspended throughout the city, and 20 days were needed to complete the restoration. The gas system, supplying gas to 3,800 households in the city, suspended entirely, and 30 days were needed for the complete recovery of the supply system. Electricty was interrupted in 4,000 households, but was mostly brought under control within 10 hours, late at night on the same day.

Survey Out of the 1,500 survey forms mailed, 965 were returned. The forms were mailed to obtain sample answers on (1) living type and (2) interruption period. The survey was conducted 2 years after the occurrence of the disaster.

Analysis First, the change of living activities (DOR) with the time was illustlated for each household. A few examples are shown in Fig. 2. These are actual measurements of the recovery process, of which the model is shown in Fig. 1.

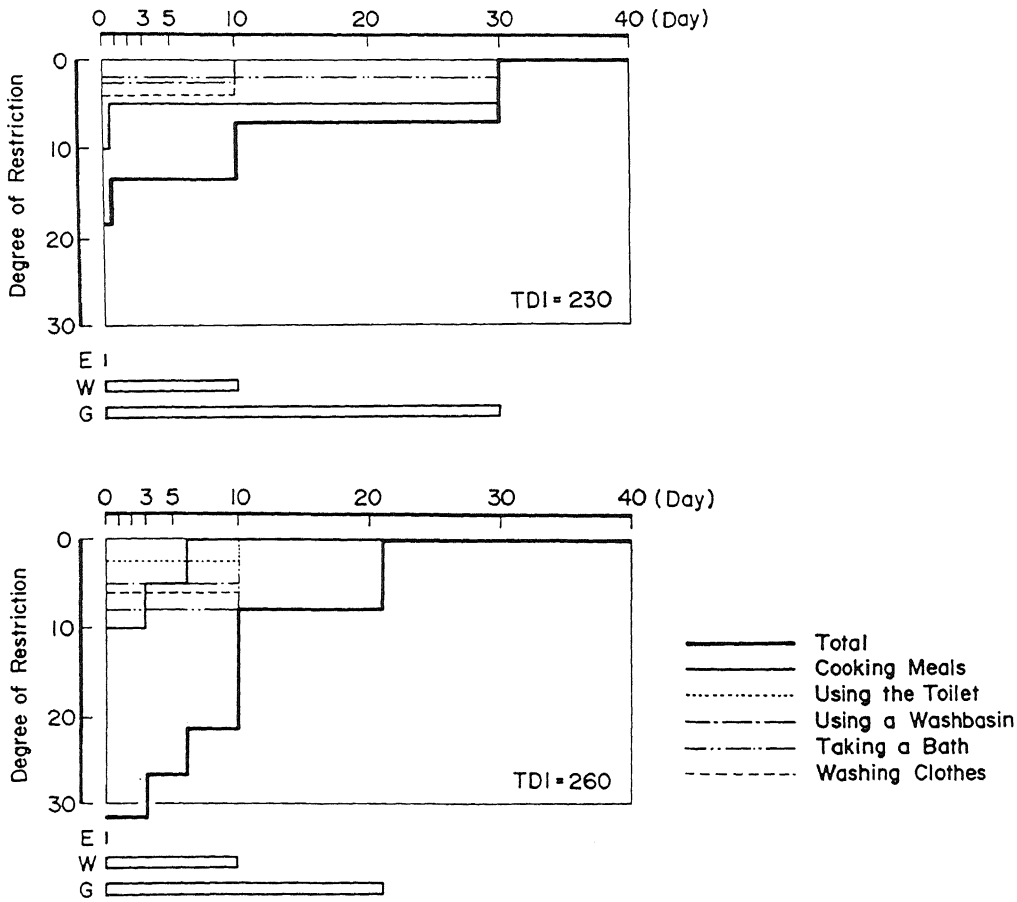
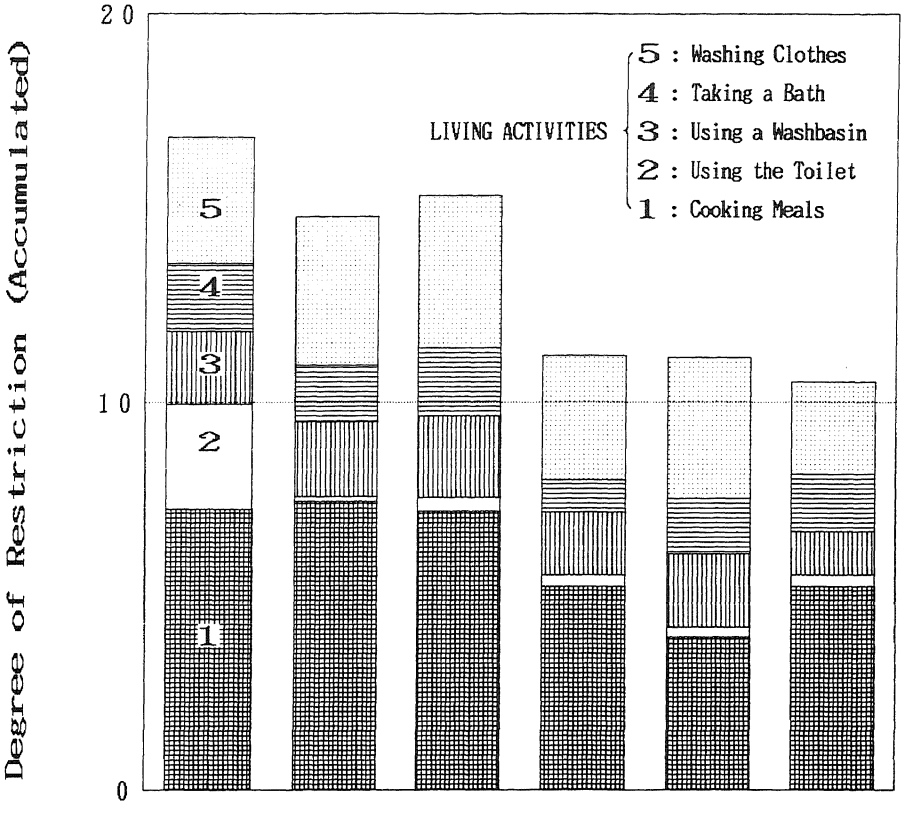


