Japan International Cooperation Agency (JICA)
Istanbul Metropolitan Municipality (IMM)

The Study on A Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey

Final Report
Main Report

December 2002

Pacific Consultants International
OYO Corporation

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PREFACE

In response to a request from the Government of the Republic of Turkey, the Government of Japan decided to conduct "The Study on A Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey" and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Noboru IKENISHI of Pacific Consultants International, and composed of members of Pacific Consultants International, and OYO Corporation, four times between March 2001 and September 2002 to the Republic of Turkey.

The team held discussions with the officials concerned of the Government of the Republic of Turkey and conducted field surveys at the study area. Upon returning to Japan, further studies and analysis were made and the present report was prepared.

I hope that this report will contribute to the promotion of the seismic disaster management of Iran and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Turkey for their close cooperation extended to the team.

December 2002

Takao KAWAKAMI
President
Japan International Cooperation Agency

Mr. Takao KAWAKAMI
President
Japan International Cooperation Agency
Tokyo, Japan

December 2002

Letter of Transmittal

Dear Mr. KAWAKAMI,

We are pleased to formally submit herewith the final report of "The Study on A Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey".

This report compiles the result of the study which was undertaken in the Republic of Turkey from March 2001 through September 2002 by the Study Team organized jointly by Pacific Consultants International and OYO Corporation under the contract with the JICA.

The Final Report is composed of the two volumes, "Main Report" and attached "GIS Maps for Disaster Prevention and Mitigation".

In the main report, existing social and physical conditions of the study area are described and seismic damage analysis was carried out based on the potential big earthquakes. Necessary recommendations for the seismic disaster prevention and mitigation were also made. The Study Team developed a comprehensive geographic database (GIS) to support data analysis and presentation of the study results. "Microzoning Maps" were compiled out of this GIS data base in such a way that those who are interested in urban analyses, detailed disaster management, studies and planning for Istanbul area may easily make use of the data base.

Finally, we would like to express our sincere gratitude and appreciation to all the officials of your agency, the JICA advisory Committee, the Embassy of Japan in Republic of Turkey, JICA Ankara Office and Ministry of Foreign Affairs. We also would like to send our great appreciation to all those extended their kind assistance and cooperation to the Study Team, in particular, relevant officials of Istanbul Metropolitan Municipality, Directorate of Soil and Earthquake, the Turkish counterpart agency.

Very truly yours,

Noboru IKENISHI
Team Leader,
The Study on A Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey

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ABBREVIATION

General Word

İLÇE	District
Mahalle	Sub-distirct

Organization

AKOM	Disaster Coordination Center, Istanbul Metropolitan Municipality
AKTAŞ	Anatolia Electric
ASK	Civil Coordination against Disasters
AYM	Disaster Management Center, Governership of Istanbul Province
BEDAŞ	Boğaziçi Electric
BIMTAŞ	The Bosphorus Landscape, Construction, Consultancy, Technical Services and Tree Company
ERD	Earthquake Research Department of General Directorate of Disaster Affairs, the Ministry of Public Works and Settlement
IGDAŞ	Istanbul Gas Distribution Corporation
IMM	Istanbul Metropolitan Municipality
ISKI	Istanbul Water and Sewage Management
ITU	Istanbul Technical University
JICA	Japan International Cooperation Agency
KIPTAŞ	The Istanbul Homes Construction and Projecting Corporation
KOERI	Kandilli Observatory and Earthquake Research Institute, Boğaziçi University
MTA	General Directorate of Mineral Research and Exploration, the Ministry of Energy and Natural Resources
SIS	State Institute of Statistics, The Prime Ministry
TCDD	The National Railway, Republic of Turkey
TEAŞ	Turkish Electric Production and Transmission Corporation
The Counterpart Agency	Department of Soil and Earthquake Research, Istanbul Metropolitan Municipality
The Study	The Study on a Disaster Prevention/Mitigation Basic Plan in Istanbul including Seismic Microzonation
TÜBİTAK	The Scientific and Technical Research Council of Turkey
USGS	United States Geological Survey

Scientific / Technical Term

DTM	Digital Terrain Models
GIS	Geographic Information System
NAF	North Anatolian Fault
UTM	Universal Transverse Mercator

Chapter 1. General

1.1. Introduction

In response to the request of the Government of the Republic of Turkey (hereinafter referred to as "GOT"), the Government of Japan (hereinafter referred to as "GOJ") has decided to conduct "The Study on A Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation" (hereinafter referred to as "the Study") in the Republic of Turkey.

Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the technical assistance programs of GOJ, undertakes the Study in accordance with the relevant laws and regulations in force in Japan. Also, the Study is undertaken in accordance with the Scope of Work agreed upon between the Istanbul Metropolitan Municipality (hereinafter referred to as "IMM") and JICA.

As the acting Counterpart Agency representing IMM, the Directorate of Soil and Earthquake Research (hereinafter referred to as "Counterpart Agency"), under the Directorate of Planning and Construction, will coordinate with the organizations of IMM and other relevant agencies and organizations.

The Study Team organized by JICA arrived in Istanbul on March 13, 2001 to conduct the Study in the following steps. The Study took approximately 19 months up to the official submission of the Final Report in December 2002.

Step 1: Existing data collection, analysis and evaluation to identify the study issue

Step 2: Site investigation on ground condition, population, building conditions, and others

Step 3: GIS database development and analysis of data

Step 4: Analysis of earthquake motion

Step 5: Estimation of seismic hazard and damage

Step 6: Compilation of hazard maps, seismic microzoning maps

Step 7: Detail examination on urban disaster prevention and mitigation plan

This Final Report covers all of the steps mentioned above.

1.2. Background of the Study

Istanbul city, which is located in the western part of Turkey, has been developed as the capital city of the East Roman Empire and the Ottoman Turkey for more than ten centuries. After the cease of the Ottoman Emperor, Istanbul has continued to grow as one of the biggest cities in the Middle East, representing a center of economic, industrial and tourist destination of the modern Turkey. The city has ten million of population today.

Geologically, Turkey is located at the boundary area where the Arabian Plate and African Plate are moving north towards the Eurasian Plate. A large scale fault line called North Anatolian Fault (NAF) is formed more than 1,000 km long from east to west in the northern territory of Turkey and historically, many strong earthquakes have occurred along this fault line. In recent years (1939 and 1992), very strong earthquakes occurred in Erzincan City, which is situated in the eastern part of Turkey. More than 30 thousand died in the earthquake of 1939 while 700 people perished in 1992. There was heavy damage to property, including the collapse of a number of buildings and infrastructures.

On August 17, 1999, an earthquake disaster called Izmit earthquake occurred around Izmit and Adapazari, which are located 110 km east from Istanbul. Recorded at a magnitude of 7.4, this earthquake caused tremendous damage to human lives and properties in the area. Another strong earthquake with M 7.2 occurred on November 12, 1999 along the NAF again. More than 1000 people died or suffered from serious injuries.

Seismologists are paying much attention to the phenomena that the epicenters of these strong earthquakes are migrating from east to west along the NAF and they are pointing out the possibility of another big earthquake hitting Istanbul where the western edge of the NAF is.

In order to manage the potential earthquake disaster in Istanbul, it is necessary to prepare a seismic disaster prevention/mitigation plan, emergency rescue plan and restoration plan of the earthquake stricken area from middle to long-term points of view. However, the IMM does not have an integrated seismic disaster prevention/mitigation plan.

Therefore, GOT requested GOJ to conduct this Study as a technical cooperation program. JICA as the official implementation agency of this Study sent a Project Formation Study Team twice to Turkey in late 1999 to discuss and formulate the project. After the necessary discussions, S/W was signed in October 2000.

1.3. Agreement on the Scope of the Study

1.3.1. Explanation and Discussion of Draft Inception Report

Prior to the mobilization to Istanbul on March 8, 2001, the Study Team prepared a Draft Inception Report in Tokyo, which contains the basic approach and methodology for the Study. Upon arrival in Istanbul, the Draft Inception Report was presented and explained to the Counterpart Agency. Based on the Draft Inception Report, following three issues were discussed:

1) Scope and basic approach of the Study;

- Clarification of final output
- Effective use of seismic microzoning results for disaster prevention/mitigation planning

2) Technical Transfer

- Main technical transfer field such as seismic microzoning methodology, disaster prevention/mitigation planning and application of GIS
- Training method for technical transfer

3) Organize a Steering Committee and a Technical Committee

During the first stay of the Study Team from March 13 to April 8, 2001, a total of 38 administrative and technical issues have been discussed. Finally, the scope, procedure and schedule of the Study are mutually agreed and summarized in the Final Inception Report.

1.4. Scope of the Study

1.4.1. Study Objective

The objectives of the Study are to compile the seismic microzonation maps which can serve as the basis of seismic disaster prevention/mitigation plan for Istanbul city and prefecture, to make recommendations for construction of earthquake resistant urbanization and to conduct effective technical transfer on relevant planning technique.

Specifically, the Study intends to:

1) Integrate and develop seismic microzonation studies being carried out in Istanbul as scientific and technical basis for disaster prevention/mitigation planning;

2) Recommend a citywide prevention/mitigation program against damage of buildings and infrastructures based on the detailed seismic microzonation study and building-

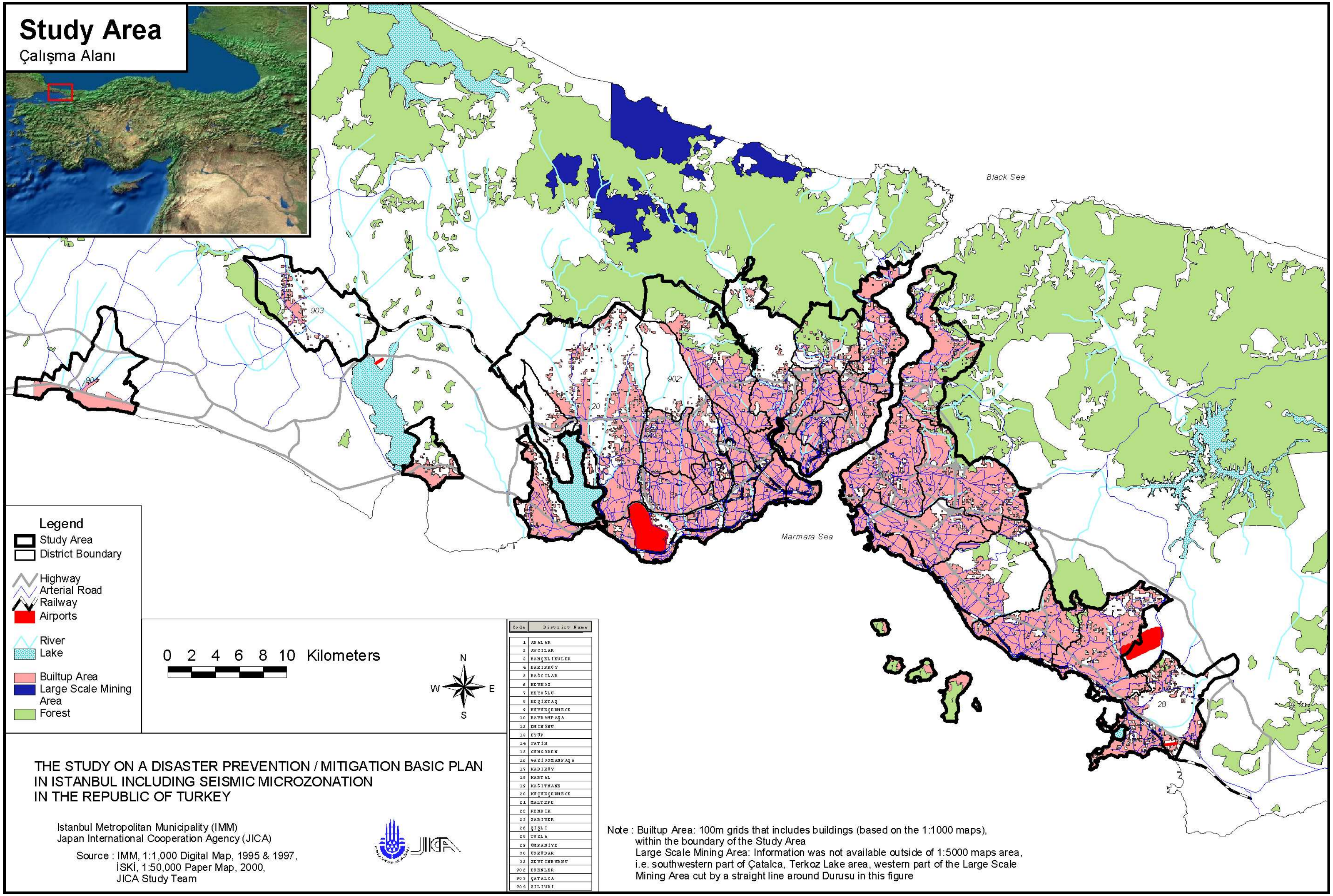
vulnerability evaluation of areas;

3) Recommend disaster prevention considerations to be incorporated in urban planning of Istanbul City including land use plan and earthquake-resistant design regulation, etc; and

4) Pursue technology transfer of planning techniques to Turkish counterpart personnel in the course of the Study.

1.4.2. Study Area

The study area consists of 27 districts of IMM and the built-up area of additional 3 districts (Büyükçekmece, Silivri and Çatalca). The study area is shown in Figure 1.4.1



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 1.4.1 Study Area

1.4.3. Schedule of the Study

The Study consists of a variety of tasks. Figure 1.4.2 shows the work schedule of, and interrelations among, the tasks and shows the logical flow of the Study.

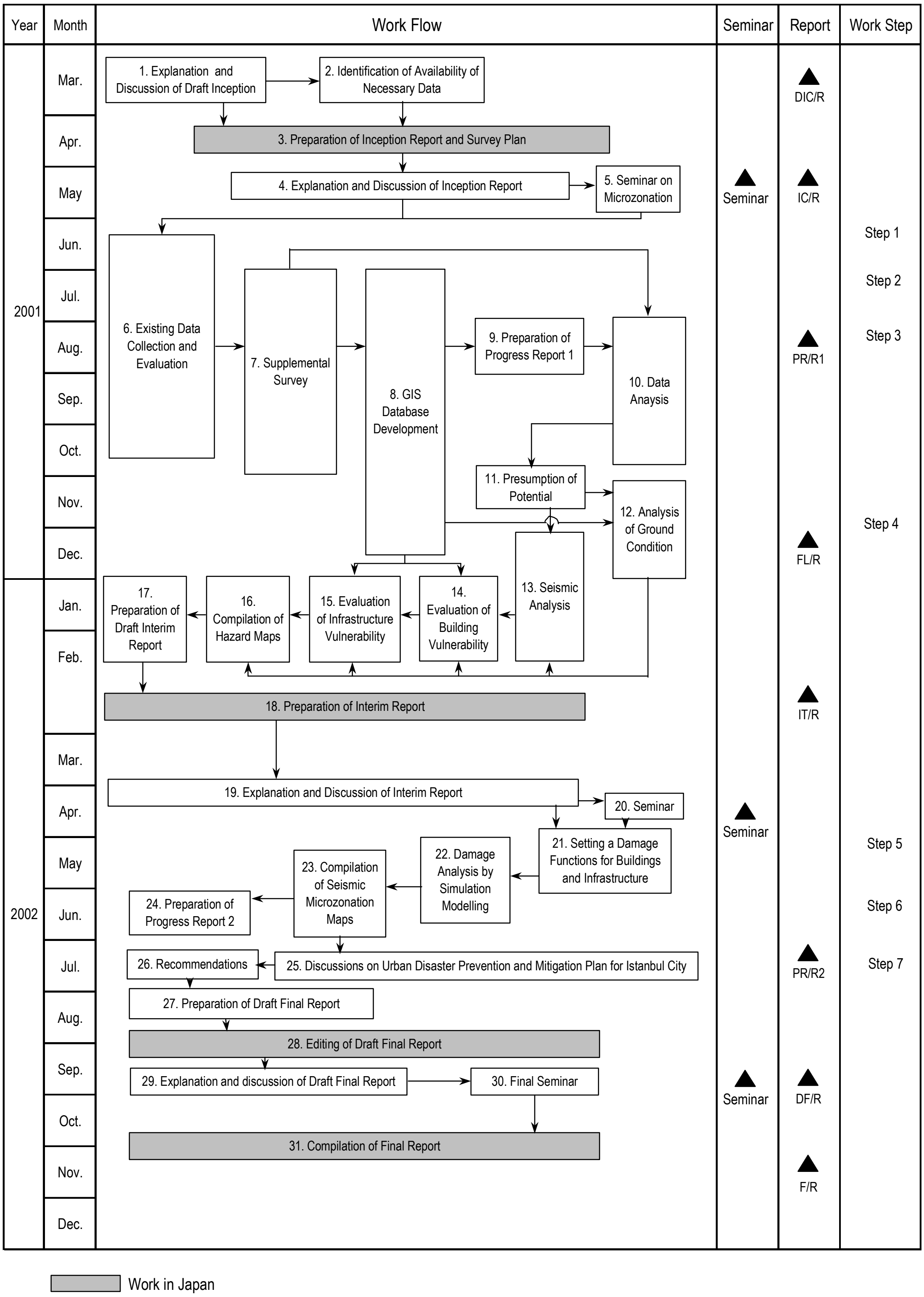


Figure 1.4.2 Work Flow of the Study

In the course of the Study, unfortunately an earthquake disaster occurred in Afyon, 250km southwest from Ankara, on 3rd of February 2002. This earthquake caused a limited number of building collapse and totally 54 human casualties. People's awareness on a potential big earthquake in Istanbul was reminded by this earthquake disaster. The final result of JICA Study was required to be submitted as soon as possible to discuss necessary measures for seismic disaster mitigation planning. Therefore, JICA decided to finalize the whole Study three month earlier than the original plan. According to this plan, original work flow chart was modified.

1.4.4. Implementation Organizations

(1) Establishment of Committees of Turkish Side

For the purpose of smooth and successful implementation of the Study, the Turkish side had established two committees, the Administrative Consulting Committee and the Scientific Consulting Committee, as shown in Figure 1.4.3.

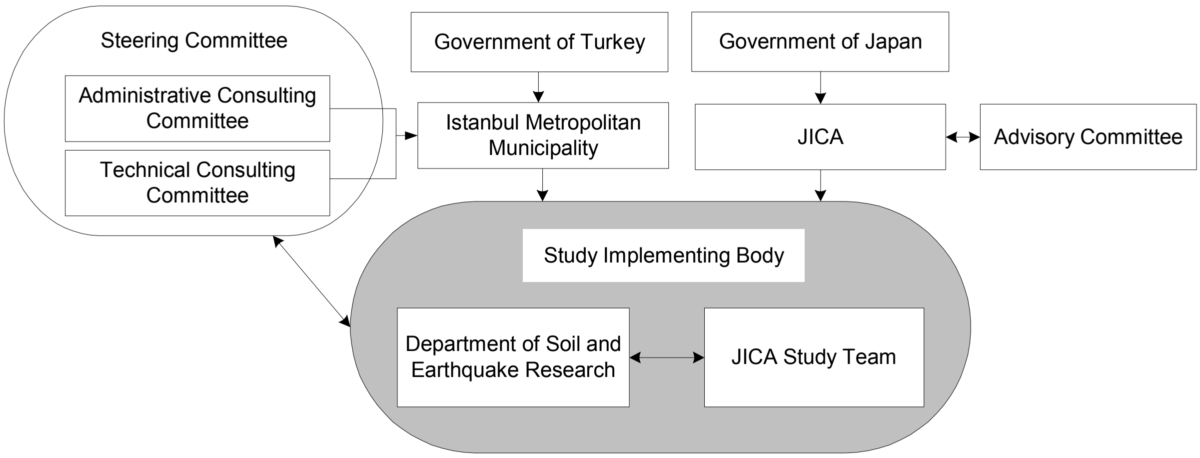


Figure 1.4.3 Study Organization

The Administrative Consulting Committee consists of both representatives from the IMM and Istanbul Governorship, more specifically, for the purpose of better coordination of two relevant organizations in Istanbul. The members are shown in Table 1.4.1.

To cover the various areas of the Study's scope, the Scientific Consulting Committee had been established as shown in Table 1.4.2.

Table 1.4.1 Members of Administrative Consulting Committee

Name	Organization	Position
Alicafer AKYÜZ	Governorship of Istanbul	Deputy Governor
İrfan UZUN	IMM	Head, Department of Planning and Reconstruction

Table 1.4.2 Members of Scientific Consulting Committee

Name	Organization	Specialty
Prof. Dr.Nafi TOKSÖZ	Massachusetts Institute of Technology, USA	Risk Analizes and Microzonation
Prof. Dr. O. Metin İLKIŞIK	Istanbul University (Retired)	Geophysics
Prof. Dr. Aykut BARKA	Istanbul Technical University	Geology
Prof. Dr. Fazlı Y. OKTAY	Istanbul Technical University (Retired)	Geology
Prof. Dr. M. Hasan BODUROĞLU	Istanbul Technical University	Structure
Prof. Dr. Ömer ALPTEKİN	Istanbul University	Seismology
Prof. Dr. Mustafa ERDİK	Boğaziçi University	Earthquake Engineering
Prof. Dr. Kutay ÖZAYDIN	Yıldız Technical University	Geotechnique
Prof. Dr. Cengiz ERUZUN	Himar Sinan University	Urban planning/Architect
Prof. Dr. Nuray AYDINOĞLU	Boğaziçi University	Structural
Mr. Ekrem DEMİRBAŞ	General Directorate of Disaster Affairs, Ministry of Public Works and Settlement	Engineering Geology
Mr. Hüseyin IŞIK	Construction and Real Estate Department	Civil Engineer
Mr. Gökmen ÇÖLOĞLU	İGDAŞ	Seismology

On 1st of February 2002, Prof. Dr. Aykut Barka was suddenly passed away by fatal accident. JICA Study Team describes this fact here to memorize and show deep appreciation to his contribution to the Study.

(2) Counterparts assigned

A total of 8 persons had been assigned as counterpart personnel in accordance with their special subjects as tabulated in Table 1.4.3.

Table 1.4.3 Members of Counterparts

Name	Specialty
Mr. Mahmut BAŞ	Disaster Management
Dr.Ali İSKENDEROĞLU	GIS Development
Mr. Hikmet KARAOĞLU	Geophysics
Mr. Mehmet AKTAŞ	Geology
Mr. İskender AKMEŞE	Geology
Mr. Öner TAYMAZ	Geophysics
Ms. Mine Nilay ÖZEYRANLI	Urban Planning
Mr. Mustafa Özhan YAĞCI	Building and Infrastructure

(3) Member of Japanese Side

Table 1.4.4 Member of Administrative Body of JICA

Name	Position
Mr. Toshio HIRAI	Director, First Development Study Division, Social Development Study Department (March 2001- September 2002)
Mr. Takeshi NARUSE	Director, First Development Study Division, Social Development Study Department (October 2002 - November 2002)
Mr. Yodo KAKUZEN	Deputy Director, First Development Study Division, Social Development Study Department
Mr. Susumu YUZURIO	Staff, First Development Study Division, Social Development Study Department
Mr. Kenishiro TANAKA	Staff, First Development Study Division, Social Development Study Department
Mr. Shinichi TANAKA	Staff, First Development Study Division, Social Development Study Department

Table 1.4.5 Member of Advisory Committee

Name	Organization
Prof. Dr. Yoshimori HONKURA	Professor, Department of Earth and Planetary Sciences, Tokyo Institute of Technology
Dr. Hiroshi FUKUYAMA	Senior Researcher, Building Research Institute
Prof. Dr. Itsuki NAKABAYASHI	Professor, Center for Urban Studies, Graduate Schol of Urban Science, Tokyo Metropolitan University
Mr. Akio Mizutani	Chubu Regional Bureau, Ministry of Land, Infrastructure and Transport
Mr. Mr. Masayuki TANAKA	Deputy Director, Earthquake and Volcano Division, Disaster Prevention Bureau, Cabinet Office

Table 1.4.6 Member of JICA Study Team

Name	Assignment
Noboru IKENISHI	Team Leader / Database
Takashi KADOTA	Deputy Team Leader / Urban Disaster Prevention
Yutaka KOIKE	Geotechnical Engineer / Soil Dynamics
Shukyo SEGAWA	Earthquake Engineer
Osamu NISHII	Geophysical Engineer
Akio HAYASHI	Structural / Seismic Behavior Engineer
Yasuhito MORIMOTO	Structural Engineer
Osamu IDE	Infrastructure (Road, Bridge, etc.)
Ryoji TAKAHASHI	Infrastructure (Lifeline) / Building and Land Use Survey
Kanao ITO	Urban Planning
Hiroyuki MAEDA	GIS Development (1)
Hitoshi SUZUKI	GIS Development (2)
Yoshitaka YAMAZAKI	Disaster Prevention Management
Tomoko SHAW	Coordinator (1)
Miho NAKANO	Coordinator (2)

Chapter 2. Lessons from Past Experience

In this section, situations and lessons during Izmit earthquake is described, based on interviews with numerous authorities that worked during the emergency period.

2.1. Lessons from 1999 Izmit Earthquake

(1) The large earthquake hit an industrial and populated area.

The earthquake with Magnitude 7.4 hit industrial and population heartland in Turkey. As a result, 1999 Izmit earthquake caused the second worst human casualties in 20^{th} century in Turkey.

The earthquake affected seven provinces, and caused death of more than 15,000, heavily damaged household of more than 77,000.

(2) The public buildings and infrastructures were not strong against earthquake.

In the affected area, 43 schools collapsed while 377 of them were damaged.

Since the municipality building was not considered safe, municipality staffs moved to drivers' building and worked for relief activities.

Local hospitals collapsed, so foreign aid team set up tent hospitals.

(3) Governmental offices are also damaged, and responsible staffs were also victims

The earthquake fault ran through the naval base at Golcuk, thus the naval headquarter was directly affected and many flag officials were killed.

(4) Initial communication was not possible

Main fibre optical cable for telecommunication was disrupted that connect Izmit to Ankara, because of fault dislocation.

The president and prime minister could not communicate from Istanbul up to four hours.

No telephone was usable for first 48 hours.

Thus, telephone and mobile phone were not usable, only radio was useful. In case radio communication lacked backup battery, it was not very usable.

It took two days to understand the situation.

(5) Initial few days were chaotic; rescue activity was done by local residents.

In Izmit, at 5pm of the second day, first Turkish rescue team arrived from outside Izmit.

In Avcilar, citizens voluntarily started rescue work on the first day morning. Construction companies offered heavy machines on the morning of the first day.

Urgent rescue and relief team formed in each province consisting of 50 to 150 personnel could only seen on the paper, as most of them lacked training, plans for their mobilization, and allocation of equipment for those who reached to the affected area.

(6) Search and rescue was not organized and not effective

In resort place where residents did not know neighbors, it was difficult to know that if possible victims are buried or not.

Without guide in the area, rescue work was difficult for non-residents members.

Searched buildings were not marked, thus several rescue team worked on same building repeatedly.

There was friction between those who tried to hear sounds from possible survivors buried under the debris, and those who wanted to bulldoze, load and remove the damaged buildings.

Amateur rescuer who lacks building's structural knowledge was dangerous.

Logistic support was lacking such as gasoline, or provision of heavy machine.

Rescue work during night was difficult due to the lack of electricity and light.

Wiring a protocol letter for asking help delayed response activities.

(7) Rescue work from collapsed building was difficult

Light rescue works up to four-storied buildings.

Fire brigade did not have enough tools for heavy rescue, and were not accustomed to heavy rescue.

It takes ten persons for two days to remove a collapsed building without buried victims, without legal problems. If there are possible buried victims, or necessary legal procedures, the work delayed much more.

Heavily machines could not cut columns of collapsed buildings.

(8) Building damage assessment not organized

Initially, municipality did rapid inspection of building safety to meet the demand of residents with the help of architects and professors within a few days. Chamber of engineers and architects provided assessment form.

Engineers from ministry of public works and settlement came after 12 days to do official building damage assessment. The result of rapid inspection were not utilised for official assessment. Nor the results of official damage assessment were given officially to the municipality.

(9) Relief activities was not organized

Municipalities tried to open bank account for donation, but could only dealt donated goods. Only governorship could deal with donated money.

Volunteers coming without preparation of won food and shelter were problematic.

Donated clothes contained food inside, and they were rotten.

(10) First Aid

During past disasters, unskilled amateur treatment of victims rather caused problems.

Medical stocks need to last for first three days. After that period, necessary medicines will be available by donation.

(11) Psychological problems

Residents afraid of earthquake still go back to sleep in prefabricated house.

Rescue workers who worked without knowing family safety had mental problems.

(12) International aid acceptance

Working with foreign rescue members was difficult because there were not translator in emergency management centre.

Some of the medicines donated from abroad were not used, because they lacked readable instructions.

(13) Relocation problem

Permanent housing areas are selected in good ground, but in distant place from the city centre. New area lacks sufficient public transportation and social facilities such as school and clinic. As a result, people still prefers to live in temporally housing near the city centre.

Tent area that lacked infrastructure was problematic.

2.2. Lessons from 1995 Kobe Earthquake

Followings are major problems during the earthquake that hit Kobe, Japan, in 1995 to show some similarity in major earthquake damages in metropolitan area.

(1) Damage

The earthquake caused damage was the worst in post war era in Japan. Kobe city had experienced maximum seismic intensity of Japanese scale. The total numbers of death exceeds 6,000, with injuries over 14,000. The maximum number of refugee was 230,000.

The major cause of death was collapse of housing or trapping under house furniture. Necropsy study shows most of them dies within 15 minutes.

Existing buildings built with old building code suffered higher degree of damage.

(2) Communication

Due to the saturation of telephone communication or functional problems in radio communication, information collection on damage status was difficult.

Satellite communication system did not work because of generator's overheat due to the breakage of cooling water pipes.

Polices were asked to help rescue on the way, and could not collect initial damage information.

(3) Information

Mass media collected damage information quicker than government, and it was the major means to know the situation for government. However, their information mostly focused on the severest damage, and insufficient to know the situation in general.

Radio was initially the most effective ways to inform situation to public.

Local government staffs that worked on site did not know the general damage situation. Newspapers by local government for citizen were also useful to them.

(4) Initial response

Gathering of local government staffs were not sufficient because they were also victims, and because of traffic problems.

Local government staffs were also victims, and heavy traffic caused delayed arrival to office.

Municipality offices were damaged structurally or non-structurally, and were not useful.

(5) Traffic control

Insufficient traffic control caused traffic jams that delayed response activities.

Narrow road had higher percentage of road closure due to collapsed buildings.

Abandoned vehicles also caused traffic jams.

Helicopters were used as emergency transport means, but assurance of airways, air traffic control during emergency period, and use of helipad were problem.

Ocean transport means were also used, but damage to port facilities was problem.

(6) Debris removal

Large heavy machine was unable to enter into pile of debris, so that small heavy machine was useful in initial stage.

Machines become useless because they are broken, or run out of fuels after the hours of operation.

Dust produced by demolition work of buildings caused health problems. Also massive garbage from damaged buildings caused environmental problems.

(7) Search and rescue activities

Major difficulty was to cut the steel bar in concrete building.

Jack or bar was useful to jack up the collapsed building.

In a village where residents know each other well, the rescue operation terminated in the first day.

Estimation shows that to rescue a person from reinforced concrete building, it took 188 man-minutes for fire brigade. Another estimation by Tokyo fire department shows it took 21 man-hours to rescue a person from fireproof collective housing.

When a dead body is found, the necropsy procedure that requires attendance of police hindered the rescue worker to move to next site.

Noise from hovering helicopters obstructed activities to detect buried victims.

(8) Emergency medical aid

Triage, initial screening of victims, was not made on site. Thus, patients of every degree of injury flooded in hospitals. Doctors also lacked experience in triage, but they had to do it first.

Information on medical needs and treatment capacity, structural and non-structural damages to hospitals, logistics of medical goods and victims was lacking. As a result, hospital in severest damaged area was flooded with many patients. Fire station, evacuation areas were also flooded with patients.

Treatment of rescued person trapped under debris for a long time had a risk of “crushed syndrome”. Though they looked fine at first, they needed an early treatment such as dialysis to be alive after rescue.

Though building was not damaged, lack of water and electricity services caused functional problem of hospitals. Lack of water caused problem for dialysis. In addition, cooling water for boiler and generators was also lacking.

(9) Evacuation shelter

Operation manual for evacuation shelter was necessary, such as maintaining sanitation, distribution of limited food, and keeping of dead bodies.

Making a list of evacuated people was necessary to respond the inquiries of safety.

Treatment of human waste was also a big problem. One temporally toilet per 100 persons was mostly sufficient, and one toilet per 75 persons caused little trouble.

Volunteers were helpful to transportation and distribution of goods and foods.

Heating could not be used in shelters for fire safety, and it caused health problems.

Mental cares to refugees and families who lost relatives were problem.

(10) Life lines

Lasting blackout and saturated calls exhausted backup battery of exchange.

Restoration of electricity to damaged area caused fire due to switched apparatus, damaged cables, or gas leakage.

For the recovery of lifeline, parking, housing, and material stockyard for external recovery assistance team was lacking. Information provision on recovery status of lifeline was lacking.

Evacuation was recommended due to the gas leakage from LNG tank in high-pressure gas facilities.

(11) External help

Acceptance of official external help was difficult, due to lack of working space, experience, and organization in local government.

Many volunteers came from outside, but local government lacked experience to work with them.

Chapter 3. Administrative Conditions for Earthquake Disaster Management

3.1. Introduction

Natural anomalous phenomena, such as earthquake, flood, landslide, heavy snows etc., can happen from time to time. These events may be a mere natural phenomena if they occur in an unpopulated area. However, if such a phenomena were to occur in a populated area, it could cause serious impacts on human life as well as on many other social aspects and the event becomes a natural disaster. In this section, disaster management is defined as various forms of organised human efforts to prepare for, to reduce, and to respond to a natural disaster. Disaster management is necessary because:

- Occurrence of anomalous natural phenomena cannot be stopped by human efforts.
- A natural disaster causes the loss of many lives and propertyand hinders national development.
- The impact of the disaster will expand, if it is not managed properly.

Scope of this Study

The object of this study is two-fold. One objective is to examine the current national and local government disaster management system in Turkey to learn its characteristics. Another is to suggest possible organisational and planning changes within current legal frameworks of the local governments in Istanbul.

The first section reviews the status of natural disasters in Turkey and existing cooperation efforts. The second through fourth sections examine the status of disaster management in Turkey from legal, institutional, and operational viewpoints, respectively. Bibliographic studies, interviews with key persons, critical readings of key legal documents and operation plans currently used in Turkey were carried out as key methods of this study. In the fifth section, disaster management systems in Japan and USA are described for a comparison. In the sixth section, some recommendations regarding local government law, organisation, and planning are presented.

