Paper No. 1595. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

DISASTER SCALING FOR RECENT EARTHQUAKES

EMIL-SEVER GEORGESCU and EIICHI KURIBAYASHI

Building Research Institute - INCERC, Pantelimon 266, 79614 Bucharest, Romania
Toyohashi University of Technology, Tempaku-cho, Toyohashi 441, Aichi, Japan

ABSTRACT

The occurrence of a disaster is characterised by a large number of casualties, homeless and affected persons, excessive losses and a loss of social control of events; the available resources for rescue and recovery become insufficient. The scaling suggested in this paper aims at using loss size and impact indicators for comparisons between contemporary countries, different historical periods of the same country or individual countries in their evolution. The GLOBAL ECONOMETRIC SCALING using KNOWLEDGE on EARTHQUAKE EFFECTS (GESKEE DISASTER SCALE, authors Georgescu and Kuribayashi, 1992) is tested on 42 earthquakes of this century, with commentaries on recent disasters. The approach allowed a promising scaling and correlation of the earthquake magnitude, loss size and ratios, the specificity of the affected areas, the level of development, the impact and recovery patterns.

KEYWORDS

size of disasters, earthquake losses, development impact, disaster indicators, econometric scaling

INTRODUCTION

The "disaster" term means nowadays more than a severe seismic motion on magnitude or intensity scales. A given seismic event may be large but not yet a disaster, if its negative effects are reduced in comparison with the existing elements at risk and resources for rescue, rehabilitation and recovery. The absence of a recognised "earthquake disaster scale" is in contradiction with the progress in the seismic risk and loss analysis. The attempts to date have given partial answers.

Bath (1967) introduced "specific destruction" as being a measure of the number of deaths per unit seismic energy; the ranking of individual earthquakes or seismic regions revealed a group of countries well known for the vulnerability of traditional buildings (a parameter not explicitly assessed in the method).Ribaric (1982) added GNP as measuring the economic capacity to rebuild; the long term economic index in relation to GNP of USA gave a reasonable ranking related to development.

Kuribayashi and Tazaki (1978) introduced composite indicators of loss and the testing on the Japanese data suggested positive trends in disaster patterns for some decades. Ohta *et al* (1986) , Ohashi and Ohta (1986) compared the monetary losses and casualties for our century; the clustering analysis revealed some patterns of disasters function of the predominance of these parameters; an obvious increase of fatalities per monetary loss is visible for low income countries. Keller (1989) suggested the Bradford Scale for disasters as a logarithmic correlation with the fatalities number. Kerpelman (1990) suggested an UNDRO Disaster proneness index for countries, using the loss to GNP ratio for 1970-1989.

An independent research of Georgescu and Kuribayashi (1992) introduced composite loss indicators for the comparison of earthquake losses in Romania and Japan, emphasising the importance of the development level and the specific features of each country. Georgescu (1992), Georgescu and Kuribayashi (1994) suggested the GESKEE Disaster Scale using specific loss indexes and a scaling related to the relative economic power, level of development and recovery patterns. Samardjieva and Oike (1992) related magnitudes to population densities for the modelling of casualties number. Klyachko (1994) reported his researches of 1989-1992, proposing a disaster scale based on a sum of logarithms of the amount of fatalities (valued in insurance terms) and financial losses; his correlations took into account a ratio of losses to a reference GNP. The suggested scores and classification may help the disasters scaling.

There is a general agreement that the main components of a disaster scale must be concentrated on three main criteria: number of deaths, number of people affected, the economic value of damage. However, the attempts to introduce some disaster categories and criteria (UNDRO, 1994) and the disaster proneness index (Kerpelman, 1990) can be criticised for mixing minor and major disasters, developing and industrialised countries, or for cumulating losses on too large periods, neglecting the coutries evolution; the results are too administrative and pessimistic concerning the increasing trend or steadiness of disasters in the world for 1963-1992.

