CHARACTERISTICS OF URBAN NATURAL DISASTER AND ITS SCENARIOS TOWARD CATASTROPHE

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INTRODUCTION

The word "city" has many meanings. In this paper, I would like to define city as an area with a large population and high population density. Now, in regards to the "large" and "high" mentioned here, what should be determined as their appropriate numerical values? Actually, there is no clear–cut criterion for them. The definition of urban disaster is very ambiguous because of this. It may be referred to as urban–type disaster or disaster due to urbanization.

If the lifeline of a city is damaged by an earthquake, for example, would it be appropriate to call it an urban natural disaster? If this particular city is small and its population is about 30,000, can this disaster be called an urban disaster? This is still not clear. The common recognition of urban natural disaster is that the characteristics of natural disaster in a city have become more complex due to changes in the social environment. Then, do urban natural disasters among populations of 500,000, 1 million, or more than 8 million such as a mega–city have similar characteristics? If they do, we can expect a high correlation and make disaster countermeasures effective by predicting the same kind of damages as the disasters which occurred in large cities in the past. Unfortunately, the history of urban natural disasters indicates that the larger the disaster is, the less similar is the pattern of extrapolated damage that emerges.

Now, firstly, the classification of urban natural disaster is proposed on the basis of their characteristics, and the scenarios of disaster amplification are pointed out focusing on human damages in the southern Kanto area due to the recurrence of an earthquake such as the great Kanto earthquake in 1923. Secondly, the damage amplification can be elucidated by sequential processing according to its scenarios. By so doing, the necessary effective disaster countermeasures will be proposed.

CHARACTERISTICS OF URBAN NATURAL DISASTER

As the definition of urban natural disaster is made clear, disaster studies and tactics for disaster prevention and mitigation, such as the formulation of a countermeasure or government policy, becomes more effective. Numerous urban natural disasters and other recent disasters occurring in our country have become diversified through modernization. It is inevitable to take the countermeasure from the viewpoint of synthesized disaster prevention. The comprehensive understanding of characteristics of the disasters holds the key to disaster prevention. To the contrary, Takayama and Murakami proposed that the method of piling up individual micro–phenomena in each scenario could solve urban disaster problems.[1/] However, under the condition of complex disaster occurrence in modern system failure, it is very difficult to specify the cause of occurrence. Today, unclear causality of a catastrophe is the prevalent characteristic of urban natural disasters. Therefore, quantitative estimation of characteristics of urban natural disaster is proposed from a macro–point of view.

Definition of City and Recent Urbanization

First of all, the definition of city in Japan is given on the basis of a population range. According to the local governing law of Japan enacted in 1947, it must have a population of 30,000 or more to be a city, but this was revised to 50,000 or more in 1954. Some exceptional application provisions were promulgated in 1965. This new measure has led to the increase in the number of cities. Today there are more than 200 cities whose population are 100,000 or more, and the administrative unit as a city can be found virtually everywhere in Japan.

On the other hand, there is no worldwide consensus on the definition of city. In this section, the changes of the number of cities with a population of more than 1 million are discussed. There were only eleven in 1900, which were located mostly in developed countries. According to the United Nations, there will be 400 or more by the year 2000, twenty–eight of which will be mega–cities and twenty–two of them will be located in developing countries. The growth of big cities contributes appreciably to the increase of world population.

The changes of ratio of population in urban areas as compared to that of the entire area are shown in table 1. Japan and Indonesia are used as examples of developed and developing countries, respectively. In the case of Japan, rapid urbanization was over by the 1970s, and the growth rate had quickly decreased. Recently, the administrative unit of urban areas has artificially been enlarged and core cities in local areas have been concentrated with increasing population. Both have led to the increase of population in urban areas. On the other hand, depopulation has been noticeable in rural areas. Urbanization in Indonesia, on the other hand, is growing rapidly and it is estimated that it will reach explosive dimensions in the early twenty–first century. The process of urbanization has unique characteristics between developed and developing countries. In both countries, more than 60 per cent of the population is estimated to live in urban areas by the year 2025.

Classification of Urban Natural Disaster

We already indicated the quantitative evaluation method of disaster prevention force and potential.[2/] The former can be expressed by the average life span and the latter is figured out by multiplying it by the number of population. According to this method, the larger the population is, the larger the disaster prevention potential must be. Therefore, essentially the bigger the city is, the larger the disaster prevention potential is. This relationship however cannot be applied to our society. The following reasons illustrate this with some interaction among them.

