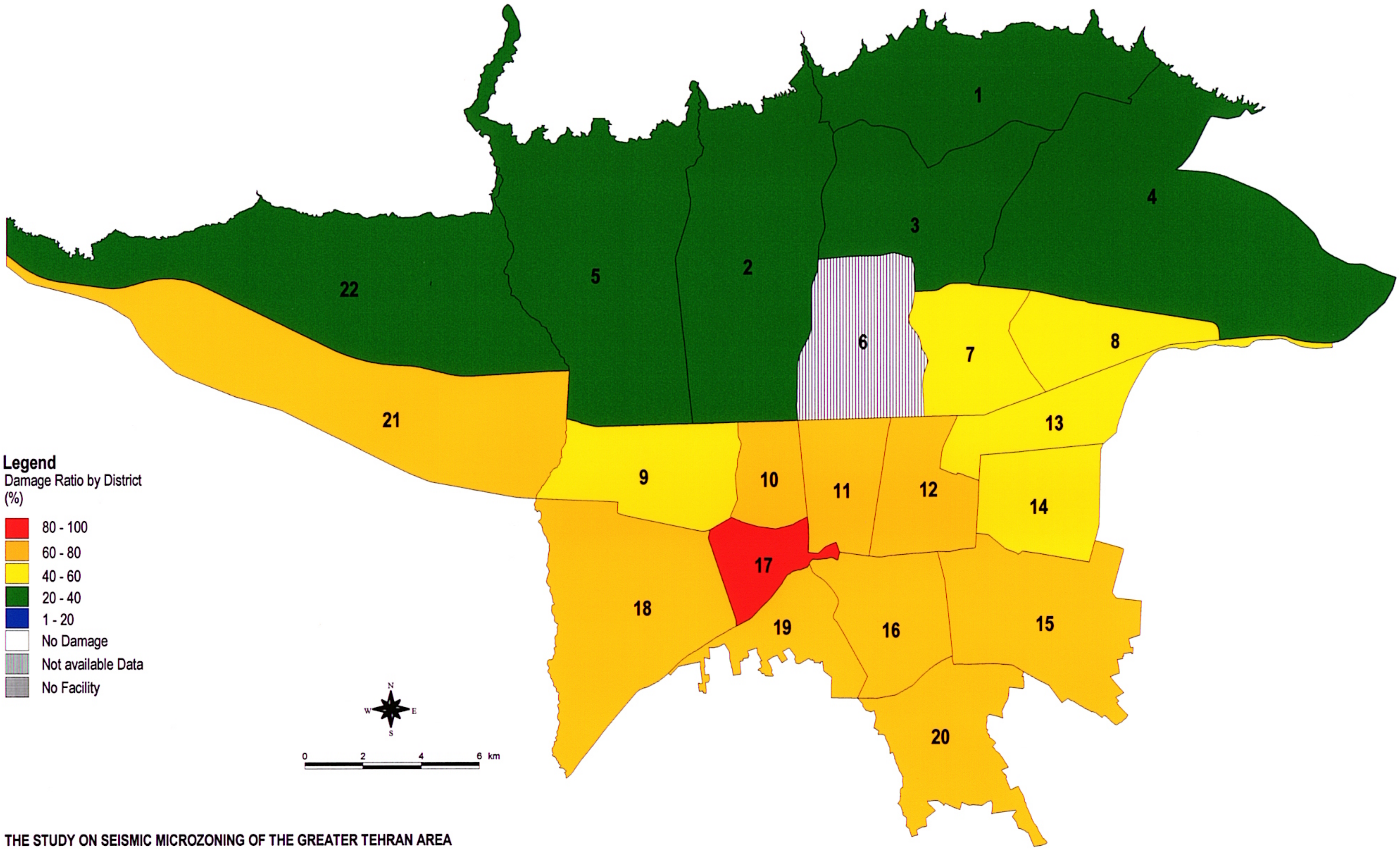
Figure 4.4.7

# Damage Ratio of School(Ray Fault model)




**THE STUDY ON SEISMIC MICROZONING OF THE GREATER TEHRAN AREA IN THE ISLAMIC REPUBLIC OF IRAN**

Centre for Earthquake and Environmental Studies of Tehran (CEST)
Japan International Cooperation Agency (JICA)