Generally, most of the criticised approaches are based on some unspecified implicit assumptions and lack of correlation with the vulnerability of causal elements at risk. On the other hand, the most available data are from the loss reports and usual statistical data. A scale of disasters must provide a ranking and predict realistically the disaster trends, avoiding saturation.

DIRECT AND INDIRECT LOSS SIZE FACTORS

The factors generally considered as affecting the earthquake losses size and impact could be summarized, as follows:

Factors affecting the direct losses size and impact:

-the size of the damaged area, the physical damage degree/vulnerability of the natural and man-made environment elements, the actual damage, life loss and injuries, the incidence of secondary or higher order disasters;
-the ratio of the damaged area vs. the country area, the ratio of suffering population to the country's population, the share of the affected economic branches in the local, regional and national product, and in foreign trade income;
-the specific pattern of the past disasters influence on the country's development, function of the return periods of strong earthquakes, the early use of aseismic design codes and their updating, effective application and observing, official endorsement of land use planning, rehabilitation and seismic risk mitigation activities, quality control in constructions, etc.;
-the density of population, settlements, socio-economic facilities and economic output in the affected area;
-the value of property losses and their distribution between sectors, the size of the national wealth and national product/income and the ratios between them;

Factors affecting the indirect and long-term size of losses and impact:

-the type of economic system, methods of planning and management, the complexity of the economic input-output relationships between the major sectors of the country's economy and the resulting patterns of development, inclu-

ding the reference to the UN classification function of GNP per capita;
-the trend of economic development and growth rates in the preceding years;
-the existence of a disasters prevention legislation and loss recovery system through insurance and government incentives (tax exemption, condolence money, compensation, etc.);
-the conjunction with other factors, as world recession, stagnation, inflation, political instability, etc.;

SPECIFIC INDICATORS OF LOSS SIZE, INTENSITY AND IMPACT

Starting from the afore mentioned factors, three main types of indicators have been identified, as follows:
1.Ratios of damage or loss, in physical and/or monetary expression for the same category of elements;
2.Composite indicators (e.g. the comparison of lost assets per damaged area unit with total existing assets per area unit);
3.Time-series of usual economic development indicators centered on the year of earthquake.

The analysis of aforementioned indicators led to the following results:
-the first type of indicators can be considered as the strongest physical predictor of the disaster size and patterns, especially for casualties and damage. However, they cannot always explain why the disaster pattern and impact are different when the economic loss is almost the same.
-the composite indicators describe the intensity of damage and loss in conjunction with some elements of regional and developmental significance, as wealth or income per capita. However, such indicators do not take into account other mechanisms of loss recovery/compensation adopted by different countries.(Table 1).
-the time-series economic indicators need detailed knowledge, since the interference of direct and indirect losses in economic development can produce visible "jumps"(e.g.GNP-Japan 1923, San Salvador 1986) or only decline periods followed by a gradual recovery (Italy 1976-1985, Greece 1978-1985, Romania since 1977, Yugoslavia 1979-1985, Mexico 1985-1995).
The ratio of losses to the Gross National Product (GNP) is easily to be used, but actually only a part of the property loss (fixed assets and lost inventory) is involved formally in the economic production. A correct analysis should separate the loss in specific shares and to report the lost assets the National Wealth and the lost outputs of goods and services to GNP.

A SCALE OF DISASTERS

The GESKEE indicator, component of the GLOBAL ECONOMETRIC SCALING using KNOWLEDGE on EARTHQUAKE EFFECTS (named also GESKEE DISASTER SCALE, authors Georgescu and Kuribayashi, 1992) which allows the relative assessment of the earthquake loss impact size, using the Equation 1:

$$\log \text{GESKEE} = \log\left[\frac{\text{E.L.}}{\text{GNP}}\cdot\frac{\text{GNP}_{\text{REF}}}{\text{GNP}}\right] \tag{1}$$

where:
E.L. = earthquake loss value
GNP = Gross National Product of a country
GNP_{ref} = Gross National Product as reference (e.g. GNP of U.S.A.).