(1) Disaster is a phenomenon that occurs intermittently with low or high frequency. In particular, extreme force which causes catastrophe occurs with low frequency, so it is difficult to maintain investment in disaster prevention.
(2) Disaster countermeasures against new types of damage are rarely carried out as future investment.
(3) Total maintenance of city infrastructure is in imbalance because population and societal capital concentrate rapidly within a short period of time.
(4) There is a large risk of occurrence of a phenomenon whose law of causality is unclear; however, predicted result by simulation cannot be applied because available modeling is not appropriate.

These aforementioned relationships are amplified as the scale of a city grows larger and its imbalance increases. There are many cities that have lifeline systems such as electricity, waterworks, and telephone. They are also constructed in mostly every town. Infrastructures such as urban highway, subway, and city gas are serviced in only city government ordinances with a population of more than 1 million in Japan. From this viewpoint, it can be easily recognized that natural disasters in urban areas mainly emphasize the damages of lifeline systems.

From this point, the following classification can be developed according to the characteristics of urban natural disaster:

(1) **Urbanizing natural disaster**: disasters occurring during the period that residential areas and urban infrastructures are developed in rural areas. In the past, in Japan this was observed in small-scale cities whose population was rapidly growing. This type of disaster is mostly seen now in developing countries. There is still much natural environment left which is not artificially controlled, so it can be referred to as disasters controlled by the natural environment.
(2) **Pseudo-urban natural disasters**: disasters with less human damages, though urban infrastructures, especially lifeline systems, are destroyed. Damages in Sendai by the Miyagiken-oki earthquake of 1978 and those in San Francisco by the Loma Prieta earthquake of 1989 are typical examples. Population density is not so large and only property damages are prevalent, so it can be referred to as disasters mainly controlled by the social environment.
(3) **Urban natural disaster**: disasters whose damages are largely amplified due to overpopulation and intensive socioeconomic activities.

These characteristics are listed in table 2. The disasters in a core city in our local area have both (1) and (2) components. That is to say, pseudo-urban natural disaster occurs in the centre of an urban area and urbanizing natural disaster in the outer area. During the flooding of Nagasaki in 1982 and of Kagoshima in 1993, urbanized flood disasters occurred in the city centres, and sediment-yield disasters, such as debris flow and landslide, occurred in the outer areas.

Analogy of Over-Damage and Over-Infection

Considering the history of human plague, it is obvious that every kind of plague has occurred irregularly throughout time and space, from epidemics in sparsely populated areas such as farm districts to pandemics in densely populated areas.[3/] How about natural disasters? Estimation of the maximum number of human lives lost is easy if the risk to life in sparsely populated small cities and in densely populated mega-cities are the same. It appears possible to calculate the loss by multiplying the number of population and the maximum risk to life (death rate), but this is not so.

The relationship between disasters and panic should be pointed out. For example, a false report or groundless rumor cannot be transmitted if people do not gather together. They are rapidly spread by word of mouth through filters such as people's obsession and misunderstanding, and consequently panic results. Some other conditions from which panic originates are pointed out elsewhere,[4/] and it is an indispensable condition that many people gather within a limited space. Of course, it has yet to be made clear to what extent population density within a limited space will constitute to leading to panic, but there must be a threshold value to set its boundary.

The biggest social aspect of human natural disaster is "undailiness". Most of those who pass through the Tokyo metropolitan area during rush hour do not anticipate the occurrence of a big earthquake at any moment. It can be said that a sudden attack is the main amplification factor of urban natural disaster. The phenomenon, in which disasters make damages explosively big, must be closely related to the absolute number of population and its density. If so, the occurrence of over-damage due to urban natural disaster can be predicted by using an analogy with the over-infection of plague.

Effect of Population Density on Urban Natural Disaster

In order to quantitatively evaluate the effect of population density on the number of casualties, the ratio of amplification of urban natural disaster is newly defined here, and its characteristic is considered through data analysis.

(1) Ratio of amplification of urban natural disaster

Now, ratio of population density in a certain (city) area to that in the total area is defined as ratio of amplification of urban natural disaster. Therefore, this ratio shows the "relatively" crowded condition of population in a certain area (It does not necessarily have to be a city). Then, is the effect of the ratio changed if the country is a different one? If it is changed, the effect of the ratio on the number of lives lost due to the disaster must be evaluated in each country, and it means a lack of universality.

The following hypothesis will be introduced and discussed. Suppose that the ratio of amplification of urban natural disaster is the same in different countries, the impact of damage in a certain area on the country is almost the same. This is because "the denser urban population is, the more the damage occurring there" is characterized as a social phenomenon. In other words, it cannot be characterized by natural force only. Differences in its society or environment depends on each country, and population density will become an indicator of its condition. If the ratio of amplification of urban natural disaster is the same, the degree that a certain area affects its own natural and social conditions in a country is approximately the same. As an extreme example, in case of occurrence of natural disasters in overpopulated areas (for example, fifty times as much as the population density of the country), there might be some unusual social phenomenon in each area in proportion to the magnification without any consideration of it being an industrial, agricultural, or nomadic country, no matter what the substance is. This point indicates that the ratio of amplification has universality without any locality.