## 4.4.2. Lifelines

Information on seismic damage to lifelines is very important for the preparation of a seismic disaster management plan. In this section, damages of lifelines are estimated. The following 4 types of lifelines are considered:

(1) Water supply pipelines

(2) Gas pipelines

(3) Electric power supply cables

(4) Telecommunications cables

Lifeline facilities are to be classified into two major categories, nodes and links. Nodes include facilities such as purification plants and substations. Links include facilities such as pipes or lines for supply and distribution purposes.

A statistical approach for damage estimation of links, i.e. distribution pipes and lines, is applicable only when information on their structures and lengths is available in any given area. This approach was used in the Study

Damages for the node facilities were not estimated in the Study, because such structures are different with respect to purpose and location and a statistical approach is not applicable for the analysis. Separate detailed surveys are required for the damage estimation of the node facilities.

### (1) Method of damage estimation

The basic concepts for lifeline damage estimation are as follows:

- Except for a few qualitative studies, no quantitative studies on seismic damage for lifelines in Iran were available.
- Structural characteristics of buildings in Iran are different from those in Japan. However, network characteristics, pipeline structures and cable structures are considered similar to those of Japan.
- Although the strength of the pipeline materials is not much different from that of the pipeline materials in Japan, it is considered that the construction quality of the joints always leads to problems.
- Therefore, an analysis method for the damage estimation of water and gas pipelines proposed by Kubo and Katayama (1975), which is widely used in Japan, was applied to the Study. However, it is considered that the damages will be more serious than those estimated.
- Details of the strength of electric power supply and telecommunications cables were not available for the Study. Furthermore, details of the structure and strength of electricity posts, which are significant damage factors for aerial cables, were not available in the Study.
- Therefore, the damages to those cables are estimated using empirical methods based upon the damages that occurred during the 1995 Kobe Earthquake, Japan.
- Consequently, the damages of lifelines estimated here indicate only a relative damage distribution rather than an absolute one.

### a. Water Supply Pipelines

Kubo and Katayama (1975) proposed a relationship between peak ground acceleration and the damage ratio of water supply pipelines as shown in Figure 4.4.8. Kubo and Katayama (1981) formulated the relationship as follows:

Rfm = Rf x Cg x Cp x Cd

where

Rfm: damage ratio (points/km)

Rf = 1.7 x $A^{6.1}$ x $10^{-16}$

in case of Rf > 2.0, Rf = 2.0

Cg: ground coefficient

1.0 for alluvial deposits

0.5 for hilly areas

Cp: pipeline material coefficient

Cd: pipeline diameter coefficient

This formula was used in the Study. Cg was defined as 0.5. Cp and Cd were assumed as 1.0, because any detailed data was unavailable. This corresponds to the case of cast iron pipe with a diameter of 100 mm.

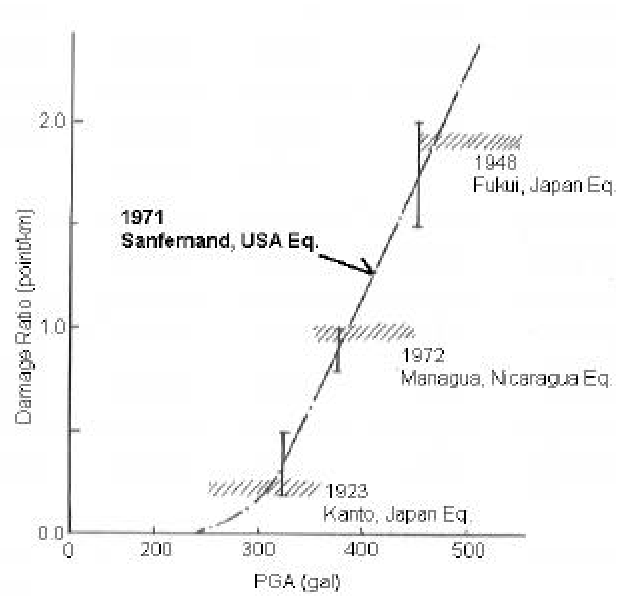



**Figure 4.4.8 Damage Ratio of Water Supply Pipelines by Peak Ground Acceleration**

### b. Gas Pipelines

The evaluation formula for gas pipelines is the same as that of the water supply pipelines.