The GESKEE indicator, expressed for a number of 42 earthquakes,including 10 events of the last five years, is presented in Table 2 (data on loss and GNP referred to the year of the earthquake), as a continuous and nominally endless scale. This most concentrated form of the GESKEE DISASTER SCALE (Georgescu and Kuribayashi, 1996)proved to be a general tool in order to explain the relationship between the classical measure of a seismic motion,the loss size,the country's economic level of development(i.e. economic power) the disaster impact and the patterns of post-disaster recovery. The worst disasters are towards the top of the table in each group or for the same country. From our data resulted that the strongly damaging magnitudes threshold is lower for the most affected countries, proving that higher vulnerability is associated clearly to the lower development and economic

Table 1. Composite indicators to be used as earthquake loss size and impact predictors.

Item No.	INPUT TERM	REFERENCE TERM	COMPOSITE INDICATOR	SIGNIFICANCE AS LOSS IMPACT PREDICTOR
1	$\frac{L}{A_D}$	$\frac{W}{P}$	$\frac{L}{W} \cdot \frac{A}{A_D}$	-relative size of assets loss and territorial concentration of damage -indicate the pattern of necessary recovery deployment of forces in zone
2	$\frac{L}{P_D}$	$\frac{W}{P}$	$\frac{L}{W} \cdot \frac{P}{P_D}$	-relative size of assets loss and social concentration of damage -indicate the availability of necessary recovery manpower
3	$\frac{E.L.}{A_D}$	$\frac{GNP}{A}$	$\frac{E.L.}{GNP} \cdot \frac{A}{A_D}$	-relative size of total loss and the territorial concentration of damage -indicate the pattern of necessary deployment of forces in zone for recovery
4	$\frac{E.L.}{P_D}$	$\frac{GNP}{P}$	$\frac{E.L.}{GNP} \cdot \frac{P}{P_D}$ $\frac{EL/cap.}{GNP/cap}$	-relative size of total loss and the social concentration of damage -relative size of total loss per capita function of nominal output per capita
5	$\frac{EL}{GNP}$	$\frac{GNP}{GNP_{REF}}$	$\frac{E.L.}{GNP} \cdot \frac{GNP_{REF}}{GNP}$	-scaling the size of total loss in national and international context and the ability for recovery, function of unique reference term
6	$\frac{EL}{P_D}$ $\frac{GNP}{P}$	$\frac{GNP}{P}$ $\frac{GNP_{REF}}{P_{REF}}$	$\frac{EL}{GNP} \cdot \frac{P}{P_D} \cdot \frac{P}{P_{REF}} \cdot \frac{GNP_{REF}}{GNP}$ $\frac{EL/cap.d}{GNP/cap} \cdot \frac{GNP/cap_{REF}}{GNP/cap}$	-scaling the loss in the national and international context, considering the economic resources for recovery -scaling the total loss per capita in national and international context, considering the economic and human resources for recovery

Symbols:

L-fixed assets loss value
W-existing assets value
A-area of analysed zone,country
A_D-damaged area of analysed zone
P-population of analysed zone,country
P_D-population of damaged area
GNP-Gross National Product(GDP-Gross Domestic Product could be used too)
GNP/cap-GNP per capita
EL-total earthquake loss value
EL/cap.d -earthquake loss per capita of damaged area
REF-the reference country for population or GDP/GNP respectively

Table 2. The concentrated form of the GLOBAL ECONOMETRIC SCALING using KNOWLEDGE on EARTHQUAKE EFFECTS (GESKEE DISASTER SCALE, Georgescu and Kuribayashi, 1996)