(2) Expression of effect of population density on disasters

An attempt was made to show the quantitative characteristics of the ratio of amplification of urban natural disaster. It could be obtained by analysing some examples of large-scale natural disasters occurring in overpopulated cities in the past. The great Kanto earthquake of 1923 and the Mexico earthquake of 1985 are used as examples here. The outlines of each earthquake disaster is stated in many other books and reports, so they are not provided here.

The method of evaluation is as follows: If the risk to life of both the whole country and any given area remains unchanged, the number of dead due to disasters can be calculated by multipling the risk to life and the number of residents in any given area. If it is changed in overpopulated cities, there must be some correlations to the ratio of amplification of urban natural disaster as mentioned above. Through much discussion and some fundamental studies, it was determined that the maximum loss of lives is a function of the ratio of amplification of urban natural disaster and the average life span which indicates social countermeasures against natural disaster.[5] The expression of the function is not clear, so it is discussed with historical data. Supposing the proportionality coefficient is α, the following relationship is established if the risk to life in the country and in any given area remains unchanged:

$$\alpha_1 Rp = 1 \qquad (1)$$

in which **R** is the ratio of amplification of urban natural disaster. In the data of the risk to life in Mexico City due to the Mexico earthquake, and Tokyo City (now, twenty-three special wards) and Yokohama City due to the great Kanto earthquake, α is depicted by the relationship expressed in equation (1) as shown in figure 1. The proportionality coefficient inordinate suddenly jumps. This means the risk to life becomes highly discontinuous (phase transition). The curve line presented by the data of these three cities is defined as the over-damage line. The area bounded by equation (1) and the over-damage line is named overpopulated-caused disasters which correspond to urban natural disaster of three types as shown in table 1. The R=17.3 in abscissa in the figure indicates the mean ratio of disaster amplification in cities whose population are more than 1 million in Japan. From this figure it is found that a high human casualty urban disaster will occur if an extremely large force is released.

This method can be applied to depopulated disasters. The area with **R** of smaller than **1** is equivalent to the areas whose population density is less than the national average. If collapse disasters or sediment disasters extensively occur many times in the area, the encounter probability of disasters and the risk to life heightens. Depopulated districts in urban areas often have poor living conditions, such as being situated at the foot of a cliff and slopes in many cases, where the encounter probability is high. The former example is the Sanin heavy rainfall disaster of 1983, and the latter is the *Baiu* front heavy rainfall disaster of 1974 in our country.

Over-damage phenomenon by urban natural disaster occurs in accordance with the increase in population density. This is very similar to the occurrence of over-influential phenomenon of plague by the increase of population density. Therefore, an analogy is established between them both. Human damages by urban natural disaster can be estimated by these ideas.

EXAMPLES OF URBAN NATURAL DISASTER -- PREDICTION OF HUMAN CASUALTIES BY THE EXPECTED KANTO EARTHQUAKE

The maximum number of dead in the southern Kanto area (Tokyo, Kanagawa, Saitama, and Chiba Prefectures) by a recurrence of an earthquake of the same scale as the Kanto earthquake of 1923 is predicted here by the method proposed. Population at present is over 30 million in the four prefectures, and Tokyo possesses 40 per cent of the computers available in Japan and more than 50 per cent of bill clearing and stock market activities; and more than 80 per cent of the information sent throughout Japan originate there.[6] Concentration of population and socioeconomic capital in Tokyo as the international financial city and metropolitan area still continues, so it is very important to estimate the worst case damages in catastrophes. The National Land Agency announced the estimated value of casualties in the four prefectures, applying the relationship of the burned area by fire after the great Kanto earthquake and the number of dead.[7]

Prediction: In case of occurrence of an earthquake (magnitude 7.9) such as the great Kanto earthquake during dinner-preparation time in winter, with wind velocity of 4 m/s:

Number of burned houses: 2.6 million
Number of dead: 150,000
Number of injured: 200,000

Number of telephone calls interrupted: 4 million (37 per cent)
Functional disorder of electricity: 43 per cent
Functional disorder of water supply: 32 per cent

Validity of these figures is made clear by application of the theory of human damage prediction.

The Rule of Damage Occurrence and Precondition

At first, an outline of the estimation method of the supposed maximum number of dead is introduced. For calculation, the following precondition is set:

(1) The maximum value of risk to life in a country unit is given by the upper limit line in figure 2.