Data was provided on the type and the distribution of the gas pipes, and the following values were used for each factor based on figures which are currently used in Japan.

Cg = 0.5

Cp x Cd: Steel pipes (250 psi) 0.1

| | |
|---|---|
| Steel pipes (60 psi) | 0.2 |
| Polyethylene pipes | 0.1 |

Damages to gas pipelines during past earthquakes show that many damages occurred at joint locations of the pipelines. The damage ratio significantly varies with the types of joints, and the damages to thread joints are ten times larger than to mechanical joints. The city area has been relatively developed in recent years, and the gas pipelines are not considered very old. Therefore, it was assumed that no thread joints were used in laying the pipes.

### c. Electric Power Supply Cables

Overhead cables:

Damage characteristics of the 1995 Kobe Earthquake, Japan are as follows:

- No damage of poles occurred in areas of seismic intensity (MMI) less than 8.
- 0.55% of the poles were broken or collapsed in areas of seismic intensity (MMI) 9 and over.
- With the assumption that the damage of a single pole causes damage to cables either one side of the broken pole, 0.275 % (=0.55 / 2) of aerial cables should be damaged in areas of seismic intensity (MMI) 9.

The strength of the poles in Tehran is assumed to be the same as those in Japan. Therefore, the actual damages are considered to be more serious than the results of the calculations.

Underground cables:

Damages characteristics of the 1995 Kobe Earthquake, Japan are as follows:

- No damage occurred in areas of seismic intensity (MMI) less than 8.
- 0.3% of underground cables were damaged in areas of seismic intensity (MMI) 9 and over.

The damage is calculated by using this damage ratio. This implies that the underground cables in Tehran have equal strength as those in Japan. Therefore, the actual damages are considered to be more serious than the results of the calculations.

### d. Telecommunications Cables

All the telecommunications cables are laid underground except for the distribution lines. Therefore, the same procedure is applied for the estimation of underground telecommunications cables as that of the electric power supply cables.

## (2) Estimation for Distribution of Lifeline Facilities in Each Census Zone

Information on the distribution of gas pipelines, electric power supply cables and telecommunication cables were provided based upon each sector’ s ‘ service districts.’ In cases of water supply pipelines, only information on the total length of the pipelines was provided.

The seismic motion was calculated for each census zone. The result was directly introduced in the calculations for the damages of the lifeline facilities. Therefore, the distribution of pipelines and cables in each census zone was subdivided as follows:

- The length of each lifeline facility in each census zone is assumed to be proportional to the number of residential buildings in that zone.

- The lifeline service districts and the census zones are correlated and the distribution is subdivided based upon the above proportions.
- In cases where census zones overlap with the service districts, the lifeline distribution area is subdivided into census zones with the weighted average of the number of residential buildings in each census zone.

### (3) Damage Estimation

The definition of damage is as follows:

| | | |
|---|---|---|
| Water Supply Pipelines<br>Gas Pipelines | Content of damage | Break of pipelines or joints |
| | Amount of damage | Number of damaged points |
| Electric Power Supply Cables<br>Telecommunications Cable | Content of damage | Rupture of cables |
| | Amount of damage | Length of cables to be replaced |

The results of the damage estimations are shown in Figure 4.4.9 to Figure 4.4.12 for each earthquake model. The damage distributions for the Ray Fault Model are shown in Figure 4.4.13 to Figure 4.4.16 for each type of lifeline. In general, the damages are huge in the southern districts in response to the seismic intensity.

The damage figures are conservative, considering the limitations of the damage estimation procedure.

It is clear that, if gas supplies do not shut off immediately, gas leakage will occur everywhere, resulting in explosions and fire outbreaks under the current manual valve shut-off manipulation system.