Natural Disasters in Turkey

Table 3.1.1 shows the percentage of dwelling units destroyed by natural disasters during the last 70 years in Turkey. Earthquakes prove to be the most damaging natural disasters in the country.

Table 3.1.1 Dwelling Units Destroyed by Natural Disasters in Turkey

Natural Disaster Type	% of Total
Earthquake	61
Flood	14
Landslide	15
Rockfalls	5
Fire	4
Avalanche, storm, rain	1

Source: Oktay Ergunay, (1999)

Figure 3.1.1 shows the number of casualties and heavily damaged buildings due to earthquakes in Turkey during the last century. In total, 130 events are recorded. Total deaths exceed 80,000, with total injuries numbering more than 54,000 , though some records are without injuries in older times. The total number of heavily damaged houses exceeds 440,000. Among them, the worst event was the 1939 Erzincan Earthquake that killed more than 32,000. The 1999 Izmit earthquake that killed more than 15,000 was the second worst.

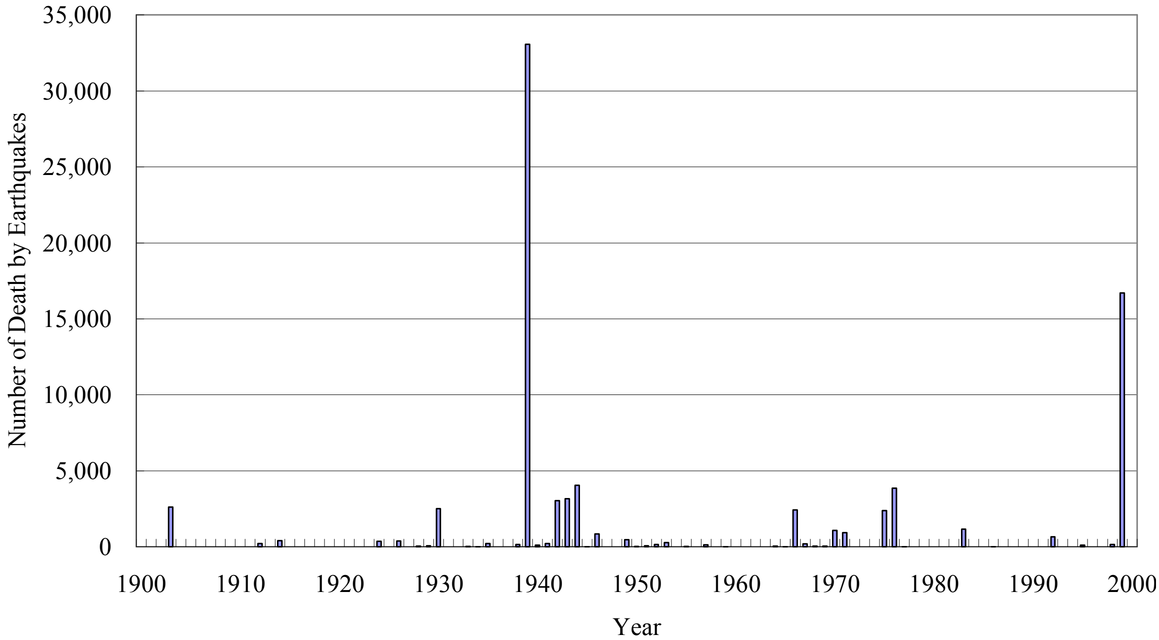


Figure 3.1.1 Number of Deaths by Earthquakes in Turkey

Source: Ministry of Public Works and Settlements (www.deprem.gov.tr). 1999 figure is according to the Prime Ministry Crisis Management Center

Existing Cooperation on Disaster Management

In Istanbul, there are two other international cooperation projects focusing on disaster management, as shown in Table 3.1.2. The "Community Impact Project" with Boazici University mainly works with local communities, in developing emergency response volunteers, with emphasis on non-structural mitigation. The project "A Cooperative Hazard Impact Reduction Effort Via Education" focus on training of disaster prevention volunteers. Though the project terminated in 2001, training and research are underway at the newly established "Center of Excellence in Disaster Management."

Table 3.1.2 Existing Cooperation on Disaster Management in Istanbul

Project name	Community Impact Project	A Cooperative Hazard Impact Reduction Effort Via Education Project
Counterpart organization	Boazici University	Istanbul Technical University
Donor	17 organisations including USAID, UNDP, Swiss Agency for Development and Cooperation, etc.	Federal Emergency Management Agency, USA
Target	Local communities	Mostly at the national level
Period	Ongoing	2000-2001
Features	Community emergency response volunteers. Non structural mitigation. Model area in Kadikoy Municipality.	Training of disaster prevention volunteers. Focused mainly at the national level. "Centers of Excellence in Disaster Management" offers courses and projects on disaster management.
Reference	www.iahep.org	atlas.cc.itu.edu.tr/~achieve www.cedm.itu.edu.tr/

Reference for Section 3.1

Oktay Ergunay, 1999, a Perspective of Disaster in Turkey: Issues and Prospects, Urban Settlements and Natural Disasters, Proceedings of UIA Region II Workshop, Chamber of Architects of Turkey

3.2. Legal Systems Related to Disaster Management in Turkey

3.2.1. Laws Related to Administration

(1) 1982 Constitution

The government of the Republic Turkey functions in accordance with its constitution. Since the establishment of the Republic in 1923, the constitution has been revised two times, both after the period of military rule following a coup. The constitution in effect today was adopted in 1982, replacing the constitution of 1961.

The fundamental change in the legislature by the 1982 Constitution was the abolition of the Senate of the Republic; thus, the Turkish Grand National Assembly became a single chamber. While the President of the Republic and the Council of Ministers carry out executive functions, independent courts exercise judicial power. The 1982 Constitution expands the authority of the president and circumscribes the exercise of individual and association rights. The 1982 Constitution has not only strengthened the powers of the president, but those of the prime minister as well.

The 1982 Constitution stipulates the fundamental duties and rights, fundamental organzation of the Republic, and financial and economic provisions. The table of contents of the 1982 Constitution related to organzation of the Republic is shown in Table 3.2.1. The 1982 Constitution defines central government as follows:

ARTICLE 1 stipulates the form of the state as "The Turkish State is a Republic."

ARTICLE 2 states the "Characteristics of the Republic."

"The Republic of Turkey is a democratic, secular and social state governed by the rule of law; bearing in mind the concepts of public peace, national solidarity and justice; respecting human rights; loyal to the nationalism of Atatürk, and based on the fundamental tenets set forth in the Preamble."

ARTICLE 123 defines the "Integral Unity and Public Legal Personality of the Administration" as follows:

"The administration forms a whole with regard to its structure and functions, and shall be regulated by law. The organisation and functions of the administration are based on the principles of centralization and local administration. Public corporate bodies shall be established only by law, or by the authority expressly granted by law."

ARTICLE 124 speaks to the issuance of “By-laws” as follows:

“The Prime Ministry, the ministries, and public corporate bodies may issue by-laws in order to ensure the application of laws and regulations relating to their particular fields of operation, provided that they are not contrary to these laws and regulations. The law shall designate which by-laws are to be published in the Official Gazette.”

Table 3.2.1 Contents of the 1982 Constitution

- PREAMBLE
- PART ONE GENERAL PRINCIPLES
- PART TWO FUNDAMENTAL RIGHTS AND DUTIES
- PART THREE FUNDAMENTAL ORGANS OF THE REPUBLIC
    - CHAPTER ONE LEGISLATIVE POWER
        - I. The Turkish Grand National Assembly
        - II. Functions and Powers of the Turkish Grand National Assembly
        - III. Provisions Relating to the Activities of the Turkish Grand National Assembly
        - IV. Ways of Collecting Information and Supervision by the Turkish Grand National Assembly
    - CHAPTER TWO THE EXECUTIVE
        - I. President of the Republic
            - A. Qualifications and Impartiality
            - B. Election
            - C. Taking the Oath
            - D. Duties and Powers
                - a) Those relating to legislation:
                - b) Those relating to executive functions:
                - c) Those relating to the judiciary:
            - E. Presidential Accountability and Non-accountability
            - F. Acting for the President of the Republic
            - G. General Secretariat of the President of the Republic
            - H. State Supervisory Council
        - II. Council of Ministers
            - A. Formation
            - B. Taking Office and Vote of Confidence
            - C. Vote of Confidence While in Office
            - D. Functions and Political Responsibilities
            - E. Ministers, and the Formation of Ministries
            - F. Provisional Council of Ministers During Elections
            - G. Regulations
            - H. Calling for Elections for the Turkish Grand National Assembly by the President of the Republic
            - I. National Defence
                - A. Offices of Commander-in-Chief and Chief of the General Staff
                - B. National Security Council
        - III. Procedure Governing Emergency Rule
            - A. States of Emergency
                - 1. Declaration of State of Emergency on Account of Natural Disaster or Serious Economic Crisis
                - 2. Declaration of State of Emergency on Account of Widespread Acts of Violence and Serious Deterioration of Public Order
                - 3. Rules Relating to the State of Emergency
            - B. Martial Law, Mobilization and State of War
        - IV. Administration
            - A. Fundamentals of the Administration
                - 1. Integral Unity and Public Legal Personality of the Administration
                - 2. By-laws
            - B. Recourse to Judicial Review
            - C. Organisation of the Administration
                - 1. Central Administration
                - 2. Local Administrations
            - D. Provisions Relating to Public Servants
                - 1. General Principles
                - 2. Duties and Responsibilities, and Guarantees During Disciplinary Proceedings
            - E. Institutions of Higher Education and Their Higher Bodies
                - 1. Institutions of Higher Education
                - 2. Superior Bodies of Higher Education
                - 3. Institutions of Higher Education Subject to Special Provisions
            - F. Radio and Television Administrations and State-Financed News Agencies
            - G. The Atatürk High Institution of Culture, Language and History
            - H. Public Professional Organisations
            - I. Department of Religious Affairs
            - J. Unlawful Orders
    - CHAPTER THREE JDICIAL POWER
- PART FOUR FNANCIAL AND ECONOMIC PROVISIONS
- PART FIVE MISCELLANEOUS PROVISIONS
- PART SIX PROVISIONAL ARTICLES
- PART SEVEN FINAL PROVISIONS

Source: Grand National Assembly website (www.tbmm.gov.tr/anayasa/constitution.htm)

Central and Local Administration

The 1982 Constitution defines central and local administration as follows:

ARTICLE 126 stipulates the meaning of "Central Administration" as follows:

"In terms of central administrative structure, Turkey is divided into provinces on the basis of geographical situation and economic conditions, and public service requirements; provinces are further divided into lower levels of administrative districts. The administration of the provinces is based on the principle of devolution of wider powers. Central administrative organisations comprising several provinces may be established to ensure efficiency and coordination of public services. The functions and powers of these organisations shall be regulated by law."

ARTICLE 127 stipulates the meaning of "Local Administrations" as follows:

"Local administrative bodies are public corporate entities established to meet the common local needs of the inhabitants of provinces, municipal districts and villages, whose decision-making organs are elected by the electorate as described in law, and whose principles of structure are also determined by law.

The formation, duties and powers of the local administration shall be regulated by law in accordance with the principle of local administration.

The elections for local administrations shall be held every five years in accordance with the principles set forth in Article 67. However, general or by-elections for local administrative bodies or for members thereof, which are to be held within a year before or after the general or by-elections for deputies, shall be held simultaneously with the general or by-elections for deputies. Special administrative arrangements may be introduced by law for larger urban centres.

The procedures dealing with objections to the acquisition by elected organs of local government or their status as an organ, and their loss of such status, shall be resolved by the judiciary. However, as a provisional measure, the Minister of Internal Affairs may remove from office those organs of local administration or their members against whom investigation or prosecution has been initiated on grounds of offences related to their duties, pending judgement.

The central administration has the power of administrative trusteeship over the local governments in the framework of principles and procedures set forth by law with the objective of ensuring the functioning of local services in conformity with the principle of the integral unity of the administration, securing uniform public service, safeguarding the public interest and meeting local needs, in an appropriate manner.

The formation of local administrative bodies into a union with the permission of the Council of Ministers for the purpose of performing specific public services; and the functions, powers, financial and security arrangements of these unions, and their reciprocal ties and relations with the central administration, shall be regulated by law. These administrative bodies shall be allocated financial resources in proportion to their functions."

(2) Municipality Act (No.1580)

The first municipal organisation was established in Istanbul in 1854. Municipalities in other cities followed with the municipal laws of 1868 and 1876. Local administrations gained their contemporary features after the establishment of the Republic in 1923.

The main legislation that gives powers and responsibilities to municipalities is the Municipality Act (No. 1580) of 1930, which is still valid to date. The law is based on the French system, prescribing the organisation and functions of the municipalities in detail.

According to this law, a municipal administration can be established in localities of more than 2,000 inhabitants with a referendum. As to provinces and districts, municipal administration has to be instituted irrespective of their population. The number of municipalities in Turkey has increased in parallel with the increase in population.

Article 15 states that “the principal duty of the municipality is to meet the local needs of the inhabitants and the citizens.”

Article 19 states that “having fulfilled the duties and services given by this law, the municipalities can execute every sort of activity concerning the common necessities of their inhabitants.”

There have been significant changes in local-level public needs and expectations and in the structure of urban settlements since the 193’0s because of major socio-economic and technological developments in Turkey. Certain municipal functions have become obsolete over time. In general, however, there has been a significant re-evaluation and expansion in the scope of municipal activities to meet the rapidly changing needs of urban life.

The most fundamental change took place in the post-second World War period, when the rapidly accelerating pace of urbanisation of the 1950's was reflected in municipal functions. In the 1960's the scope of authority of municipalities in regulating urban economic activities and consumption was expanded. In the 1970's, certain duties in the field of environmental protection were added.

(3) Metropolitan Municipalities Act (No. 3030)

In 1984, a different type of municipal administration, namely a “metropolitan municipality” defined as "a city that comprises more than one district within its own boundaries," was introduced by the Metropolitan Municipalities Act (No. 3030). This type of administration was first set up in Istanbul, Ankara and Izmir, and later extended to 15 metropolitan municipalities.

The 1984 Metropolitan Municipalities Act requires that all intra-city services be carried out in accordance with plans and programmes prepared by the metropolitan municipalities within the framework of the objectives of the National Development Plans.

Table 3.2.2 Contents of the Metropolitan Municipalities Act

Part	Title	Article	Contents
1	Object, contents, definition	1-3	Object, contents, definition of the law
2	Establishment and boundary	4-5	Establishment and boundary of the greater municipality
3	Duties, rights	6-8	Duties and rights of greater municipality
4	Organs in greater municipality	9-15	Organs, council, committee, lord mayor
5	Organs in greater municipality	16-17	Secretary general and sub secretary general
6	Finance in greater municipality	18-20	Revenue, expense, plan, budget
7	Decisions	21-26	Settlement of dispute, transition to greater municipality

3.2.2. Development Laws

(1) The 1982 Constitution

Article 57 of the 1982 Constitution states the “Right to Housing.” “The state shall take measures to meet the need for housing within the framework of a plan which takes into account the characteristics of cities and environmental conditions and supports community housing projects.”

(2) National Development Plan

In the 1930’s, the Republic of Turkey introduced the first of its five-year plans. The State Planning Organisation (SPO) was established in 1961 to regain stability in the economy after social turmoil. The SPO developed its first five-year national development plan in 1962. Currently the eighth national development plan for the years 2001 to 2005 is in effect, with reference to the long-term development for 2001 to 2023. Major objectives of each five year plans are summarised in Table 3.2.3.

Table 3.2.4 shows the table of contents of the 8th National Development Plan. In the plan, section seven "Urban and Rural Infrastructure" in chapter eight "Development Objectives and Policies Related to Social and Economic Sectors" refers to urbanization and housing. In addition, section seven in chapter nine "Enhancement of Efficiency in Public Services" refers to natural disasters.

Table 3.2.3 Major Objectives of the Republic's Five-Year Plans

Plan	Term	Objectives
	1930's	Firstly introduced five-year plans as part of the etatist industrialization drive, provided guidance for the development of infrastructure, mining, and manufacturing.
	1940's	Plans was drafted but only partially implemented because of World War II.
	1950's	The Democrat Party (DP) eliminated central economic planning.
	1961	The 1961 constitution made social and economic planning a state duty.
1st	1963-1967	What should be accomplished by the mid-1970s
2nd	1968-1972	What should be accomplished by the mid-1970s
3rd	1973-1977	Goals for 1995, including a customs union with the EC
	Late 1970's	The economic and political disorder made it impossible to achieve plan targets.
4th	1979-1983	Modified to favor the private sector, labor-intensive and export-oriented projects, and investments that would pay for themselves relatively quickly.
5th	1984-1989	Called for a smaller state sector. The state would take more of a general supervisory role than it had in the past, concentrating on encouraging private economic actors. Nevertheless, the state was to continue an aggressive program of infrastructure investments to clear bottlenecks in energy, transport, and other sectors.
6th	1990-1995	Called for overall economic growth of 7 % per year. The growth of private-sector investment was targeted at an average of 11 % per year, whereas the aim was to increase exports 15 % per year. The inflation rate was targeted at 10 % per year.
7th	1996-2000	development and physical planning studies is emphasized to reduce interregional development disparities.
8th	2001-2005	Called for improvement of life quality of the society, start of a continuous and stable growth process, realization of basic transformations within the process of European Union membership, integration with the world.

Table 3.2.4 Contents of the 8th National Development Plan

CHAPTER ONE DEVELOPMENTS PRIOR TO THE 8TH FIVE YEAR DEVELOPMENT PLAN
CHAPTER TWO BASIC TARGETS AND STRATEGY FOR LONG-TERM DEVELOPMENT (2001-2023)
CHAPTER THREE BASIC TARGETS, PRINCIPLES AND POLICIES OF THE 8TH FIVE YEAR DEVELOPMENT PLAN (2001-2005)
CHAPTER FOUR MACROECONOMIC POLICIES, OBJECTIVES AND PROJECTIONS OF 8TH FIVE YEAR DEVELOPMENT PLAN
CHAPTER FIVE RELATIONS WITH THE EUROPEAN UNION
CHAPTER SIX TURKEY'S ECONOMIC RELATIONS WITH COUNTRIES IN THE REGION AND WITH OTHER COUNTRIES
CHAPTER SEVEN REGIONAL DEVELOPMENT OBJECTIVES AND POLICIES
CHAPTER EIGHT DEVELOPMENT OBJECTIVES AND POLICIES RELATED TO SOCIAL AND ECONOMIC SECTORS
I. INTRODUCTION
II. THE DEVELOPMENT OF HUMAN RESOURCES
III. CULTURE
IV. ENHANCEMENT OF WELFARE
V. INDUSTRIALISATION
VI. IMPROVEMENT OF THE SCIENTIFIC AND TECHNOLOGICAL CAPACITY
VII. INFORMATION AND COMMUNICATION TECHNOLOGIES
VIII. AGRICULTURAL DEVELOPMENT
IX. ENERGY
X. TRANSPORTATION
XI. TOURISM AND PROMOTION
XII. URBAN AND RURAL INFRASTRUCTURE
1. SETTLEMENT AND URBANISATION
2. HOUSING
3. MUNICIPAL WATER, SEWERAGE, WASTE WATER TREATMENT AND WASTE MANAGEMENT
4. URBAN TRANSPORTATION
5. CONSTRUCTION, ENGINEERING, ARCHITECTURE, TECHNICAL CONSULTANCY AND CONTRACTING SERVICES
6. MAP, LAND REGISTRATION AND CADASTRAL SURVEY, GEOGRAPHICAL INFORMATION SYSTEMS AND GLOBAL POSITIONING SYSTEMS
7. RURAL INFRASTRUCTURE
XIII. ENVIRONMENT
CHAPTER NINE ENHANCEMENT OF EFFICIENCY IN PUBLIC SERVICES
I. IMPROVEMENT AND RESTRUCTURING OF THE PUBLIC ADMINISTRATION
II. EFFICIENCY IN JUDICIAL SERVICES
III. EFFICIENCY IN SECURITY SERVICES
IV. LOCAL ADMINISTRATIONS
V. EFFICIENCY IN PLANNING AND IN IMPLEMENTATION OF PUBLIC INVESTMENTS
VI. NON-GOVERNMENTAL ORGANISATIONS (NGOs
VII. NATURAL DISASTERS
VIII. TRAFFIC AND LIFE SAFETY
CHAPTER TEN ENHANCEMENT OF EFFICIENCY IN ECONOMY
BASIC TARGETS AND STRATEGY OF TURKEY'S
LONG TERM DEVELOPMENT (2001-2023) AND 8th FIVE YEAR DEVELOPMENT PLAN (2001-2005)
I. DEVELOPMENTS IN THE WORLD
II. TURKEY'S EXPERIENCE AND MAIN PROBLEM AREAS
III. BASIC TARGETS AND STRATEGY OF LONG TERM DEVELOPMENT(2001-2023)
IV. BASIC TARGETS, PRINCIPLES AND POLICIES OF THE 8th FIVE YEAR DEVELOPMENT PLAN (2001-2005)
1. THE PROCESS OF ACCESSION TO THE EUROPEAN UNION AND FOREIGN ECONOMIC RELATIONS
2. MACRO-ECONOMIC TARGET FORECASTS AND POLICIES
3. DEVELOPMENT OF HUMAN RESOURCES
4. CULTURE AND ARTS
5. ENHANCEMENT OF SOCIAL WELFARE
6. INDUSTRIALISATION
7. DEVELOPMENT OF SCIENCE AND TECHNOLOGICAL CAPACITY
8. INFORMATION AND COMMUNICATION TECHNOLOGIES
9. AGRICULTURAL DEVELOPMENTS
10. ENERGY
11. TRANSPORTATION
12. TOURISM AND PROMOTION
13. REGIONAL DEVELOPMENT
14. SETTLEMENT, URBANISATION PROVINCIAL AND RURAL INFRASTRUCTURE
15. ENVIRONMENT
16. NATURAL DISASTERS
17. ENHANCEMENT OF EFFICIENCY IN PUBLIC SERVICES
18. ENHANCEMENT OF EFFICIENCY IN ECONOMY
GLOSSARY

Source: State Planning Office website (www.dpt.gov.tr/dptweb/ingin.html)

(3) Development Law (No. 3194)

The Ministry of Reconstruction and Settlement, the predecessor organisation of the current Ministry of Public Works and Settlements, was established in 1958 to reduce the risk of death and injury to the population, and to reduce the scale of the economic risks involved from earthquake and other natural disasters. The single and most important mandate was to implement two laws, the so called “Development Law” and “Disaster Law,” which were created by the Ministry of Reconstruction and Settlement in 1959.

The current Development Law (No.3194, termed the “Reconstruction Act” as literally translated from Turkish) was enacted in 1985, and it is the fourth generation in a tradition of such legislation in Turkey. The contents are shown in Table 3.2.5.

The Development Law is the principal legal instrument governing how buildings are constructed. This law was devised to ensure the establishment of settlement areas and structures in compliance with planning, health and environmental conditions.

The construction process in Turkey is illustrated by a schematic diagram in Figure 3.2.1. This law has a few articles in Part 4 that regulate the supervision of building construction. The law holds municipalities (or governorates for buildings outside of urban areas) responsible for design supervision. Construction supervision is entrusted to the inspector, so-called “engineers of record.” For certain classes of buildings to be built in non-municipality areas, non-engineering degree holders have also been enabled to serve in this capacity. There are other exceptions granted for rural settlements. Plans for areas remaining inside or located outside of municipal and residential areas, and all structures to be constructed are subject to provisions of this law.

In Turkey, the legal system functions by chartering by-laws, regulations, or statutes that regulate how a given law is enforced. Numerous regulations complement the Development Law as follows:

- Standard building regulations for non-metropolitan municipalities

- Land and property sharing with renewed alignments according to Article 18

- Standards and procedures for preparing and revising plans

- Building regulations for areas without a plan

Table 3.2.5 Contents of the Development Law

Chapter	Article	Contents
CHAPTER ONE General Provision	1-5	Purpose
		Scope
		General Principle
		Exceptions
		Definitions
CHAPTER TWO Principles Pertaining to Zoning Plans	6-14	Planning Stages
		Current Maps and Zoning Plans
		Preparation and Putting in Effect of Plans
		Authority of the Ministry for Zoning Plans
		Reconstruction Programs, Expropriation and Restriction
		Public Owned Real Estate
		Front Line
		Places Reserved for General Services in the Zoning Plans
		Servitude Rights
CHAPTER THREE Separation and Unification Matters	15-19	Separation and Unification
		Registration and Division
		Parts Remaining after Expropriation
		Regulation of Fields and Lands
		Preparation and Registration of Parceling Plans
CHAPTER FOUR The Structure and Principles Relevant to the Structure	20-37	Structure
		Structure License
		Conditions of License
		Structure License in Redevelopment Areas
		Classification of Independent Sworn-In Architecture and Engineering Bureaus
		License for Public Structure and Buildings and Industrial Plants
		Structures Not Subject to Licensing and Principles They Should Abide By
		Technically Responsible Persons, Responsibilities Thereof and Contractor Records
		License Term
		Structure Habitation License
		Structures Without Utilisation Permit
		Structures Started Without License or in Contradiction to the License and Appendices
		Temporary Structures on Areas Reserved for General Services
		Measures and Liabilities Pertaining to Construction, Repair and Landscaping
		Dig of Natural Ground Between the Building Frontline and Road
		Apartments of the Doormen and Shelters
		Parking Lots
CHAPTER FIVE Miscellaneous Provision	38-45	Preparation and Application of Current Maps, Zoning Plans and Structure Designs
		Structures Dangerous to the Degree of Collapse
		Measures For the Safety of the Public
		Lands Facing the Road
		Punitive Sanctions
		Repealed Provision
		Regulation
		Settlement Area
CHAPTER SIX Provision Regarding the Bosphorus Act 2960	46-48	
CHAPTER SEVEN Temporary Provisions, Effectiveness and Enforcement	49-50	Utilisation of Structures for their Purposes
		Parking Lots Utilised for Other Purposes
		Licenses and Permits Granted Previously
		Joint Entrance
		“Tenures” and Land Holds
		Period for Promulgation of Regulations
		Effectiveness
		Enforcement

BUILDING TYPE → BUREAUCRATIC STEP ↓	PRIVATE PROPERTY			INSTITUTIONAL BUILDING
	Single Detached Building (Business or Rental Facility)	Collective Housing through Cooperatives	Land-in-Exchange for Share of Property (Build-Sell)	
1. Establish land ownership	The Deeds Bureau or Assignment/Lease Bureau: Acquisition of the deed or assignment paper			Deed and/or expropriation
2. Financial arrangements	Individual	Collect money from members	Private agree-ment between parcel owner/ contractor	Budget and funds
3. Conformance with development plan	Municipality or Provincial Office of Ministry of Public Works and Settlements Deed holder Applies	Deed holder (or Coop. Board) applies	Deed holder applies	End user applies w/ deed + petition
	For lands with no plans, new plans must be attached			
4. Design: architectural, structural, installations	Design Offices (Engineer-Architects) Municipality or Provincial Office of Ministry of Public Works and Settlements			Subcontracted, with in-house check or design in-house
5. Building permit	An engineer of record must be designated			
6. Preparation for construction/ contracting	Private award to contractor, Invite for tender, or turnkey Arrangement		Private agreement	Follow Contracts Law procedures
7. Construction	Contractor + (subcontractor) + engineer of record (Municipality checks only foundation, subbasement and story elevations)			Contractor + sub-Contractor + site engineer
8. Supervision, progress payment, quantity surveys, workplan, conformance check	Private Supervisors Engineer of record		As per Agreement between parties	Agency units, supervisory units, engineer of record
9. Engineering responsibility	The engineer of record designated during the taking out of the permit is on paper only. Law holds contractor responsible, even for design errors. He often is able to pass it on to the site engineer.			True responsibility does not exist: civil employees cannot be held liable
10. Occupation permit: delivery of works to owner	Check with Social Security Agency for workers' compensations; check for completion of project (municipality, public health, fire bureau, architectural and engineers chambers, utility connections)			Supervisory unit within agency grants certificate of completion

Figure 3.2.1 A Simplified Description of the Construction Process in Turkey

Source: Polat Gulkan (2000)

(4) Illegal Housing Construction Laws

In Turkey, the informal settlement sector plays an important role in housing construction. Illegal housing, or so-called "gecekondou", a Turkish word meaning "overnight construction", began to appear in the 1940's. At first, the government tried to remove gecekondou. However, rapid increase of gecekondou and massive political power of its inhabitants forced the governmental policy to take more feasible measures (Hirayama,2001;Kobayashi et al.,2001).

In 1953, a law was issued to prohibit new gecekondou but permit existing illegal housing. In the late 1950's, construction of illegal housing became industrialised. Planned but illegal housing development, and its selling and renting were established as a commercialized system.

In 1963, the Republic's five-year national development plan was institutionalized, and housing provision was included under the plan.

In 1966, a major shift in the housing policy was made when a gecekondou law was issued. The law designated gecekondou areas that satisfied certain conditions as "improvement areas," and their improvement and infrastructure were promoted. Gecekondou areas that did not satisfy certain conditions were designated as "prohibited areas," and the removal of housing from these areas along with provisions of alternative housing were promoted. Illegal occupants in public areas were requested to buy the land in short period of time as sub-division, and then they become subject to property taxation. Gained revenue was to be used for the improvement of the gecekondou areas.

In Istanbul in the 1950's, the informal sector consisted of 45% of its housing construction. In the 1970's, the informal sector accounted for over two thirds of housing construction. Gecekondou law was revised later in 1976 and in 1983, maintaining basic principles from its first version.

In 1985, financial assistance systems for acquisition of housing such as the Mass Housing Law, and the Mass Housing Fund were outlined under the 5th National Development Plan. In the same year, a new reconstruction law penalized illegal development covering areas over 1000 m2, but small illegal housing developments covering areas less than 1000 m2 were legalized.

(5) Recent Decrees related to Safe Construction

Following two earthquakes in 1999, new decrees were developed to ensure safe construction (Polat Gulkan, 2001).

a. Building Construction Supervision (Decree No. 595, April 10, 2000)

Decree No. 595 was issued to ensure that nominal quality standards are abided within the building construction continuum. Institutional buildings are excluded. The individuals deemed responsible for a given building are the design engineer, contractor, site engineer and building supervision firm. Design engineers are required to have the title of "expert engineer," similar to a professional engineer. In essence, the building supervision firm exercises the duties of the municipal or governor offices in ensuring both the correctness of the designs and conformance of the actual construction to the design.

In each provincial capital and town with populations numbering more than 50,000 inhabitants, a building supervision oversight commission is established under the general coordination of the field office of the Ministry of Public Works and Settlements. Ankara's "Building Supervision Supreme Council" is embedded in the same ministry and manages this hierarchical structure.

Fees for design and construction supervision range from 4 to 8 percent of the estimated cost of the building and are disbursed by the owner through the municipality. Unless there exists a confirmation that the building has been completed in conformance with the actual design, municipalities are not able to grant occupation permits for people to move into the premises.

The building construction supervision firm is the party primarily responsible for offsetting any losses incurred by the owner that may arise during the first ten years after the occupation permit is issued, including those caused by natural disasters. To ensure this compensatory liability, firms must purchase insurance for each job they supervise. All firms engaged in this type of activity have this coverage.

The enforcement of this decree was initiated in 27 pilot provinces, including all that were impacted by the 1999 earthquakes. An omission in the text of the decree is the detailed construction inspection procedures that are required for effective quality assurance. Architects have been left out of the inspection procedures, with the civil engineering profession having received prime responsibility there. A number of regulations have also been issued to facilitate the implementation of the decree.

b. Regulation for Implementation of Construction Supervision (May 26, 2000)

Construction supervision firms are classified into three groups in order of reduced responsibility and manpower requirements. These firms must be owned by a majority of engineers or architects. Their chief mission is to ensure that the designs conform to the appropriate building code as well as the seismic code. Local site evaluations are specifically mentioned because of past experiences with liquefaction and loss of soil strength. This regulation also contains clarifications regarding the manner in which different-level supervision councils are to function, and how their records are to be kept.

c. Revision of the Law on Engineering and Architecture No. 3458 and Law on the Union of Chambers of Turkish Engineers and Architects No. 6235 (Decree No. 601, June 28, 2000)

The practice of engineering and architecture, and the empowerment of engineers and architects to organise themselves into chambers and a union comprising the different chambers are regulated by these two laws.

With the introduction of "expert" engineers or architects in the process of construction supervision, corresponding amendments to the parent laws were required. This decree achieves that objective. The chambers are enabled to set the guidelines for conferral of the expert title, but generous transition (grandfather) clauses have also been admitted.

d. General Conditions for Mandatory Financial Liability Insurance for Construction Supervision Firms (July 10, 2000)

This directive issued by the Undersecretariat of the Treasury sets the rules and procedures for the purchase of the mandatory financial liability insurance all supervision firms must have for each construction they undertake to oversee. Coverage articles refer to "unreasonable" damages caused by the disaster as being excluded from the intent of the underwriting, but no specific guidelines are mentioned.

In successive articles, the obligations of the insurer and the insured are spelled out when events leading to physical damages have occurred because causes of damage are often not easily ascribed to only one party in the building delivery process. The insurance premium is 1.3 percent of the insured value.

e. Testing Laboratory Requirements for Decree No. 595 (July 30, 2000)

Independent testing laboratories must certify that minimum requirements are met for building materials used in construction. This directive and a companion set out the requirements for these laboratories.

3.2.3. Disaster Laws

(1) The 1982 Constitution

The 1982 Constitution outlines the rules and procedures for the declaration of a state of emergency and the suspension of fundamental rights.

Article 15 describes the suspension of the "Exercise of Fundamental Rights and Freedoms" as follows:

"In times of war, mobilization, martial law, or state of emergency, the exercise of fundamental rights and freedoms can be partially or entirely suspended, or measures may be taken, to the extent required by the exigencies of the situation, which derogate the guarantees embodied in the Constitution, provided that obligations under international law are not violated."

Article 119, "Declaration of a State of Emergency on Account of Natural Disaster or Serious Economic Crisis," in the constitution defines the activation of a state of emergency. The article states that "in the event of natural disaster, dangerous epidemic diseases or a serious economic crisis, the Council of Ministers, meeting under the chairmanship of the President of the Republic may declare a state of emergency in one or more regions or throughout the country for a period not exceeding six months."

Article 121 states the "Rules Relating to the State of Emergency" as follows:

"In the event of a declaration of a state of emergency under the provisions of Articles 119 and 120 of the Constitution, this decision shall be published in the Official Gazette and shall be submitted immediately to the Turkish Grand National Assembly for approval. If the Turkish Grand National Assembly is in recess, it shall be assembled immediately. The assembly may alter the duration of the state of emergency, extend the period, for a maximum of four months only, each time at the request of the Council of Ministers, or may lift the state of emergency.