INPUT DATA: ITEM	INPUT DATA: RANGE OF VALUES	RANGE OF log GESKEE (Eq.1)	OUTPUT DATA: RELATIVE DISASTER SIZE SCALING WITH LOG GESsKEE	OUTPUT DATA: COUNTRY PATTERN, PREDICTED ECONOMIC IMPACT AND RECOVERY POLICY
GNP/cap	AS FOR LOW-INCOME AND LOWER-MIDDLE INCOME COUNTRIES	0.7 to 3.0	2.80 Nicaragua 1972 2.27 El Salvador 1986 2.23 Guatemala 1976 1.70 Ecuador 1987 1.33 Yugoslavia 1963 1.18 Chile 1985 0.87 Japan 1948 0.73 Japan 1923	-SMALL COUNTRIES -COUNTRIES IN EARLIER STAGES OF DEVELOPMENT OR DIFFICULT CIRCUMSTANCES -SUDDEN DROP OF ECONOMIC INDICATORS WILL BE RECORDED -THE RECOVERY (IF MADE) IS DIFFICULT WITHOUT INTERNATIONAL ASSISTANCE -THE DEBTS ASSOCIATED WITH RECONSTRUCTION LOANS MAY HAMPER THE GROWTH IF THE LOCAL ECONOMY CANNOT PROVIDE DEBT SERVICE AND DEVELOPMENT
M(Richter)	5.4 - 8.0			
$\frac{E.L.}{GNP}$	10 - 50%			
$\frac{GNP}{GNP_{USA}}$	2 - 0.05%			
DIRECT AND COMPOSITE INDICATORS OF LOSS SIZE AND IMPACT				
GNP/cap	AS FOR MIDDLE - INCOME AND UPPER MIDDLE -INCOME COUNTRIES	- 0.5 to 0.7	0.67 Algeria 1980 0.60 Yugoslavia 1979 0.58 Iran 1990 0.47 Romania 1977 0.41 Philiphines 1990 0.40 Egypt 1992 0.30 Greece 1981 0.24 Greece 1986 0.12 Venezuela 1967 0.082 Romania 1940 -0.15 Mexico 1985 -0.36 Japan (hyp) 1988	-MIDDLE SIZE COUNTRIES -OIL EXPORTER,CENTRALLY PLANNED AND TOURISTIC INDUSTRY COUNTRIES -THE DECLINE OF NATIONAL ECONOMIC INDICATORS WILL BE RECORDED -THE RECOVERY IS POSSIBLE, FÚNCTION OF STRATEGY AND TACTICS, WITH LOANS PROPERLY DIRECTED
M(Richter)	5.7 - 8.1			
$\frac{E.L.}{GNP}$	3 -10%			
$\frac{GNP}{GNP_{USA}}$	10 - 2%			
DIRECT AND COMPOSITE INDICATORS OF LOSS SIZE AND IMPACT				
GNP/cap	AS FOR HIGH-INCOME INDUSTRIAL COUNTRIES	$\leq$ - 0.5	-0.55 Turkey 1970 -0.57 Italy 1980 -0.90 Italy 1976 -0.92 Turkey 1992 -1.00 China 1976 -1.08 Armenia 1988 -1.20 Turkey 1976 -1.26 Japan 1964 -1.45 Japan 1995 -2.09 USA 1906 -2.18 Japan 1968 -2.33 USA 1994 -2.54 Japan 1978 -2.82 USA 1989 -2.84 Japan 1983 -3.07 USA 1964 -3.19 India 1993 -3.32 USA 1971 -3.33 Japan 1993 (07) -3.56 Japan 1993 (01) -3.73 Japan 1994 (10) -4.28 Japan 1994 (12)	- INDUSTRIAL HIGH INCOME OR JUST LARGE ENOUGH COUNTRIES TO BEAR EASILY THE IMPACT OF LOSSES -THE ECONOMIC INDICATORS OF AFFECTED ZONES MAY PRESENT TEMPORARY FALLS, POSSIBLY RECESSION, FUNCTION OF LOCAL AND INTERNATIONAL CONJECTURE -THE RECOVERY IS POSSIBLE WITH LOCAL NATIONAL RESOURCES
M(Richter)	6.5 - 8.3			
$\frac{E.L.}{GNP}$	0 - 3%			
$\frac{GNP}{GNP_{USA}}$	$\geq$ 10%			
DIRECT AND COMPOSITE INDICATORS OF LOSS SIZE AND IMPACT				

weakness, difficult circumstances, etc. There is a general trend of chronological improvement of a given country's relative ability to cope with disasters, as the development becomes significant. For the same relative loss, a more developed or a larger country will suffer less, being more able to rebuild if a sound policy is adopted. The particular heavy damage in the most urbanized zones or in the capital city, strongly increases the impact of losses and the disaster pattern.

