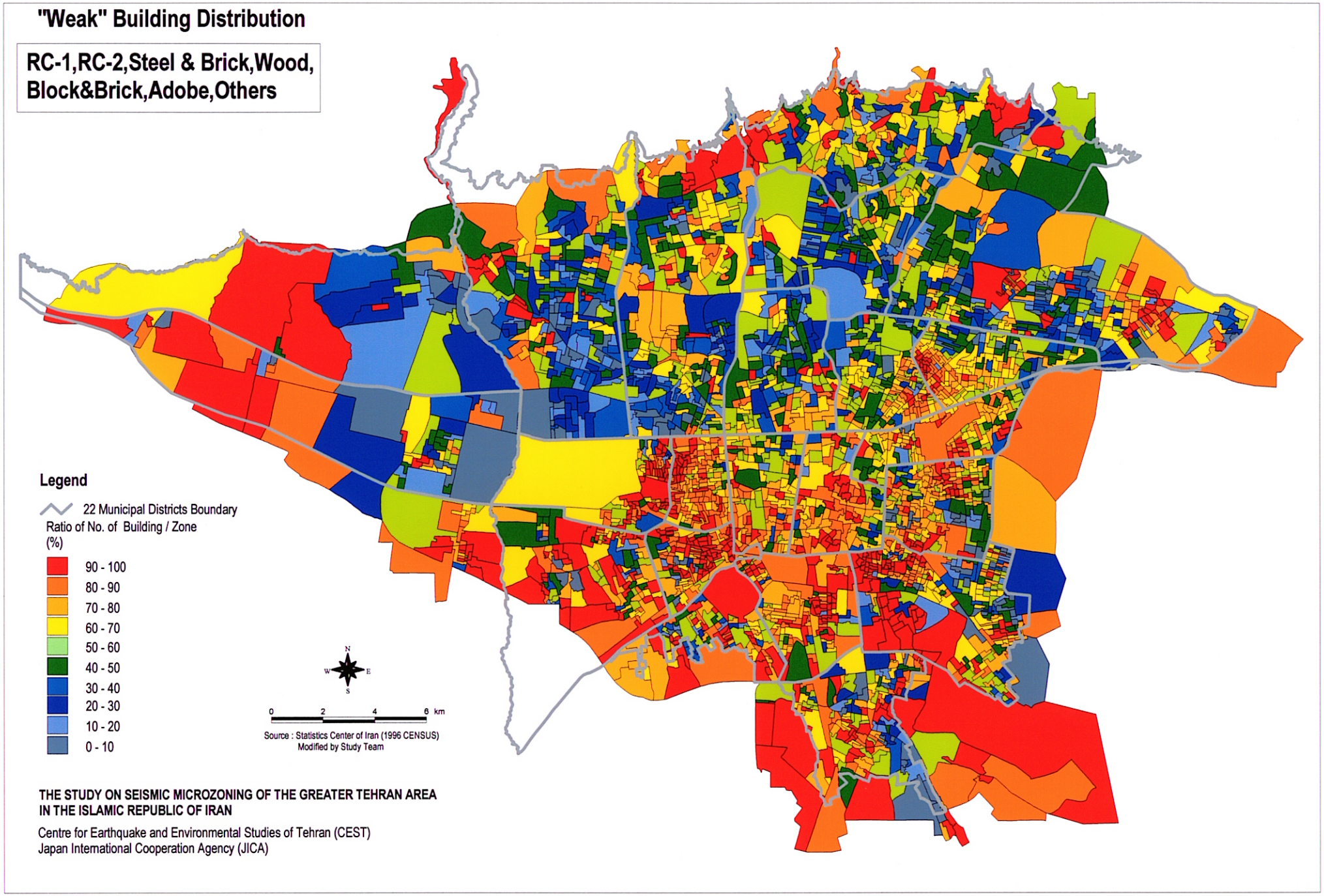
Figure 4.1.13


"Weak" Building Distribution
RC-1,RC-2,Steel & Brick,Wood,
Block&Brick,Adobe,Others
Legend
22 Municipal Districts Boundary
Ratio of No. of Building / Zone
(%)
90 - 100
80 - 90
70 - 80
60 - 70
50 - 60
40 - 50
30 - 40
20 - 30
10 - 20
0 - 10
N
W
E
S
0 2 4 6 km
Source : Statistics Center of Iran (1996 CENSUS)
Modified by Study Team
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)
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4.1.3. Damage Estimation

The residential building damages were calculated for 4 scenario earthquakes. In these calculations, commercial buildings and factories were not included. Important public facilities such as schools, hospitals and fire fighting stations are studied in section 4.4.1. ‘ Damaged’ buildings implies that buildings are heavily damaged or collapsed and that these are unfit for living without proper repair. Further, the cause of the damage is limited to the seismic vibration itself. The damages caused by secondary disasters such as liquefaction, landslides, fire and explosions are not included in this calculation.