The financial, material and labour obligations which are to be imposed on citizens in the event of the declaration of state of emergency under Article 119 and, applicable according to the nature of each kind of state of emergency, the procedure as to how fundamental rights and freedoms shall be restricted or suspended in line with the principles of Article 15, how and by what means the measures necessitated by the situation shall be taken, what sort of powers shall be conferred on public servants, what kind of changes shall be made in the status of officials, and the procedure governing emergency rule, shall be regulated by the Law on State of Emergency.

During the state of emergency, the Council of Ministers meeting under the chairmanship of the President of the Republic, may issue decrees having the force of law on matters necessitated by the state of emergency. These decrees shall be published in the Official Gazette, and shall be submitted to the Turkish Grand National Assembly on the same day for approval; the time limit and procedure for their approval by the assembly shall be indicated in the Rules of Procedure."

(2) National Development Plan

Unlike former plans, the 8th National Development Plan fully addresses natural disasters in section seven, "Natural Disasters," and in chapter nine, "Enhancement of Efficiency in Public Services."

The plan describes objectives and principles as follows:

"The main objective is to establish the social, legal, institutional and technical structure for reducing the damages of disaster to the minimum through measures to be taken. Central coordination in the establishment of this structure is the main principle.

Through continuous and systematic training efforts, measures shall be taken against earthquakes and other disasters, and it shall be ensured that these disasters shall be perceived as common natural events. Training efforts for people shall be continued to include the social ethical rules.

Necessary efforts shall be made to guarantee sufficient security for all the existing or future infra and superstructures.

A small part of the large resources, which were utilised after the disasters but proved not to be efficient, shall be utilised under a plan before the disaster to take measures for reducing the damages of a possible disaster.

Since design of the disaster-proof buildings requires specialization, emphasis shall be given to earthquakes and other issues on disasters in engineering graduate programs. Furthermore, programs improving the sense of responsibility of the engineers and laying down a professional ethic shall be emphasized. Earthquake Engineering postgraduate programs shall be introduced by the technically eligible universities and existing programs shall be improved. Efforts shall be made to reduce deficiencies of engineering in practice.

Since most of the building stock is not secure against earthquakes, these buildings shall be examined and strengthened systematically against earthquakes, starting, first of all, from the places where earthquake occurrence possibility is high.

Establishment of Building Assessment Centres where competent engineers shall work for assessment and strengthening of the existing buildings against earthquakes shall be supported.

With a view to making the principles and methods of the field use and construction plans sensitive against disasters, related legislation shall be reviewed and effective mechanisms shall be introduced for strict implementation. Liabilities and relevant sanctions of those who will act against the rules shall be revised.

A disaster management system, in harmony with the existing legal and institutional structure and including the studies for National Extraordinary Situation Plan shall be made. This system shall cover a fast, effective and comprehensive rescue and first aid operation in order to reduce the damages of the disasters before and during the disaster and accomplish the functions towards eliminating the economic, social and psychological damages of the disaster."

The plan describes legal and institutional arrangements as follows:

"Necessary arrangements shall be made in the legislation to make the Turkish Emergency Management Institution operative.

The Law on Engineers and Architectures laying down the duties, authorities and responsibilities of the engineers and the Law concerning the Turkish Engineers and Architectures Chamber Union setting out the duties and authorities of the professional chambers shall be revised to introduce a concept of Competent Engineering.

Construction Law shall be amended to introduce a sound construction control system and revised to include the liabilities of those acting against the rules and the sanctions to be applied to them.

The Law on Municipalities and the Metropolitan Municipalities Law shall be amended to bring about a sound construction control system and revised to arrange the duties, authorities and responsibilities of the local administrations on the determination of natural disaster threats and risks and reduction of their likely damages.

Full and accurate implementation of the provisions of the Natural Disaster Regulation is considered adequate for ensuring earthquake-proof building design in the future. Legislation for other disasters needs to be updated and accurately implemented.

Related provisions of the Civil Code, Law of Obligations and Trade Law shall be reviewed as regards construction controls, responsibilities and insurances, and necessary legal arrangements shall be made to this end.

The Law on the Measures and Assistance in Natural Disasters Affecting Life which considers the state as a natural insurer covering all damages incurred shall be amended to cover only the cases which are impossible to be insured, thus public liability shall be limited.

A national disaster information system shall be established through which cooperation with institutions in the other countries and international bodies shall be possible.

A national disaster communication system that would provide continuous service during the disaster shall be established."

(3) Disaster Law (Law No. 7269)

A "law on the measures to be taken and assistance to be directed due to disaster having influence on social life," or so called "Disaster Law," was issued in 1959 as a fundamental law in dealing with disasters, and was later amended in 1968. The contents and relevant articles are shown in Table 3.2.6.

The main scope of this law is to provide public intervention capacity and to improve the efficiency of relief operations after disasters such as earthquakes, fires, floods, erosions, rockslides, avalanches, etc.

For this purpose, the law entitles extraordinary powers for provincial and district governors, making them the sole authority with powers commanding all public, private, and even military resources to manage response activities.

Each governor is responsible for drawing a relief operation plan to become effective immediately after a disaster. The relevant ministries, provincial administrations, and sub-districts are required to draw up their own emergency preparedness plans.

A disaster fund is allocated annually from the national budget for all recovery expenses.

Table 3.2.6 Contents of the Disaster Law (No. 7269)

Articles	Titles
1-5	General Principles
6	Extraordinary Powers Granted to Civil Servants
7-11	Liabilities
12	Compensation, Bonus and Advance Payments
13-15	Technical Operations at the Disaster Areas
16	Moving a Community Present at Disaster Areas to Other Places
17-32	Valuation, Division and Distribution
33-46	Fund Creation and Assistance through Fund and Forms of Spendin
47-49	Penal Provisions
50-53	Miscellaneous Provisions

Following are seven by-laws prepared in association with the Disaster Law:

- Regulations concerning the fundamentals of emergency aid organisation and planning associated with disasters
- Regulations concerning the basic principles of determining the degree by which the general public is affected by disasters
- Regulations concerning the identification of disaster affected individuals
- Regulations concerning the remissions of loaned sums for expenditure in connection with buildings to be built as a consequence of disasters
- Regulations concerning the valuation of leftover buildings, lots, and lands appropriated after disasters
- Regulations concerning the expenditures from the disasters fund established in accordance with Law No. 7269-1051
- Regulations for structures to be built in disaster areas

(4) Regulations Concerning the Fundamentals of Emergency Aid Organisation and Planning Associated with Disasters (Decree No. 88-12777)

As one of the by-laws pursuant to Article 4 of the Disaster Law, this regulation was established in 1988 by the Ministry of Public Works and Settlements. The contents of the regulations are shown in Table 3.2.7.

The object of these regulations is to define the formation and duties of emergency aid organisations by effectively planning the facilities and resources of the State before natural disasters occur to ensure that, in case of a natural disaster, the State gets fastest access to natural disaster areas and survivors get efficient first aid..

Provincial and district governors are entitled with the most responsibility and given extraordinary power to seize men, vehicles, land, and properties in the event of a disaster.

These regulations stipulate that the Provincial Emergency Aid Committee be formed under the governor and that the Permanent Provincial Disaster Office be established under the Provincial Directorates of the Ministry of Public Works and Settlements.

The Provincial Disaster Office is composed of nine service groups and associated sub-service groups, formed by various public organisations. The service groups will work for the victims from the beginning of the disaster up to 15 days, though the termination date of the services may be extended.

The regulation also stipulates that district governments set up district emergency aid committees including the district mayor and formed under the district governor, and to form district emergency aid service groups and provide services which are similar to or reduced in scale to the provincial ones.

Table 3.2.7 Contents of the Regulations Concerning the Fundamentals of Emergency Aid Organisation and Planning Associated with Disasters

Part	Contents		Article
1	GENERAL PRINCIPLES		1-5
2	EXTRAORDINARY POWERS AND OBLIGATIONS		7-9
3	GENERAL PRINCIPLES OF PLANNING PROMPT ASSISTANCE		10-13
4	PROVINCIAL AND DISTRICT PROMPT ASSISTANCE ORGANISATION AND DUTIES		
	1	PROVINCIAL PROMPT ASSISTANCE ORGANISATION AND DUTIES	14-45
	2	ORGANISATION AND DUTIES OF DISTRICT PROMPT ASSISTANCE	46-48
5	ASKING FOR HELP		49-50
6	CENTRAL PLANNING AND COORDINATION		51-53
7	DUTIES OF PRIME-MINISTRY, DEPARTMENT OF GENERAL STAFF, MEMBER MINISTRIES OF THE CENTRAL COORDINATION BOARD OF DISASTERS AND THE RED CRESCENT		54-69
8	MISCELLANEOUS		70-76

(5) Regulations for Structures to Be Built in Disaster Areas

Seismic regulations in Turkey are developed in conjunction with a nation-wide zone map and associated codes. The first seismic regulation in Turkey was developed in 1944 with two zones, motivated by severe damage due to the 1939 Erzincan earthquake that killed more than 30,000 people. The national zone map has been revised three times since then. Changes are associated with increment of zones, increment in fundamental base shear coefficient, and inclusion of more coefficients such as structural type, ground type, spectral, and importance, as shown in Table 3.2.8.

The current seismic building code, "Regulations for Structures to Be Built in Disaster Areas," was established by the Ministry of Public Works and Settlements as another by-law in pursuant to the Disaster Law.

The latest revision of the seismic zone map was made in 1996. In the previous 1972 map, the boundary of each zone was made based on observed ground motions. However, in the new map, the boundary of each zone is based on calculations of the maximum effective acceleration for a return period of 475 years.

Figure 3.2.2 shows the latest 1996 revision of the national seismic zone map. Because of the existence of North Anatolian fault, the highest risk area (zone I) extends in the east-west direction in Turkey. According to the map, the southeastern part of the Istanbul Province on the Asian side is located in one I, while most of the European side of the province is located from zone II to zone IV.

Table 3.2.8 Development of Seismic Regulation in Turkey

Year	Event	Fundamental base shear coefficient	Structural coefficient	Ground type coefficient	Spectral coefficient	Importance coefficient
1939	Erzincan earthquake					
1944	First seismic regulation Zone I-II	Zone I 0.02-0.04 Zone II 0.01-0.03				
1949	Code revision	Editorial change in zone division				
1953	Code revision	Editorial change in zone division				
1961	Code revision	Story shear coefficient and regional coefficient	Coefficient by ground and structural type introduced			
1963	**Zone map revision Zone I-IV**					
1968	Code revision	Zone I 0.06, Zone II 0.04, Zone III 0.02, Zone IV 0		Introduced	Introduced	Introduced
1972	**Zone map revision Zone I-V**					
1975	Code revision		Introduced	Ground type and spectral coefficient introduced		Same
1996	**Zone map revision**					
1998	Code revision	Zone I 0.4, Zone II 0.3, Zone III 0.2, Zone IV 0.1, Zone V 0	Revised	Ground type and spectral coefficient revised		Revised

Source: Kobayashi, K. et al. (2001)

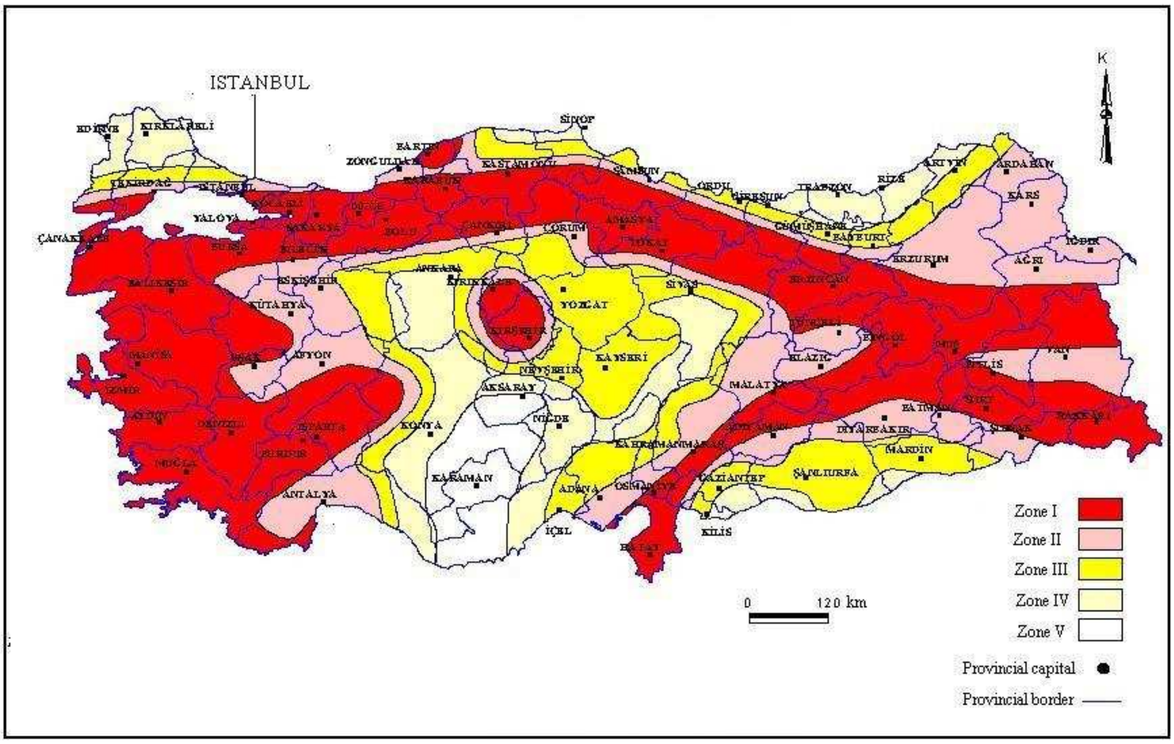


Figure 3.2.2 National Seismic Zone Map as Revised in 1996

Source: Ministry of Public Works and Settlements (www.deprem.gov.tr)

(6) Civil Defence Act (No. 7126)

Civil Defence Act (No. 7126) was issued in 1959 and serves as a legal basis of present civil defence. This act entitles civil defence with rescue work authority. Organisations that operate rescue activities must have a protocol with civil defence.

(7) Laws Related to Fire Brigade

Services of the fire department and control of hazardous facilities are defined as duties of municipality, as defined in the Municipality Act, and in Metropolitan Municipality Act. In addition, there are 30 laws, rules and regulations in total that are concerned with fire, though special fire laws do not exist.

(8) Laws Related to Compulsory Earthquake Insurance

Following are a set of decrees related to earthquake insurance that were issued after the 1999 Marmara Earthquake (Polat Gulkan, 2001):

a. Compulsory Earthquake Insurance (Decree No. 587)

Compulsory earthquake insurance was issued as an act on December 27, 1999. All existing and future privately owned property is required to contribute to the Turkish Catastrophe Insurance Pool (TCIP). Non-engineered rural housing and fully commercial buildings are excluded. The intention of this decree is to create a fund contributed to by homeowners' annual payments for use in disasters so that no one will be left homeless, with a nominal sum, currently capped at US$28,000, being disbursed immediately to homeowners who are left homeless.

An important feature of this decree is its denial of assistance in accordance with the Disasters Law No. 7269 when homeowners have not participated in the TCIP. This article became operational in March 2001. A number of penalty clauses, missing from the original text, have been added when the draft law was forwarded by the Undersecretariat of the Treasury to parliament.

b. General Conditions for Compulsory Earthquake Insurance (September 8, 2000)

Issued by the Undersecretariat of the Treasury, this directive regulates the manner in which insured parties shall make claims for losses against the Natural Disasters Insurance Council ("DASK" is the Turkish abbreviation). The amount payable by DASK essentially covers the minimum amount required for a modest new accommodation. Homeowners can, of course, purchase additional voluntary insurance if their property is worth more. However, for additional coverage to be purchased, the compulsory insurance policy must be presented to the insurer. TCIP coverage is for property only and does not extend to contents or life.

TCIP is insurance, not compensation. This means that payments will be proportional to actual losses, i.e. an indemnification will occur. TCIP is a policy that specifically covers the earthquake peril. Damage due to fires, explosions and/or landslides triggered by an earthquake is also automatically covered. Homeowners may purchase additional voluntary insurance for their property if they so wish.

c. Tariff and Instructions for Compulsory Earthquake Insurance (September 8, 2000)

While, for 2000, the limiting compensation equals 20 billion TL (approximately US$28,000), premiums are differentiated based on location with respect to the earthquake zone map and on type of construction. The premium for the highest risk buildings such as non-reinforced masonry is rated at 0.5 percent of the assessed value, which cannot exceed 20 billion TL. For a reinforced concrete building, the premiums are set at 0.2 percent. On this basis, the premium for a regular, reinforced concrete building in the highest hazard zone will be about US$50 per year. While this sum is not unaffordable, annual property tax for many homes is less than this amount. This is because no property value assessment is made, but homeowners declare what they believe is the taxable value of their property. While sale prices for homes substantially exceed their declared value for taxation purposes, this discrepancy is not noted. DASK will utilise the existing sales network of the insurance companies doing business in Turkey. The commission to be paid to these companies is 12.5 percent of the premiums. Even so many insurance agencies are reluctant to collect premiums for DASK because it is incumbent upon them to notify homeowners when renewal is due. They claim that the expenses for notification that must be forwarded through a public notary are exorbitant. DASK is currently considering a differentiated commissions structure for less seismically hazardous areas in order to achieve higher rates of penetration there. Table 3.2.9 shows the basic TCIP premium structure.

Table 3.2.9 Tariff for TCIP Premiums (Percent of Insured value)

Type of Construction	Unit Cost (US$/m2)	I	II	III	IV	V
Steel or Reinforced. Concrete	220	0.20	0.14	0.08	0.05	0.04
Masonry	150	0.35	0.25	0.13	0.05	0.04
Other	75	0.50	0.32	0.16	0.07	0.05

Source: Polat Gulkan (2001)

Reference for Section 3.2

Hirayama, Y., 2001, Housing and Urban Reconstruction, Report on the Damage Investigation of the 1999 Kocaeli Earthquake in Turkey, Architectural Institute of Japan, Japan Society of Civil Engineers, The Japanese Geotechnical Society, pp. 410-419

Kobayashi, K., Nagano, T., and Kobayashi, J., 2001, Earthquake Resistant Design Code of Turkey, Report on the Damage Investigation of the 1999 Kocaeli Earthquake in Turkey, Architectural Institute of Japan, Japan Society of Civil Engineers, The Japanese Geotehnical Society, pp. 439-451

Law on the Measures to be Taken and Assistance to be Directed due to Disaster Having Influence on Social Life, 1959, Law No. 7269, Published in the Official Gazette of: 25/5/1959 No. 10213

Polat Gulkan, 2000, Code Enforcement at Municipal Level in Turkey: Failure of Public Policy for Effective Building Hazard Mitigation, Proceedings of the 6th International Conference on Seismic Zoning, Earthquake Engineering Research Institute, No. 21

Polat Gulkan, 2001, Rebuilding the Sea of Marmara Region: Recent Structural Revisions in Turkey to Mitigate Disasters, Issues Paper for a Wharton-World Bank Conference on Challenges in Managing Catastrophic Risks: Lessons for the the US and Emerging Economies

Reconstruction Act, 1985, Act No. 3194, Published in the Official Gazette of 9/5/1985, No. 18749

Regulations Concerning the Fundamentals of Emergency Aid Organization and Planning Associated with Disasters, 1988, Decree No 88/12777, Published in the Official Gazette of 8/5/1988, No. 19808

Regulations for Structures to be Built in Disaster Areas, 1997, Published in the Official Gazette No.23098

State Planning Office, 2001, Long-Term strategy and Eight Five-Year Development Plan 2001-2005, Decision No. 697

Istanbul Fire Department, 2001, Fire and Fire Brigade Legislation

The Constitution of the Republic of Turkey, 1982, Turkish National Grand Assembly, Published in the Official Gazette of 9/11/1982, No. 17863

3.3. Institutional System Related to Disaster Management in Turkey

3.3.1. Administrative Structure

(1) Organisation in Central Government

The Government of the Republic of Turkey functions according to the provisions of the 1982 Constitution. The government is divided into legislative, executive, and judicial establishments as illustrated in Figure 3.3.1.

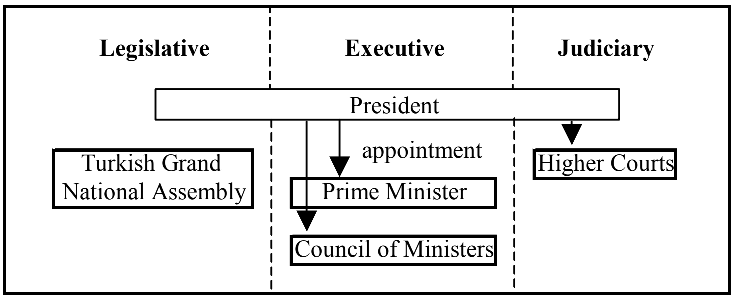


Figure 3.3.1 Central Administration Establishment in Turkey

a. Legislature

Legislative authority is vested in the Turkish Grand National Assembly (TGNA). The TGNA is composed of 550 deputies. Parliamentary elections are held every five years. Deputies represent the entire nation and, before assuming office, take an oath, the text of which is included in the Constitution.

The duties and authority of the TGNA are outlined as follows:

- To adopt, amend and abrogate laws
- To supervise the Council of Ministers and ministers
- To give authority to the Council of Ministers to pass decrees with the power of law
- To adopt the budget and final account draft laws
- To ratify the printing or minting of currency
- To make decisions for declaring war, martial law or emergency rule, to approve the signing of international agreements
- To make decisions for declaring general or special amnesties

b. Executive

The executive branch in Turkey has a dual structure. It is composed of the President of the Republic and the Council of Ministers.

President

The president, who is the head of state, represents the Republic of Turkey and the unity of the Turkish Nation. The president oversees the workings of the constitution and ensures that the organs of the state function in an orderly and harmonious manner. He is elected for a one-time term of seven years either from among the members of the TGNA or from among those who are Turkish citizens of over 40 years of age and eligible to be elected to the TGNA, from among persons who have completed standard education.

The duties and authority of the president with respect to legislation are:

- In the event that he deems it necessary, to deliver the opening speech on the first day of the legislative year
- To summon the Turkish Grand National Assembly to session
- To publish laws
- To return laws to the assembly for reconsideration
- If he deems it necessary, to present laws related to changes in the Constitution to public referendums
- Should the whole or some of the provisions of laws, decrees with the power of law or Grand National Assembly internal regulations be considered to be in violation of the terms of the Constitution in term or in content, to file a suit with the Constitutional Court for the repeal of such laws, decrees or regulations,
- To decide upon renewal of parliamentary elections

The duties and authorities of the president in the exercise of executive power are:

- To appoint the prime minister or to accept his resignation
- Upon the recommendation of the prime minister, to appoint or remove ministers to and from office
- In the event that he deems this necessary, to chair the meeting of the Council of Ministers, or to summon the council to meet under his chairmanship
- To appoint accredited envoys to represent the Turkish State in foreign countries and to receive the representatives of foreign states to the Republic of Turkey
- To ratify and publish international agreements
- To represent the Commander-in-chief of the Turkish Armed Forces on behalf of the Turkish Grand National Assembly
- To decide upon the use of the Turkish Armed Forces
- To appoint the chief of general staff
- To summon the National Security Council to convene and to chair the meetings of the council
- To proclaim martial law or impose state of emergency by decree to be decided by the Council of Ministers meeting under his Chairmanship, and to issue decrees with the Power of Law
- To approve decrees as signatory

- To commute or pardon the sentences of certain convicts on the grounds of old age, chronic illness or infirmity
- To appoint the members and president of the State Auditory Council
- To conduct investigations, inquiries and research through the State Auditory Council
- To select the members of the Higher Education Council
- To appoint university chancellors

Duties and authority of the president related to the Judiciary are:

- Appointing the members of the Constitutional Court, one fourth of the members of the Council of State, the Chief and Deputy Chief Public Prosecutor of the Supreme Court of Appeals, the members of the Supreme Military Tribunal of Appeals, the members of the Supreme Military Administrative Tribunal and the members of the Supreme Council of Judges and Public Prosecutors.

All decrees, with the exception of those with which the president is specifically empowered by the constitution or by other laws to sign singly without need for the co-signature of the prime minister and the related minister. The prime minister and the related minister shall be held accountable for these decrees.

No appeal may be made to any legal body, including the Constitutional Court, against the decrees and presidential orders signed directly by the President of the Republic.

Prime Minister and the Council of Ministers

The prime minister is responsible for ensuring the Council of Ministers functions in a harmonious manner. He/she supervises implementation of government policy. The prime minister is the de facto head of the executive branch. Each minister is accountable to the prime minister, who in turn ensures that ministers fulfil their functions in accordance with the constitution and its laws.

The Council of Ministers consists of the prime minister, designated by the President of the Republic from members of the TGNA, and various ministers nominated by the prime minister and appointed by the President of the Republic. Ministers can be dismissed from their duties by the president or upon the proposal of the prime minister when deemed necessary.

When the Council of Ministers is formed, the government's program is read at the TGNA and a vote of confidence is taken. Members of the Council of Ministers are responsible for the execution of general policies. The ministers assume two kinds of political responsibilities. First is responsibility for the general policy of the government, shared equally by all ministers. Second, each minister is individually responsible for matters within the jurisdiction of his/her own ministry and for the acts of his/her subordinates.

The fundamental duty of the Council of Ministers is to formulate and to implement the internal and foreign policies of the state. The council is accountable to parliament in execution of this duty.

The constitution also includes national defence in the section related to the Council of Ministers. The Office of the Commander in Chief, the Office of the Chief of the General Staff and the National Security Council form the authoritative organisations for national defence.

Figure 3.3.2 shows the structure of the Prime Ministry Central Organisation. Providing general directorship of emergency management in Turkey is one of the main services assigned to the deputy undersecretary.

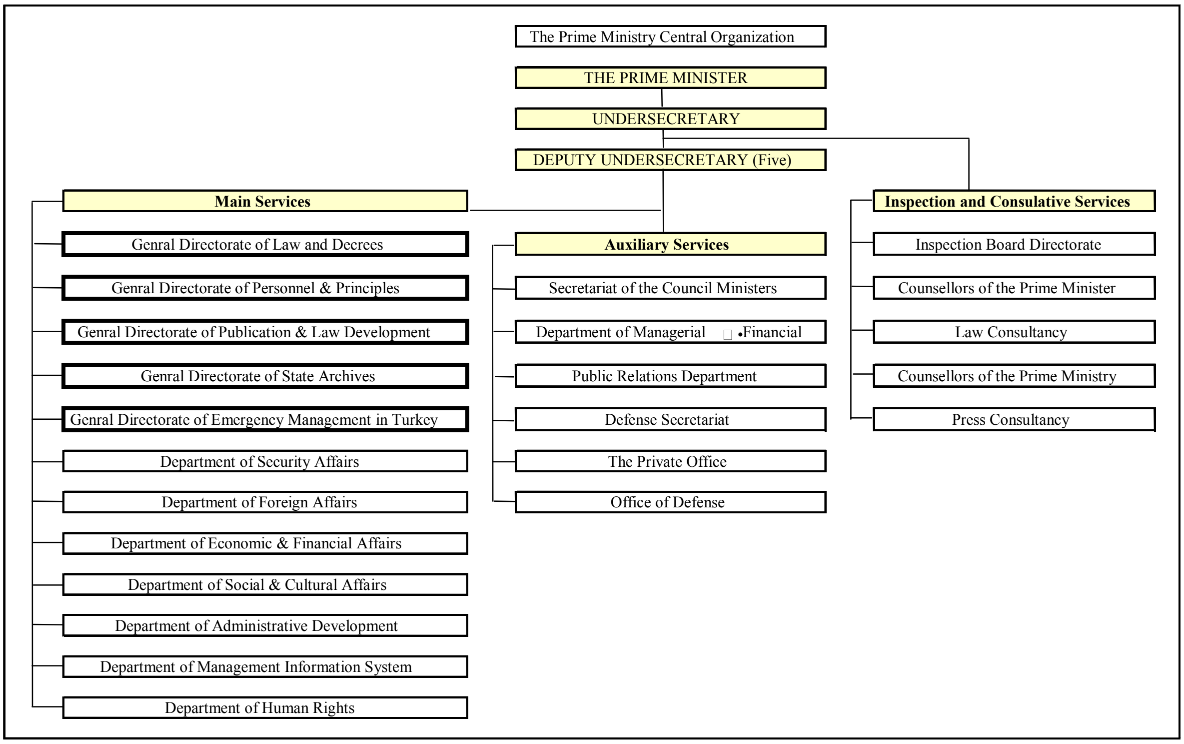


Figure 3.3.2 Organisation of the Prime Ministry Central Organisation

Source: Prime Ministry website (www.basbakanlik.gov.tr)

c. Judiciary

The judicial system in Turkey is independent of other state organizations; its autonomy is protected by the High Council of Judges and Public Prosecutors. Higher courts include the Constitutional Court, Council of State, Court of Jurisdictional Dispute, Court of Cassation, and the Military Court of Cassation. For the purpose of civil and criminal justice, the Court of Cassation serves as a supreme court.

The judicial section of the Constitution, with the principle of a legal state as its basis, is founded on the independence of the courts and the judges, and the guarantee of judges' rights. Judges rule on the basis of constitutional provisions, law, and jurisprudence.

The legislative and executive organs must comply with the rulings of the courts and may not change or delay the application of these rulings. Judges also assume the duties of monitoring elections.

Functionally, a tripartite judicial system has been adopted by the Constitution and, accordingly, it has been divided into an administrative judiciary, a legal judiciary and a special judiciary.

The Constitutional Court, the Supreme Court of Appeals, the Council of State, the Supreme Military Court of Appeals, the Supreme Military Administrative Court and the Court of Jurisdictional Conflicts are the supreme courts mentioned in the judicial section of the Constitution. The Supreme Council of Judges and Public Prosecutors and the Supreme Council of Public Accounts are two organisations that also have special functions in the judicial section of the Constitution.

(2) Organisation of the Provincial Government

Currently, the Republic of Turkey is divided into 81 provinces. Each province is further subdivided into districts, and each district is segmented into sub-districts.

The 1982 Constitution retains Turkey's centralised administrative system. Each province is administered by a governor appointed by the Council of Ministers with the approval of the President. The governors function as the principal agents of the central government and report to the Ministry of Interior. The structure of the local government in relation to the central government is illustrated in Figure 3.3.3.

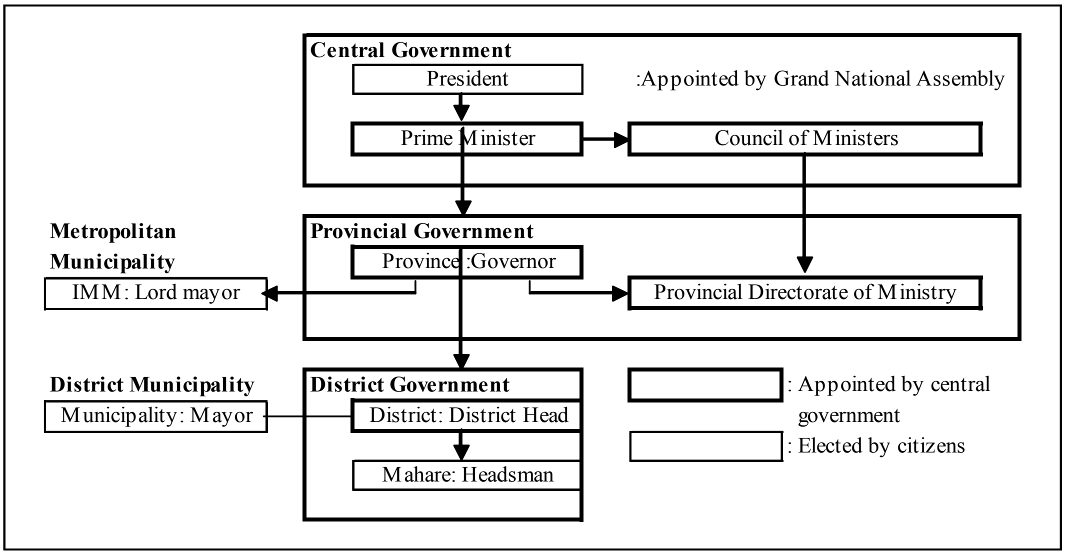


Figure 3.3.3 Structure of Central and Provincial Governments

Provincial Governor

The provincial governor, the representative of the central administration, is also the head of the provincial local administration and its chief executive. The governor usually acts in line with the decisions made by the Provincial General Assembly.

The Provincial General Assembly, the most authoritative body of the organisation, consists of members elected for a term of four years. Meeting every year for forty days under the governor, it approves the provincial budget and makes decisions regarding the institutional services of the province.

As chief executive of the province and principal agent of the central government, each governor supervises other government officials assigned to carry out ministerial functions in his or her province. Civil servants head offices of the national government that deal with education, finance, health, and agriculture at the provincial level. In each province, these directors form the Provincial Administrative Council, which, with the governor as chair, makes key administrative decisions and, when necessary, initiates disciplinary actions against errant provincial employees.

The governor also heads the Provincial Assembly, several service departments concerned mainly with local trade, and industrial matters.

Provincial General Assembly

The Provincial General Assembly, which advises and works closely with the Provincial Administrative Council, is elected every five years. The Provincial Assembly, with the governor chairing, meets annually to approve the provincial budget and to select one person from each district to serve on the province's administrative commission. With the governor presiding, the administrative commission meets weekly for mutual consultation. Provincial budgets derive their income from rents, payments for services, fines, state aid, and 1 percent share of national tax revenues.

Members of the Provincial General Assembly are elected by the proportional representation system, if their parties receive at least 10 percent of the votes. Each district forms an electoral zone for elections to the Provincial General Assembly.

Provincial Council

The provincial council, composed of four members elected for a term of one year by the Provincial General Assembly from among its own members, reviews and approves fiscal matters, informs the Provincial General Assembly of the state of affairs of the organization and submits to the mayor, upon his request, its views related to local administration operations.

Functions

The provincial government is responsible for implementing national programs for health and social assistance, public works, culture and education, agriculture and animal husbandry, and economic and commercial matters.

The constitution stipulates that the central administration oversee elected local councils in order to ensure the effective provision of local services and to safeguard the public interest. The minister of the interior is empowered to remove from office local administrators who are being investigated or prosecuted for offences related to their duties.

(3) Organisation of the District Government

District Head

Each district in a province has its own administration based in the district seat. The district administration consists of a district head, central government representatives, and a district administrative board. The more than 500 district heads are appointed by the president upon nomination by the minister of the interior.

Each district head is reports to the governor, serving essentially as his or her agent in supervising and inspecting the activities of government officials in the district. The district in which a provincial capital is located may not have a district head but instead be headed directly by the governor.

(4) Organisation of the Mahalle

The smallest unit of local government in Turkey is the Mahalle. The principal authority of the Mahalle is the headman chosen by an assembly of all the village's adults. This informal assembly also makes decisions pertaining to village affairs and elects a council of elders that includes the village schoolteacher and the imam.