The thresholds and figures in table 1 must be considered as preliminary. Earthquakes before 1945 shall be assessed with caution due to the input data; the losses of Romania (1977) were presumably underestimated in comparison with the scale of damages in Yugoslavia (1979). The relative size of losses when the country is very large (China, 1976) or belonged to a federation (Montenegro/Yugoslavia, 1979; Armenia/USSR, 1988) may give another ranking than expected, since the reference GNP was larger. Thus, using the GNP of Montenegro (1979), the disaster locus is as for Nicaragua (1972). The rather reduced losses of Turkey in 1976 (rural zones damaged) led to a better scaling than for Italy in 1976-1980, although the territorial damage pattern was obviously different.

Several disasters of the 1985-1995 require commentaries, since their ranking group does not correspond to the loss threshold or development country groups (established by UNO, function of GNP per capita). These cases are Chile (1985), Iran and Philippines (1990), Egypt and Turkey (1992), India (1993). In such situations one of the parameters of Eq. 1 overwhelmed the other. Chile (1985) had, probably, a lot of modern and costly elements at risk to be damaged but a circumstantially weak economy. For Egypt, the losses of 0.5 bln. US$ (El Samny and Ghobarah, 1994) gave the listed index; other unofficial data, 2 to 6 times higher would give a locus near Japan (1923) and Chile (1985), but the field damage seems to indicate similarities with the cases of Philippines (1990) and Greece (1981). For Iran (1990) and Philippines (1990) the disaster has rather a social component than an economic one, in terms of the used approach (the GNP of Iran is greatly related to the oil export). The locus of India (1993) reflects a relatively reduced assessed loss for the size of India.

In the cluster of industrial countries, the unexpected locus of Turkey (1992) has the significance of a rather local disaster for a large country, similar in impact to some Italian earthquakes of the decade 1970-1980. As a matter of fact, Turkey concentrated public and private resources to rebuild Erzincan and the economic growth of the past decade in Turkey allowed the progress of works. Taking into account that Erzincan was rebuilt after the 1939 earthquake, the 1992 losses were probably reduced by the use of many aseismically designed buildings.

The four North Japan earthquakes of 1993 and 1994 indicate local disasters at the scale of Japan , whose, losses were aggravated by the large magnitudes, landslides, liquefaction and tsunami effects; the disaster loci confirm the reduction trend after the 1948 Fukui earthquake. The 1995 Kobe earthquake (property loss of 57 to 100 bln US$) reversed this positive trend, the disaster locus being next in order after Niigata (1964) earthquake, but before San Francisco, USA (1906) earthquake .The locus in table 1 was assessed for 100 bln US$ loss; the index for 57 bln US$ is 1.69.

Kuribayashi (1995) used the initial property loss value of 57 bln US$ to assess the total and specific loss ratio for property loss (see item no.2 in table 1) in comparison with the data on Japanese earthquakes for different facilities. The total loss ratio is closer or next in range after 1964 Niigata earthquake ratio, observing the trends of other earthquakes, while the individual loss ratio is equal to the Niigata case for electric power facilities and is less than those of Niigata for other types of facilities (except buildings). The Kobe disaster must be analysed not only by total or individual loss ratios, but mainly as a great disorder in the system of input-output economics and foreign trade, finally influencing the GNP of Japan.