Almost all of the water supply lines will be out of service, and electricity and telecommunications will not be available in the southern part of the city. If independent power generators are not adequately available, the electric power failure may seriously affect the function of other lifelines.

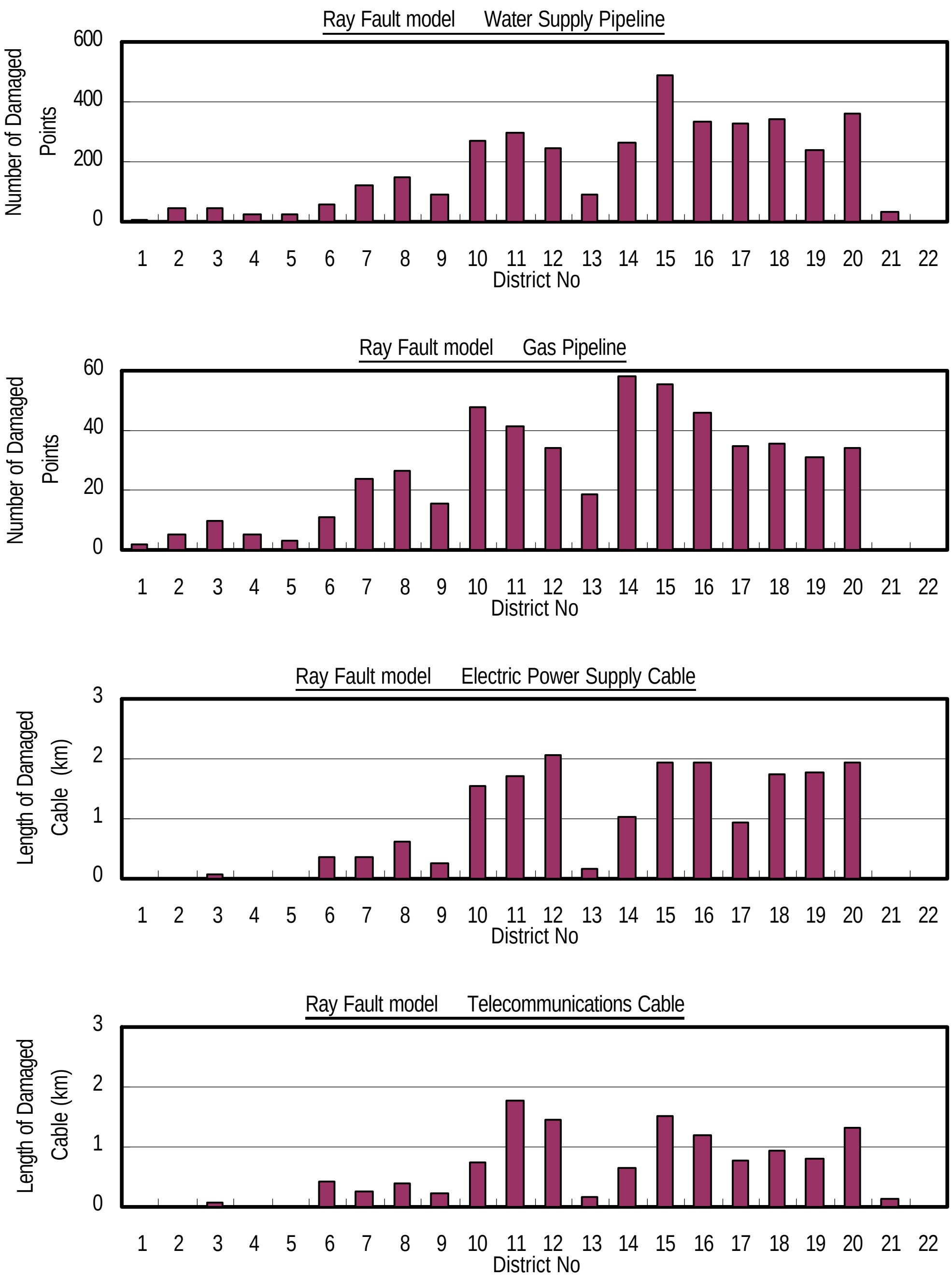