The headman supervises the planning and operation of communal projects and services and administers directives from higher authorities. The headman receives government officials, maintains order, collects taxes, and presides at civil ceremonies.

The Village Assembly supervises village finances, purchases or expropriates land for schools and other communal buildings, and decides on the contributions in labour and money to be made by villagers for road maintenance and other community improvements. The Village Assembly also arbitrates disputes between villagers and imposes fines on those who fail to perform the services allotted to them.

(5) Organisation of theDistrict Municipality

Each provincial capital, district centre, and town with more than 2,000 populations is organised as a municipality headed by an elected mayor. All municipalities are public corporate entities. Municipalities are required to meet the common regional and civic needs of the region and the regional populace.

Mayor

The mayor is the chief executive and representative of the municipality. The mayor is elected for a term of five years. Deputy mayors, department heads and branch directors assist the mayor in the performance of municipal duties.

In big cities, where there is more than one district within municipal borders, the electoral zone for the election of the mayor of the metropolitan municipality is restricted by the municipal borders of the metropolis. Each district elects its own mayor and municipal assembly members.

Municipal Assembly

The municipal administration comprises an assembly and a mayor. The Municipal Assembly, elected by popular vote by simple majority, varies in size with the population. Municipal elections are held every five years. Holding three regular meetings every year, the assembly approves the annual budget of the municipality, plans, projects related to public works and city planning and determines taxes, rates of duties, fees and tariffs of various sorts.

A variety of municipal standing committees appointed by the mayor and municipal department directors, or selected by municipal assembly members from among them, deal with financial issues and decide on the appointment and promotion of municipal personnel.

Municipal Assemblies, also elected for five years by the proportional representation system, vary in size according to each town's population. Municipal Assemblies meet three times a year to decide on such issues as the budget, housing plans, reconstruction programs, tax rates, and fees for municipal services.

The Municipal Assembly consists of the mayor, the heads of the municipal departments and members elected by the Municipal Assembly from among its own members. It prepares transport tariffs and fees, sets commodity prices, determines municipal fines, checks budgets and decides on the hiring, firing and promotion of city employees.

Function

Municipalities and villages located near big cities and with populations greater than 300,000 according to the the last census may be attached to the metropolitan municipality so that basic municipal services can be carried out in an adequate and efficient manner and under complementary plans. The distance between the metropolitan municipality and the municipality or village to be attached, as well as the feasibility of combining the services, should be taken into consideration during the course of the attachment process.

Municipal governments are responsible for implementing national programs for health and social assistance, public works, education, and transportation and are authorised to carry out the following:

- To impose and enforce rules and municipal prohibitions prescribed by law
- To punish those who violate the prohibitions
- To collect municipal taxes, duties, and fees
- To set up drinking water, gas, electricity and transport facilities and networks or transfer their operational rights
- To run transport vehicles within municipal borders
- Urban planning and implementation, mapping, regulating construction, and the issuing of construction permits
- Land development and the opening up of new settlement areas
- Urban renewal
- Planning and construction of social housing

- Organisation and management of mass transportation systems, passenger and freight terminals and parking lots
- Construction and maintenance of parks and the other green areas
- Construction and maintenance of urban roadways, public squares and bridges
- Provision of water, sewerage and public utility gas services
- Garbage collection and disposal, cleansing of public spaces
- Provision of fire-prevention and fire-fighting services
- Establishment and operation of slaughterhouses and wholesale facilities
- Establishment and management of recreational, sports, and cultural facilities
- Provision of veterinary services
- Establishment and management of health and social welfare facilities such as hospitals, nurseries, dormitories, orphanages, and convalescent homes, etc.
- Municipal policing
- Regulation of industrial waste with regard to environmental pollution
- Protection and conservation of areas of natural and historical value and of coastlines
- Nuptial services
- Vocational training
- Helping and supporting the poor, handicapped, etc.

(6) Organisation of the Metropolitan Municipality

Lord Mayor

Figure 3.3.4 shows the organisational structure of the Istanbul Metropolitan Municipality. The lord mayor is popularly elected every five years. He is the chief executive and coordinator for the metropolitan area and represents the metropolitan government. He has the power of veto over all decisions made either by the Metropolitan Assembly or by the District Municipal Assemblies, which may override this veto with a two-thirds majority vote.

Metropolitan Assembly

The assembly is the ultimate decision-making organization of this body. It is composed of one-fifth of the members of district and lower-tier municipalities within the metropolitan boundaries who have had the most number of votes, as well as the mayors of these municipalities. The assembly is chaired by the lord mayor. The term of office for assembly members is five years.

In addition to carrying out its own duties, the Metropolitan Assembly has the power to discuss and approve some of the decisions of district municipalities.. For example, the district budgets accepted by the district municipalities are discussed and may be amended by the Metropolitan Assembly in order to ensure integrity between investments and services. It may also make executive and regulatory decisions that provide solidarity, unity and conformity amongst the overall integrity of the metropolis in services carried out by district municipalities.

Important functions of the Municipal Assembly are:

- Reviewing and controlling the award of contracts
- Approving the use of reserves to cover un expected expenses
- Setting of fare prices for municipality transport

Metropolitan Executive Board

The Metropolitan Executive Board is both an organ of decision making and execution and an advisory body of the municipality. There is no elected member on the board other than the mayor. The board, headed either by the mayor or by someone to be assigned by the mayor, is made up of the secretary general and the heads of the units of construction, public works, legal affairs and accounting, and personnel.

Because there no specific regulations in Law No. 3030 exist concerning the meeting,working principles, and duties of the board, the principles determined by Law No. 1580 for other municipal executive committees prevail.

Services

The total number of officers and workers serving the Municipality of Metropolitan Istanbul is 13,235 (as of 20/1/2000), with workers representing 60% of the total personnel and officers representing 40% of the total. There are four units where the number of personnel exceeds 1,000. These are theCentral Fire Brigade 2000, Directorate of Road Repair and Maintenance 1269, Municipal Police 1166, and Social Administrative Affairs 1134.

Municipal services other than those which were exclusively given to the metropolitan municipalities are rendered by district municipalities, or both metropolitan municipalities and district municipalities.

In this context, the responsibilities of metropolitan municipalities can be summarized as follows:

- Drawing up city master plans
- Approving the applications of master plans drawn up by district municipalities and to supervise their implementation
- Building and operating major infrastructure installations such as water and sewage systems, waste water and solid waste treatment plants, and gas and central heating systems
- Selection of solid waste disposal sites

- Construction and maintenance of major roads, bridges, squares, etc.
- Completion of city-scale projects
- Development of major parks
- Building and operation of passenger and freight terminals
- Location, construction and operation of cemeteries
- Naming and numbering of all public thoroughfares
- Construction and operation of wholesale markets and slaughterhouses
- Operation and coordination of municipal police and fire services
- Implementation and coordination of city-scale joint ventures
- Dealing with other services beyond the capacity of district municipalities
- Coordinating and controlling the activities of municipalities within its boundaries
- Settling the conflicts among municipalities within their own boundaries

Municipality Companies

IMM has 23 companies, the majority of which are listed in Table 3.3.1, to provide essential public services to its citizens. The Municipal Companies Department is responsible for the daily administration and financial coordination of 21 companies. The IMM has a majority shareholding in 18 companies, all of whom provide essential services to the municipality, and it has a minority stake in three companies.

These companies cover a wide range of services such as supplying water, gas, bread, transportation, construction, etc. The total number of employees of these companies is more than 26,000. During the 1999 Marmara Earthquake, many of these individuals provided voluntary help to the victims in the disaster area.

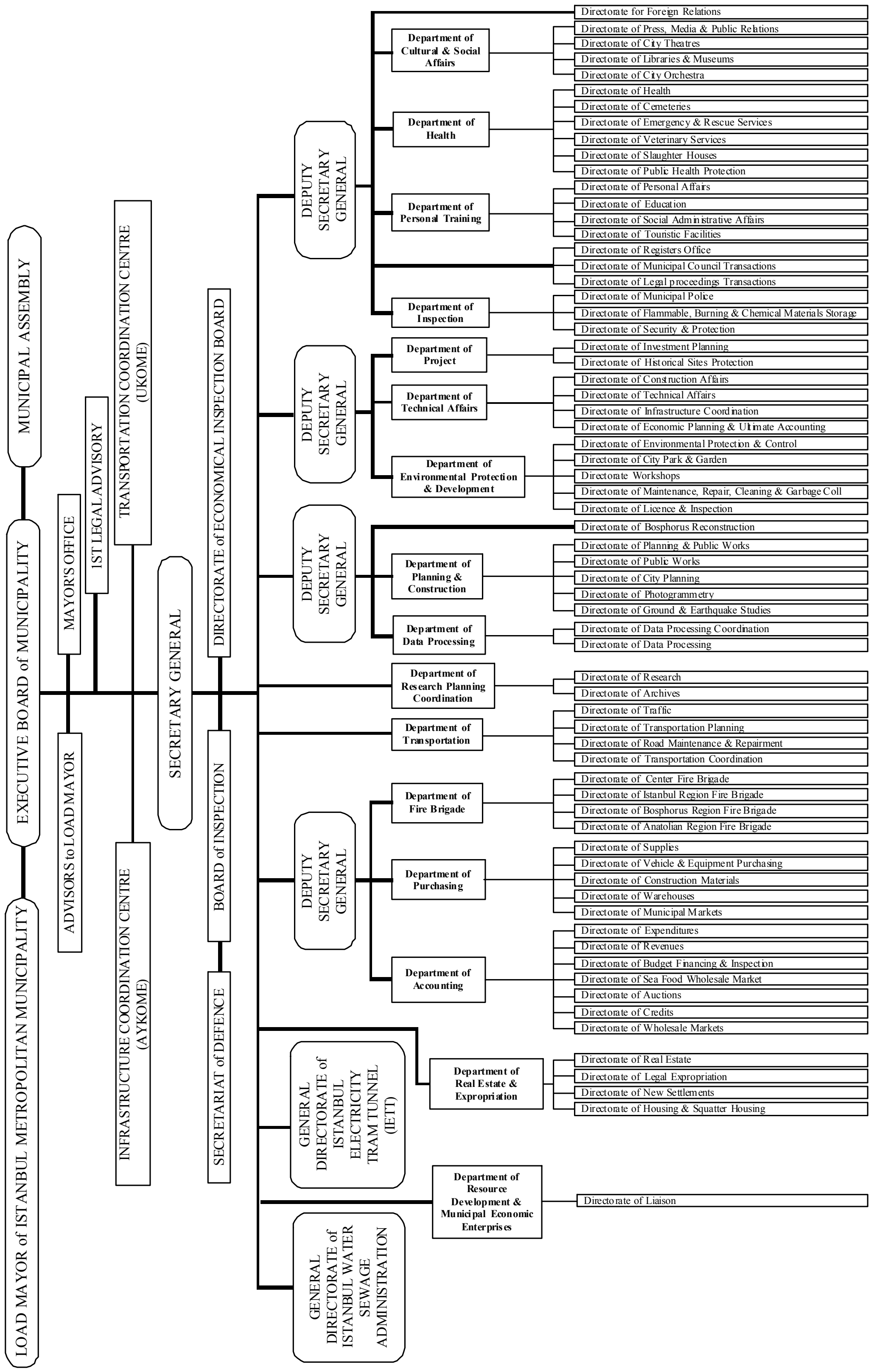


Figure 3.3.4 Organisational Structure of the Istanbul Metropolitan Municipality

Table 3.3.1 List of Public Service Companies in the IMM

Name of Company	Establish-ment	No. of Employees	Capital (Million USD)
Istanbul Bus Transportation Company (IETT)	N/A	8,068	N/A
Istanbul Water and Sewage Operation (ISKI)	N/A	7,306	N/A
Istanbul Transport Corporation (ULASIM)	1988	3,050	20.0
Istanbul Gas Distribution Corporation (IGDAS)	1986	2,677	340.0
The Istanbul “People’s Bread” Flour and Flour Products Corporation	1978	564	20.0
The Municipal Data Processing Corporation of Istanbul (BELBIM)	1987	552	2.0
Istanbul Sea Buses Corporation (IDO)	1987	550	40.0
Istanbul Cultural and Artistic Products Corporation (KULTUR)	1989	455	2.6
The Istanbul Environmental Protection and Waste Processing Corporation (ISTAC)	1994	432	8.7
Istanbul Asphalt Factories Corporation (ISFALT)	1986	366	1.2
The Istanbul Concrete Elements and Ready Made Concrete Mix Production Corporation (ISTON)	1986	358	6.0
Municipal Maintenance Corporation of Istanbul (ISBAK)	1986	352	4.0
Hamidiye Spring Water Corporation (HAMIDIYE)	1979	346	3.0
The Bosphorus Landscape, Construction, Consultancy, Technical Services and Tree Company (BIMTAS)	1997	276	1.4
Istanbul Sports Activities Company (SPOR)	1989	252	2.0
The Istanbul Homes Construction and Projecting Corporation (KIPTAS)	1995	210	22.0
Grand Istanbul Tourism and Health (BELTUR)	1996	190	3.0
The Istanbul Tree and Landscape Corporation (AGAC)	1998	111	3.0
Petroleum and Petroleum Products Company (BELPET)	1962	30	0.6
The Istanbul Health Enterprises Corporation (SAGLIK)	1998	22	18.0

Source: IMM website (www.ibb.gov.tr)

3.3.2. Disaster Management Organization

With the experience of two earthquakes in Turkey in 1999, many disaster management organisations were established at various levels, from prime ministry to municipality. The following describes the foundation, organisation and function of these organisations:

(1) Central Government

a. Prime Ministry Disaster Crisis Management Centre

The Prime Ministry Crisis Management Centre was established at the time of 1999 Marmara Earthquake to integrate the disaster response of the government. Later, the General Directorate of Emergency Management under the Prime Ministry was established as a permanent organisation to ensure efficiency in emergency management.

The activities of the general directorate are as follows:

- To establish emergency management centres within local governments, determine their principles and carry out inter-institutional coordination

- To carry out preliminary actions, make short- and long-term plans, monitor and evaluate databases in order to prevent and mitigate disasters
- To coordinate the utilisation of public and civilian vehicles and facilities in case of emergencies
- To promote volunteer efforts by organisations and individuals in emergencies
- To coordinate the procurement, warehousing and distribution of relief materials

b. Ministry of Public Works and Settlements

Motivated by frequent earthquakes in Turkey, the Ministry of Reconstruction and Resettlement was established in 1958. Its aims were to reduce the risk of death and injury to the population, and to reduce the scale of the economic risks. The name of the ministry has been changed to the current name through organisational restructuring.

General Directorate of Disaster Affairs

In the ministry, the General Directorate of Disaster Affairs is the organisation responsible isfor disaster management. In the directorate, the Earthquake Research Department has three sub-departments focusing on earthquake research.

- The Earthquake Engineering Department is responsible for providing the necessary measures for constructing earthquake-resistant structures and for providing and developing basic principles for the rehabilitation of structures damaged by earthquakes.
- The Seismology Division is responsible for the establishment, operation and development of the National Seismological Observation Network and for the monitoring of micro seismic activity to aid in earthquake prediction and to study aftershock activities.
- The Laboratory Division is in charge of carrying out international joint projects and is responsible for building and updating a GIS, which covers earthquakes and other data for the whole country. It also sets up and operates the strong motion recording stations covering the whole country.

Central Disaster Coordination Council

The Central Disaster Coordination Council is formed in case of a disaster as shown in Figure 3.3.5. However, since the prime ministry has established a crisis management centre that deals with administrative aspects, this ministry now mainly deals with technical aspects.

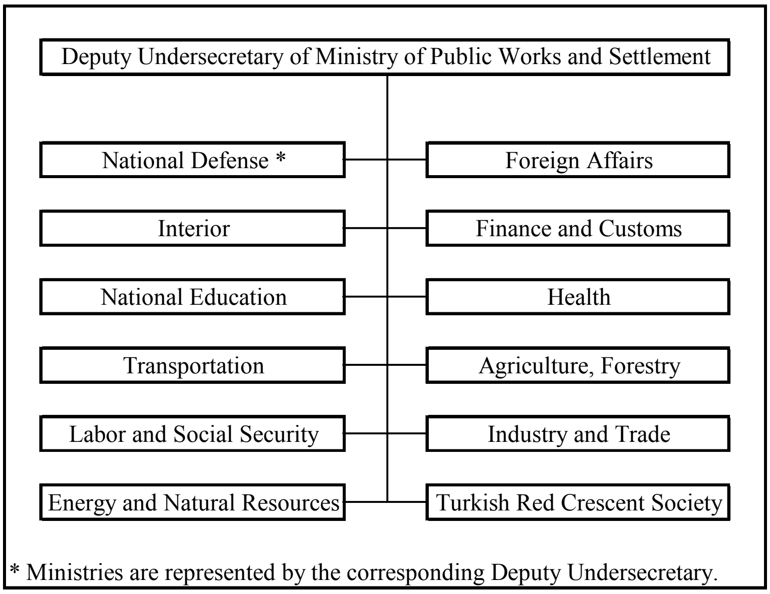


Figure 3.3.5 Organisation of the Central Disasters Coordination Council

Source: Oktay (1999)

c. Civil Defence

The Civil Defence was organised as apart of military in 1928. The current Civil Defence became an independent organisation with the "Civil Defence Act" of 1959. With the experience of major earthquakes, the Civil Defence has reinforced its rescue teams. The brief history of the National Civil Defence is summarised as in Table 3.3.2.

The Civil Defence is unarmed, protective, and involved in the development of rescue measures and activities. The General Directorate of Civil Defence has been carrying out these services under the auspices of the Ministry of Interior.

The organisation consists of both central and provincial bodies. The central organisation includes the General Directorate, Civil Defence College, and the Warning and Alarm Centres. Provincial organisations have been set up as Province and Town Civil Defence Directorates, Civil Defence Local Forces, and Civil Defence Search and Rescue Units Directorates.

In addition, every governmental organisation must have a civil defence section, for firefighting, rescue, first aid, and the security of each organisation. The head of the civil defence section in each organisation is appointed by the central government. The duties of the Civil Defence Directorate are as follows:

- To set up civil defence services nationwide and to ensure the planning application, coordination and supervision of measures taken by the public and private establishments

- To plan and execute all activities for unarmed, protective, and , emergency rescue and first aid
- To set the standards for fire departments, educate their staff, and supervise and coordinate their fire protection and prevention efforts
- To train civil defence staff and inform the public about the Civil Defence
- To manage civil defence funds
- To fulfill the Ministry's Defence Secretariat duty
- To perform other duties required by special laws

The goal and purpose of the Civil Defence Organisation is to minimise life loss and other types of losses during warfare or any natural disaster. The main purposes of the organisation are as follows:

- Securing the lives and assets of civilians during warfare
- Saving lives and assets of people during natural disasters
- Reducing the damage to the lives and the assets of victims in a fire
- In case of damage, renewing, repairing and protecting public and private institutes of vital importance
- Supporting every defence effort during time of warfare
- Raising the morale of civilians during time of warfare

Table 3.3.2 Development of the Civil Defence

Year	Event
1928	Organised under the supervision of the Turkish Armed Forces
1938	Passive Protection Law
1952	Turkey's entry into NATO, Civil Defence role re-examined
1959	Civil Defence Act
1983	**Erzurum earthquake**
1986	First civil defence unit was established in Ankara
1992	**Erzincan earthquake**
1993	Surplus soldiers and officers from civil defence oOrganisations were replaced byprofessionals in Ankara
1996	Two new civil defence units formed by professionals were also established in 1996 in Istanbul and Erzurum
1999	61 civil defence personnel in Ankara, 24 personnel in Istanbul, and 30 personnel in Erzurum
1999	**Marmara and Düzce Earthquake**
1999	Eight civil defence search and rescue units deployed in provinces (Adana, Afyon,Bursa, Diyarbakır, İzmir, Sakarya, Samsun and Van). Civil defence teams have also been established in all provinces where civil defence units were not established.

Source: Civil Defence General Directorate website (www.ssgm.gov.tr)

d. Turkish Red Crescent

The International Federation of Red Cross and Red Crescent Societies was founded in 1919, and it comprises 176 members (making up the world's largest humanitarian organisation). The international federation provides assistance without discrimination as to nationality, race, religious beliefs, class or political opinions. The federation's secretariat is located in Geneva and more than 60 delegations are strategically located worldwide to support activities around the world.

The federation's mission is to improve the lives of vulnerable people by mobilising the power of humanity. Vulnerable people are those who are at greatest risk from situations that threaten their survival, or their capacity to live with an acceptable level of social and economic security and human dignity.

The federation carries out relief operations to assist victims of disasters, and combines this with development work to strengthen the capacities of its member National Societies. The federation's work focuses on four core areas: promoting humanitarian values, disaster response, disaster preparedness, and health and community care.

The Turkish Red Crescent Society is a member society of the international federation. The Turkish Red Crescent Society was founded on the 11th of June, 1868, under the name "Society for Helping Sick and Wounded Ottoman Soldiers. "It was rebaptised as the "Ottoman Red Crescent Society" on the 14 of June, 1877, the "Turkish Red Crescent Union" in 1923, the "Turkish Red Crescent Association" in 1935, and the "Turkish Red Crescent Society" in 1947.

The Turkish Red Crescent has a fund source independent of the government. Planning of the Turkish Red Crescent is centralised under the Ankara Planning Directorate, which plans the distribution of food and tents. There are 600 branches in Turkey covering every province. The Turkish Red Crescent Society's services are relief services, youth services, blood services and health services.

e. Natural Disasters Insurance Council

As earthquake insurance became obligatory for building owners in urban areas on March 27, 2001, management of the insurance pool is entrusted to a new entity called the "Natural Disasters Insurance Council" (DASK), under the General Directorate of Insurance in the Ministry of the Treasury. The model of the pool management was patterned after exhaustive examinations of New Zealand's Earthquake Commission (EQC) and the California Earthquake Authority (CEA).

In effect, DASK is different from both these public institutions. DASK is governed by a seven-man board whose members are of mixed public and private background. It has no staff of its own and outsources all of its requirements. Milli Re, the largest private reinsurer in Turkey, has been retained as the "operational manager" for five years. Of the 40 non-life insurance companies in Turkey, 34 have agreed to sell Turkish Catastrophe Insurance Pool policies.

(2) Provincial Government

Provincial Rescue and Relief Committee

On February 1999, before the Marmara Earthquake, the Istanbul Governorship had established a provincial disaster relief committee and execution groups, according to regulation, as shown in Figure 3.3.6.

The committee is the decision-making body chaired by the governor. Nine provincial emergency service groups were formed for the execution of emergency response efforts in different categories of service.

Governorship Disaster Management Centre (AYM)

The Istanbul provincial governorship established the Disaster Management Centre (AYM in Turkish abbreviation) as the organisation for integrated disaster management, by the order of president just after the 1999 Marmara Earthquake.

The Disaster Management Centre consists of the council, the scientific consultancy committee, the administrative board, and the management office as shown in Figure 3.3.7. Under normal conditions, it aims to promote and coordinate disaster preparedness of concerned organisations, and it will be shifted to the Provincial Disaster Management Centre in case of crises.

In addition, in case of a major disaster that affecting several provinces, a Regional Disaster Management Centre is established under the MPWH.

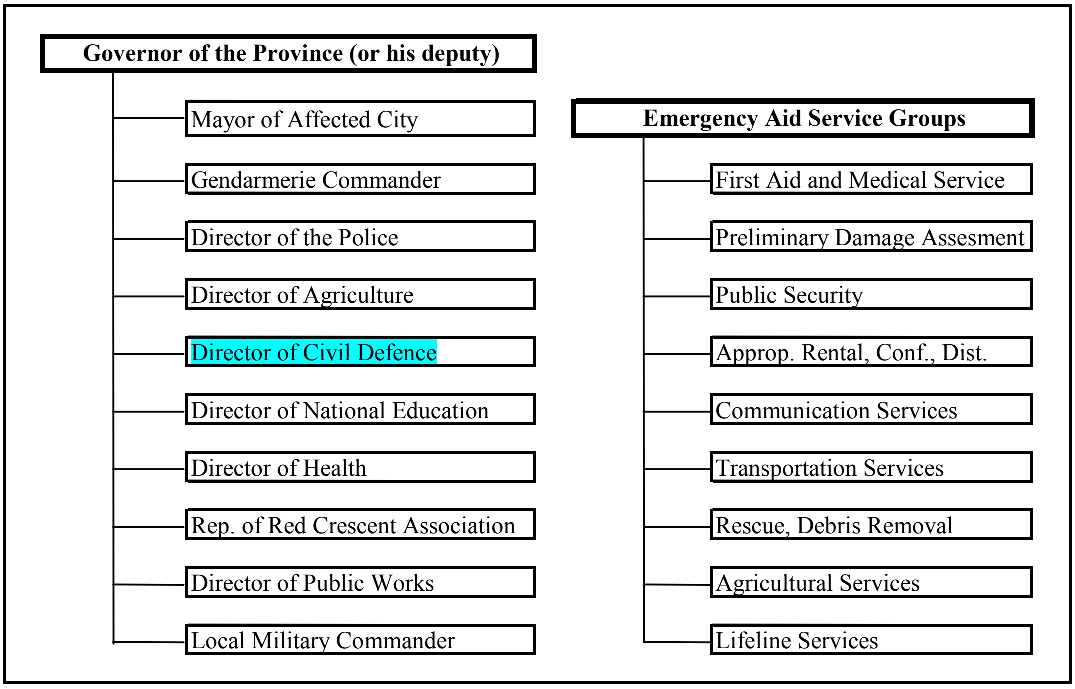


Figure 3.3.6 Organisation of the Provincial Rescue and Relief Committee

Source: Oktay (1999)

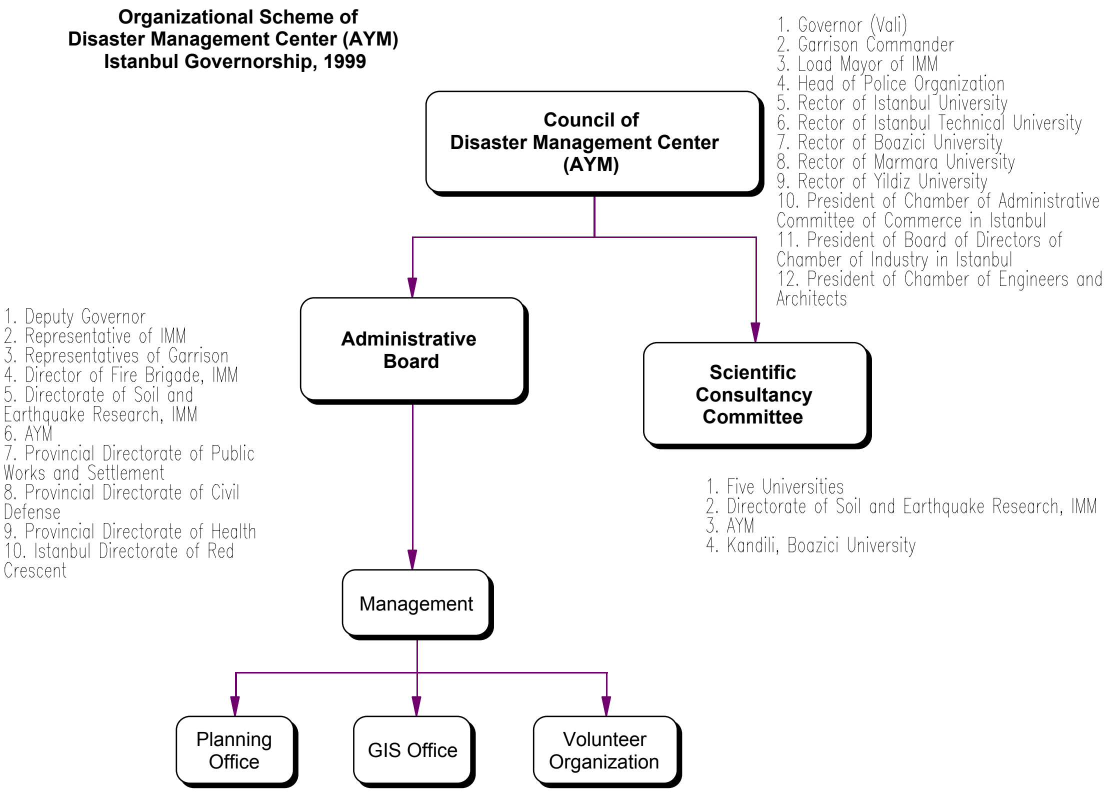


Figure 3.3.7 Organisation of Governorship Disaster Management Centre

(3) Metropolitan Municipality Government

Istanbul Metropolitan Municipality Disaster Coordination Centre (AKOM in Turkish abbreviation) was established in 2000 due to the necessity to establish a communication channel within IBB, by the order from mayor and authorisation by the Municipal Assembly. The initial members of the centre were the fire department, health department, ISKI and IGDAS. Planning, mapping, and other departments joined later on to form the current organisation.

The object of AKOM is to coordinate tasks among organisations within Istanbul Metropolitan Municipality.

The organisation structure of AKOM is shown in Figure 3.3.8. In AKOM, organisations are included by importance, unlike the service groups of the Governorship Disaster Management Centre. The president of AKOM is the vice general secretary of IBB. The vice president of AKOM is the department head of the fire brigade.

IMM's related companies are included via the shareholders department. Some key organisations in AKOM, such as ISKI or IGDAS, are also designated in AYM. AKOM does not have direct relations with municipalities within the IMM.

AKOM has its own new building constructed by IMM's budget in ISKI’s area. Currently AKOM's operational budget comes from the fire brigade, but AKOM will eventually have its own budget.

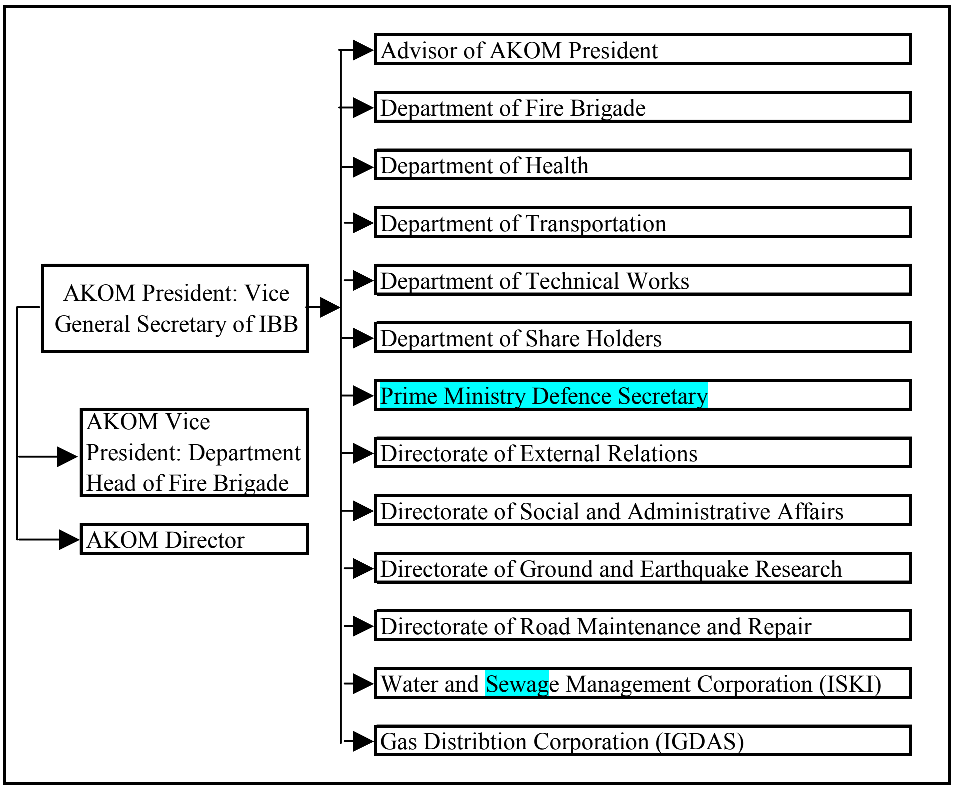


Figure 3.3.8 Organisation of Disaster Coordination Centre in IMM

(4) District Disaster Management Centre

The district disaster regulation requires establishing a permanent district disaster management centre in every district, with the district head serving as the head of the centre. Mayors in each municipality will work with district heads under the governorship.

Each disaster management centre is connected to AYM, but it does not have a direct relationship with AKOM. ISKI and IGDAS have subsidiary offices in each district, and they are designated to work with each district management centre.

The real situations of the district disaster management centres vary from district to district. In some municipalities, the municipalities have built their own disaster management centre, and it provides office space for a district head. In this way, the municipality disaster management centre practically works as a district disaster management centre.

In other municipalities, existing buildings are used as a district disaster management centre, and district head and related service group organisation are included.

Reference for Section 3.3

Oktay Ergunay, 1999, A Perspective of Disaster in Turkey: Issues and Prospects, Urban Settlements and Natural Disasters, Proceedings of UIA Region II Workshop, Chamber of Architects of Turkey

3.4. Disaster Management Plan and Activities in Turkey

3.4.1. Central Government

(1) Ministry of Public Works and Settlements

a. Earthquake Observation

The Ministry of Public Works and Settlement's Laboratory Division operates a nation wide strong motion network as a national project. During the 1999 Marmara earthquake, 24 stations recorded strong motions.

The Seismology Division established and operates a national seismological observation network, and it carries out microseismic activity monitoring for a Turkish-German project on earthquake prediction.

An earthquake disaster prevention research project was also carried out with JICA, Japan in 1993 and has concluded. As part of three sub-centres within the project, the earthquake data collection and vulnerability evaluation sub-centre in Ankara has ten stations around Ankara, and data collected are used for rapid damage estimation.

b. Earthquake Damage Inspection

The Ministry of Public Works and Settlements is the single authorised body to conduct building damage inspections after a damaging earthquake. In case engineers from the Ministry of Public Works and Settlements are not enough, help from the chamber of architects and civil engineering is requested. Muhtar in the area, who know the area well, guide engineers.

Damage assessment is conducted in two stages. The format for assessment was developed with the help of universities. The preliminary assessment is done by visual inspection for all buildings. Secondary assessment is carried out to classify the degree of damage. The result is shown to the owners to ask for their approval. The result will be used as a basis for financial aid for reconstruction. Heavily damaged building will be demolished under the district head's orders.

The state of ownership and financial aid from government is summarised in Table 3.4.1. Only owners of legal houses can receive financial aid from government. However, shelter is provided to all victims who lose houses, regardless of the ownership or legal condition.

After the Marmara Earthquake, 2,000 engineers were dispatched to aid in building damage inspections in response to owners' request. It took four months to study 20 districts in Gorcuk. The overall result was that 96,000 buildings were severely damaged, 58,000 buildings were moderately damaged, 122,000 buildings were slightly damaged, and 33,000 buildings were undamaged.