The definition and contents of damage for residential buildings are as follows:

Damage of residential buildings	Heavily damaged or collapsed, unfit for living without repair
Calculation unit	Each residential building
Cause of damage	Seismic vibration

The damages were calculated for each census zone and structural type. Results are shown in Table 4.1.3 and Figure 4.1.14. It must be noted that the total number of buildings in Table 4.1.3 does not correspond with that of the inventory data since some census zones are located outside of the boundary of Tehran’ s 22 districts. These data were excluded from Table 4.1.3. Further, there was not enough data on some buildings for the damage estimation. These were also excluded.

Table 4.1.3 Damage of Residential Buildings by District

District	Ray Fault Model		NTF Model		Mosha Fault Model		Floating Model		Total Number of Buildings
	Number	Ratio %	Number	Ratio %	Number	Ratio %	Number	Ratio %	
1	11,665	30.4	23,633	61.6	6,869	17.9	19,905	51.9	38,365
2	26,980	41.3	29,862	45.7	7,248	11.1	33,617	51.5	65,335
3	13,974	40.5	19,231	55.7	5,656	16.4	20,928	60.6	34,513
4	23,060	28.0	31,697	38.5	11,328	13.8	37,296	45.3	82,320
5	18,996	35.8	25,111	47.3	4,553	8.6	25,345	47.7	53,083
6	13,842	45.0	10,884	35.4	3,894	12.7	13,997	45.5	30,741
7	23,061	51.4	15,585	34.7	5,712	12.7	21,116	47.0	44,892
8	26,115	51.4	17,092	33.6	5,631	11.1	23,737	46.7	50,798
9	11,936	58.2	5,559	27.1	1,759	8.6	10,621	51.8	20,514
10	27,450	68.1	12,382	30.7	4,014	10.0	22,502	55.8	40,329
11	25,920	78.6	12,818	38.9	6,316	19.1	19,643	59.5	32,991
12	22,118	77.1	14,115	49.2	9,056	31.6	19,418	67.7	28,691
13	17,958	50.8	10,423	29.5	4,295	12.2	17,123	48.5	35,332
14	31,484	57.6	14,653	26.8	7,197	13.2	27,969	51.2	54,636
15	48,707	65.7	19,141	25.8	9,057	12.2	35,985	48.5	74,159
16	27,673	77.2	10,812	30.2	5,248	14.6	19,920	55.6	35,845
17	28,025	82.2	10,086	29.6	4,288	12.6	19,235	56.4	34,078
18	27,446	77.5	8,942	25.3	3,618	10.2	18,437	52.1	35,399
19	18,437	75.0	4,817	19.6	1,669	6.8	10,381	42.2	24,578
20	29,306	78.6	8,379	22.5	4,121	11.1	18,887	50.6	37,295
21	7,009	46.9	4,944	33.1	1,148	7.7	6,857	45.9	14,931
22	2,051	30.7	2,785	41.7	456	6.8	3,039	45.5	6,684
Sum	483,212	55.2	312,951	35.7	113,132	12.9	445,958	50.9	875,509

Characteristics of damage for the four earthquake models are as follows:

Ray Fault Model

The total number of damaged buildings is estimated as 480,000 in the entire city of Tehran. The total damage ratio is 55%. It should be noted that the number of damaged buildings in District 15 is the largest. The total number of the buildings is also largest in this district. The damage ratio in Districts 11, 12, 16 to 20 is a very high value of approximately 80%. The reason for this high damage ratio is the existence of many vulnerable buildings and the strong seismic motion, MMI = 9, in these Districts. The damage ratio in Districts 1 to 5, located in the northern part of the Tehran, is relatively small, approximately 30%.

NTF Model

The total number of damaged buildings is estimated as 310,000 in the entire city of Tehran. The total damage ratio is 36%. The damage ratio in Districts 1 to 5, located in the northern part of the city, is approximately 50%. The damage ratio of the southern part of the city is less than 30%. The difference in damage between the south and the north is not as big as observed in the Ray Fault Model. In the case of the NTF model, seismic intensity is high in the northern area, where vulnerable buildings are not prevalent. In the case of the Ray Fault Model, seismic intensity is high in the southern area, where vulnerable buildings are prevalent. This is the reason for the difference in the damage ratios of the northern and southern parts of the city.

Mosha Fault Model

The damage ratio for most of the districts is almost 10% except in the case of District 12. The damage ratio of District 12 is approximately 30%. As shown in Table 4.1.2, the number of vulnerable ‘ adobe’ or ‘ wood and brick’ structures in District 12 is higher than in other districts and it is the reason for its high damage ratio. This tendency is also observed in the results of Floating Model.