The applicability of the theory is uncertain because there has been no field verification. However, according to the data analysis of catastrophic natural disasters after the twelfth century shown in the abovementioned figure, no natural disaster exceeds the risk to life (death ratio) indicated by the line, which roughly means it is the maximum value.

(2) The number of residents is based on nighttime population.

As shown in figure 3, population increases during the daytime in Tokyo but decreases in Yokohama. This means that some parts of Yokohama are bedtowns of Tokyo. But it is not clear if all the population flowing out in the daytime toward Tokyo actually gather in Tokyo. And daytime population in other areas is unclear. Accordingly, nighttime population is regarded as being based in the southern Kanto area, and the number of dead based on daytime population is presented only for Tokyo and Yokohama.

(3) Proportionality coefficient α is determined by the amplification ratio of urban natural disaster **R**.

If changes of the proportional coefficient with the amplification ratio of urban natural disaster differ in each densely populated city (there is currently only one, but by surveying the historical data, additional curve lines responding to any stage of urbanization may be found), it must be dependent on the difference of natural environment. This is because the average life span and the amplification ratio of urban natural disaster amplification represent the effect of the social environment. For example, the proportionality coefficient in steep areas may be different from that in low-lying coastal areas. Now, there are only three available data, therefore, it is assumed that the smooth curve line connecting these points show a general relationship.

Results of Estimation

Estimated results using the population in 1985 are shown in table 3. It is concluded that the maximum number of deaths in the southern Kanto area may reach 140,000 if an earthquake of the same scale as the Kanto earthquake of 1923 occurs. Twenty-three special wards in Tokyo, Yokohama, and Kawasaki Cities will occupy about 93 percent of the death toll. This means that the disaster is an urban natural disaster. The numbers in parenthesis signify the number in case of occurrence of the earthquake in the daytime. About an increase of 17,000 deaths will occur in comparison with an earthquake in the nighttime. In Tokyo, these estimated numbers prove the appropriateness of the results estimated by the National Land Agency.[8/] As a result, the validity of the prediction method is enhanced.

SCENARIO OF AMPLIFICATION OF URBAN NATURAL DISASTER

Importance of Scenario

In the previous section, the maximum number of victims as a result of the recurrence of the Kanto earthquake was estimated. This estimation appears very persuasive. However, a strategy of disaster reduction and prevention cannot be designed unless the processes of human damage occurrence are made clear. Scenarios of damage amplification processes are required for disaster–related administrative efforts against disaster prevention which become effective by clarifying them. Some researchers in the field of natural disaster science tend to be convinced that it is unscientific because of qualitative estimation. However, there are two problems as shown below.

One is that quantitative estimation needs some modeling and accurate understanding of the cause–and–effect relationship including dynamics of disaster occurrence mechanism with boundary conditions, and force and resultant damages. As mentioned in the introduction, a characteristic of urban natural disasters are that patterns of past disasters change with time; and simulation without consideration of the changes has lesser meaning, if not so, due to the lack of needed accurate information. In reliability analysis of lifeline systems, it has been treated as if the resistance force against disasters has increased after several efforts towards improvement. However, in this analysis, the viewpoint of natural environmental changes has been neglected.

The other is that the understanding of residents makes the strategy for disaster prevention and reduction useful; however, with only the presentation of difficult theory and numerical value, it is very difficult to persuade administrative officers who are in charge of mediating and persuading the residents. An feasible way is to firstly exercise the residents' imagination. Numerical estimation is not useful without this process.

Concrete Scenario

According to Katayama[9] (personal communication), prediction of earthquake disasters in Japan needs to be divided into two, one being the type of occurrence by spread of fire; the other is the type where functional obstruction widely affects lifeline systems. Large–scale human casualties occur only in the former case. Is this really true? With this classification, there is an implicit understanding that the reduction of human damages due to fires alone was considered significant among decision–makers and research scientists. It is of course very important but it would be questionable to consider only earthquake and fire as external causes. From this standpoint, the characteristics of natural force changes over time are neglected.