Table 3.4.1 State of Ownership and Financial Aid from Government

Ownership	Financial aid from government
Owner of a slightly damaged house	600 million TL.is given
Owner of a slightly damaged tenants for more than two years	100 million TL is given or rent fee
Owner of a moderately damaged house	10% of credit (2 to 4 billion TL) to repair the building is given
Owner of a heavily damaged house	Credit to rebuild the building is given
Owner of an apartment	Safe house is provided or government shall construct new house
Residents of irregular house	Shelter is given if house is heavily damaged
Residents of gecekondou	Help is not mentioned in law
All victims who lost houses	Everyone is entitled to obtain shelter

(2) Ministry of Health

a. Operation Centre

In case of emergency, the Ministry of Health will work under the Prime Ministry Crisis Centre. Information will be provided by the Prime Ministry or Provincial Directorate of Health. In the Ministry of Health in Ankara, four departments are standing by on alert for a possible disaster 24 hours a day. These include the Information Flow Gathering and Coordination, Administration and Financia, the Secretary for Communication and Documentation, and the Computing Departments.

b. Resource Inventory

In the ministry, a resource inventory that includes staff, medicines, trucks, and ambulances for each province was prepared in the year 2000, and it is updated every six months. The number of beds includes beds available in hotels and lodgings. Inventory is sent to neighbor provinces for mutual aid.

c. Emergency Response Planning

The ministry plans access routes to dispatch aid to damaged areas. Provincial hospitals are listed, but emergency medical operation will not be performed inside the hospitals.. Tent hospitals in open spaces are considered as possible locations. Open spaces are also considered to accommodate the efforts of foreign medical aid organisations.

d. Mutual Help System among Province

The Ministry of Health has a mutual help system set up among neighbor provinces, where each regional crisis center is programmed to help a neighbor province. A copy of this information is sent to the Ministry of Public Works and Settlements.

Three stages for mutual help according to the degree of damage, location, and population are planned. For Istanbul Province, seven neighbor provinces are designated to help in first stage, and another five provinces are designated for second stage help.

(3) Civil Defence

a. Civil Defence College

Civil Defence College was established in Ankara in 1960 for education and training, focused on search and rescue and first aid issues. The trainees are teachers of local civil defence centres, governmental officials, fire brigade members, and NGOs. Between 1960-2002, 18,266 personnel have been trained. Since 1982, 1,374 trainees from the fire department haveparticipated.

b. Rescue Activities

Duties of civil defence related to disaster management are as follows:

- To fulfil search and rescue, first aid, and social relief services during warfare, natural disasters, and big fires
- To coordinate search and rescue activities of both foreign and local search and rescue teams during a disaster
- To provide social relief and temporary lodging services for refugees
- To prepare weekly, monthly, and yearly education and training programs and carry them out in order to improve physical capabilities of the personnel with knowledge of practical and theoretical issues
- To train search and rescue teams assigned by public and private institutions and search and rescue teams of NGO's
- To plan and carry out day and night exercises
- To participate in training and exercises to be organised both in the country and abroad, and to participate in search and rescue activities abroad when necessary or requested
- To assist the Civil Defence College and governorships with rescue, first aid, and social relief courses
- To perform communication, information gathering, and mobilization exercises in order to reach a disaster area rapidly when necessary
- To fulfill other duties given by the Ministry of the Interior and the governorships

Before the 1999 Marmara Earthquake, only three provinces had search and rescue units. After the event, the Civil Defence has added search and rescue teams in another eight provinces. In addition, Civil Defence teams have been established in all provinces where civil defence units are not established.

The results of recent rescue works are tabulated in Table 3.4.2. The number of rescue personnel from different provinces engaged in recent rescue works are shown in Table 3.4.3.

Table 3.4.2 Activities of the Civil Defence Units during 1992-2001

			Rescued		
Date of Disaster	**Place and Type of Disaster**	**Rescue personnel**	**Rescued Dead**	**Rescued Alive**	**Total Rescued**
1992/3/13	Erzincan - Earthquake		34	4	38
1993/4/24	İstanbul / Hekimbaşı - Explosion of Dust Heap		12	0	12
1995/7/13	Isparta / Senirkent- Flood		37	1	38
1995/10/1	Afyon / Dinar - Earthquake		23	9	32
1995/11/4	İzmir - Flood		2	0	2
1995/11/27	Alanya - Flood		1	0	1
1998/3/22	Bingöl and Tunceli - Avalanche		4	0	4
1998/5/21	West Black Sea- Flood		1	101	102
1998/6/27	Ceyhan - Earthquake		62	2	64
1998/8/11	Trabzon / Köprübaşı - Flood		1	0	1
1999/1/14	K.Maraş/ Ekinözü - Avalanche		0	3	3
1999/2/7	Denizli / Honaz - Avalanche		1	1	2
1999/4/1	Niğde / Çamardı - Avalanche		0	1	1
1999/7/7	Erzurum Aşkale - Flood		2	0	2
1999/8/8	Antalya / Elmalı - Flood		1	0	1
1999/8/17	Marmara earthquake	110	349	194	543
1999/11/11	Bolu-Duce earthquake	108	56	30	86
2000/6/6	Çankırı / Orta - Earthquake		1	-	1
2001/5/8	Hatay and Samandağ - Flood		0	3	3
2001/6/10	Sivas / Kangal - Landslide		4	0	4
2002/2/3	Afyon earthquake	197	14	0	14
	Total		**605**	**349**	**954**

Source: Civil Defence General Directorate website (www.ssgm.gov.tr)

Table 3.4.3 Number of Civil Defence Rescue Workers in Recent Earthquakes

	Earthquake		
Name of the Unit	1999 Marmara	1999 Duzce	2002 Afyon
Afyon			72
Ankara	60	59	40
Bursa			13
Sakarya			36
İzmir			36
Istanbul	24	24	
Erzurum	26	25	
Total	110	108	197

Source: Civil Defence General Directorate website (www.ssgm.gov.tr)

(4) Turkish Red Crescent

The Turkish Red Crescent Society is the largest non-governmental organisation in Turkey. The society plays a significant role in relief activities from disasters, and it is embedded in the governmental emergency management system. In 1999, the total amount of internal assistance for relief was 541,630,369,000 TL, among which, 6,165,000,000 TL was used for disaster relief.

In case of an emergency, an aid assessment team is sent to the affected areas by the decision of the Red Crescent headquarters in Ankara. In addition, one representative is sent to the prime minister's crisis centre. Another representative is sent to the emergency management centre of the provincial governorship. The Prime Ministry, General Directorate of Red Crescent in Ankara, and governorship form a triangle of corporation. An emergency response plan is developed that includes shelter provisions. This plan includes the number of necessary tents and total tent area.

(5) Natural Disasters Insurance Council

Being that the Natural Disasters Insurance Council is a new organization, management of the fund and its risk will be the major challenges. Istanbul Province has the largest number of policy holders in Turkey, 931,554 holders that make up 39 % of the total holders as of March 2002. The distribution of holders according to seismic zone (I to V) is shown in Table 3.4.4, which shows zone I has the largest share. Government deed offices require submission of proof of TCIP coverage during property-related transactions such as sale or succession, but this currently affects only a small part of all property.

Table 3.4.4 Distribution of Earthquake Insurance Holders According to Seismic Zone

Seismic Zone					
I	II	III	IV	V	Total (%)
67	11	4	18	0	100

Source: Natural Disasters Insurance Council website (www.dask.gov.tr)

Table 3.4.5 shows the history of refunds by earthquake insurance for recent earthquakes, with an average refund amount per file. The Afyon Earthquake of February 3, 2002 has had the largest number of files so far, and the average refund for the total 1,450 files is 961,880,350 TL.

Table 3.4.5 Refunds by Earthquake Insurance

Date	Location of earthquake	Magni-tude	File number	Total amount of refund (TL)	Rrefund (TL) /file
2000/12/15	Afyon / Bolvadin	5.8	7	23,022,000,000	3,288,857,143
2001/1/17	Osmaniye / Merkez	4.9	1	960,000,000	960,000,000
2001/5/29	Erzurum / Pasinler	4.6	2	815,000,000	407,500,000
2001/6/22	Balıkesir / Savaştepe	5.0	3	537,500,000	179,166,667
2001/6/25	Osmaniye / Merkez	5.5	132	43,546,400,000	329,896,970
2001/6/26	İzmir / Merkez	3.9	6	5,724,200,000	954,033,333
2001/7/11	Erzurum / Pasinler	5.4	10	8,206,250,000	820,625,000
2001/7/30	Yalova/Merkez	3.8	3	372,000,000	124,000,000
2001/8/9	Osmaniye/Merkez	4.0	4	1,275,000,000	318,750,000
2001/8/26	Düzce/Yığılca	5.4	7	820,000,000	117,142,857
2001/9/12	Siirt/ Pervari	4.5	1	1,421,000,000	1,421,000,000
2001/10/13	Osmaniye/Merkez	5.2	136	29,215,000,000	214,816,176
2001/10/18	Adana/Merkez	4.9	45	14,540,250,000	323,116,667
2001/12/2	Van / Merkez	4.5	3	3,920,000,000	1,306,666,667
2002/2/3	Afyon	6.2	1,090	1,260,351,907,522	1,156,286,154
Total			1,450	1,394,726,507,522	961,880,350
					(Average)

Source: Natural Disasters Insurance Council website (www.dask.gov.tr)

3.4.2. Provincial Government

(1) Governorship Disaster Management Centre

In the year 2000, the Scientific Consultancy Committee proposed an action plan for improving the disaster preparedness and mitigation in Istanbul. The plan proposes:

- To stimulate the damage/risk assessment based on seismic microzonation
- To prepare the seismic risk maps
- To review the city master plans
- To protect cultural heritage
- To improve/strengthen buildings
- To improve the current building permission procedure

Accordingly, current tasks at the Disaster Management Centre of the Governorship are:

- Collection and compilation of resource inventory using GIS for disaster response
- Provision of resource maps to district disaster management centres
- Planning of temporary housing areas
- Revision of disaster preparedness plan by emergency response service groups
- Preparation of infrastructures in temporary housing areas
- Coordination of disaster drills
- Operation of FM radio station for disaster prevention
- Information provision via internet
- Construction of helipads

- The construction of new disaster management centre near international airport

Two types of regular meeting are held at AYM, and agendas and orders made in these meeting are given to AKOM. These include executive meetings with the governor on first Tuesday of every month, and decision-making meetings with the vice governor every Tuesday.

Currently, AYM is located in the centre of Istanbul, in a two-storied pre fabricated building. The location of the new centre was chosen because of its access to transportation channels via air, sea, and road. The new centre area will consist of a main building serving as the disaster management centre, housing, training, warehouse for civil defence, and temporary housing area.

At AYM, police and military staff are standing by 24 hours a day in the centre, which is equipped with satellite communication to the central government. Communication with the 32 district disaster management centres in the Istanbul Province will be made possible via satellite telephone, internet, and UHF band radio. In addition, volunteer amateur radio operators can assist with communication.

In case of an emergency, representatives in emergency service groups will gather the governorship without a direct order. Communication will be established with every district head to collect each district's damage status. A decision-making group and situation study group will gather in the same room. The decision-making group includes eleven members from various organisations. The situation study group consists of 22 staff persons and contact organisations and works a 24 hourshift. The ministry from central government will come to the governorship centre at the time of emergency, as it did in the Marmara Earthquake.

Mayors of each district municipality will work with the governorship via the district head. IMM and AKOM will work under the governorship, but they are not linked with mayors in municipality.

Within 15 days after the occurrence of the emergency, the governor is given extraordinary power and has the authority to coordinate and mobilise organisations in the province for execution of emergency services. The governor's authority includes the following abilitities:

- To charge duties to all males aged between from 18 to 65
- To impound or lease without restriction all means of transport whether public or private, including construction machinery

- To execute all procurements or rentals required for first aid, relief, feeding and sheltering
- To occupy temporarily all property regardless of ownership

However, the governor has no operational role and no financial funds to impound or lease necessary lands, buildings, machinery and cars. The governor has to request assistances from the central government and armed forces, and assistance from other provinces.

(2) Turktelekom

Turktelekom is a nationwide government-owned company, with its office located on the European side, and it is the head organisation of a communication service group that includes 12 companies.

Turktelekom has 12 offices on the European side, and it has eight offices on the Anatolian side. The European staff is comprised of 6,000 people. In case of an emergency, 570 engineers are assigned to go to designated or nearby locations, where they will work under AYM. The Asian side office staff is comprised of 522 people, and 179 vehicles are available. Each member has first to third priority responsible locations, with alternative staff.

Each company has a civil defence group that works on a voluntary basis, and members are trained regularly for light rescue. Within Turktelekom, civil defence staff numbers 249. Though they have tents, civil defence members do not have vehicles or equipment. The communication service group has 176 staff members trained for search and rescue in total among the 12 companies on the European side.

The Provincial Civil Defence Directorate offers search and rescue training at four levels. Training for the first level is given to the civil defence section in Turktelekom, for five days and 35 hours in total. IMM civil defence also offers a three day training course.

Turktelekom has frequent meetings among its communication service group members, and an emergency plan established independently in each organization is now joined within the service group, and an emergency communication facility can be shared by these organizations.

Turktelekom provided the NMT (Northern Majority System) as an emergency system for use by governmental organizations. NMT is an analog system with a 400Mhz bandwidth, capable of servicing 90,000 users. It has been in place since 1987, when it was used as a first-generation mobile phone system (used with a car battery). Since the current number of NMT users is 23,000, no communication traffic congestion is expected during an emergency. Emergency public telephones are planned to be made available at planned tent locations. Normally, 20 lines will be installed in an area for 500 tents, and 10 lines for 250 tents.

Turktelekom's buildings are visually inspected by their own engineers. Five buildings have been diagnosed by ITU. Projects to strengthening buildings to comply with the 1998 building seismic code have begun.

Turktelekom has eight architects, but this is not sufficient personnel to check all the buildings. Damage to buildings will be assessed by the Ministry of Public Works. Damage to telephone lines will be assessed by Turktelekom. Upper ranking staffs are to report damages to governorship.

(3) Highway 17th Regional Directorate

The Highway 17th Regional Directorate is the head organisation in the transportation service group. The directorate is in charge of Turkey's European highways, while the Highway 1st Directorate is in charge Turkey's Anatolian highways. The transportation service group has seven subgroups. Each sub-group has head organisations as follows.

- Highway and express way group, headed by Highway 17th Directorate
- State and provincial road group, headed by Highway 1st Directorate
- Inner city road group, headed by IMM
- Village road group, headed by Rural Affairs
- Seaway group, headed by the Maritime
- Railroad group, headed by the Turkish Railroad
- Airway group, headed by Turkish Airways

In case of an emergency, one person from each of the seven subgroups will come to the governorship. Other members will gather at the 17th Highway Directorate. The highway directorate and rural affairs office will exchange their staff for the cooperation of debris removal. Emergency damage assessment shall be performed by highway patrol members and teams dispatched from the governorship. For cooperation with other taskforces, information will be exchanged via the governorship.

Damage information will be provided to the public by radio or TV. Use of helicopters is planned by the governorship, but this directorate is not informed of their use.

The 17th Highway has established a response and prevention plan. The plan specifies each member organisation's responsibilities with respect to emergency response for road systems. The plan lists allocations of heavy machines and personnel. If allocated resources are insufficient, additional machinery can be procured from military or private companies by law. The plan also includes a list and map of possible detours.

(4) Provincial Directorate of Rural Affairs Services

The Provincial Directorate of Rural Affairs is the head organisation of rescue and debris removal service groups. There are 13 organisations under the taskforce classified into three sub-taskforces. This directorate is responsible for debris removal for rescue. Principal organisations and their duties (by sub-group) are the following:

- IMM Road Maintenance is in charge of debris removal for road opening
- Civil Defence is in charge of search and rescue
- IMM Fire Department is in charge of fire fighting

In Istanbul, 7,000 heavy machines are registered for emergency response use under the governorship; 20% of these belong to the government. Existing heavy machinery is only for debris removal. Heavy machinery for cutting through building columns is lacking, and purchase of such machines is planned. Civil defence does not have heavy machinery for debris removal. Though civil defence has cutting tools, these are not sufficient for cutting through building columns.

There are 34 gathering points, such as stadiums and large parking lots, designated in Istanbul. The European and Asian sides are to work independently in case of emergency. Debris deposit areas are planned.

The surrounding 19 provinces have protocols with Istanbul to help Istanbul in case of an emergency. Each surrounding province has designated which municipality will help. However, resources in neighbouring provinces on the European side may be insufficient. Sea transport from the Asian side has also been considered for efforts to provide help to the European side.

(5) Provincial Directorate of Civil Defence

The Provincial Directorate of Civil Defence is the head organisation of the rescue and debris removal service groups.

Istanbul's provincial civil defence has a warehouse and training centre in Avcilar, and administration offices in Fatih. Since administrative offices have been moved to the city centre, the former building is used as the District Disaster Management Centre of the Avcilar District.

Under normal conditions, the fire department handles rescue work dealing with car accidents or collapsed buildings. However, if the work is difficult, civil defence is requested to help. If a state of emergency is declared by the central government, then the rescue responsibility is shifted primarily to civil defence.

During the two earthquakes in 1999, 24 civil defence personnel from Istanbul Province responded and rescued 50 people in total.

(6) Provincial Directorate of Health

The Provincial Directorate of Health is the chief organization of the First Aid and Health Service Group. The organization sends a list of hospitals and respective pertinent information (such as address, name of hospital head, number of beds, and hospital type) to the governorship. A seismic strength assessment was performed for hospitals by order of the Ministry of Health.

There are 12 organisations in five sub-groups. The service group had four sub-groups defined in the plan before the 1999 Marmara Earthquake; however, the fifth sub-group for burial of the dead was added afterwards. Sub-groups and their tasks are as follows:

First Aid and Emergency Relief

This group aids in the triage and transportation of victims to hospital. During the 1999 earthquake, this sub-group worked for the first 48 hours.

Hospitalisation

This sub-task group is responsible for the selection, treatment, and hospitalisation of victims. In two districts, local capacity was insufficient, so they sent victims to other district and university hospitals. By way of helicopter or by highway, they also sent victims to Istanbul. This group mainly worked for a few months after earthquake.

Supply and Logistic Support

The duties of this sub-task group include the collection of medicine from abroad, distribution and delivery of this medicine to hospitals. The group also helps to assess and fill hospital personnel needs.

Rehabilitation and Primary Care

This sub-task group studies environmental health andepidemic diseases, and it works long-term.

Dead Body Burial

The main task of this group was to assist with burial services for the victims. The Population Census Directorate and religious organisation worked as part of this group.

(7) Red Crescent

The Red Crescent works within the Health, Purchase, and Preliminary Assessment service group. The Provincial Directorate of the Red Crescent in Istanbul has a staff of 58. In addition, in Istanbulthere are two blood donation centresand two regional warehousing centres. These groups work directly under Ankara's general directorate, and they work independently in each province. No regular contacts are made with other sections.

In case of an emergency, a representative is sent to the emergency management centre of the provincial governorship. The Red Crescent works within a triangle cooperation of the Prime Ministry, General Directorate of Red Crescent in Ankara, and the provincial governorship. The Red Crescent also has education programs.

(8) Provincial Directorate of Public Works and Settlements

The Provincial Directorate of Public Works and Settlements is the chief organisation of the Preliminary Damage Assessment and Temporary Housing service group. The service group has two sub-groups, Preliminary Damage Assessment and Temporary Housing.

According to the Disaster Law, the Provincial Directorate of Public Works and Settlements should function as a disaster management centre. Currently, a section in charge of information collection only remains within Provincial Directorate of Public Works and Settlements. Communication within service sub-groups is managed within the office of this directorate.

In the Istanbul Province, there are 450 staff members in the Directorate for Preliminary Damage Assessment. Two engineers per each team will form 120 teams and will conduct secondary assessments. Type of temporary house, tent or pre fabricated house, is decided according to the climate. The number of necessary temporary homes is estimated using results from a scenario carried out by Boazici University and the Ministry of Public Works and Settlements. The ministry gives owners a lot for reconstruction. The Ministry of Public Works and Settlements will consult the IMM and decides reconstruction and planning.

Seismic retrofitting is overseen by various ministries. The Ministry of Education is responsible for retrofitting schools. The Ministry of Religious Affairs is responsible for retrofitting of religious facilities.

(9) Provincial Directorate of Police

The Provincial Directorate of Police is the head organisation of the security service group. Istanbul Province is divided into 10 regions. The police force is in charge of urban areas. The gendarme and military are in charge of rural areas. IMM cooperates with 15 assistants from the Transport Planning Directorate.

The police force's responsibilities include preventing the blocking of traffic ways and escorting the deliveries of goods, and rescue teams. They have a disaster plan consisting of 900 pages. The main information contained in this plan is the list police forces in each district, their traffic plans, logistic centres for civil defence, their district vehicle gathering centres, location information of major traffic, list of tea houses, mosques, and flammable materials storage sites as priority locations for search and rescue.

The police department has two helicopters and plans to buy two more. Helicopters will be used only for monitoring purposes in case of an emergency. The police department has a protocol established with surrounding provinces. Schools, dormitories, and locations of flammable tanks are checked. Police department buildings are partially inspected as part of a seismic diagnosis effort.

In case of an emergency, damage observation will be carried out by foot, bike or helicopter. Damage status is reported to the district head but not to the municipality. Walkie-talkie or mobile phones are to be used as the mode of communication. Radio communication channels differ between the police, military, and gendarme, but all radio communication is transferred to the AYM. To prevent looting, police will be sent to shopping centres and historical places. Police forces also take precautions against possible sabotage during a disaster.

(10) Provincial Directorate of Agriculture

The Provincial Directorate of Agriculture is the head organisation of the Agriculture service group. There are 370 staff members in the provincial office's department. The main activity is to make a list of food-related major facilities, such as food production plants, warehouses, and supply facilities. The list includes location, address, and possible supply, most of which is from private companies. The list is updated every year. In case of a disaster, the same list will be sent to the central government. In Istanbul, about 80% of food production comes from outside of the province, though the supply's origin is not well known at the provincial directorate.

The Disaster Law and the tasks outlined therein are not known by the Directorate of Agriculture. No information for disaster coordination has been provided by the governorship, nor has any coordination between the agriculture taskforce members and the provincial directorate been outlined. No drills are held.

Technical matters for disaster response are handled within the Agriculture Department. The responsibility of damage assessment for the farmers is not clearly defined. The Ziraat Bank will give credit to farmers. In the Agriculture Directorate, there are 66 members assigned to the civil defence section. They receive training from the fire department and civil defence.

3.4.3. Istanbul Metropolitan Municipality

(1) Disaster Coordination Centre (AKOM)

AKOM was established on August 14, 2000 by order from the mayor in February 2000. The IMM Assembly authorised AKOM on December 2000. The object of AKOM is to coordinate tasks among organisations within IMM. Including member privatized companies, IMM has 30,000 staff members, 70 directorates, and 30 department heads. AKOM is funded by the IMM through the Metropolitan Municipality Act.

In AKOM, organisations are grouped by importance. IMM's related smaller companies are also included via the Enterprise Department. The chief of AKOM is the deputy general secretary of IMM. The assistant of chief is the department head of the fire department.

AKOM’s building was constructed under IMM's budget. Currently AKOM's operational budget comes from the fire brigade, but it will eventually have its own budget. Traffic monitoring by real time video from the IMM Transport Directorate is transmitted to AKOM. All organisations, such as the Kandili observatory group, civil defence, governorship representatives, the fire brigade,etc., are provided work space within AKOM’s building. Communication is done by walkie-talkie, equipped in each room.

In normal times, there are 15 staff members working in AKOM. They collect information on inventory and report to the governorship every month. Every Tuesday, one representative attends the meeting with the governorship. Every Wednesday, the meeting is held in AKOM to inform the member on the agenda covered during the preceding day’s meeting with the governorship.

In case of an emergency, 120 people from organisations are to report to AKOM, where they will be awaiting decisions and any order from the governorship. Their main responsibility is to execute orders rather than make decisions. They will work in AKOM around the clock in shifts. Within AKOM, only the IMM, fire department, ISKI, and IGDAS have rescue units. These units may be asked to assist in rescue efforts by the governorship.

Some important organisations in AKOM, such as ISKI or IGDAS are also part of the AYM. In case of an emergency, each director of such doubly assigned organisation will report to the governorship, and the deputy head will be in AKOM. ISKI and IGDAS also have subsidaries in each district, and they work with each respective district management center. Mayors in each municipality will work with the district head under governorship. District disaster management centers are connected to the governorship. IMM does not have a mutual help protocol established with other metropolitan municipalities. The governorship does have a protocol of mutual help with other provinces.

During past earthquakes, each organisation made announcements independently and caused confusion. In the AKOM building, a press room is provided, but any broadcast announcement is uniquely authorised by the governor, or mayor if permitted. The facility's web server is not mirrored, and updating is done by a private company.

IMM planned and constructed helipads according to a request from the governor. The IMM has one helicopter for agriculture use and two helicopters from the transportation company. However, the total number of helicopters and their use in an emergency is only known in governorship.

Disaster prevention education is done by the Directorate of Emergency Relief, fire department, and civil defence. These groups held a conference last November and will have another this August. They have a pilot study in Zeytinburunu that includes the seismic retrofitting of buildings. Table 3.4.6 shows a list of activities undertaken in AKOM, classified by area of activities and by status of progress.

Table 3.4.6 Activities undertaken in AKOM

Area	Contents of Work	Status
Study	The geological and geotechnical reports of the Zeytinburnu District, chosen as a pilot area, have been prepared by the Zeytinburnu Municipality.	Done
Study	A meeting was held in November, 2001 entitled, "Istanbul Earthquake and Safe Structures." The notes of the participating academicians and experts were later compiled as a book and distributed to related organisations.	Done
Study	GIS activities are mostly completed. The input of data is continuing.	Done
Study	The 1/5000 scale construction/improvement geology map of Istanbul are completed.	Done
Study	The JICA Project, which is being carried out with IMM, will be completed in 2002.	Done
Study	Studies related to the Olympics are completed, and the necessary controls have been taken. Coordinating units are the Directorate of External Affairs, ISKI, IGDAŞ, Dir. of Transportation Planning, Dir. of Road Maintenance and Repair.	Done
Study	According to the decision made at the executive board meeting held at the Provincial Disaster Management Centre, the studies and work requested by and given to the IMM are completed and submitted to the Provincial Disaster Management Centre via a file.	Done

Study	Crisis Centre functional system.	Future plan
Structural reinforcement	After the Marmara Earthquake, a tender was held for the construction work and retrofitting activities together with project and consultancy services of the 15 IMM building properties with prices of 18.719.440.000.000 TL (according to the year 2001 unit construction prices of the Structural Works Directorate) and 30.887.074.500.000 TL (according to the year 2002 unit construction prices of the Structural Works Directorate).	Done
Structural reinforcement	The statistical projects and calculations of the Kartal and Cebeci Public Bread Factories are reconsidered and checked with respect to seismic considerations and the General Directorate of Public Bread is informed of the results.	Done
Structural reinforcement	Emergency exit doors will be constructed in the Main building of the IMM, and a fire exit (ladder) and emergency exits will be included as part of the retrofit project.	Done
Structural reinforcement	The seismic inspection of the Edirnepkapı General Directorate of Public Bread building is completed.	Done
Structural reinforcement	Based on the concrete inspection report to be received from BIMTAŞ, the studies are continuing to aid in the development of a proposal to ISTON A. Ş. For the retrofitting of the Kartal Public Bread Factory.	Ongoing
Structural reinforcement	To assess Istanbul's building inventory, to inspect buildings to understand their seismic resistivity, and to classify buildings in terms of earthquake safety (Zeytinburnu can be pilot area).	Future plan
Structural reinforcement	All units must make detailed studies to give ideas and recommendations regarding what can be done to improve the seismic resistance of buildings and houses in which important rescue unit members and individual's responsible for disaster management are living.	Future plan
Structural reinforcement	The number of abandoned houses, especially within the historical settlement areas of Istanbul, must be counted accurately, and precautions must be taken against potential collapses.	Future plan
Training	The training of the security staff at the Istanbul metro is completed, emergency rescue units are formed, other safety systems are checked and their deficiencies are addressed.	Done
Training	The drill named "Disaster 2001, Crisis Management," which was held between Nov. 13-15, 2001 under the coordination of the General Secretariat of National Security Board, the Istanbul Governorship, and AKOM, has completed the drill.	Done
Training	On April 12, 2001 a fire and rescue drill was held by the Department of the Fire Brigade.	Done
Training	The activities and preparations for before and after a disaster are discussed and talked over with the EUCOM mission from USA and the mission from China.	Done
Training	At the "S.O.S 2001, Preparation Before Disaster Fair," held August 17-21 2001, at the CNR International Fair Center, AKOM set up a stand to exhibit the tools, materials, vehicles and the disaster preparation studies of IMM.	Done
Information system	A disaster recovery system was successfully established on May 16, 2002, the project is considered, the test has been done and currently is on-going. After the completion of the data processing system of AKOM, the system, including back-up systems, will work fully.	
Information system	To determine addresses for "specialty offices/businesses", to inspect these places by with respect to transportation, fire hazard, activity field, number of people, working style, etc. All sections will work from a common data gathering form and the information will be input to into a computer system which will aid in the development of location maps.	Ongoing
Information system	Within the scope of taking air photos and land photos for activities related to disasters, every section should inform AKOM about the locations and studies that they want to photograph.	Future plan
Disaster management	The determination of suitable locations for storage buildings,considered within the framework of disaster preparedness activities. The ground studies of these locations are complete and the construction of the storage buildings is ready to start.	Done
Disaster management	In time of a possible disaster, the cities, which will provide support and help, are already contacted. Information is received on the activities that will be done.	Done
Disaster management	Providing GIS information to aid in disaster preparedness efforts.	Ongoing
Disaster management	Pertinent parties are examining and deciding on sites for "Emergency Response Stations," which will be newly established.	Ongoing
Disaster management	To discuss with the district municipalities the opening of the information in each district municipality to common use (without making any changes) and to give access to IMM and other units to view these information.	Future plan
Disaster management	On an appropriate date, a meeting shall be held with Civil Society Organisations (NGOs), and information will be taken from these organisations relating to their activities on disasters. Also, cooperation possibilities will be sought.	Future plan

Communication	An introductory seminar and a demonstration was given to related organisations of IMM by the SETKOM Company on the Motorola Dimetra Wireless (Walkie-Talkie) Communication Solution.	Done
Transport	By May 22, 2002, 50 helipads have been constructed in important locations of Istanbul.	Done
Transport	The junction images that are transferred to the Transportation Coordination Center are also transferred to AKOM as a demo.	Done
Transport	In case of heavy snow and rainfall, the "Alternative Transportation Road" plans are completed, and, in the framework of a certain plan, the implementation test is done in Eminönü District.	Done
Transport	The widening and maintenance of 39 critical roads that have priority for road accessare completed, and the results are shown on a map.	Done
Transport	The inventory of the streets and narrow streets of Istanbul is completed and marked on the map.	Done
Transport	To designate areas and routes to be used for burial sites, and the input study of the records into a computerized system to find the cemeteries easily.	Done
Transport	Making a street and wide street inventory, to determine appropriate evacuation routes. Gather information on number of people in the area, materials, equipment to be used, etc. (Zeytinburnu can be a pilot area).	Ongoing
Transport	The information which will be received from districts will be marked on map for the already prepared "Alternative Transportation Roads" plan to be applied in case of heavy snow and rain.	Ongoing
Fire fighting	The number of water hydrants which ISKI and fire brigade plans to install around 5,000 by the end of 2002 has reached 3,113 by May 22, 2002.	Done
Fire fighting	The Directorate of flammables and explosive chemical storage has made an inventory of the hazardous facilities and working offices within the city, and these have been included in the records.	Done
Fire fighting	Using CPS systems to develop physical controls for existing hydrants, to determine their coordinates accurately. Also, there is a need to take into consideration the narrow roads and streets, when determining the locations of new hydrants, and these points should be marked on the map and digitalised.	Ongoing
Fire fighting	To work together with Universities to prepare a Fire Risk Map of Istanbul, to prepare projects and have a bigger range of studies, to prepare fire hazard information and an analysis of the last 10 years, and to develop the software.	Ongoing
Fire fighting	ISKI and the fire brigade are continuing to work water tanks with 60-100 ton capacities and hydrants.	Ongoing
Fire fighting	The work on the fire outbreak risk map is continuing by preparing the information and fire analysis of the last 10 years.	Ongoing
Fire fighting	To determine the locations of explosive, hazardous, and flammable material-producing facilities and storage locations within Istanbul, to clarify the legal responsibility and authority of the municipality, and to study on the present data.	Future plan
Fire fighting	Research whether ground-level water storage in the fire brigade facilitiesbe used as cold storage. Research whether ice rings be constructed in certain locations of Istanbul.	Future plan
Fire fighting	To gather the rain water in artificial ponds, etc., and to utilise this water in future.	Future plan
Fire fighting	The Dir. of Flammable Chemical Storages should work on activating the storage facilitiess within the Municipality, a study should start to facilitate the use of private company storage locations.	Future plan
Rescue	As entrust method, a tender was held in 3 regions (Anatolia, Istanbul and Bakırköy) for renting heavy work machinery to be utilized in times of a possible earthquake. Also the request is made for the purchase of heavy work machinery, which will be used, by the Directorate of Road Maintenance and Repair.	Done
Emergency Medical	In order to use medical equipment and materials more efficiently and effectively, the Directorate of Emergency Relief Lifeguard has prepared two storage sites with materials and equipment: one on the Anatolian side (in the garden of Zeynep Kamil Hospital) in Uskudar, and the other on the European side (at a fire brigade station) in Gaziosmanpaşa.	Done
Emergency Medical	Health materials and equipment are placed in the sea ferries of IDO, and arrangements are made to give immediate response to injured citizens.	Done
Emergency Medical	Simple but effective Emergency Health Sets (2,500) were prepared to be used in the first steps of a possible crisis.	Done
Burials	The purchase of 6 collective funeral cars, 10 cars for mobile dead cleansing, 5 emergency ambulances, and 3 closed cooler cars has been completed.	Done
Burials	In order to be used after a possible earthquake, 3 large locations in Istanbul are designated to be used as cemeteries.	Done

Burials	In time of a possible earthquake, the purchase of a greater number of body bags and ID cards has been made (up to 50,000).	Done
Burials	The location on maps of existing cemeteries for the general area of Istanbul. (Also information on ratio of capacity, availability of empty graves, place to wash the dead, how many burials can be done at the same time, etc.)	Done
Burials	Additional to the studies of increasing the number of ice rings and cold storages, the determination and finding of the facilities that have cold storages, ice factories, slaughterhouses and producing carbon ice.	Future plan
Food	A mobile kitchen which can serve up to 20,000 people a day, is provided by the Directorate of Social and Administrative Affairs and it is waiting in preparedness.	Done
Food	In times of disaster, the production of bread which will contain high nutrition and calories and to which vitamins are added is attractive.Studies concerning the production, storage and distribution of the bread is completed. It is possible to make any amount of production in times of necessity.	Done
Food	25,000,000 food packages are purchased to be given in times of disaster to rescue units and citizens.	Done
Food	In case the natural gas for the 3 big bread production facilities is cut during a natural disaster, a study on a system, which will work on LPG for at least a week, is completed.	Done
Food	In times of crisis the locations for bread distribution (Public Bread Buffets, I.E.T.T Stops, Muhtars, Police Stations, Hamidiye Water sale points, etc.) are fixed and marked on map in digital format.	Done
Food	To take into consideration the tent areas for mobile food houses, to consider the cooking activities in every area, to increase the number of places for serving and eating meals.	Ongoing
Food	To have cooperation between TUBITAK-MAM and the General Directorate of Public Bread for long lasting consumption goods (food).	Future plan

Source: AKOM (2002)

(2) Istanbul Fire Department

The legal foundation of the Istanbul Fire Department came about through the Municipality Act. The Istanbul Fire Department belongs to the municipality, and it is a key organisation in the AKOM. The department is also the head organisation of the Rescue and Debris Removal Service sub-group of the governorship disaster management centre.