Floating Model

A uniform input motion on the seismic bedrock for the entire Study Area is hypothesised for the calculations of the Floating Model. Therefore, this calculation does not reflect a specific earthquake and the results indicate a relative vulnerability in the entire Study Area. The damage ratio of Districts 12 and 3 is relatively high. The major reason for the high damage ratio in these districts is that relatively soft soil is deposited in these areas and the seismic motion is amplified by this soil.

The distribution of the number of damaged buildings in each census zone is shown in Figure 4.1.15 to Figure 4.1.18, for each scenario earthquake. As for the Ray Fault Model, a big disaster, with damaged buildings exceeding 200 in each census zone, is estimated for a wide area of the southern part of the city. For the NTF Model, location of census zones where the number of damaged building exceeds 200, is limited only to the northern edge of the city. For the Mosha Fault Model, damages are relatively small for the whole city. In southern zones of Districts 11 and 12, the number of damaged buildings exceeds 100.

The distributions of the damage ratio for each census zone are shown in Figure 4.1.19 to Figure 4.1.22. Above-mentioned characteristics are obvious. In the case of the Ray Fault Model, zones with a very high damage ratio, more than 80%, are widely distributed in the southern part of the city. In the case of the NTF model, zones with a very high damage ratio are observed but limited. The high damage zones of Districts 12 and 15 under the NTF Model are the zones where the proportion of ‘ adobe’ building structures is about 80%.