Tokyo and Osaka have the most unusual natural conditions of big cities located in seismic zones in the world. In wide, low–lying coastal areas protected by sea walls, subways run in all directions, and underground shopping centres are sprawled. The daily number of passengers is 2 million at the underground north terminal in Osaka. The population of underground space is always dense. Areas below sea level are 124 km^2 in Tokyo and 60 km^2 in Osaka, which will increase in the future contrary to sea level rising. In the beginning, over–pumping of ground water led to land subsidence. For example, Koto ward in Tokyo is about 4.5 m lower; and Minato ward in Osaka is 2.8 m lower now than in 1935. Even though tsunami do not strike, the danger of occurrence of seismic flood immediately after the earthquake is high because of the destruction of hardware countermeasures against storm surge due to liquefaction of ground. In the study of anti–earthquake facilities, only the destruction of buildings and non–uniform subsidence are considered at the moment of earthquake strike. But the occurrence of seismic flood in low–lying areas has frequently been experienced as shown by the Niigata earthquake. From this viewpoint, the Mexico earthquake of 1985 and the Loma

Prieta earthquake of 1989 have yielded very important data for earthquake-resistant design for any structure and lifeline system which are useful for measures against such earthquakes in Tokyo and Osaka. The characteristics of geographical condition in both cities are not taken into account for earthquake disaster countermeasures.

Human Damages

(1) Rupture of anti-storm surge facilities

At the recurrence of an earthquake of the same magnitude as the Kanto earthquake, areas where seismic intensity is more than 6 could unexpectedly occur locally. Facilities against storm surge disasters would be partially destroyed, and sea water and urban river water will flow into lowland below sea level. Subways passing through the area and underground space will be inundated. Panic by disruption of subway and blackout at underground shopping centres will amplify the damage.

Figure 4 shows inundated flooding wave propagation at certain subway lines in Tokyo due to tsunami, storm surge, and river flood.[8] Subways situated at hills in Tokyo have sloped railway, so the velocity of flood water propagation is over 3m/s. Very dangerous conditions will arise when trains are stopped at the bottom area of tracks due to power failure. This fear surfaced when the heavy rain of Typhoon No. 11 in August 1993 occurred. At that time, the subways of the Marunouchi, Ginza, and Tozai lines were severely inundated with flooding water. It is a sign that this scenario is real.

(2) Liquefaction and seismic flood

Liquefaction occurs in the area of soft ground in which some flood countermeasures have been constructed. Sea water and urban river water easily flow into the area and flood damage is amplified by the same process as (1).

(3) Gas explosion in underground space

When gas pipelines are damaged by an earthquake, underground space becomes filled with city gas, so that a gas explosion occurs and burst into flames. We already have experienced such events in Shizuoka and at the Tenroku gas explosion accident.

(4) Destruction of flammables storage and fire and seismic flood occurrence at the same time

Lightweight flammables such as gasoline and chemical combustibles flow over flood water surface at high speed. The fire easily spreads out over a wide area.

(5) Panic during rush hours

In Tokyo about 2 million commuters and students pass through each terminal during rush hours. If an earthquake were to occur, follwed by a blackout and disruption of the telephone network, panic would inevitably develop due to inaccurate or little information available. In Tokyo, average commuting distance is about 70 km and commuting time is ninety minutes, which greatly differ from the distance of 4 km on foot during the great Kanto earthquake in 1923. Therefore, if transportation is suspended, it will be difficult to go home on foot. It means that most people will remain in the danger zone for a long period of time, so the risk of injury from fire and other dangerous situations will be heightened.

The scenarios of (1) and (3) correspond to seismic flood, and its occurrence is a matter of serious concern in Tokyo and Osaka. Especially, large-scale underground space has many entrances which are connected with many complicated routes. Therefore, route and distance between the entrances and the flooded sources are very important to prevent inundating disasters.

CONCLUSIONS

Urban natural disasters are characterized by catastrophe due to overpopulation and dense concentration of social capitals which has not maintained its balance with investment for disaster prevention. The population density in large cities of over 1 million inhabitants is the most important factor which amplifies the casualties and damages to property. The maximum risk to life can be estimated with the function of lifespan which expresses a disaster prevention force in every country. With this relationship, the maximum loss of lives in Tokyo due to the expected Kanto earthquake can be estimated to be as much as 140,000. In order to mitigate this damage, we propose several scenarios that extend into larger damage assessment due to new types of damage processes.

NOTES

1/ H. Takayama and S. Murakami, *Disaster Planning* (Urban problems series; no. 7) (Tokyo: Yuhikaku, 1966), pp. 201–21 (in Japanese).

2/ Y. Kawata, "Estimation of Countermeasures against Natural Disasters," *Journal of Natural Disaster Science*, Vol. 9, No. 1 (1990):1–16 (in Japanese).

3/ W. H. McNeill, *Plagues and People* (Tokyo: Shinchosha, 1983).

4/ Institute of Journalism and Communications Studies, *Disaster and Human Behavior* (Tokyo: University of Tokyo, 1982) (in Japanese).

5/ "Reconstruction Planning after Earthquake Disaster," *Asahi Shimbun* (29 September 1980) (in Japanese).