The fire department has been under the Istanbul Municipality, not under the central government. When the IMM was established in 1985, 16 fire departments in each municipality were united, and the Istanbul fire department then became the central fire department of the IMM. Currently, the IMM fire department has 38 stations in total within Istanbul. The IMM fire department helps fire departments of other municipalities within the IMM.

The fire department has 38 stations, 307 vehicles, and 2180 staff members in total in Istanbul. They have rescue teams, which consist of 4 to 7 people, equipped with audio-visual search detectors, cutting tools, and breaking devices, and these teams work in all fire stations in 3 shifts, 24 hours a day. In addition, new rescue teams are formed which will work under the responsibility of the disaster intervention centre, equipped with 20 fully equipped vehicles.

In theory, one fire brigade is necessary for every 1000 citizens. In this sense, 9,000 brigades would be necessary to meet the real demand in Istanbul. The fire fighting force in IMM is divided into three sectors. The Boazici area has a staff of 543, the Istanbul area has a staff of 650, and the Asian side has a staff of 709. In addition, there are 119 logistics staffmembers. In both the European and Asian side, the fire departments have disaster centres with 50 staff members.

A quarter of the budget is from project licenses, project settlements, insurance companies, and routine service. The rest of the budget comes from the municipality. In the year 2000, the group's annual budget was 20.1 trillion TL. 1.5 trillion TL was spent on the salary of staff members. In the year 2001, 4.5 trillion TL was spent for new vehicles. In five years, new vehicles will be purchased for 30 million Deutsch Mark.

Combating forest fires are the responsibility of the civil defense. Fire on roads are officially the responsibility of the Ministry of Public Works and Settlements, but the fire department actually attends these fires. In Turkey, not like other countries, civil defence conducts all aid. Training, checking, and standardisation is the fire department's responsibility. Public training focuses on self-survival rather than helping others.

According to the Disaster Law, the fire department must have apreparedness plan for all kinds of disasters, though no specific scenario is considered. The responsibility of the fire department during an emergency is primarily fire extinction. Debris removal is the responsibility of the Road Maintenance Department and the Provincial Directorate of Rural Affairs. It is the fire department's secondary responsibility. Rescue from fire zones is their primary responsibility. The fire department staff has the advantage of daily experience in rescue efforts. The fire brigade can work independently, that is, without external assistance. NGO's lack experience in rescue, and it is desirable that this effort be under control of the fire department. In case of an emergency, the fire department can work voluntarily based on information collected at each fire station.

The governorship, civil defence, and fire department are connected via a wireless communication system. Earthquake information from the Kandili observatory is directly reported to the fire department. Calls to the fire department from citizens are directed to the nearest fire department. Recently, all calls are channeled to a single call centre. During the Marmara Earthquake, since earthquake damage information was not available initially, the fire department dispatched staff based on their working knowledge of the areas.

(3) Istanbul Water and Sewage Operation (ISKI)

ISKI is the head organisation of the Electricity, Water, and Sewage service group. ISKI is responsible for the IMM's urban area and for small water reservoirs. Rural and state water agencies are responsible for areas outside IMM and for dams.

In the 1999 Marmara Earthquake, the Istanbul Water and Sewage Management repaired damage to the water supply system in the gulf region and secured clean and drinkable water for survivors.

Only telephone service is excluded from the lifeline service group because it belongs to the communication taskforce. The lifeline taskforce includes five subgroups: water, electricity, gas, sewage, and support. In an emergency, a member from the civil defence section in each organisation is assigned to the governorship to receive orders, while the rest of member will report to AKOM. Seven members from the civil defence team for search and rescue and appointed by the central office of the province are also present.

In case of an emergency, nine assigned authorities, six department heads, the Director General of IGDAS, and an operator will report to AKOM.

95% of the pipeline has been moveed; the remaining 5% is located in its historical site. The SCADA (Superuser Control and Data Acquisition) system has been in operation for two years in ISKI. ISKI and IGDAS developed a map of the distribution of the area's geology and their pipeline networks. An emergency response drill is planned for the future. Retrofitting work of the reservoir is not clearly understood.

Regional help from neighbourhood provinces times of emergencies is coordinated under the governorship. ISKI has prioritized sites for water service restoration with respect to their functions, for example, governmental organisation, hospital, or community centre. ISKI prepares repair materials for a case that 30% of pipelines are damaged by warfare.

(4) Soil and Earthquake Research Directorate

The Soil and Earthquake research directorate was established in 1997. The current staff numbers 70 in this department, and the reconstruction department has 90 staff members. This department is in same directorate as the reconstruction directorate, which works for urban development. IMM's major disaster-related tasks deal with preventive measures, not response measures.

This directorate has prepared a 1/5,000 scale geological map of the IMM area, based on a compilation of existing boring results secured by the IMM and other organisations.

Municipalities prepare 1/1,000 scale geological maps and present their maps to this directorate.

These maps are disclosed to public and help planners of new construction to see the vulnerability of the site they may be interested in. IMM's task is to check if the presented geological map from each municipality matches the IMM's map. Resulting maps are sent to the General Directorate of Disaster Affairs for approval. The classification is the same as the one used in the building code of the Ministry of Public Works and Settlements. In each geological map, the geology of the land is classified according to four types:

1) Area suitable for settlement

2) Area suitable for settlement under some measures

3) Area suitable for settlement but needs detailed geological study

4) Area not suitable for settlement

This department checks plans for new construction, and it has the authority to require a new study or prohibit construction according to geological conditions of the proposed site. The Reconstruction Department permits new construction plans, in accordance with reconstruction laws.

Other studies undertaken in this department are deep tectonic studies via seismic refraction and pilot studies for urban rehabilitation.

IMM has formed a committee of 12 members that meet once a week to establish an earthquake master plan. The members are from different disciplines, such as geology, geophysics, mapping, architecture, civil engineering, city planning, and law. IMM Soil and Earthquake Research Directorate works as head of the committee. The committee is trying to establish a protocol that asks for consultancy from major universities.

Prior to 1999, this department also had eight stations for monitoring micro-earthquake, via dial-up connection to the IMM. Six more stations will be added by JICA. Data analyses are conducted within this department, and, if necessary, are sent to TUBITAK for consultancy. TUBITAK has online monitoring stations for hydraulic, radon, and geo-chemical around the Marmara area. The observed acceleration and epicentre location will be reported to governorship, police, and IMM's disaster coordination centre within three minutes of the event to aid in the initial damage estimation.

Since this department mostly deals with research, education is currently not considered. The Department of Education issued a brochure for disaster prevention. The brochure was originally intended to be distributed in schools, but plans to do so were later.

(5) Istanbul Gas Distribution Corporation (IGDAS)

IGDAS has its own crisis management centres in three district centres in Beyoglu, Istanbul, and Anatolia. These centres are coordinated by IGDAS headquarters, and they are connected to AKOM. IGDAS has its own emergency action plan. Its damage extent shall be expressed using three degrees of measurements and will be reported to AKOM. IGDAS uses common frequency bandwidths for radio communications with the fire brigade.

IGDAS uses European design standards for its pipelines. Daily repair of lifelines for various companies are coordinated by the IMM Infrastructure Coordination Department. Since fiscal years differ from company to company, coordination is difficult. The gas network in Istanbul is under surveillance 24 hours a day, with a night watch shift of 250 technical personnel. Mobile teams are on continuous patrol along the network.

IGDAS has an “Emergency Action Plan”, under which all personnel will be immediately called to their places of duty. After the Marmara Earthquake, the plan was revisited with new additional earthquake scenarios. The Action Plan also requires the personnel and equipment of gas companies also be involved in search and rescue operations under the corporation’s supervision.

If an emergency occurs, mobile team from its own 30 substations can shut down pipelines faster than the fire brigade. For emergency support, IGDAS has 280 personnel that reside in close proximity to their duty points. They are prepared to go on site within two hours. Under the plan, a meeting with gas companies in Bursa and Ankara is to be held to agree on mutual help efforts. The provincial civil defence provides them with training on rescue operations, first aid, and fire fighting.

Three control centres will shut down at once, then their operation will be restored gradually according toorders from AYM. AYM is responsible for ordering gas restoration. Restoration work for lifelines will be done independently by each company.

At the time of the 1999 Izmit Earthquake, the corporation formed a search and rescue team of 50 personnel in cooperation with the Civil Defence Directorate of the Provincial Government and the Metropolitan Municipality’s Fire Brigade.

IGDAS does not have a representative in AYM, and it is directly connected to AKOM. Only via AKOM is IGDAS is linked with the governorship. In the past, a new gas and petroleum taskforce within AYM was planned, but the plan failed due to legal difficulties.

(6) Department of Health

Before 1985, ambulance service was provided by individual hospitals. In 1985, the Health Department was established in Istanbul to provide ambulance service. The department had an emergency call number, 112, the first of this kind in Turkey. In 1994, the Provincial Health Directorate established its own ambulance service, and it and took over the emergency call number. The location of Provincial Health Centre was selected not to overlap with existing health centres.

The IMM Health Directorate has 21 ambulances in total at 13 different locations, mostly housed within fire stations. The fire brigade carries out rescue efforts and ambulance staff provides medical care.

The Provincial Health Directorate has 40 ambulances at 40 independent stations. IMM Health Directorate now focus on training rather than daily ambulance work. IMM Health Directorate and the Provincial Health Directorate have a good working relationship towards a common goal.

Under normal situations, patients are sent to the appropriate types of hospitals according to the insurance of the patient. Patients with workers' insurance are sent to social insurance hospitals under the Ministry of Labor. Patients with governmental insurance are sent to state hospitals under the Ministry of Health. Patients with private insurance are sent to the university or private hospitals under the Ministry of Health. In case of a state of emergency, however, such distinction will not be applied.

By law, each hospital should have an emergency section. The municipality, as a tax collecting body, can call for the construction of a hospital building. However, the municipality cannot operate the hospital according to the law that prohibits the recycling of funds. Doctors in the municipality work in ambulances or in treatment centres. The capacity of one university hospital is approximately equal to that of five state hospitals. State and insurance hospitals have major capacity in terms of total capacity.

Among AKOM, only the Health Department is responsible for the preparation of equipment. The IMM Health Department has emergency relief plan. They built two medical equipment centres, one on the Anatolian side and one on the European side. Equipment is mainly stored as medicines that have an expiration date are not stored.

Medicines will be sent to the centres through arranged protocols with private companies. These centres also have a protocol with the sea transport company to aid in the transportation of victims. Seats of these sea ferries can be used as a bed in case of emergency.

The centres recognize that the first three days after the earthquake event are the most critical. After that period, they know by experience that necessary medicines will be donated from external sources.

Emergency hospital services will be provided out of one-storied hospital buildings. They do not count on existing hospital buildings after the earthquake. They count on tents or ships as hospitals. The IMM Health Directorate will work from ambulances. Operations at hospitals and preparation for water or electricity are the responsibility of each hospital.

The IMM Health Directorate attend AKOM and works with the AKOM in case of an emergency. They do not work directly with the AYM, but the Deputy Director from IMM Health Directorate report to the governorship in case of an emergency.

The IMM Health Directorate does not have the right to sign protocols. It took a year to achieve a protocol with the sea transport company. Some seismic retrofitting of the building has been completetd. Many organisations work independently on this effort, and the results have not been made known.

Even in normal situations, the number of exisiting hospitals is insufficient to meet patient needs. In a disaster, many officers or drivers may not report to work because of injury to them or their families, or because of traffic problems. External help will be needed. Staff living on the Anatolian side may not be able to report to the European side. Capacity of Istanbul Province is larger than the sum of five of its neighbouring provinces, though Istanbul has a protocol established with them.

From their experiences in past disasters, they recognised that unskilled amateur first aid caused problems to victims rather than help; thus, they focus on providing first aid training to the public, so as to reduce the potential to worsen patients' condition due to unskilled first aid. Trainees are mostly limited to professionals such as traffic police, fire fighters, etc. There are 20 trainees in a class, and two classes are held at a time. The training program lasts seven hours a day for three days using an "American first aid standard." They limit the program offering because there are only six trainers. Training is provided on a voluntary basis free of charge, since volunteerism is the most important factor in first aid. They managed to gather a 20,000 member audience on a voluntary basis for a seminar, and they trained 3,750 applicants. Their goal is to have one trained person in each building, then one person in each family. Red Crescent or international hospitals also offer first aid training on acommercial basis.

(7) IMM Civil Defence Directorate

In Istanbul, there are two rescue organisations. The Provincial Directorate of Civil Defence works under the governorship of Istanbul and belongs to Ministry of Interior. The director is appointed by the Ministry of Interior. The Provincial Civil Defence has 44 highly skilled rescue workers and 7 vehicles.

The IMM Civil Defence has 41 highly skilled rescue workers and six vehicles. They work under the governorship via the Provincial Civil Defence. The number of workers in civil defence including less trained rescue workers amounts to 7000. Three rescue dogs are trained everyday at the police department dog training facility.

IMM civil defence has radio communication with three different channels. The first channel is between the governorship and the Provincial Civil Defence, the second one is for use among the civil defence in IMM, and the third one is with the police department. Communication is establsishedwithin five minutes and it takes three minutes to leave office. The IMM civil defence does not have a direct access phone number for the public to use. They are called on duty by the Provincial Directorate of Civil Defence.

Both civil defence organisations are located on the European side, and there is no civil defence office on the Anatolian side. In case of an emergency, the IMM Civil Defence is designated to work in the two districts, Eminonu and Fatih. Other districts are within the responsibility of the Provincial Civil Defence. The fire brigade also executes rescue operations, but they may have little knowledge of heavy rescue. Military rescue would also be a major force.

In the past, the governor or vice governor had to be present on site to command rescue operations. However, this precedent has been changed recently. The district chief must be present on site to command efforts, and the fire brigade is in charge of the rescue operation. Civil defence in the IMM is called only in case of a serious situation. In the year 2002 so far, there were eight rescue operations regarding building collapse cases. Due to insufficient cooperation on the part of the fire brigades, some operations were not successful. The major role of the fire brigade is extinguishing fires and light rescue.

IMM civil defence has three staff members fully assigned to rescue training. Training is given to students and staff in high schools and universities. In addition, training is given to district municipality, sports club, or NGO members. Training is done at the AKOM site. One training course takes a week, four hours a day, for a total of 20 to 25 hours. In one class, the maximum number of students is 15. 25 hours are necessary to teach the basic rescue operation. Upon completion, a certificate is issued to the participants. Provincial Civil Defence gives continuous rescue training to civil defence sections in each governmental organisation. The total number of trainees amounts to over 10,000.

(8) Department of Transportation Planning

In this directorate, there exist three departments that are related to disaster management. The Coordination Department is in charge of coordination with external organisations. The IMM Road Maintenance section is included in the governorship taskforce via the Highway 17th Directorate.

The Planning Directorate is in charge of transport planning and attends the AKOM meeting regularly. This directorate planned helipad construction according to the request from AKOM and AYM, but it is not responsible for emergency response. Their task is uniquely limited to the planning of helipads. Helipads will be used for emergency purpose only. Up to now, 50 out of 76 planned helipads are completed. However, information on the total number of helicopters and their operation could not be obtained from the governorship.

In the traffic monitoring room, 21 points along the highways and main roads with heavy traffic have been monitored since 1997. Realtime traffic monitoring results are aired on 22 radio stations and five TV stations, two to three times a day. The realtime traffic information is also seen on internet. The information is communicated via digital form from ten stations and via analog fromeleven stations. No batteries are installed in the cameras, though a uninterruptible power system lasting for few hours is to be installed. Five electric boards are installed to indicate detour routes to drivers.

For disaster management issues, the Transportation Planning Directorate only develops plans. The Traffic Control Directorate appoints 15 staff persons to help police with traffic control, without police authority.

The transportation directorate does not have a direct tie to the governorship. No cooperation regarding emergency management exists between the 17th Highway Directorate. No meetings are held among transportation taskforce organisations.

To promote communication during normal circumstances, the Transportation Coordination Centre meets once a month. The centre includes the 1st and 17th Regional Highway

Directorates, IMM transportation companies, IETT, the mayor, the Transportation Department head, the Traffic Coordination Directorate, and traffic police.

3.4.4. District and Municipal Government

Avcilar District has a population of more than 230,000. In the Istanbul Province, this district suffered the heaviest damage during the 1999 Izmit Earthquake, with 281 deaths, 40 collapsed buildings, 86 heavily damaged buildings, and 488 moderately damaged buildings.

(1) Avcilar District

District Disaster Management Centre

The Avcilar District has a disaster management centre within the site of the Provincial Directorate of Civil Defence, in a two-storied old building formerly used as an administration building by civil defence. Two other buildings are planned as alternative sites in case the current building suffers damage. Currently telephone, fax and radio are installed.

Two staff members from Avcilar Municipality work in the centre. In case of an emergency, 11 members will meet as a decision group; nine members meet as an execution group. The execution group includes the fire department, police, and gas company, etc. The first story of the building serves as the working room for the execution group. The second story serves as the meeting room for the decision-making group, and a separate room is provided for a secretary.

A resource map for the district was provided by the governorship. The map will be updated with disaster scenarios based on experience. The extent of damage in the scenario is not known.

Municipality

There are two rescue teams in the civil defence section of the municipality. Only a list of the staff and their tasks exist in the municipality now. Damage or experience reports have not been completed by the municipality. The emergency centre established by municipality during the Marmara earthquake was moved to the District Disaster Management Centre. The municipality only receives an agenda or memo from the governorship once every three months, and most of the topics have to do withrescue efforts.

The Municipality has amended a plan note to conduct a geology study if needed after the Marmara earthquake. The geology maps divide areas into four categories according to ground conditions. Before the Marmara Earthquake, the number of construction permits was 200 per year on average. After the earthquake, only 18 buildings have been permitted. This sharp drop is mostly due to the economic recession.

(2) Kadikoy District

Municipality

Kadikoy District has a population of over 660,000, which is the largest within the IMM. The district has 28 Mahalles, which are grouped into ten areas according to the population. The municipality executes various disaster prevention activities, with the active participation of many volunteers.

In the municipality, the Project Coordination Directorate developed a disaster prevention plan, based on their principle "to solve the problem with, and, by local people," by consultancy with civil society. Their planning includes an organizational plan, the location of a disaster management centre, the locations of pertinent facilities on maps and GIS, citizen's participation planning, and concrete and ground testing.

The municipality coordination group includes the mayor, vice mayor, planning and the directorate. The consultancy group includes the Boazici University and chambers. The executive group has a meeting every 15 days. There are ten service groups, which are parallel to the ones in AYM, including 28 neighbouring volunteer groups. Each service group has a director and trainer, and aims to form a bottom-up organization. In addition, there are a study group, financial group, and executive group.

In the municipality, the location of useful facilities for disaster management, such as hospitals, pharmacies, fire stations, doctor and nurse offices, fuel stations, military posts, district health centres, cemeteries, and storage buildings, are contained in an urban information database using GIS, which also contains information on the facilities' attributes, and such information will be posted on the internet.. Such GIS data are passed to the AYM. In the next 2.5 years, building identification and street-based community information will be completed.

Though the building code is issued by the central government, the municipality can specify the number of stories or the structure of a planned building. The municipality's building safety inspection is now mandatory. If the inspected new building does not meet specified requirements, they can stop construction.

Kadikoy Municipality Disaster Management Centre

The Kadikoy Municipality built a disaster management centre covering 90,000 m^2, including training rooms. The municipality provided a working office for the district head and all related organisation representatives, including those of ten NGOs. Thus, the centre will also work as a district disaster management centre. Communication between the governorship will be made via the district head. The municipality does not have an official relationship with the IMM or the AKOM.

The DMC has a power generator and an emergency water tank. The DMC will have satellite telephone communication to the AYM, a Local Area Network is ready in the centre, and a web server will be installed – all for disaster information management. Tents and lamps are stored from past rescue work experiences during the Marmara earthquake. Six flat buildings plus office are provided for AKUT and major rescue NGOs.

DMC has a dining hall for emergency use; the hall is currently used as kitchen for another project. Cooks for the kitchen are trained for eight months as vocational training. The centre is used as a training and seminar room on weekend.

(3) Building Quality Study in Laboratory

The municipality disaster management centre has a concrete quality and soil laboratory, run by municipality with municipal staff. It was built in 2001, motivated by the Marmara Earthquake. Before, private companies inspected building quality as of 1994. Experts from the centre make observations on site, take concrete samples, and inspect iron bars with X-rays on a non-profit basis. They mostly work in this municipality, but some also work in other municipalities.

They have only one team for concrete testing, so that their services are usually reserved for two months ahead. Owners or residents of an existing building can apply for a safety inspection, and they are informed the results. 6,000 samples of concrete cores have been tested so far. A total of 40,000 buildings in the municipality are inputted in GIS. However, the municipality cannot enforce retrofit work or the budget to do so. The result of the evaluation will be used to classify buildings in a new project currently being proposed.

Another corporation in the IMM also works on building quality inspections on a profit basis with five staff members. However, their test is based on comparison of plans and the actual building, and the report is not a detailed one.

The municipality has drilled at 93 sites, 1500 m in depth in total. In addition, 84 existing boring data were collected from public services in the IMM. Geology base maps, geotechnical maps, and settlement maps are made using the collected data, and they will be disclosed on Internet.

Though the municipality understands the needs for retrofitting, retrofitting faces difficulties in two aspects. The first problem is that the municipality does not have the legal authority to enforce retrofitting. Also, if reconstruction is done, the height of the new building will be lower than the original one if it follows MPWS's request to limit the height of new buildings. The second problem is that the cost of retrofitting is estimated to be about 70% of the cost of construction. The municipality cannot afford assistance under the present economic situation. Nor can the municipality provide credit, though it can pay monthly for the work.

References for Section 3.4:

Oktay, E. "A Perspective of Disaster in Turkey: Issues and Prospects, Urban Settlements and Natural Disasters." Proceedings of UIA Region II Workshop. Chamber of Architects of Turkey, 1999.

AKOM. Activity Report, 2002.

3.5. Disaster Management Systems in Japan and USA

3.5.1. Disaster Management System in Japan

(1) National Disaster Management System in Japan

Due to its geological setting and its location in a monsoon area, Japan has repeatedly suffered from various types of natural disasters: typhoons, heavy rains, earthquakes, volcanoes, etc. Figure 3.5.1 shows the number of deaths by natural disaster in Japan since 1946, the year which marked the end of the Second World War.

In the post-war period, Japan's national land was deteriorated and was susceptible to natural disasters. Motivated by the major typhoon disaster that killed more than 5,000 people in 1959, the "Basic Law for Disaster Prevention" was issued in 1963. This law aimed to implement a major shift in Japan's national disaster management policy from being post-disaster focused to placing more emphasis on pre-disaster mitigation.

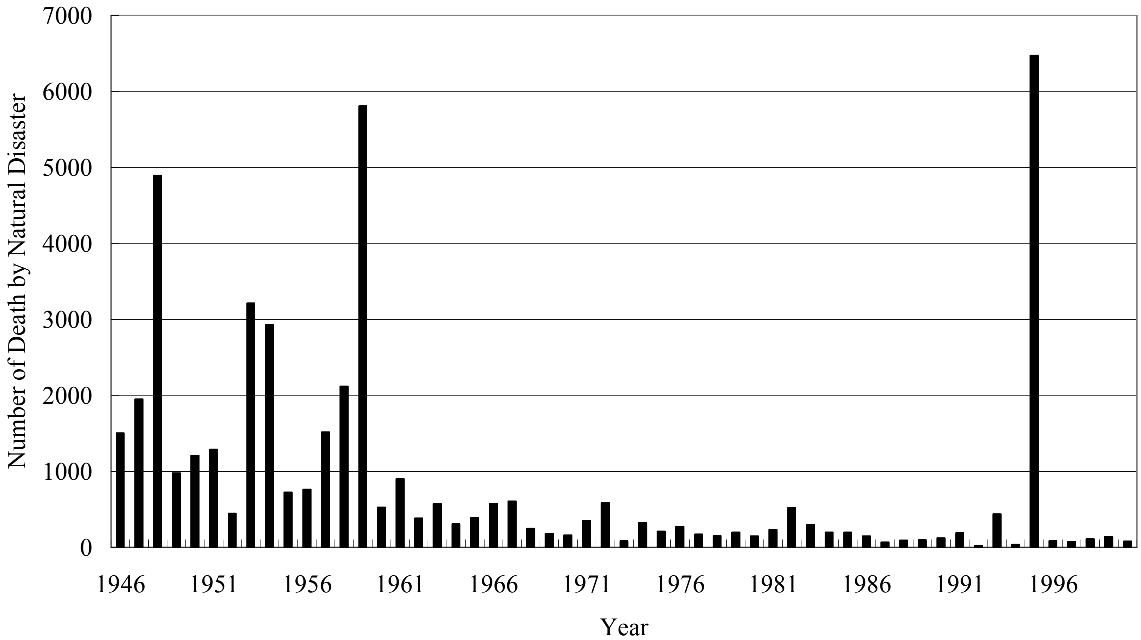


Figure 3.5.1 Number of Deaths by Natural Disaster in Japan

Source: Cabinet Office (2002)

The table of contents in the Basic Law is shown in Table 3.5.1, and Japan's disaster management organisations, as specified by the law, are illustrated in Figure 3.5.2. The main features of the Law are the following:

- Responsibility for disaster prevention is defined at every level and stage.

Responsibilities are defined for the national government, prefecture government, municipality, designated public services at national and local levels, and citizens. Responsibility for prevention, emergency response, and recovery stage efforts is defined for the national and local governments.

- Council is established at national, prefecture and municipality level.

A central council for disaster prevention with the prime minister as its head is established in the national government as a comprehensive coordination organisation. A prefectural council is also established with the governor as its head, including local ministry offices and designated public services. The municipality also establishes a similar council.

- A disaster prevention plan is made at every level based on the national basic plan.

The central council for disaster prevention establishes a basic plan for disaster prevention, a comprehensive and long-term plan. Designated administrative organisations and public services make operational plans for disaster prevention, based on the national basic plan. Prefectural and municipal councils for disaster prevention also make their own plan according to the national basic plan.

-Establishment of disaster prevention research organisation in government.

The need for scientific research to mitigate damages due to natural disasters was recognised at a national governmental level.

- Reconstruction from disaster should aim to improve facilities.

Reconstruction after a disaster should not only restoredamaged infrastructure, but also strengthen it against future disasters.

Japan's "Basic Plan for Disaster Prevention," whose contents are shown in Table 3.5.2, was issued in 1963 according to the Basic Law. The plan deals with different natural and industrial disasters, but the earthquake case is given primary attention. In each chapter, measures for prevention, emergency response, restoration, and reconstruction are described.

A notable feature in the law's section for prevention is that it includes urban planning and states that national development should be taken into consideration in disaster prevention. Section three describes the duty of the central and local governments to let the public know their potential risk using the result of damage estimation and so on, as well as their duty to urge citizens to prepare for the disaster with active participation. Section four mentions the government promotes scientific, engineering, and social studies for disaster prevention. It obligates responsible personnel of damaged facilities to collect damage information, to analyse the cause of damage, and to report findings to the government, if necessary, for further study and clarification of responsibility and for the future improvement of standards.

A gradual decrease in the number of deaths after the enactment of the Basic Law in 1963 indicates that major policy change combined with comprehensive long-term mitigation efforts have been successful in reducing human casualties to some extent.

However, the 1995 Kobe earthquake that killed more than 6,000 --many of them killed due to the collapse of old buildings-- demonstrates urban areas still remain in Japan. With the experience of the Kobe earthquake, the following items were amended:

- Prohibition of regular traffic to assure emergency transportation
- Establishment of an emergency response centre, regardless of the declaration of the state of emergency
- Empowerment of the mayor to request to the governor that self defence forces be dispatched for disaster response

Table 3.5.1 Table of Contents of Japan's "Basic Law for Disaster Prevention"

Table of contents		Contents	Articles
Chapter 1 General rules		Object of the law, definition of terms, responsibilities of national, provincial, municipal governments, designated public services, and citizens. Mutual cooperation among local governments	1-10
Chapter 2 Organizations related to disaster prevention			
	Section 1 Central disaster prevention committee	Establishment and responsibilities of central council.	11-13
	Section 2 Local disaster prevention committee	Establishment and responsibilities of prefecture and municipal council.	14-23
	Section 3 Emergency operation center	Establishment and responsibilities of emergency operation center.	24-28
	Section 4 Dispatch of staffs during emergency	Request of staffs' dispatch.	29-33
Chapter 3 Planning of disaster prevention		Planning and accouchement of disaster prevention plan at national, prefecture, and municipal government and designated public services.	34-45
Chapter 4 Prevention of disaster		Responsibilities of preventive measures. Disaster drills.	46-49
Chapter 5 Emergency response measures		Responsibilities of emergency response, notification of warning, mayor's authority in order of evacuation and precaution area, request of help to governor, traffic during emergency, priority of communication, compensation of losses.	
	Section 1 General rule		50-53
	Section 2 Notification of warning etc.		54-57
	Section 3 Preventive measures and evacuation		58-61
	Section 4 Emergency response		62-86
Chapter 6 Recovery from disaster		Responsibilities of recovery, cost estimation for recovery works, report to council, financial assistance from national government.	87-90
Chapter 7 Financial assistance measures		Prefecture and national assistance for recovery works executed by municipality.	91--104
Chapter 8 Activation of state of emergency		Declaration and termination of state of emergency, acceptance of national diet.	105-109
Chapter 9 Miscellaneous rules			110-112
Chapter 10 Penalty rules			113-117

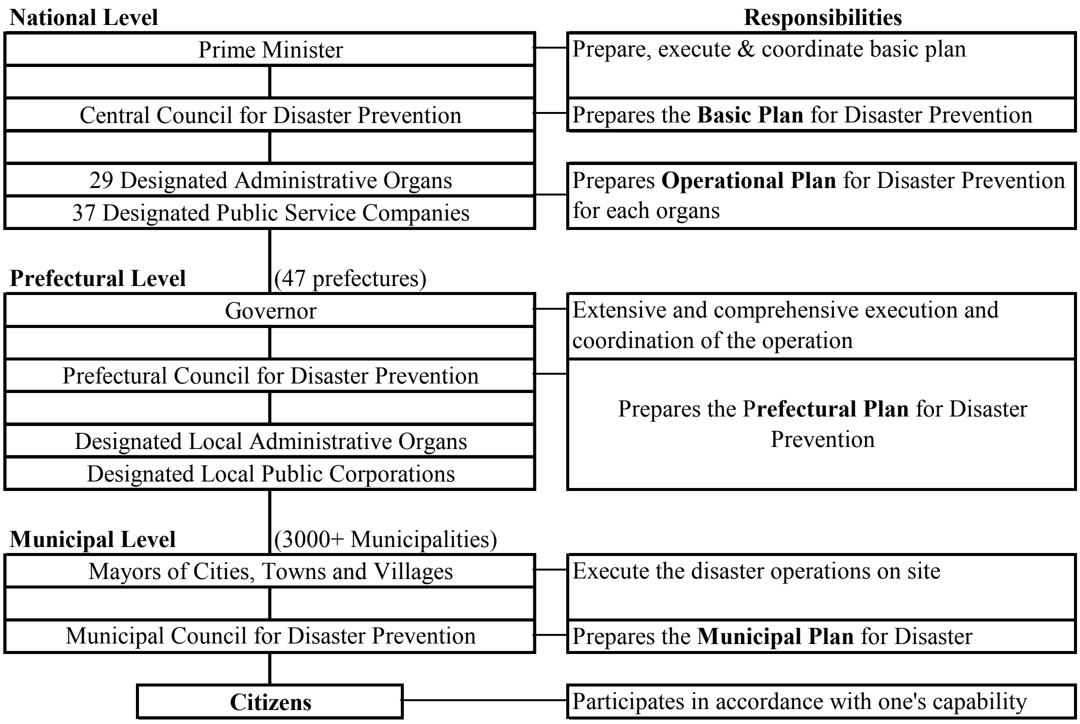


Figure 3.5.2 Japanese Disaster Prevention Organizations and their Responsibilities

Table 3.5.2 Contents of The Basic Plan for Disaster Prevention

Part	Contents	
1	General	
2	Earthquake disaster prevention	
	Chapter 1Disaster prevention	
		Section 1 Building seismic resistant country and cities
		Section 2 Rapid and smooth emergency response, preparation for restoration and reconstruction
		Section 3 Promotion of citizens' disaster prevention activities
		Section 4 Promotion of research and observation for disaster and disaster prevention
	Chapter 2 Emergency response	
		Section 1 Collection of information and assurance of communication and command
		Section 2 Establishment of emergency response system
		Section 3 Rescue, first aid, medical treatment, and fire fighting
		Section 4 Assurance of emergency traffic, emergency transportation
		Section 5 Evacuation and its acceptance
		Section 6 Procurement of food and water and its distribution
		Section 7 Hygiene, prevention of disease, body treatment
		Section 8 Maintenance of social order and stability of prices
		Section 9 Emergency restoration of facilities
		Section 10 Precise public relation to victims
		Section 11 Prevention of secondary disasters
		Section 12 Acceptance of voluntary help
	Chapter 3 Restoration and reconstruction	
		Section 1 Decision of basic orientation for restoration and reconstruction
		Section 2 Method of rapid restoration
		Section 3 Methods for planned reconstruction
		Section 4 Support for victims' daily life reconstruction
		Section 5 Support for restoration of small-medium business and other economic recoveries
	Chapter 4 Measures for tidal waves	
		Section 1 Prevention of disaster
		Section 2 Emergency response
3	Storm and Flood disaster prevention	
4	Volcanic disaster prevention	
5	Snow disaster prevention	
6	Maritime disaster prevention	
7	Air traffic disaster prevention	
8	Railway disaster prevention	
9	Road disaster prevention	
10	Nuclear disaster prevention	
11	Hazardous material disaster prevention	
12	Large scale fire disaster prevention	
13	Forest fire disaster prevention	
14	Other types of disaster prevention	

(2) Disaster Management in Tokyo Metropolitan Municipality

Tokyo has been the capital of Japan since the 17th century, and it has suffered major earthquakes repeatedly. The last major earthquake Tokyo suffered occurred on September 1st in 1923; the eventkilled more than 140,000 people in a great fire after the earthquake. On the memorial day of this event, disaster drills are held by many governmental organisations in Japan.