The property loss to GNP ratio for the Kobe earthquake (1995) may range from 1.30% to 2.30%, being 2-3 times higher than the ratio for Niigata (1964), but much less than the ratio for Fukui (1948) earthquake (15.56%). The ratio of property loss to national wealth is likely to range between 0.2 % and 0.8% for Kobe (1995) earthquake, while for Niigata (1964) it was 0.193%, decreasing then sharply during three decades (Georgescu and Kuribayashi, 1992). Although the ports and harbours in Kobe had a share of 30% of Japan international containerised trade, the social and economic potentiality of damaged areas is very important only at the Hyogo Prefecture scale; it represents merely 2-3% at the scale of Japan (Kuribayashi, 1995) but produced major ripple effects.

The suggested overall scale needs special care for the specific case of zones where a very large share of national GNP is produced. For instance, the Tokyo area with a gross production of about 30% of the Japan nominal GNP, was considered to be struck by the simulated New Kanto Earthquake (1988), and a loss of capital stock equal to 23% GNP was predicted. Such a loss is specific in our scaling for low-income countries and the GESKEE indicator would locate the simulated case in the range of middle income countries with a difficult recovery conditioned upon the adopted strategy and tactics. As a matter of fact, the Tokai Bank simulation considered that during the reconstruction a GNP drop of -1% will be followed by a positive but decreasing growth of Japan's GNP for 6 years, up to zero and also the sharper decline of GNP of many other countries and of World GNP with -2.6%. (Tokai Bank, 1989). Therefore, the concentration of assets and the interdependence at national or international level is a factor to be carefully considered. For these zones or countries other special assessment/scaling instruments are required.

For USA, the chronological trend of disaster scale reduction since 1906 was reversed by the 1989 and 1994 earthquakes. The 1994 Northridge earthquake seems to be the worst after the 1906 one, followed by Loma Prieta (1989), no matter if 20 to 50 bln. US$ losses are considered. The locus in the table 1 is for 30 bln US$ loss. If California had been considered a separate economy, the scaling would have given for the 1994 earthquake a ranking locus as for the Italy earthquakes of 1976-1980. The US Federal and State assistance, as well as the insurance, provided coverage for loss recovery and rehabilitation, but the roots of the disasters remain to be the old buildings and vulnerable lifelines.

CONCLUSIONS

The earthquake disasters scaling can be provided in direct, indirect and developmental expressions using specific indicators. The most promising seems to be the GESKEE DISASTER SCALE, allowing the following sequence of loss impact assessment with an expert system:
-input data:earthquake size (M), direct, composite and developmental indicators (GNP), assessed loss (E.L.), patterns of the affected area;
-processing of data:log GESKEE using Equation (1);
-output data:relative scaling of the seismic event impact (disaster size) versus other national and international disasters, alternatives of recovery and needs of assistance, projections of the GNP falls and development implications of the respective loss, recommended rehabilitation policies to be endorsed by the concerned boards.

The trend of earthquake disasters in the world is towards the relative disaster reduction for the countries able to provide simultaneously disaster prevention and development. The remarked steps backwards, following some recent disasters in USA and Japan are a warning about the role of preventive rehabilitation, especially in large industrialised and agglomerated urban areas. Neglecting the up-to-date assessment of hazard and vulnerability leads to painful losses. While the industrialised, high income countries cope with disasters with large economic losses but usually with reduced life losses and affordable recovery, the countries engaged in development suffer larger losses in relative terms,that may endanger their future if a culture of disaster prevention has not been built .

The gathering and processing of more earthquake loss data will improve the accuracy of the disasters scaling and its predictive use, contributing to the IDNDR goal of achieving a sustainable development. Besides economic impacts, the scaling of casualties require further study in order to avoid the influence of the excessive scattering of data.

ACKNOWLEDGEMENTS

This research was initiated in a larger study carried-out within a Fellowship for a long-term research, awarded by the Japan Society for the Promotion of Science in the fiscal year 1991-1992, under the supervision of Professor

Eiichi Kuribayashi, at the Toyohashi University of Technology, Aichi, Japan. This generous opportunity is gratefully acknowledged.