6/ National Land Agency, *Report on Expected Damages due to a Possible Earthquake in the South Kanto District* (1988) (in Japanese).

7/ T. Katayama, "Prediction of Damage to Urban Systems and Measures for Earthquake Resistance of Cities" (Report of Grant–in–Aid for Scientific Research on Priority Area 1) (Principal researcher: A. Shibata) (1990), pp. 37–40 (in Japanese).

8/ Y. Kawata and M. Hattori, "Study on Coastal Disaster Prevention in the Lowland Mega–city" in *Proceedings of Coastal Engineering, JSCE,* 1993, Vol. 40, pp. 1176–80 (in Japanese).

9/ Katayama, "Study on Coastal Disaster Prevention".

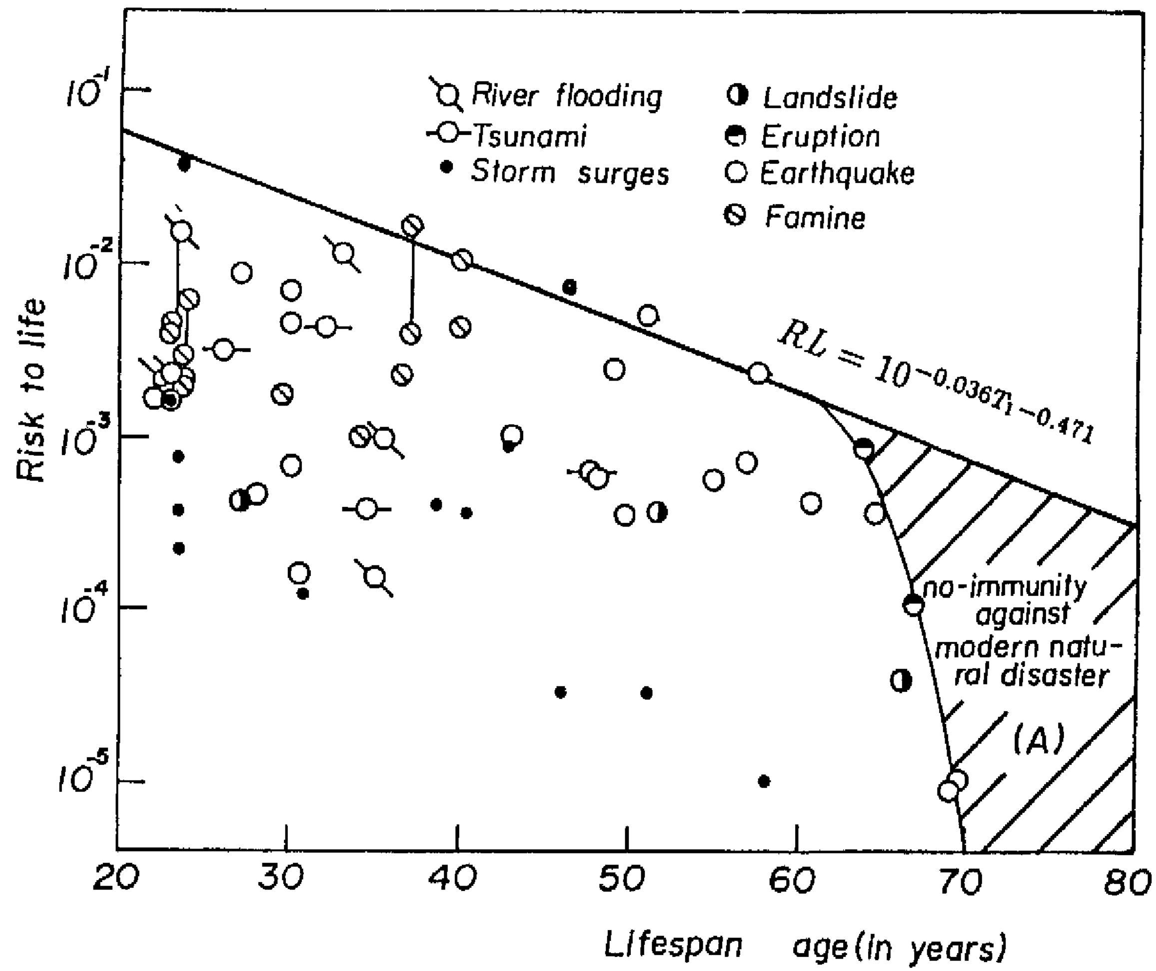


Figure 1. Changes of Risk to Life in Catastrophic Disasters Occurring in the World since the Twelfth Century