Fig. 2. A few exapmples of actual recovery process. The bars with letters E, W,and G indicate the interruption period of electricity, water, and natural gas, respectively. The total Difficulty Index (TDI) for each household is determined.



Living Type	1	2	3	4	5	6
Dwelling	Apartment	House				
Private Water System (Well)	Unpossessed					Possessed
Heat source for Cooking [1]	Natural Gas			LP gas [2]	Stove [3]	—
Heat source for Bath	Natural Gas		Oil		—	—
Toilet	Flash	Dipping-up				
Number of Samples	97	76	120	98	21	54

[1] Households using electricity as well are included.

[2] Each household uses a private gas holder (cylinder).

[3] In some cases equipment is possessed but not for daily use.

Fig. 3. Degree of Restriction (DOR) averaged for each living type.

Second, the Difficulty Indexes (DI's) were calculated for each household. As an example of application, a zoning map showing the average DI's area-by-area in the city (Ref. 1) was developed. As the DI was used as a common index, a direct comparison of the difficulty across the areas was accomplished. Other indexes than the average, for example, the product of the average DI and the population in the area, can be introduced as a regional index.

Third, the relationship between living type and the DOR, one of the two components used in the determination of DI's, was investigated. DOR's immediately after the earthquake are shown in Fig. 3. Six predominant living types, as shown in the lower part of Fig. 3, were identified in the survey area.

Figure 3 provides a numerical understanding, for example, in which the accumulated DOR for living type 1 exceeds that for living types 5 and 6 by approximately 60 percent. Accordingly, if the period of restriction is the same, the difficulty (total DI) posed on a family in living type 1 will exceed that posed on a family in living type 5 or 6 by 60 percent.

Another important point derived from Fig. 3 is that the DI, although it was developed originally to evaluate survey results, can be used as a scale to estimate, in advance, the seriousness of a disaster in the future. The following procedure is to be introduced; First, the living type is surveyed to determine the potential DOR. A numerical evaluate of DOR for each living type, Fig. 3, is utilized for the determination of a potential DOR. Second, the term of restriction is determined on the basis of the damage estimation for the utility services in the area concerned. A DI, which can be regarded as a vulnerability measure, is finally obtained as the product of an estimated DOR and an estimation of the restriction term.

CONCLUDING REMARKS

The application of the procedure developed in this study sufficiently demonstrated, through a pilot survey, that it provides a common index to compare the seriousness of a disaster. The numerical scale proposed here is a remarkable improvement over conventional descriptive approaches, because it can work as a tool not only for analysis of a disaster but also for systematic accumulation of research data.

Improvement of the method is still necessary. Particularly, it is important to determine the weighting coefficients that account the importance of each living activities in a disaster. Further development of the method will be accomplished through an in-depth understanding of residents' behaviors in a disaster as well as additional field testing of the procedure.

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