REFERENCES

Båth, M.(1967). "Earthquake, Large, Destructive". In: *International Dictionary of Geophysics*, S.K.Runcorn et al. Eds. Pergamon Press, Oxford and New York.

El Samny, M.K.,Ghobarah, A. (1994) Structural response during the 1992 Cairo earthquake.*10-th ECEE*, Vienna, Austria, vol.1, pp.793-798, Balkema, Rotterdam.

Georgescu, E.S. (1992). The Seismic Disaster Mitigation and Anticipated Earthquake Preparedness, Analyzing the Earthquake Resistivities of Densely Populated Urban and Rural Centers. *Research Report under JSPS Fellowship,* Toyohashi University of Technology Aichi, Japan.

Georgescu, E.S., Kuribayashi, E. (1992).Study on seismic losses distribution in Romania and Japan *Proc. 10-th WCEE*, Madrid, Spain, vol.10 pp 5977-5982, Balkema Rotterdam.

Georgescu, E-S.,Kuribayashi,E.(1994)Earthquake disasters scaling.*Proc.10-th ECEE*; Vienna,Austria,vol.2, pp. 1157-1162, Balkema, Rotterdam.

Georgescu, E.S., Yarar, R., Popescu, O.(1993). Comparative study of earthquake losses in Romania and Turkey. *Proc.2-nd National Turkish Conference of Earthquake Engineering.* -TUNCEE-ITÜ-TMMOB, Istanbul.

Keller, A.Z.(1989) Bradford Disaster Scale. In: Disaster Database Planned to Help Prevent Tragedies.*The Independent*, September ,13,1989, London, U.K.

Kerpelman, C. (1990). *Preliminary Study on Identification of Disaster Prone countries Based on Economic Impact.* UNDRO, Geneva.

Klyachko, M.A.(1994) The Unified Scale for Earthquake Disaster Magnitude Measurement. *Bulletin of Construction and Architecture,* no. 5-6/1994, GOSSTROI, VNIINTPI, Moskva.

Kreimer, A.Munasinghe, M., Editors. (1991). *Managing Natural Disasters and the Environment.* The World Bank, Washington D.C.

Kuribayashi, E., Tazaki, T.(1978). An evaluation study of property losses caused by earthquakes. *Proc.5-th JEES,* Tokyo, Japan.

Kuribayashi,E.(1995).The Japan's earthquake in Kobe of January 17,1995 (The Hyogo-Ken Nanbu Earthquake) A Reconnaissance Report.*Research Report* **No.95-1**, Toyohashi University of Technology, Aichi, Japan.

Münchener Rück, (1988), *World Map of Natural Disasters.* München.

Ohta, Y., Kagami ,H., Okada ,S., Ohashi ,H.(1986). Characterization of earthquake disasters in several tens of countries. *Proc. 8-th ECEE,* Lisbon.

Ohashi, H., Ohta, Y.(1986), A U.S-Japan comparison on earthquake disasters by 1900-1979 damage data statistics. *Proc.3-rd US National Conference* EERI, USA.

Ribaric, V. (1982). An extension of the concept of specific distruction of earthquakes on the basis of Gross National Product of affected countries. In: *Social and Economic Aspects of Earthquakes,* Jones, B.G. and Tomazevic, M.Eds., Cornell University, Ithaca, New York.

Samardjieva,E.,Oike ,K.(1992) Modelling the Number of Casualties from Earthquakes. *Journal of Natural Disaster Science,* **vol.14 ,No. 1**, pp.17-28, DPRI, Kyoto University.

Tokai Bank. (1989). A South Kanto area earthquake and the Japanese economy. *Tokai Monthly Economic Letter,* **no. 122**., Tokyo.

UNDRO-IDNDR (1994) World Conference on Natural Disaster Reduction, Reports and addendum, Yokohama.

World Bank, (various years editions), *World Bank Tables.* Johns Hopkins University Press.