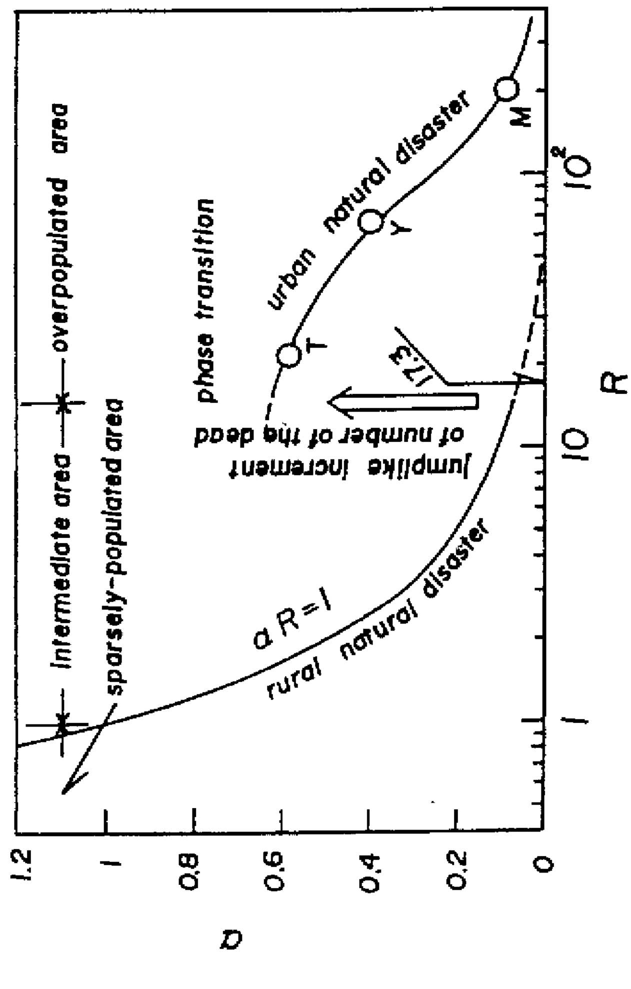


Figure 2. Changes from Rural to Urban Natural Disasters due to Phase Transition

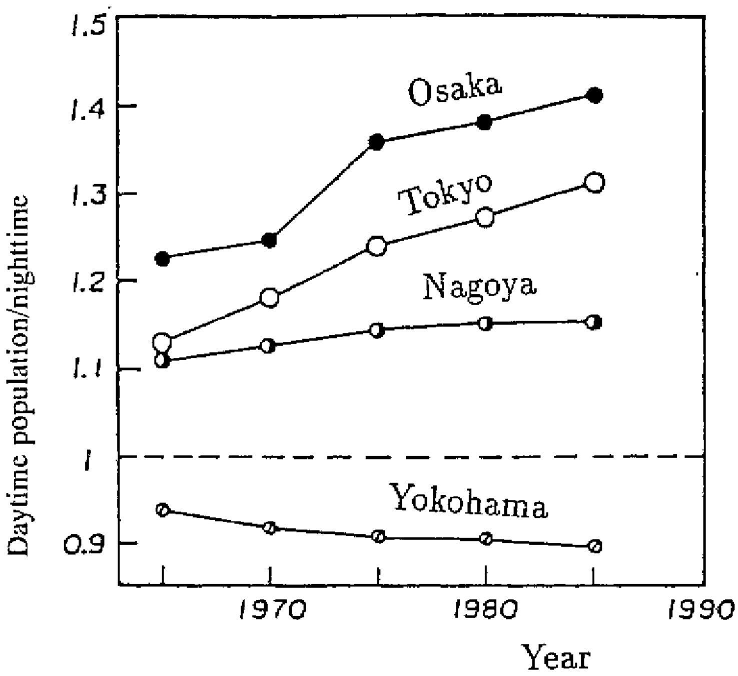
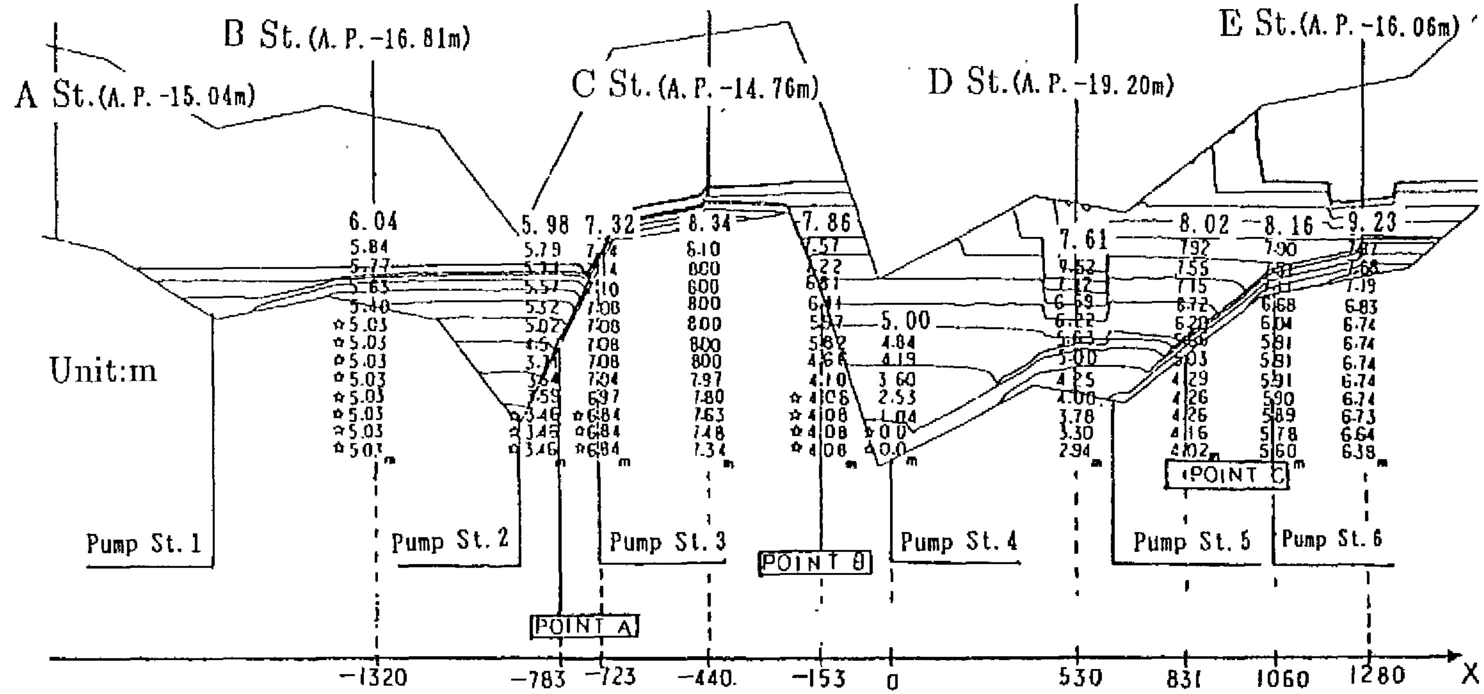