Based on the "Basic Law on Disaster Prevention" of 1961, the Tokyo Metropolitan Government formed the Metropolitan Disaster Prevention Council and established a disaster prevention plan in 1963.

In 1971, Tokyo's metropolitan government issued the "Earthquake Disaster Prevention Act." The contents of the act are shown in Table 3.5.3. The act stresses seismic reinforcement of structures. In addition, the act requests the cooperation of citizens to create disaster prevention organisations, to be educated, and to practice drills.

In 1973, based on the act, the first "Five-year Plan for Earthquake Disaster Prevention for Tokyo" was established to realise items mentioned in the act and to integrate disaster prevention-related projects executed in various sections of the metropolitan government independently.

In 1978, the study on seismic damage estimation in Tokyo, the first one among local governments in Japan, was completed for 23 central districts. The result of estimation has been made public to form realistic disaster prevention initiatives, and to promote public awareness.

Table 3.5.3 Contents of Earthquake Disaster Prevention Act

Chapter 1 General		Article
	Section 1Definition	1
	Section 2 Responsibilities of governor	2-8
	Section 3 Responsibilities of district, cities, and villages	9-10
	Section 4 Responsibilities of metropolitan citizens	11-12
	Section 5 Responsibilities of private sectors	13-15
Chapter 2 Urban planning for disaster prevention		16-19
Chapter 3 Prevention of destruction		
	Section 1 Strengthening of seismic resistance	20-26
	Section 2 Prevention of earthquake disaster in made land	27-28
	Section 3 Prevention of subsidence	29
Chapter 4 Prevention of fire		
	Section 1 Prevention of fire breakout	30-32
	Section 2 Prevention of fire spreading	33-36
Chapter 5 Evacuation		37-42
Chapter 6 Systems for information and communication		43-44
Chapter 7 Cooperation by citizens		
	Section 1 Disaster prevention organization	45-47
	Section 2 Disaster prevention education	48
	Section 3 Disaster prevention drill	49-50
	Section 4 Opinion of metropolitan citizens	51-52
Chapter 8 Authorization		53

The plan has been updated regularly since then every three to six years. The 7th Earthquake Disaster Prevention Plan for Tokyo Metropolitan Government, established in 1999, has contents as shown in Table 3.5.4.

Table 3.5.4 Contents of 7th Earthquake Disaster Prevention Plan for Tokyo Metropolitan Government

I. General
- 1 Basic characteristics of earthquake disaster prevention
- 2 Background of establishment for seventh plan
- 3 Basic principles of plan establishment
- 4 Period of plan
- 5 System of plan
- 6 Outline of plan
- 7 Size of projects

II. Sectorial Plans

Part 1 Building seismic resistant city
- Chapter 1 Urban structure redevelopment
  - Section 1 Promotion of disaster prevention urban plan
  - Section 2 Redevelopment of dense wooden housing areas
  - Section 3 Strengthening of Road, bridges, rivers, coast, and ports
  - Section 4 Strengthening of lifeline facilities
  - Section 5 Assurance of open space inn urban area
  - Section 6 Strengthening of buildings
  - Section 7 Strengthening against liquefaction
- Chapter 2 Mitigation of earthquake damage
  - Section 1 Prevention of earthquake fire
  - Section 2 Prevention of slope and wall failure, and fallen objects
  - Section 3 Prevention hazardous materials risk

Part 2 Building seismic resistant societies
- Chapter 1 Diffusion and education
  - Section 1 Awareness promotion of disaster prevention
- Chapter 2 Cooperation among citizens
  - Section 1 Establishing mutual help network
  - Section 2 Strengthening of civic organization for disaster prevention
  - Section 3 Strengthening of disaster prevention system in corporation
  - Section 4 Development and assistance of volunteers
- Chapter 3 Helping weak people
  - Section 1 Security assurance for weak people
  - Section 2 Assistance for foreigners
  - Section 3 Promotion of measures for difficulties to home coming

Part 3 Building seismic resistant systems
- Chapter 1 Strengthening of initial response system
  - Section 1 Preparation for allocation
  - Section 2 Preparation of activity centers
  - Section 3 Strengthening of communication
- Chapter 2 Strengthening of rescue and support system
  - Section 1 Preparation of evacuation area and evacuation route
  - Section 2 Strengthening of function in evacuation area
  - Section 3 Assurance of water and food
  - Section 4 Preparation of fire fighting and rescue
  - Section 5 Preparation of ambulance and medicals
  - Section 6 Preparation of transport and logistics
- Chapter 3 Recovery from earthquake disaster
  - Section 1 Recovery from earthquake disaster
- Chapter 4 Strengthening of cooperation
  - Section 1 Strengthening of mutual help
  - Section 2 Strengthening of disaster drill
- Chapter 5 Research and study
  - Section 1 Research and study for damage estimation and local risk
  - Section 2 Information collections for disaster prevention measures

3.5.2. Disaster Management System in the USA

(1) National Disaster Management System in USA

History of Disaster Management in USA

In the United States, the first piece of disaster legislation can be traced back to the Congressional Act of 1803, which provided assistance to a New Hampshire town following an extensive fire. In the following century, legislation was passed in an ad hoc manner more than 100 times in response to hurricanes, earthquakes, floods, and other natural disasters.

By the 1930s, the Reconstruction Finance Corporation was given authority to make disaster loans for repair and reconstruction of certain public facilities following an earthquake, and later, other types of disasters.

In 1934, the Bureau of Public Roads was given authority to provide funding for highways and bridges damaged by natural disasters. The Flood Control Act, which gave the U.S. Army Corps of Engineers greater authority to implement flood control projects, was also passed. This piecemeal approach to disaster assistance was problematic and it prompted legislation that required greater cooperation between federal agencies and authorised the President to coordinate these activities.

The 1960s and early 1970s brought massive disasters requiring major federal response and recovery operations by the Federal Disaster Assistance Administration, established within the Department of Housing and Urban Development (HUD). These events served to focus attention on the issue of natural disasters and brought about increased legislation. In 1968, the National Flood Insurance Act offered new flood protection to homeowners, and in 1974 the Disaster Relief Act firmly established the process of presidential disaster declarations.

However, emergency and disaster activities were still fragmented. When hazards associated with nuclear power plants and the transportation of hazardous substances were added to natural disasters, more than 100 federal agencies were involved in some aspect of disasters, hazards and emergencies. Many parallel programs and policies existed at the state and local level, compounding the complexity of federal disaster relief efforts. The National Governor's Association sought to decrease the many agencies with which state and local governments were forced work. They asked President Jimmy Carter to centralise federal emergency functions.

Establishment and Development of FEMA

President Carter's 1979 executive order No. 12127 merged many of the separate disaster-related responsibilities into a new Federal Emergency Management Agency (FEMA).

- To reduce the expense of the federal government due to duplicated emergency response activities
- To establish an effective partnership between central and local government, by establishing unified coordination organisation in central government

FEMA absorbed the Federal Insurance Administration, the National Fire Prevention and Control Administration, the National Weather Service Community Preparedness Program, the Federal Preparedness Agency of the General Services Administration and the Federal Disaster Assistance Administration activities from HUD. Civil defense responsibilities were also transferred to the new agency from the Defense Department's Civil Defense Preparedness Agency.

FEMA is an independent agency reporting to the President and with responsibilities of responding to, planning for, recovering from and mitigating against disasters. Today, FEMA has more than 2,600 full time employees. FEMA also has nearly 4,000 standby disaster assistance employees who are available to help out after disasters. Often FEMA works in partnership with other organisations that are part of the nation's emergency management system. These partners include state and local emergency management agencies, 27 federal agencies and the American Red Cross. The organisation of FEMA is illustrated in Figure 3.5.3.

John Macy was named as FEMA's first director. Macy emphasized the similarities between natural hazards preparedness and civil defense activities. FEMA began development of an Integrated Emergency Management System with an all-hazards approach that included direction, control and warning systems, which are common to the full range of emergencies from small isolated events to war.

The new agency was faced with many unusual challenges in its first few years that emphasized how complex emergency management can be. The Loma Prieta Earthquake in 1989 and Hurricane Andrew in 1992 focused major national attention on FEMA.

In 1993, President Clinton nominated James L. Witt as the new FEMA director, the first director with experience as a state emergency manager. He initiated reforms that streamlined disaster relief and recovery operations, giving a new emphasis regarding preparedness and mitigation, and focused agency employees on customer service. The end of the Cold War also allowed Witt to redirect more of FEMA's limited resources from civil defense into disaster relief, recovery, and mitigation programs.

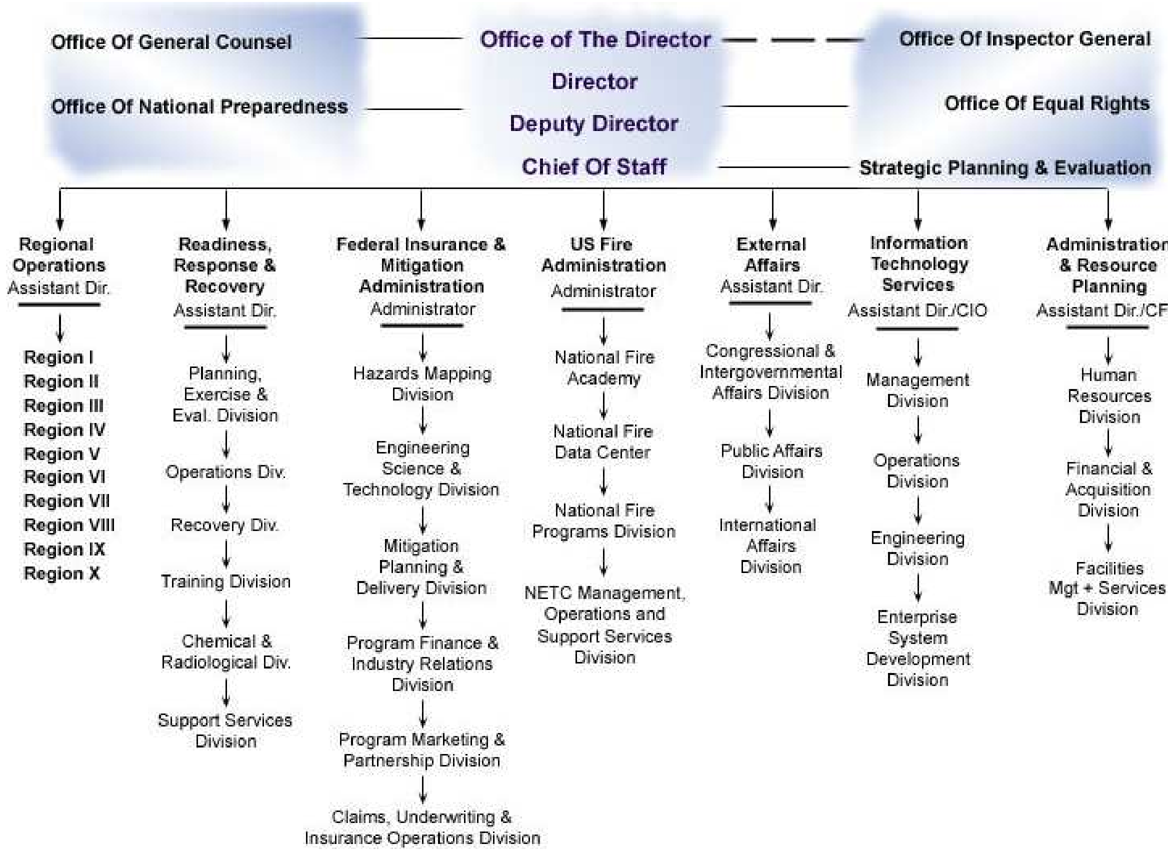


Figure 3.5.3 Organisation of FEMA

Source: Federal Emergency Management Agency website (www.fema.gov)

FEMA's Earthquake Program

FEMA's earthquake program was established in 1977, under the authority of the Earthquake Hazards Reduction Act of 1977, enacted as Public Law 101-614. The purpose of the National Earthquake Hazards Reduction Program (NEHRP) is to reduce the risks of life and property from future earthquakes.

FEMA serves as lead agency among the four primary NEHRP federal partners, Research Centers at the National Science Foundation, and National Institute of Standards and Technology, and the US Geological Survey, Engineering, and is responsible for planning and coordinating the Program.

FEMA's Earthquake Program has four basic goals directly related to the mitigation of hazards caused by earthquake as follows.

- To promote understanding of earthquakes and their effects
- To work to better identify earthquake risk

- To improve earthquake-resistant design and construction techniques
- To encourage the use of earthquake-safe policies and planning practices

As a part of the earthquake program, FEMA publishes guidelines and a safety checklist to prepare against various natural disasters.

The Southern California Earthquake Preparedness Project, an experimental project funded by the federal government and State of California started in 1980 and lasted for three years. The object of the project was to establish an earthquake preparedness plan, and to promote earthquake prevention measures against a potential major earthquake.

In the project, a procedure to establish earthquake disaster prevention measures for high earthquake risk areas was developed. Also, an earthquake disaster prevention plan was established including governmental and private sectors, and considering the case of earthquake prediction as both possible and impossible.

The results of the project were published as part of the "Comprehensive Earthquake Preparedness Planning Guidelines" for corporations, counties, and citities in 1985; namely FEMA 71, 72, and 73, respectively. Table 3.5.5 shows the contents of FEMA 72, a guideline for counties.

The guidelines includes long-term and short-term preparation, assuming that earthquake prediction is possible, emergency response within a few weeks after the occurrence of an earthquake, and short-term recovery within a few months. A matrix to define the division of roles among related organisations, and to specify the primary responsible organisations and supportive ones is given for each stage.

Table 3.5.5 Contents of FEMA's Comprehensive Earthquake Preparedness Planning Guidelines: County

Part One User's Guide
- A. Introduction
- B. Phase one: About planning
- C Phase two: Plan Establishment
- D Phase three: Plan Implementation

Part Two Planning Guide
- A Elements of plan
- B Activities and division of roles for earthquake response
- C Preparation in long term (Activities to be done in few years to several ten years before earthquake)
  - 1 Safety measures against earthquake
  - 2 Incentives for damage mitigation
  - 3 Mutual help and mutual aid protocol
  - 4 Disaster assistance
  - 5 Earthquake preparation
  - 6 Mitigation of structural damage
  - 7 Seismic resistant measures for non structural elements and facilities
  - 8 Public relations and education
  - 9 Emergency shelters and large scale aid
  - 10 Disaster management
  - 11 Safety of schools
  - Duties and division of role matrix for long term preparation
- D Preparation in short term
  - (Activities to be done in few days to few weeks before earthquake, if earthquake is predicted)
  - 1 Preparation for emergency response
  - 2 Traffic and transportation
  - 3 Communication
  - 4 Public relations and warning
  - 5 Human and material resource management
  - 6 Support for logistics
  - 7 Hazardous and toxic material management and fire protection
  - 8 Safety of
  - 9 Evacuation
  - 10 Emergency shelters and large scale aid
  - 11 Emergency medicals
  - 12 Maintenance of law order
  - Duties and division of role matrix for preparation in short term
- E Emergency response (Activities to be done within 72 hours to few weeks after earthquake)
  - 1 Traffic and transportation
  - 2 Communication
  - 3 Removal of debris
  - 4 Fire fighting and management of hazardous or toxic materials
  - 5 Repair of road and bridges
  - 6 Damage inspection, prohibition, and demolition
  - 7 Support for human and material resources and logistics
  - 8 Emergency medicals and public health
  - 9 Search and rescue for victims
  - 10 Necropsy
  - 11 Public relations
  - 12 Emergency shelters and large scale aids
  - 13 Investigation of damage status
  - 14 Recovery of lifelines and public service
  - 15 Disaster management
  - 16 Maintenance of law order
  - Duties and division of role matrix for emergency response
- F Recovery in short term (Activities to be done in one to two months after earthquake)
  - 1 Recovery of traffic network
  - 2 Disaster assistance
  - 3 Public relations, information transmission
  - 4 Reopening of governmental activities
  - 5 Resume of public service
  - 6 Demolition of dangerous structures
  - 7 Damage cost calculation and refund
  - 8 Redevelopment and reconstruction
  - Duties and division of role matrix for recovery in short term
- G Glossary

(2) Emergency Operations, City of Los Angeles

In the City of Los Angeles, California, the Emergency Operations Organization (EOO) was created by the Emergency Operations Ordinance in 1980, as the only local government organisation of its kind in the United States at that time.

The EOO is an operational department of Los Angeles, which centralises command and information coordination to enable its unified chain-of-command for planning, coordination, and management of disaster preparedness, mitigation, response, and recovery.

The City's emergency preparedness goal is to effectively bring every available resource to bear against the problem in times of crisis. Accomplishing this task requires multifaceted interdepartmental and inter-agency cooperation and the resolution of complex operational, legal, legislative and administrative issues. The operational priorities of the EOO are the followings:

- To save lives and protect property
- To repair and restore essential systems and services
- To provide a basis for direction and control of emergency operations
- To provide for the protection, use and distribution of remaining resources
- To provides for continuity of government
- To coordinate operations with other jurisdictions' emergency service organisations

The Los Angeles Emergency Operations Master Plan was established in accordance with Division 8, Chapter 3, Article 1 of the Los Angeles Administrative Code of 1980, and Emergency Operations Ordinance amending Chapter 3, of Division 8 of the code. The Emergency Operations Master Plan is consistent and compatible with the State Emergency Plan. The contents of the Emergency Operations Master Plan in 1996, as shown Table 3.5.6, include the following novel features:

- Plan maintenance and distribution in Part 1
- The organisation and duties of emergency operation centres are defined in Chapter 4
- Multi-agency coordination is stressed in Chapter 5
- Importance of emergency public information is stressed in Chapter 6
- Plans for each division in the city are defined in Chapter 7
- Response plans to various kind of disasters are described in the Annexes

Reference for Section 3.5:

United States Cabinet Office. White Paper on Disaster Prevention, 2002.

Table 3.5.6 Contents of Emergency Operation Master Plan of the City of Los Angeles

Part 1 Introduction
1 Basis for planning
2 Purposes of the plan
3 Objectives
4 Planning assumptions
5 Plan activation
6 Authorities and references
7 Plan maintenance and distribution
8 Organization of the plan
Part 2 Authorities related to emergencies
1Emergency laws and regulations
2 Definitions of emergency
3 Authorities and actions under local emergencies
4 Continuity of government
Part 3 Emergency operations
1 Introduction
2 Emergency operations organization
3 Emergency operations organization coordinator
4 EOO authority and powers
5 Activation of the emergency operations organization
Part 4 Emergency operation centers
1 Primary emergency operations center
2 Organizations of the EOC
3 Duties and responsibilities of EOC sections
4 Activation of the EOC
5 Overview of EOC operations
6 Action planning in the EOC
7 EOC equipment and support systems
8 EOC information management system
9 Information flow within the EOC
10 Multi agency coordination within EOC
11 Mobile emergency operations center
Part 5 Multi agency coordination
1 Mutual aid
2 City county joint emergency operations procedures
3 Multi agency or inter agency coordination
4 State and federal coordination
5 America red cross assistance
6 Volunteer and private sector coordination
7 Payment for emergency services
Part 6 Emergency public information
1 Background
2 Development of public information
3 Coordination with other agencies
4 Means of dissemination
Part 7 Emergency operations organization -functions and resources summary
1 Table of function and resources
Part 8 Division plans
Annexes to the emergency operations master plan
Civil disturbance
Earthquake prediction
Storm
Earthquake
Major fire
Hazardous materials
Aircraft accident
Recovery and reconstructions

Source: Los Angeles City website (www.lacity.org/epd/epdep.htm)

3.6. Recommendations for Improved Disaster Management in Turkey

Recommendations for the improvement of the current disaster management system in Turkey, categorised by legal measures, organisational structure, and planning, are based on an examination of current conditions, interviews, and comparisons with other management systems. These recommendations are discussed in this section.

3.6.1. Recommendations on Legal Measures

Many researchers have pointed out weaknesses of the disaster management system in Turkey (Ergunay, 1999; Gulkan, 2000; Balamir, 1999). Problems with basic laws are discussed respectively.

(1) Development Law

The Development Law should cover the entire construction process:

The law should control not only the construction phase, but also investments and entrepreneurial organisations, provision of land and infrastructures, and technical means of control during the construction.

The Development Law should include concerns for disaster mitigation:

The law should have direct reference to the precautions needed for disaster mitigation. Land-use and zoning, transportation and infrastructure, land-use and density changes, and planning of open spaces should be taken into account by the law. Thus, the multi-disciplinary basis of disaster management should be established.

The Development Law should take integrated approaches for property management:

The Low should control land-use in an integrated manner for areas currently treated as special cases (such as metropolitan areas, national parks and reserves, areas of historical and natural significance, tourism centres, areas of ecological significance, and shores).

Planning control should be unified to avoid diffusion of authority:

Within Istanbul Province, there are four heads of land control, that is, the provincial government, IMM, districts within IMM, and districts outside IMM. IMM can develop city plans only after build-up areas are submitted to IBB. As such, IMM cannot control new development areas. To pursue the uniform control of the contents and procedures of plan development, particularly for disaster mitigation purposes, there should be a unified authority.

(2) Building Code Enforcement

a. Project Supervision

Engineers in public service companies in IMM should be utilised to assist with structural design checks.

Higher authorities should provide oversight for designated supervisory bodies.

Legal arrangement should be made for consumers to be able to sue the design engineer, inspection engineer of record, or approving agency for design errors in case of losses.

Legal measures should require the presence of a site engineer for construction projects exceeding certain limits.

A simplified check method should be developed for simple, ordinary designs.

Distinction should be made between ordinary and unusual engineering projects.

b. Construction Supervision

Professional qualification of the inspection engineer should be made.

The Development Law does not specify qualifications of inspectors who control designs. Supervising inspectors (called "engineers of record" in the law) only need to have valid diplomas. Experiences or professional qualifications do not count. In fact, some municipalities have transferred this duty to the local branches of the Chambers of Civil Engineers or Architects through informal agreements.

The inspectors should be empowered, and they should have liability insurance.

Inspectors have obligations but no real power. Even if they are required by the court to pay compensation, they cannot do so. There is no liability insurance.

The inspector should be separated from the contractor, and their minimum fees should be set:

The law requires inspectors to report any violation by the contractor he supervises to the municipality or governorate. The law also defines corrective actions and penalties if such violation occurs. However, the inspectors are usually hired by a contractor, not by the property owner. It is very difficult for inspectors to report because contractors are their employers in most cases. In addition, there are no minimum fees for supervising engineers.

Qualification requirement of the contractors should be made:

Currently, no particular requirements exist for people to pursue careers as contractors. The only guidelines are those in the Trade Law.

A building inspection process should be privatised to service companies:

Building plans are submitted to the municipal authorities with the signature of a design engineer who is responsible for code compliance. However, municipality engineers cannot adequately check all of the design calculations because of their heavy load. In addition, municipalities have no mechanisms other than citizen informants to become aware of illegal construction violating some legal article.

Seismic regulations should include other design aspects and building layouts:

Current regulation only includes structural aspects. The regulation should be broad, including other aspects such as fire and roofing materials.

Legal procedures should be simplified to ensure effective corrective action by authorities:

The legal procedures leading to the eventual tearing down of unpermitted construction take at least one year. Even if the court orders the tearing down, municipalities do not have necessary equipment or personnel to do it. In any case, it would be expensive to demolish buildings, and violators are frequently able to wait until some form of amnesty is declared. Compensatory awards against contractors take a long time to collect and, because of inflation, are meaningless when finally collected. Contractor errors or negligence can be addressed only through obsolete articles of the Law of Indebtedness. These do not constitute sufficient disincentives against fraud.

(3) Laws Related to Illegal Housing Construction

Disaster funds or catastrophe insurance pool funds should be allocated for improvement or relocation of illegal housing in advance of a disaster.

Currently, the fund for the “improvement area” designated by the law is lacking. In Istanbul, only 10% of illegal housing ownership has been transferred until 1980. In addition, alternative housing for the residents of “prohibited areas” is lacking.

Small-scale development would be necessary to regulate new development.

The Gecekondou Law of 1985 does not require construction permission for housing developments smaller than 1000 m2 and less than three stories. This would encourage new illegal developments.

(4) Disaster Law

Pre-disaster efforts should be stressed in the law:

The law primarily focuses on post-disaster intervention. Only a few mention preparations and responsibilities before disasters. The decrease of casualties due to natural disasters in Japan after a major shift of policies toward pre-disaster efforts indicates that pre-disaster efforts did pay off in the long-term. Efforts to mitigate possible damage should be included in the law as a national strategy.

The law should be standardised to learn from disasters:

The law stresses extra-ordinary power of authority for emergency response. This allows production of special decisions with every occurrence of disasters by political authority, and tends to forget the past experience, which should be the lessons for the future. Standardised emergency management is necessary to discourage special decisions and to encourage learning from past disasters.

The law should differentiate between those who do not comply with development regulations and those who do:

Providing equal help for everyone after every disaster should not be the standard response to promote efficient and just allocation of resources, to promote respect for the entire technical process, and to encourage responsible development in the long-term.

Specialised funds should be created for reconstruction:

It is necessary to avoid the extended and translocated use of pecialised funds by political bodies to gain popularity. The use of a fund should be decided by a lower echelon technical committee to be more efficient and precise in the allocation of financial resources.

(5) Emergency Aid Organisation and Planning Regulations

These regulations mostly describe the planning and duties for efficient activities after the disaster. Actions to reduce the damages or reconstruction in the long-term should be mentioned. The need for education and disaster drills should also be included.

Regulations should deal with different types of disasters separately:

These regulations deal with disasters in general. However, disaster situations and necessary responses will be different between earthquakes and other types of disasters. Thus, measures for different types of disasters should be described in different chapters.

Recent topics in disaster response should be included in the regulations:

Topics such as industrial, environmental, or psychological aspects not mentioned at the time of the issuing of the regulations should be included.

Special legislation for urban earthquake disasters should be made:

Regulations implicitly assume the disaster situation will occur in general in a province. However, the population in some districts in Istanbul nearly equal the population of an entire province, and the possible impact of a major earthquake in Istanbul will most likelu be much larger compared to the case in another province. Therefore, special legislation for an anticipated earthquake, such as the "Earthquake Disaster Prevention Act" by the Tokyo metropolitan government, should be made.

(6) Laws Related to Fire

A specific fire law should be integrated into the legal system.

A special fire law, one that specifies a a central regulation of all existing redundant rules and regulations issued by municipalities, should be made. The law should include scientific studies such as calculations of fire prevention, fire resistance, and fire strength. Additionally, the legislation should include volunteering.

(7) Earthquake Insurance

Retrofitting efforts should be reflected in insurance premiums:

Currently, only structural type is considered in the calculation of insurance premiums. In order to promote seismic retrofitting, retrofitted buildings should be given lower premiums.

More provinces should join the insurance:

To gain more popularity, not only should the pilot province, but also more provinces join the insurance in the future.

3.6.2. Recommendations Related to Organisation

(1) The disaster management should be distributed in a bottom-up system.

In case of a disaster, the initial gathering of officials at the management centre would be slow due to their own safety or traffic problems, as observed in past experiences. Communication and traffic between central and local offices during disaster would be very limited. Under such a situation, local offices should manage to work independently for the first few days, with little external help. Thus, local offices should be empowered with resources, information, and authority.

In addition, the hierarchical, top-down nature of the system tends to discourage local initiative, and it undermines the role of local authorities that must face the affected people.

(2) Linkage between central and local government should be made clear.

Adequate coordination between provincial governors, provincial directorates of ministries, and respective ministries in the central government should be made. The role of regional disaster management centres, which will be established to cover several provinces in case of large disaster, should be well defined.

(3) Command system should be well defined.

The command system between the Prime Ministry Crisis Management Centre and GDDA in MPWS in the central government, as well as between AYM and the provincial directorate of MPWH in the local government should be well defined. Command system to public service companies between AYM and AKOM should be made simple, since a few companies belong to both, while the rest are under AKOM.

(4) Weak links between organisations should be strengthened.

Linkages between AYM and AKOM, as well as between district heads and mayors, are not necessarily strong. In general, provincial officials charged with disaster management are not themselves from the province where they work, and may be unfamiliar with the local situation. The rapid turnover of government officials may make plans obsolete. These officials have to deal with other more pressing priorities than reviving the province plan. However, such linkages are very important because disaster response should essentially be done locally, especially during the initial period when sufficient external help cannot be expected. In addition, linkages between IMM and each district municipality, which are currently made via AYM, are important for disaster management in public services.

(5) Citizens and volunteers should be fully involved in the management system.

Citizens, if trained and organized properly, could be major players in disaster response, because they are the ones who are the closest to the disaster area, and they best know the local situations. However, they are a hidden resource in the current disaster management system. The total number of official rescue members may not be sufficient in case of a large-scale earthquake, because some of them may be also victims, and because they will have difficulties reaching the disaster area due to communication and traffic problems.

3.6.3. Recommendations Related to Disaster Management Plan

(1) Each member organisation should make its own plans and be checked on its conformity to these plans.

Each organisation responsible for emergency service should make its own plans. Moreover, the chief organisation of the corresponding service group and/or AYM should check the conformity to the plan within service groups and emergency services as a whole, as Turktelekom does with its communication service groups. Making a responsibility matrix showing the relationship between each task and responsible organisation should help this process. This is necessary to clarify the responsibility of each member and to improve the coordination among member organisations.

(2) Communication within service groups should be made.

Communication among service groups, between head organisations of service groups and the head organisations of sub-groups, and between sub-group organisations and member organisations, should be made. If regular meetings areheld among members for daily matters, as done in the transportation service groups, disaster management should also be included in the topics of discussion. An additional advantage for implementing these communication channels is that having a personal contact before the disaster will help groups to work more efficiently in case of a disaster.

(3) Inter-organisational cooperation should be considered.

Inter-organisational cooperation should be considered to avoid sectionalism created by the division of members into service groups. Examples of tasks that need cooperation from several service groups are listed below.

Communication service group will have to collect and distribute damage status information on roads, ports, public facilities, stockyards, etc. for rescue and recovery work.

Transportation service group will have inter-organisation tasks such as the provision of information on detour routes, debris transportation, hospitalisation of victims, donation goods transport, traffic control, and repairs of roads.

In most cases, debris removal from roads will be necessary before starting debris removal from buildings.

First aid groups will need assurance of lifeline services, and the distribution of donated medicines for purchasing service groups.

Damage assessment and temporary housing group will need to obtain damage information from the debris removal group and purchasing group. Cooperation with lifeline services will be necessary to set up temporary housing.

Security groups will need to work with transportation groups for traffic control, with rescue groups to control security in the rescue area, and with purchasing groups to secure goods against looting.

Agriculture groups could help purchasing groups by providing their list of food stocks.

Purchasing groups will need information of victims from rescue or damage assessment groups to estimate the amount of goods to be distributed.

Public services such as telephone, electricity, water, gas are mostly underground. The telephone companies belong to the communication service group, while other services belong to the lifeline service group. This would make cooperative repair work difficult. Even in normal times, the repair work coordination among public services does not work well.

(4) Methods of provision of information to the public should be studied.

There are many possible means to provide information -- from cellular phone messages, to telephone, fax, radio, TV, newspapers and the internet. Provided information will be warnings of aftershocks or secondary disasters, status of damage and response operations, coordination of external help, and the extinction of rumours. Information provision to service members as well as to the public should play an important role in disaster management. For this purpose, use of existing means for public relations should be considered. The FM radio station in AYM should be more well known. Internet web sites should have links to other governmental sites, to pages that inform on the damage situation, to pages in English for an international audience. Websites should be maintained within the disaster management centre.

(5) Training of trainees and simplified courses should be considered.

Much effort has been made by various organisations to offers rescue and first aid training for officials and the public. However, common problems observed in such efforts are the limitation in number of trainers. With more trainers, such training could be more widely exercised. Therefore, training of trainees should be considered first. Moreover, current training takes more than 20 hours, which is sufficient but may be too long for ordinary people, so that a more simplified course may be necessary to gain additional trainees.

(6) Use of helicopter should be well planned.

One of the major efforts in the AYM and AKOM is to build new heliports to prepare against the possible interruption of road traffic. The total number of helicopters in many organisations, and their purpose, their capacities, their logistics support should be planned, and this information should be relayed to each owner. In addition, air traffic control and cooperation with rescue teams to maintain for the silence that is sometimes needed in the search for survivors, (which was a major problem during rescue operations in Kobe) should also be considered.

(7) Resource inventories should be organised and checked.

To construct a useful resource inventory for disaster management using GIS, various attributes of said resources, such as types or capacity, in addition to their location should be noted. Also, collected data from various organisations should be cross-checked on a uniform basis, their locations to start with.

(8) Joint disaster drills including citizens should be exercised.

Full scale disaster drills should be executed in a realistic manner. For this purpose, drills should include AYM and AKOM members, volunteers, and citizens. Drills should be made simultaneously in various places. Inter-operation between different service groups should be tested. Use of key equipment such as helicopters or radio should be tested. Disaster drills should not necessarily be successful. Instead, finding many problems during the drill should be the objects for the improvement of current system.

(9) Building damage inspections should be completed in a shorter time.

The object of building damage inspections by MPWS is to evaluate the damage extent for the owner's compensation. Since the number of official engineers for the inspection is limited, it took four months to complete inspections after the Marmara Earthquake. To conduct inspections more rapidly, professional engineers from chambers of engineering should be involved. Also, results of inspections done by professionals on a voluntary basis to meet the urgent demand of residents could be used as a reference, and the official results should be provided to the municipality as information for reconstruction.

(10) Evaluation of ground study results and its use is unjust.

After the Marmara Earthquake, ground studies before construction become obligatory when deemed necessary. However, much ambiguity remains in the interpretation of the study results. Communication between civil engineers, geophysicists, and geologists working on ground studies should be enhanced to make an balanced engineering decision.

References for Section 3.6:

Balamir, M. “Reproducing the Fatalist Society: An Evaluation of the 'Disasters' and 'Development' Laws and Regulations in Turkey, Urban Settlements and Natural Disasters.” Proceedings of UIA Region II Workshop.Chamber of Architects of Turkey, 1999.