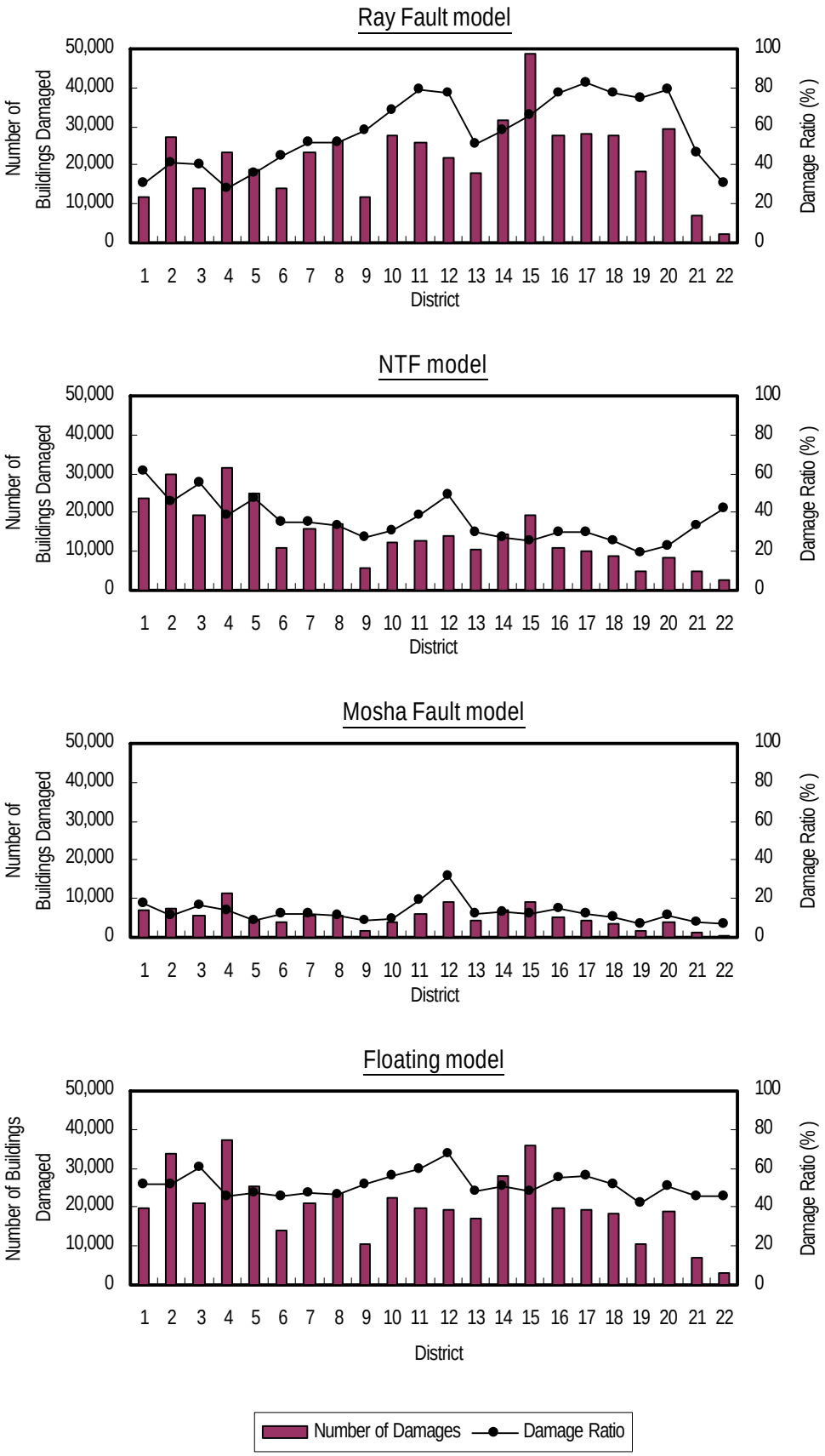
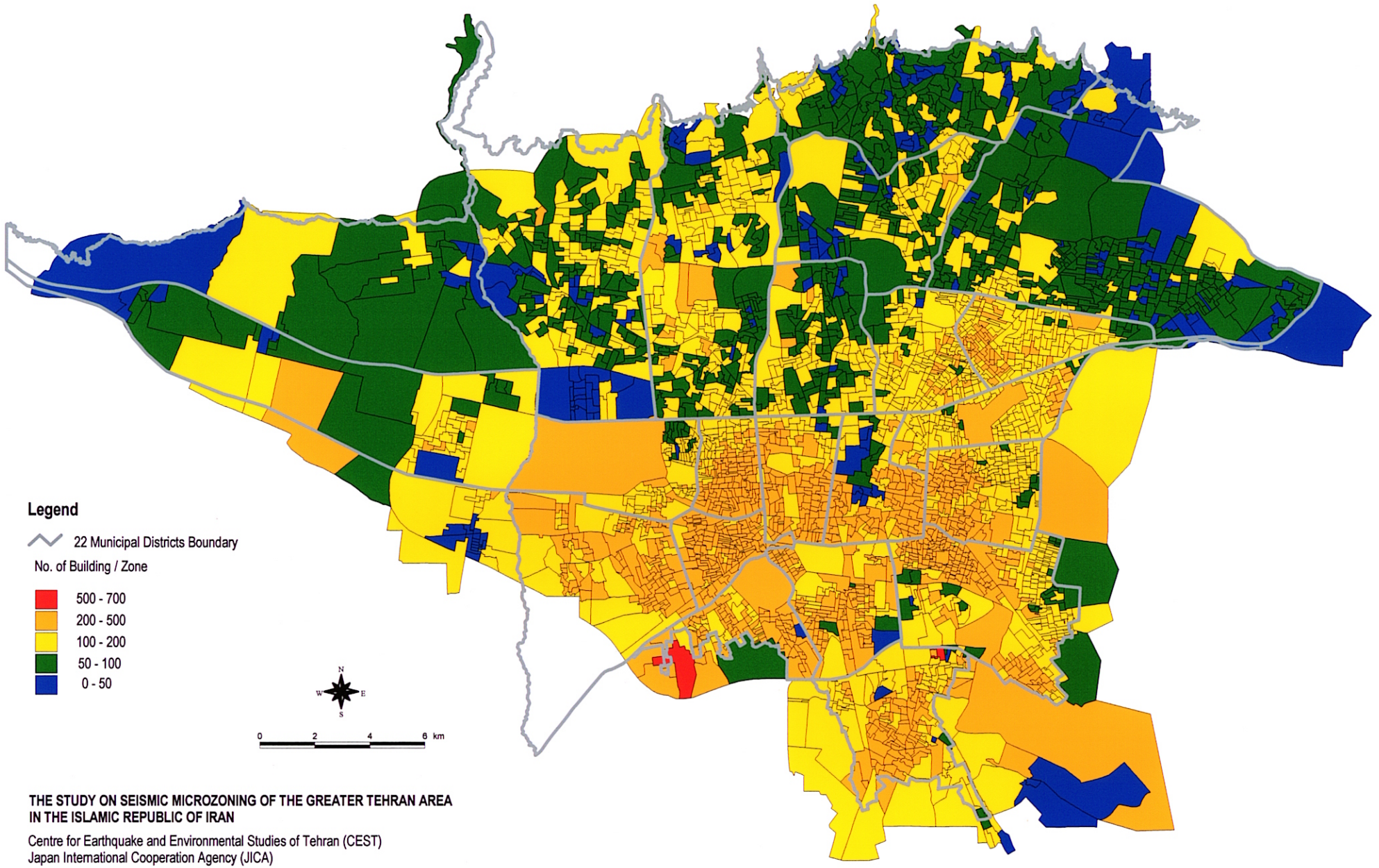


Figure 4.1.14 Damage of Residential Buildings by District

Figure 4.1.15

Heavily Damaged or Collapsed Building Number Distribution (Ray Fault model)



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