Figure 3. Changes of Population in Daytime and Nighttime



Number in parenthesis shows height of railway.

Final water level shows at 90 min. after occurrence of inundation.

In this area, the inundated water depth due to Typhoon Katherine in 1947 is A.P. +3.15 m.

Figure 4. Examples of Flooding of Tokyo's Subways

TABLE 1. URBANIZATION IN THE WORLD

(%)

Region/Country	1970	1990	2000	2025
Worldwide	36.6	45.2	51.1	64.6
Developed countries	66.6	72.6	74.9	82.5
Developing countries	24.7	37.1	45.1	61.2
Japan	71.2	77.0	77.7	80.1
Indonesia	17.1	30.5	39.5	58.8

TABLE 2. CLASSIFICATION OF URBAN NATURAL DISASTERS

	Population density	Infrastructure	Characteristics of damages	Patterns of enlargement
Urbanizing natural disaster	in progress	in progress	classical (well forecasted)	single
Pseudo-urban natural disaster	several to ten times the nationwide density	temporal complete	mostly property damages	known
Urban natural disaster	more than 20 times the nationwide density	imbalance and insufficient	potential loss of lives and properties	unknown

TABLE 3. ESTIMATED NUMBER OF LIVES LOST DUE TO THE POSSIBLE KANTO EARTHQUAKE

Prefecture \ Variables	Population (x 10^4)	Population density (/km^2)	Ratio of population density (specific area/nationwide)	number of lives lost (x 10^4)
Tokyo	1,209.4 (total)			
1) Central wards	835.4	13,879	57.1	9.24 (10.93) *
2) Others	374.4	764	2.4	0.18
Kanagawa	743.2 (total)			
1) Yokohama City	299.3	6,928	19.3	2.03 (1.89) *
2) Kawasaki City	108.9	8,007	25.0	0.82
3) Others	335.0	1,826	5.7	0.18
Chiba	514.8	999	3.1	0.28
Saitama	586.4	1,543	4.8	0.31
Total	3,053.8			13.04 (14.59) *

1) Parenthesis shows the case of occurrence at night.
2) Nationwide population density is 320/km^2
3) Overall risk to life is 4.27×10^{-3}