**Figure 4.4.9 Damage of Lifelines by District – Ray Fault Model**

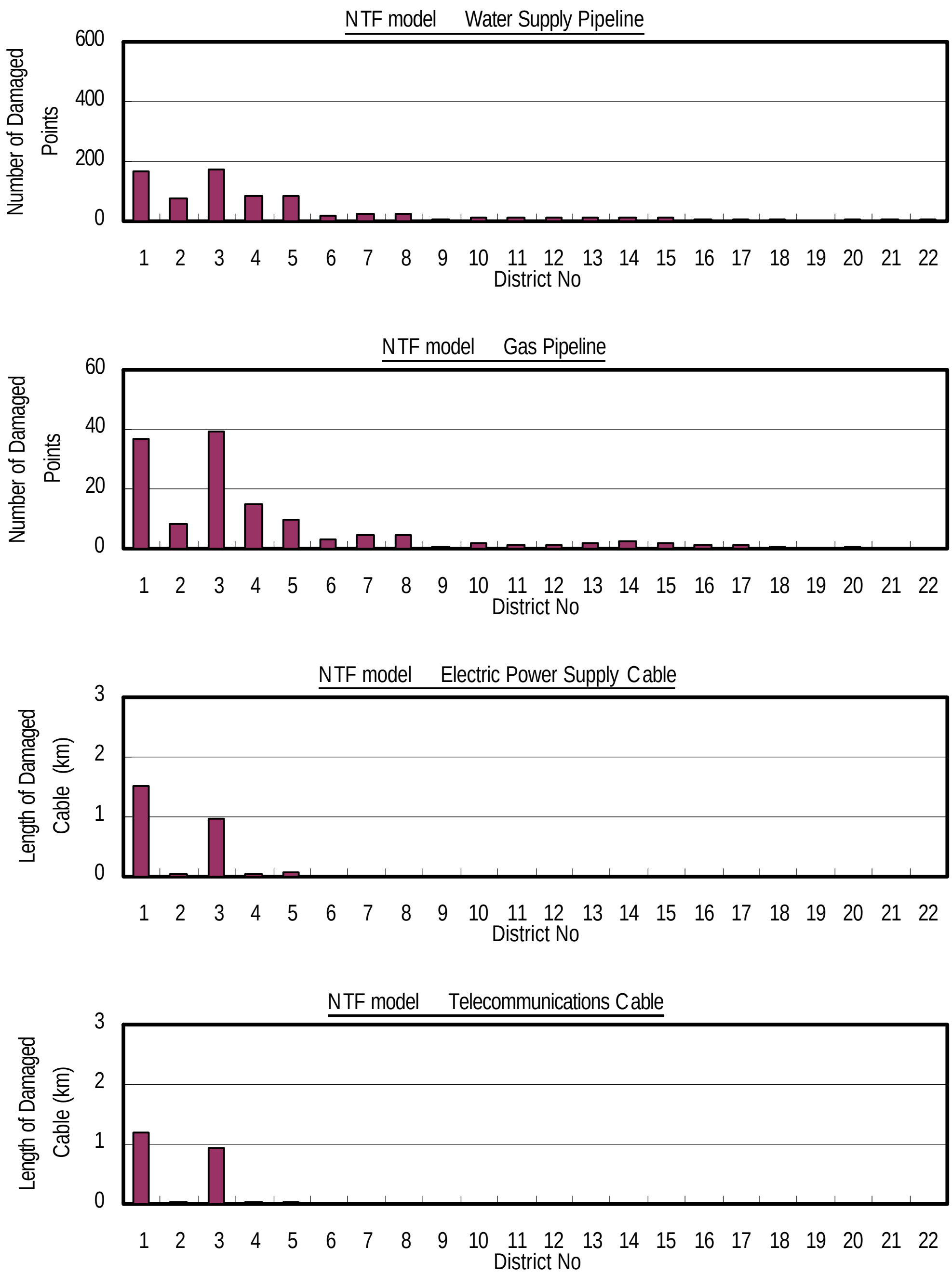



**Figure 4.4.10 Damage of Lifelines by District – NTF Model**

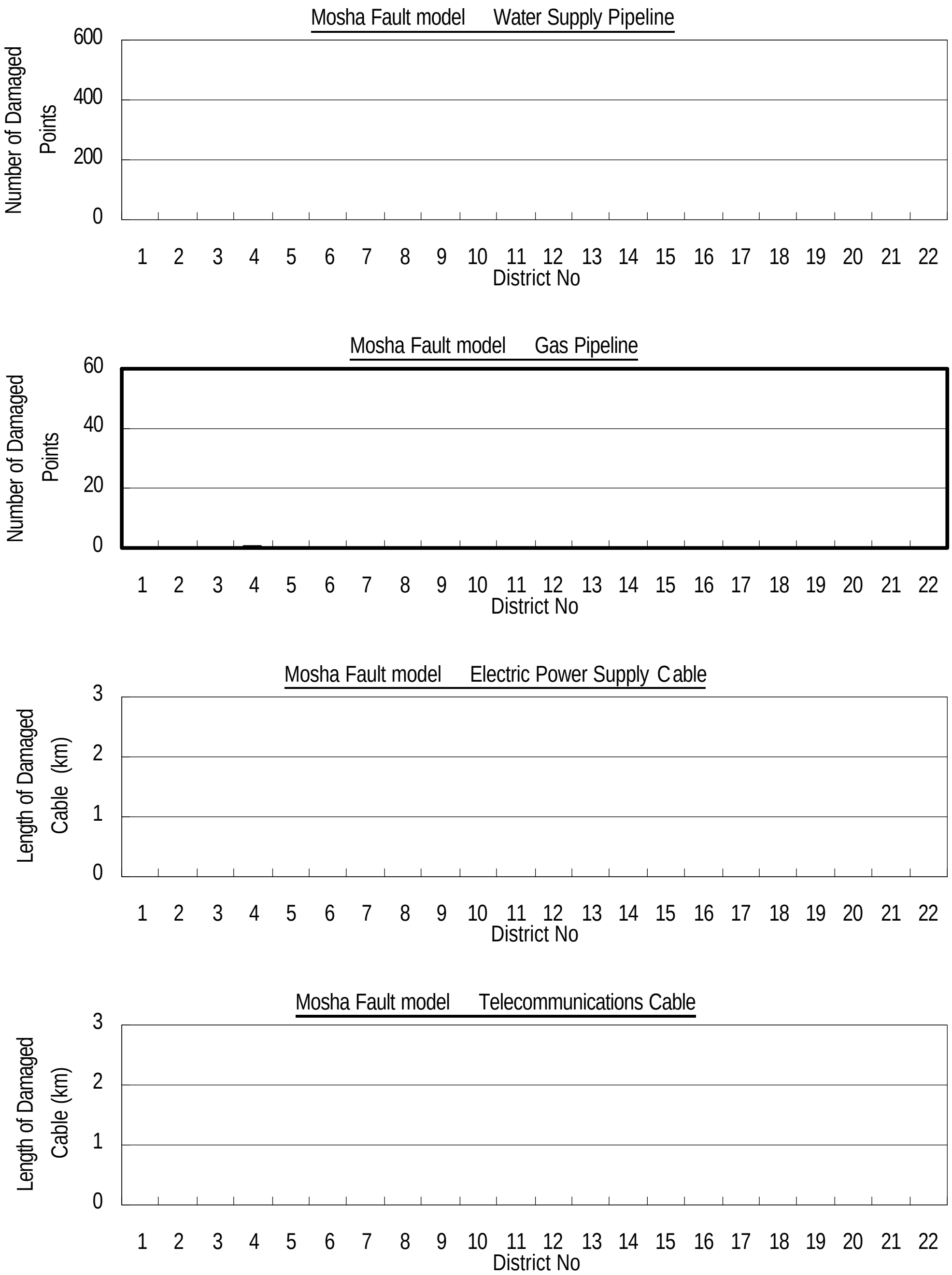



**Figure 4.4.11 Damage of Lifelines by District – Mosha Fault Model**

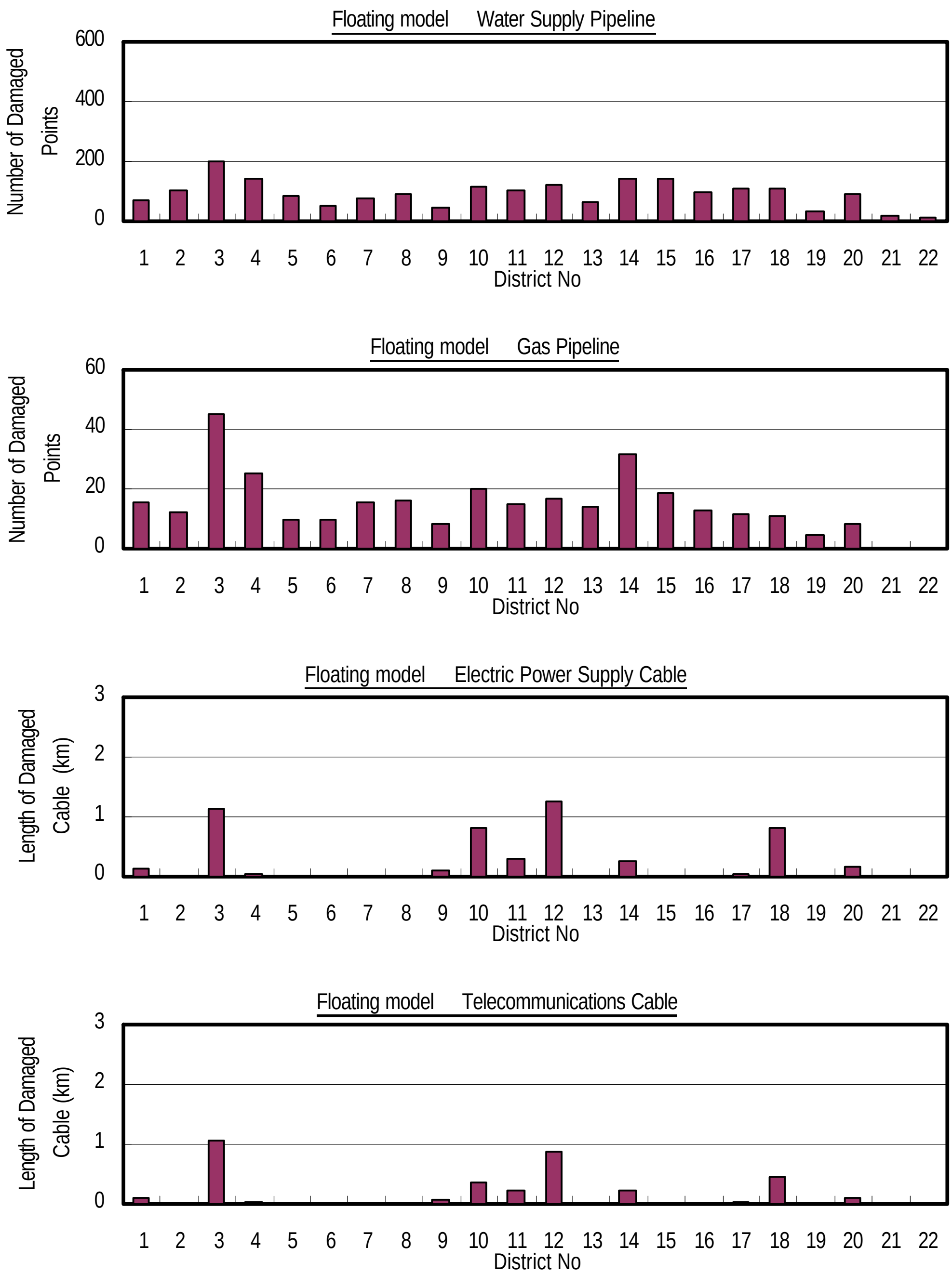
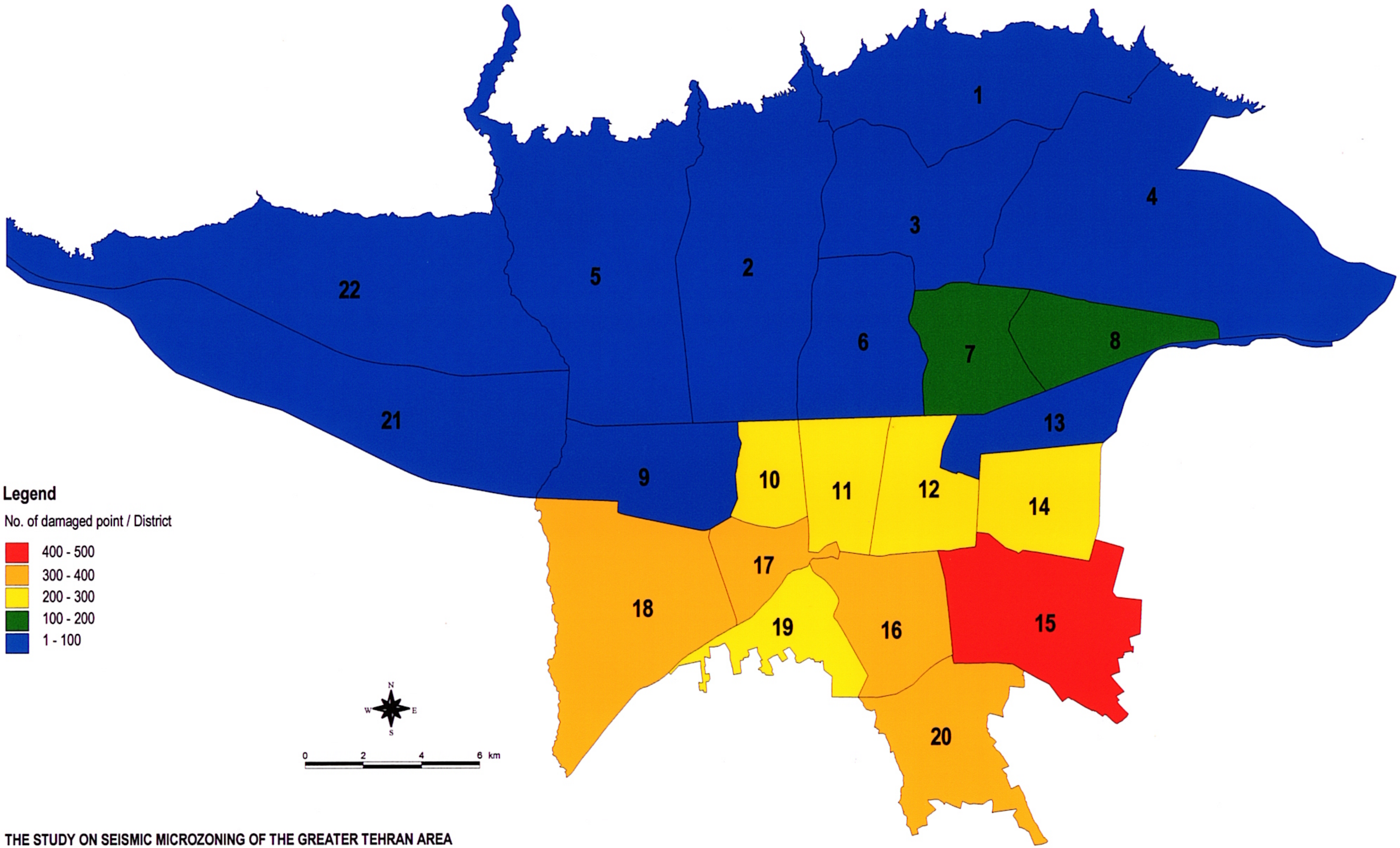



**Figure 4.4.12 Damage of Lifelines by District – Floating Model**

Figure 4.4.13

## Damage of Water Supply Pipeline(Ray Fault model)

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