Ergunay, O. “A Perspective of Disaster in Turkey: Issues and Prospects, Urban Settlements and Natural Disasters.” Proceedings of UIA Region II Workshop. Chamber of Architects of Turkey, 1999.

Gulkan, P. “Code Enforcement at Municipal Level in Turkey: Failure of Public Policy for Effective Building Hazard Mitigation” Proceedings of the 6th International Conference on Sesimic Zoning, No. 21. Earthquake Engineering Research Institute, 2000.

Chapter 4. Civil Society Organizations for Disaster Management

4.1. Turkish Civil Society Characteristics

4.1.1. Civil Society

In this chapter, civil societies are defined as autonomous social units and organisations, such as voluntary associations, private companies, family and professional associations, etc. These social units are based on the principles of basic human and civil rights. In each civil society, citizens act collectively in a public sphere to express their interests and ideas, exchange information, achieve mutual goals, and make demands of the public authorities.

4.1.2. Strong State and Emerging Civil Society Initiative

The Turkish government is often referred to as the "strong state," and civil societies are still constrained by the state.[1] However, civil societies are growing in size and influence. To change the climate of the Turkish civil society, there were three major milestones: two major UN conferences, the Rio Summit in 1992 and HABITAT II in 1996, and the earthquakes in the Marmara region in 1999.

The Local Agenda 21 of the Rio Summit has been instrumental in promoting good local governance and local democracy. Moreover, formal and informal organisations, as well as grass-roots movements, were recognised as partners in the implementation of Agenda 21.

The action program passed by the HABITAT II Conference in Istanbul emphasises the significance of civil society: "The most efficient and effective disaster preparedness systems and capabilities for post-disaster response are usually provided through the contribution of volunteers and local authority action on a local level. Great importance is placed on international cooperation between cities in industrial and developing countries." Being the first of its size in Turkey, preparation for the Habitat II Conference was a huge capacity-building exercise for Turkish civil society.

Civil society's real contribution took place after the two earthquakes in the Marmara region. At the time, there was some hindrance of NGO activities by public authorities, such as NGOs being exiled from certain disaster affected areas by a provincial directorate whose power was stipulated by the Disaster Law. However, many Turkish civil society

[1] Civil Society and State: Turkey after the Earthquake, Rita Jalali, Disaster, 2002, 26(2): 120-139

organisations emerged, linking and coordinating remarkably well with international organisations, and developing networks.

4.2. Civil Society Organisations in Past Earthquakes

At the time of the two earthquakes of August 17th and November 12th in the Marmara region, many civil society organisations were newly established and existing ones became active and developed their capacities working with international development cooperation agencies and foreign civil society organisations. It is notable to point out that an umbrella coordination body, the Civic Coordination for the Earthquake, was founded to support and coordinate the activities of civil associations, state foundations, regional directorates, and professional associations. This organisation played an intermediary role in matching resources with people's needs. It also established a database wherein all data related to the structure and operation of governmental institutions, local administrations, professional organisations, NGOs, and civic initiatives was compiled, and the coordinates of intermediaries were stored whereby access to this database was immediately provided. This coordination body functioned very effectively.

For the rehabilitation phase, earthquake victims associations were established in many areas to provide solidarity and help to the earthquake victims, erasing negatives caused by the earthquake. They provided assistance such as trauma care, securing a united struggle, solving problems together, providing an income-generating opportunity for producing handicrafts, etc.

4.3. Disaster Management Activities of Civil Society Organisations

It being more than 3 years since the Marmara earthquakes, some of the organisations expanded during the disaster, decreased the number of staff and limited their activities, or split up due to differing ideologies among members. However, civil society organisations overall have developed their capacities through the emergency response and recovery process of earthquake disasters. Some of the organisations that are sensitised to mitigation have commenced studies and activities for preparedness.

Some of the organisations are highly sensitised, saying that there is no time to lose in preparing for an impending earthquake in Istanbul. Actually, a large number of search and rescue organisations exist. Some are community-based self reliant disaster management organisations, aiming to be prepared for the coming earthquakes. Public authorities, whether they are at the provincial or municipal level, that have directly experienced or responded to the real struggle of earthquake affected areas tend to nvolve these organisations in their disaster management frameworks.

Kadikoy Municipality is one of the rare and precedent cases reflecting a participatory, bottom-up approach; it involves civil organisations in the planning process of disaster management. It also assists their activities by providing operational space free of charge. However, even such organisations are faced with insufficient operational expenses to just maintain the activities. In Turkey, civil society organisations are regarded as purely voluntary. Thus, most members have primary jobs to engageand have to find time and spend their own money on the organisations. Most members of newly emerged civil society organisations are more or less in managerial positions in private companies or qualified professions.

The photo (left) is one of the civil society organisations called, "Earthquake Committee of Moda Habitants," whose operational space was provided by Kadikoy Municipality. The area where the office is located has characteristics of a community centre, where local people come and gather in a style of caravansary. Offices of locally-based social organisations, along with small shops and a mosque, encircle the courtyard is an ideal physical setting for community-based activities (photo right).

Photo 4.3.1 Office of the Earthquake Committee of the Moda Habitants, Inside (Left) and Outside (Right)

4.4. New Municipal Approach of Community-based Disaster Management Activities

4.4.1. Basic Belief of the Local Municipal Initiatives

In this section, we will introduce participartory inter-disciplinery disaster mitigation and preparedness approach as a case of one of the best practices in Istanbul. The Kadikoy Municipality clearly states that the principle duty of municipalities is to meet the local needs of inhabitants and emphasises democratic and participatory approaches.

The UN Rio Summit of 1992 emphasised that local problems can be solved best with the corporation and coordination of the local administration. Kadikoy Municipality thinks that disaster management should also be carried out by a local municipal initiative with coordination of the civil society, scientific society, central government and volunteer organisations. Thus, a disaster management program was started under the initiative of the Research and Planning Coordination Directorate of the municipality, and this directorate is in charge of disaster management before, during, and after an earthquake.

4.4.2. Best Practices: Institutional Arrangement and Practical Operation

The best practices of the Kadikoy Municipality can be summarized in two points. One is the coordination arrangement and the other is practical operation for earthquake disaster mitigation and preparedness. Three coordination bodies has been established; namely Institutional Planning Coordination, Physical Planning Coordination, and Participartory Planning Coordination. As for operation, Municipality Disaster Management Center which operates involving local NGOs and citizens has been established and within the same compound, Concrete and Ground Testing Laboratory is functionaing for safer construction. It is a good conbination of mitigation and preparedness, institutional management and physical enforcement, such as ground and building which will directly relates to earthquake disaster risks. With regards to the public involvement, municipality tries to empower both locall civil organization and individuals. Furthermore, the municipality has set the institutional framework of disaster preparedness mechanism of being a mediator of the province-district government and civil society including NGOs and citizens.

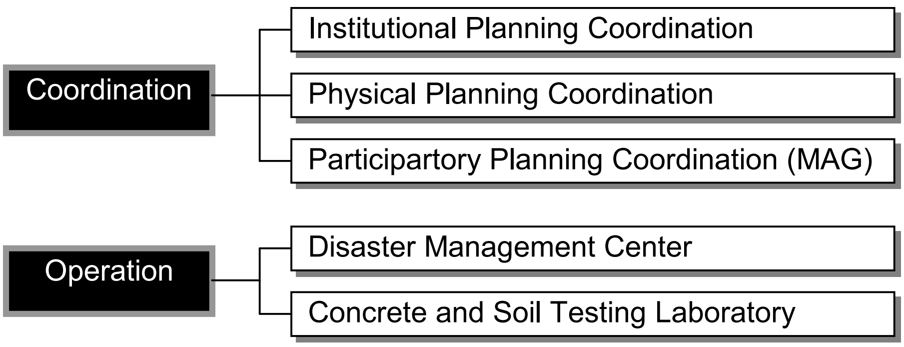


Figure 4.4.1 Municipal Disaster Management Structure

Institutional Planning Coordination was established to develop task force groups in the Municipality and to coordinate province-district task force groups and urban partners that are made up of members of central government, local government, university professors, business sectors, local volunteers, and NGOs. Physical Planning Coordination was established to integrate a Disaster Settelement Plan in GIS and to submit it to urban partners. In this plan, the municipality was demarcated into 10 regions to balance population density, size of the area, and resources. Participatory Planning Coordination has been focused and Community-based Disaster Management Volunteers Program (MAG) has been organizing governmental rescue teams and 28 community volunteers, two of which are selected from each mahalle. The structure of the participatory planning coordination (MDV) is shown in the following chart. Participatory Planning Coordination is made up of 3 working groups: namely, volunteer training, logistic support, and local survey. Each working group has task forces such as search and rescue, first aid and health, distribution and relief, transportation security and shipping, correspondence and communication, data collection and preliminary inventory, and damage and temporary housing.

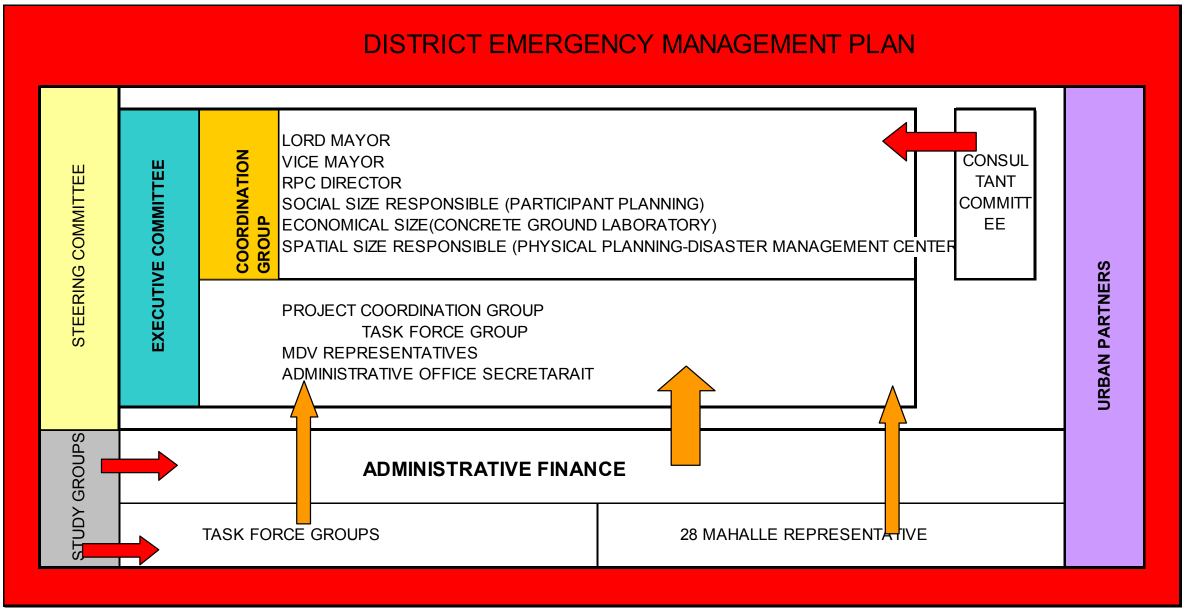


Figure 4.4.2 Structure of the Participatory Planning Coordination

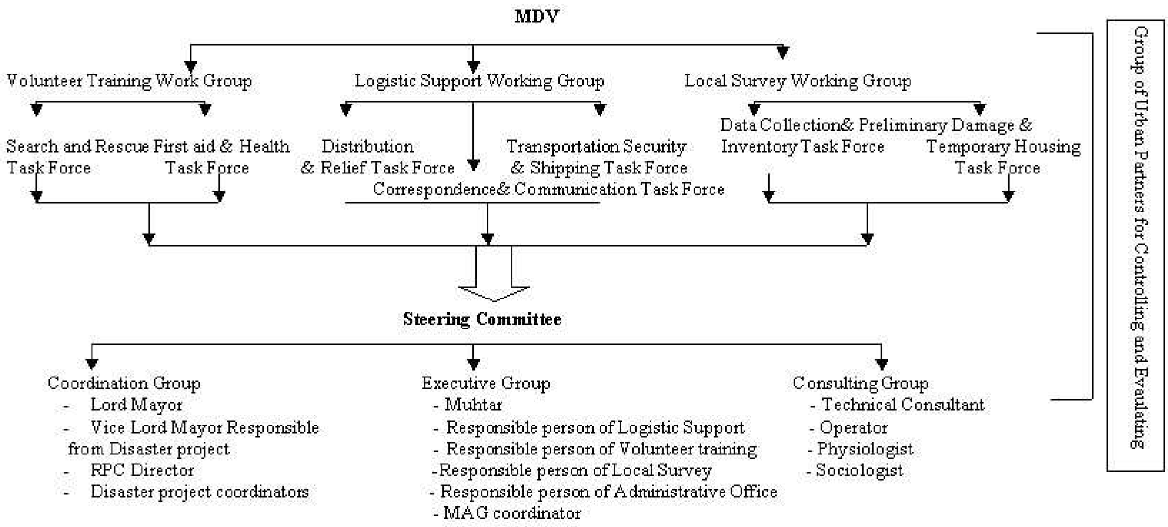


Figure 4.4.3 Participatory Planning Coordination in Kadikoy Municipality

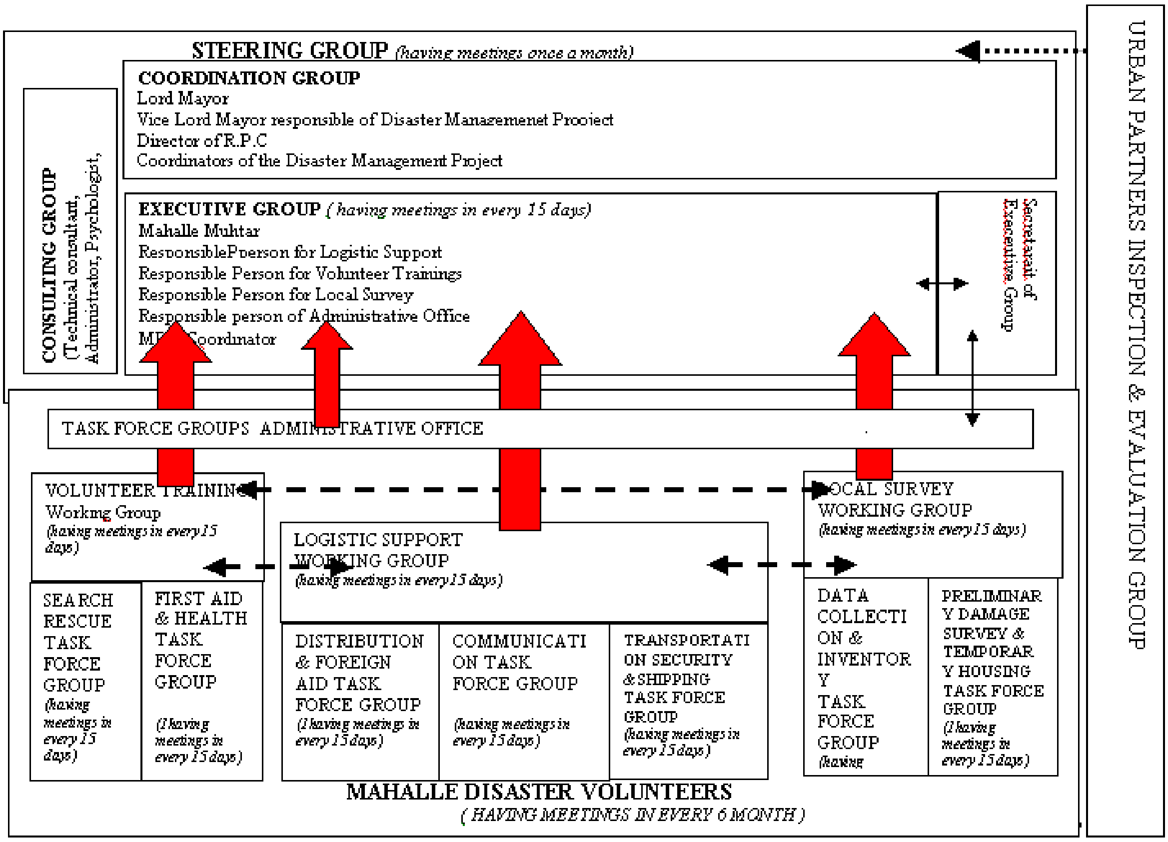


Figure 4.4.4 Disaster Management Organzation in Kadikoy Municipality

For operation, Disaster Management Center has been operating to coordinate pre-and post-disaster activities and to store required equipments for post-disaster response activities. Concrete and Soil Testing Laboratory has been operating at the Disaster Management Center to develop a safer city and coordinate the studies to promote safe constructions. This laboratory examines soil properties to define foundation types that determines the

Geological Land-use Map and eventually regulates the number of building floors, which is the practical approach in the current construction situation in Turkey that demanding the quantitative and qualitative structural requirements for safer buildings is difficult. Concrete strength analysis for existing buildings including reinforcing bar detection, carrot test are conducted. All the buildings can be checked by the request of the citizens, and there are long waiting lists. However, examination for each building is provided, but providing the consultation service for safer construction has not started yet. The municipality is trying to provide such services and this initiative has indeed the great potential for strengthening the structures and safer environment for primary earthquake mitigation.

4.5. Status of Civil Society Organisations

Turkey is said to have approximately 4,500 foundations, 72,800 associations, and other organisations, including professional organisations, trade unions, employers unions, and cooperatives. Most of them were established after 1980, especially in recent years. The 1990s in Turkey have been a period of rapid expansion of civil society organisations. Recently in Turkey, newspapers frequently report on activities of civil society organisations, which both reflect and stimulate the public's interest in civil society.

As to the establishment of civic social organisations, state permission is required and criminal records are to be checked, but the state is generally negative about organising them. Most civil society organisation concerning disaster management can be roughly categorised as one of two types: foundations (vakif) or associations (dernek).

Foundations (vakif) have a long history, developed during the Seljuk period (1078-1293), and they were institutionalised and experienced their heydays during the Ottoman period (1299-1920). Foundation activities are based only on donations, which provide for the utilisation of private wealth for the public benefit to support public services and research in fields such as social welfare. Donations made to foundations are tax exempt. Foundations are easier to establish, but their activities can only be focused on a single initiative at a time. Profit-making or religious activities are prohibited.

Although associations (dernek) are difficult to establish, multi-activities can be registered and financial resources are generated by membership dues, donations, and revenues collected from publications, lotteries, concerts, exhibitions, etc.Rights and liberties of associations are not sufficiently guaranteed. The following chart summarises the two organisation types.

Table 4.5.1 Civic Society Types

Status/Type	Legal background	Charged Min.	Registered activity	Numbers	Operation
Foundation (vakif)	Foundations Law (1935)	Prime Ministry	Single	4,500	Only donations
Association (dernek)	Dernek Law 2908 (1983)	Min. of Interior	Multiple	72,800	Membership dues and donations

Another form of disaster management civil society is chambers. Chambers are professional groups that stand rather neutral as public independent authorities and could serve as pressure groups. There are different varieties of chambers, such as civil engineers, architects, urban planners, doctors, lawyers, commerce, etc.

Although very rare, some civic society organisations have different status besides foundation, association, or chamber. One if them is a “cooperative.” Cooperatives can possess certain capital to fulfill their operational needs, and they operate for the economical benefit of their members. Cooperatives are often formed to build an apartment house or execute collective agricultural activities.

To avoid formalities and unnecessary control by public authorities, self-reliant neighborhood community organisations have a “committee” status. Committees can be established by the protocol of the local municipality.

4.6. Summary

As described above, civil society organisations have different legal frameworks. Despite their limitations, they are searching for the best solutions to fit their aim and goals. The complexities that arise from the variety of group types and status, and the limitations of their activities, are some reasons why civil societies have not matured.

In summary, the following recommendations can be made to increase the effectiveness of civil society organisations, with special reference to disaster management:

(1) Flexibility for civil society organisations

Disaster mitigation initiatives require a holistic approach, with participation from different parts of the society and strong networking among communities. The current legal status of “derneks” prohibits them from taking part in more than one initiative at a time, and, thus, constrains their effectiveness in being part of disaster management activities.

As stated above, the legal status of civil society organisations are rather complex in Turkey, which in turn cause problems and concerns with respect to the execution of their activities. A simplified legal framework for non-profit organisations should be developed, and all civil society organisations should considered as part of a single category to ensure their effective service to society, with reference to disaster management.

(2) Proper resource utilisation and management for civil society organisations

Most civil society organisations run on voluntary contributions from theirmembers, in terms of time and resources. Most of their members have steady primary jobs, and civil society activities are part of their voluntary work. Any successful initiative needs professional input and involvement, and resources are a key factorfor its sustainability. Thus, proper resource utilisation and management will be the key factor for the sustainability of civil society organisation and their disaster management efforts.

(3) Appropriate allocation of responsibility

With a specific focus on disaster management, it has been observed that there exist a considerable number of civil societies with operation mandates of search and rescue (SAR). Also, with respect to SAR activities, there are overlaps of operational focii between government organisations like the fire-brigade, civil defence, army, etc., and that of civil societies. There should be clear-cut and predefined roles for these public authorities and civil society organisations, where the latter can play more effective roles in the light aspects of SAR.

(4) Motivation for strengthening of buildings

It has been observed from recent earthquakes in Turkey and elsewhere that building collapse is the major cause of casualties; thus, it is necessary to strengthen buildings to save the maximum number of lives. This effort requires awareness raising initiatives in the communities, and civil society organisations can play a significant role in this aspect by motivating people to strengthen their buildings.

Chapter 5. Public Awareness and Education for Disaster Mitigation and Preparedness

Public information and awareness raising is a powerful tool for earthquake safety. Disaster education is considered an important and essential element of disaster preparedness and mitigation. Educational aspects have different target groups. Needless to say, school students are the first target group, and to promote disaster education in the future generation is the prime objective. Also, it is important to generate awareness in the communities for these to perceive their earthquake risk and to take effective measures to reduce their risks. Public administrators also play a very important role in disaster management, before, during, and after the event. Different approaches should be incorporated for different target groups. In the following sections, the current status of disaster management is described, followed by recommendations for future actions.

5.1. Governorship-Level Activities

5.1.1. Education for Students

In 2000, after the Marmara Earthquake, the Ministry of Education published 150 thousand copies of a textbook for school children on earthquakes. This textbook explains earthquake mechanisms and illustrates the way people can protect themselves from earthquakes. Each national primary school started teaching a subject on earthquake disaster management. At the high school level, earthquake disaster education is included in geography class. About 2,900 school teachers took a one-day basic seminar on earthquake disaster preparedness hosted by the "Istanbul Crisis Preparedness Education Project" of Bogazici University Kandilli Observatory in 2001. After the Duzce earthquake of 1999, the 12th of November was designated to be an earthquake memorial day, and each school conducts earthquake drills with a collaboration of civil defense.

5.1.2. Training for Disaster Management Centre

Most staff at the Disaster Management Centre are provided with search & rescue training, disaster management principles instruction, and disaster preparedness education incorporated with Civil Defence, the Ministry of Public Works, military, and the Red Crescent. However, specific responsibilities for emergency response have not clearly been defined and assigned. Accordingly, training for emergency response has not been conducted.

The Disaster Management Centre has been utilizingcompact booklets and theme-wise leaflets, which the Civil Defence produced on first aid, fires, chemical warfare, and earthquake disaster.

It is notable that there is a disaster FM radio station located on the second floor of the Governorship Disaster Management Centre (see Photo 5.1.1). It has daily hour-long programs on earthquake disaster management. Each day of the week coverss different topics with different guests, and the audience can participate in the discussions. Some of the programs include questions and answer sessions for children, discussions for students and teachers, introducing newspaper articles regarding earthquakes, general earthquake knowledge dissemination by invited scientists, and first aid explanation by the civil defence.

Table 5.1.1 Disaster Radio Programs

Day	Time	Contents
Monday	10:30-11:00 14:30-15:00	Q&A session for school children
Tuesday	14:00-15:00	Lessons on how to live with earthquakes
Wednesday	14:00-15:00	Lecture on earthquake disaster management
Thursday	14:00-15:00	Introducing newspaper articles on earthquakes
Friday	10:30-11:00 14:30-15:00	Q&A session for school children

Photo 5.1.1 Disaster FM Radio Station at DMC

5.2. Municipality

5.2.1. Citizen Education Activities

The municipality has published compact booklets for citizens on earthquake preparedness and mitigation in 2001. The Directorate of Ground and Earthquake Research also produced a leaflet illustrating basic tipson how to protect oneself from earthquakes that it aims to distribute to schools. However, the schools are not under the command of the municipality and it could not distribute them through the official channel, and the Istanbul Metropolitan Municipality (IMM) distributed them to schools and citizens upon request basis.

The Directorate of Press, Media and Public Relations under the Dep. of Cultural and Social Affairs has close ties with the media, and it issues monthly magazines for citizens. It can easily obtain information and become a good means to raise public awareness on earthquake disasters and publicise the mitigation and management activities the IMM has been working on.

The Directorate of Emergency Rescue Services under the Dep. of Health is organizing training programs and drills incorporated with the civil defence andfire brigades. It also targets training volunteers and certifies their accomplishments (see photos below).

Photo 5.2.1 Earthquake Drill Organized by IMM

The Civil Defence Directorate under the Defence Secretariat of IMM has been performing rescue training for high school and university students as well as ordinary citizens. Their training program is more professional rather than mere general awareness raising: the week-long program takes 25 hours and consists of both lectures and actual training. Three professional staff members train a maximum of 15 persons at one time. The Directorate issues a certificate to those who complete the course. Information on training activities is transmitted through the elected official district leaders (*muhtar*) and school and university heads.

Even though the civil defence serves citizens, the general public and municipality staff have little knowledge on the civil defence and its regular activities and services available to the general public.

5.2.2. Staff Education Activities

The Directorate of Education under the Dep. of Personnel and Training provides 2-5 days of general disaster management educational programs to IMM staff. For higher ranking officials, specific programs in outside countries are provided. Officials are sent to related earthquake disaster management conferences, workshops, and educational programs organised by universities and other organisations. The Directorate itself organises workshops and relays information on these activities on the IMM web page.

5.3. Non-government Initiatives on Disaster Education

5.3.1. Disaster Education Center

The private insurance company, Ak Insurance, has an education and simulation centre, which is open to school groups and citizens free of charge by appointments. The centere is facilitated with earthquake and fire safety simulations and provides package programs for basic fire and earthquake disaster education twice a day (see photos below). The centre opened in 1996, and 30,000 people, mostly school children between 7 and14 years old, have visited the centre since then.

Photo 5.3.1 Earthquake Simulation **Photo 5.3.2 Fire Extinguishing Exercise**

5.3.2. University Initiatives

The Kandili Observatory of Bogazici University and the Earthquake Research Institute have jointly initiated the "Abcd of Basic Disaster Awareness" program, with funding from USAID. This program aims to provide correct and necessary basic information on earthquakes to communities, and provide training at the mahalle level. The major outputs of the training and capacity building programs are the production of educational booklets, posters, and fact-sheets related to earthquakes, and trained communities. Bogazaci

University has recently constructed a shake table on its Kandili campus that will be used public awareness raising experiments, in addition to its civil engineering research programs.

Another interesting initiative is the planning of a disaster management graduate course at the Istanbul Technical University (ITU), proposed to begin in October 2002. The initiative is based on a collaborative program with the Federal Emergency Management Agency (FEMA) of the USA and aims to promote the development of human resources and expertise in the specified field.

5.3.3. Private Initiative of Building Improvement and Retrofitting

Seker Bank, a private bank, is preparing to disburse retrofit loans. It has an earthquake support Centre, which introduces technical assistance and helps project formulation. Professors of architecture, civil engineering, geology, and geophysics of Gazi University are involved in assessing the seismic condition of the buildings and designing the retrofit plan. After this preliminary phase, the actual retrofitting starts. The loan system excludes the preliminary study, which will roughly cost US$300 for a 100m^2 apartment, and the actual retrofitting costs will be covered by the bank loan.

Kadikoy Municipality has a laboratory for concrete testing in its disaster management centre and has been checking the quality of existing buildings in the municipality. The municipality is projecting to be able to provide a solution for strengthening buildings.

In the community-based activities in Gayrettepe, a preliminary building survey has been done on the intervention of local civil engineers. One of the apartments was retrofitted as part of the efforts of residents. No public intervention to promote retrofitting has been done.

5.4. Media Initiatives on Disaster Education

The role of the media as a major instrument for promoting disaster education is very important. One of the major roles performed by the media during the Marmara Earthquake was to provide information on relief materials to thepublic. In the long-term recovery process, the media changed its role into that of an educator, rather than only providing information dissemination, and the media has developed several educational targeting school children of different age-groups. In addition, for communities, educational programs have been developed in terms of 'dos and don'ts' during the earthquake. Professor Ahmet Ishikara of the Kandili Observatory is known as an "earthquake father" and appears on a TV cartoon program to provide tips on disaster preparedness activities for common people. Memorial programs on August 16 and November 12 are also telecast on major TV channels.

5.5. Recommendation on Disaster Education

Disaster education is not just to acquir knowledge but to take concrete actions to increase resistance and resilience within the capacity and resources of each stakeholder. In summary, the following recommendations can be made for improvements on rasing public awareness and education with regards to disaster mitigation and preparedness:

(1) Effective Utilisation of Media

One of the roles of the media is to provide public information and education. Because of the fatalism outlook society has, some people tend to distance themselves from information on disasters. However, ignorance is hazardous. The approach of the mass media needs to be encouraging; media information is recommended to be based on real implementations being carried out by various stakeholders that stimulate and motivate general citizens to be involved in synergetic efforts. It is receommended that newspapers publish a special series of earthquake disaster management columns on the occasion of pertinent conferences and memorial days.

(2) Development of Common Codes of Conduct for Mass Media

Common language, correct information and knowledge of earthquake disaster management on the part of media is essential and critical. It is recommended that common codes of conduct at the time of disasters be developed. These codes should be based on past devastating disaster experiences, so that the roles and responsibilities of the mass media can be clearly defined and more effective disaster management can be achieved.

(3) Extensive Information Circulation

It has been observed that many earthquake disaster mitigation efforts have been taking place, especially after the two earthquakes in the Marmara Region. Many people are sensitised to be involved in disaster management activities, but public information distribution are apt to be on based on human networks, such as through the Muhtar, and not always distributed to the right people. Since information is the first source of judgment for further steps. Equal opportunity, easy access to information, and extensive information circulation need to be carefully considered, utilizing various media.

(4) Promotion of Earthquake Safety School Programs

Most children spend most of their time in school. The strengthening of the school building is important, but at the same time, school teachers and administrators need to be prepared to respond effectively. It is important to assist school boards and administrators in setting up an earthquake emergency procedure system. The school can also produce informational pamphlets to supplement a regular textbook produced by the Ministry of Education, to be used in the classroom and later send home with students to share with their parents and families. Earthquake drills are important and should routinely be held n cooperation with the civil defense and fire brigade to train school children to stay safely within the buildings and evacuate when necessary.

(5) Capacit-uilding and Human Resource Development for Different Stakeholders

Capacity-building is critical for all stakeholders; however, it is a complex and long-term effort requiring human resource development, the establishment of well-functioning organisations within a suitable work environment, and a supportive socio-political environment, to improve the performance of institutions and personnel. Capacity-building needs to be done in terms of resources, skills, and information availabilities. The networking of resources and information is also critical to capacity- building for coordinated efforts. It is important for all stakeholders to complement each other's efforts to achieve an efficient overall disaster management system. There should be a strategic plan developed to utilise human resources for disaster management. A true enterprise of public-private partnerships is needed. To start these efforts, community-level disaster management activities should include all the concerned people and be realistic and practical.

(6) Increased Focus on Public Information to Address the Root Causes of Vulnerability

It has been observed that many efforts are being made to train ordinary citizens in search and rescue. However, strengthening buildings and civic structures is the most effective approach to solving the root causes of their vulnerability and to effect earthquake disaster mitigation. This initiative is the most time and resource intensive issue; thus, more involvement is needed to raise public awareness and ensure the support and intervention of various stakeholders.

5.6. Proposals for Future Actions

5.6.1. Necessity of Community-based Disaster Management Activities

Under the Disaster Law, the responsibilities of the provincial and central government agencies are defined, but the responsibilities of the district municipality, non-government organisations and the private sector are not included. While effective disaster management requires empowerment of local authorities and the local community, as well as a multi-sectorial inter-disciplinary approach, it is also necessary to institute community participation in the planning process to meet real needs and intentions, which will lead to mitigation of future disaster risks.

Moreover, national development plans specify effective decentralisation as a prerequisite for substantive progress in all fields. Complex institutional arrangements, legal regulations, inflexible budgetary practices, fragmented resources and authorities shared between the provincial government and municipalities, and constraining local initiatives need to be improved through public and private cooperative efforts. Local capacity-building and the enhancement of civic engagement need to be stressed.

After the last earthquakes in the Marmara region, it has been observed that there is a significant awareness among the common people regarding the possibility of a future earthquake in the Istanbul region. Many disaster mitigation and management efforts have been made at different levels, including various types of community activities. The community is the first to respond to a disaster, and community-based disaster management activities are more successful since community residents are deeply rooted in the society and culture of the area. They enable people to express their real needs and priorities, allowing problems to be correctly defined and responsive mitigation measures to be designed. A public-civil society synergetic network needs to be developed.

First of all, information sharing among public authorities, academic circles, private sectors, and civil society is the essential factor in beginning to develop this partnership. Secondly, existing resources and activities need to be managed and incorporated in the network. The creation of community space is an option to promote community-based activities to increase overall social resilience. Lastly, proper institutionalisation maximises the efforts made at different levels.

The following strategies and actions are recommended to promote effective community-based disaster management in Istanbul, with a focus on community participation and an interdisciplinary approach:

Basic strategies are summarised under three categories: information sharing, resource management and networking, and institutionalisation.

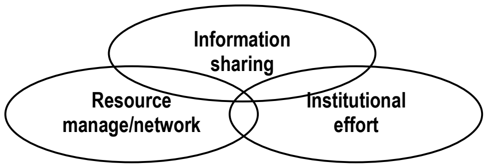


Figure 5.6.1 Strategy for Community Based Disaster Management

Strategy 1: Information Sharing

It has been observed that information sharing, especially between public authorities and citizens, is an important aspect for effective disaster management. Most importantly, citizens, need to be informed of the hazard and risk assessment for each district. Based on this information, a disaster management plan should be developed. Lessons learned from past earthquakes need to be input in the participatory planning process between not only the local public sectors and civil society, but also those in disaster affected areas and academic and professional societies. To achieve this, the following activities can be proposed:

Activity 1.1: Publicise information on hazard and risk assessment to citizens

Activity 1.2: Disseminate disaster maps and information at the community level

Activity 1.3: Document past earthquake experiences and lessons

Activity 1.4: Promote participatory planning processes at the citizen level

Activity 1.5: Use media to disseminate appropriate information and sensitise the community

Strategy 2: Resource management and networking

Appropriate resources in terms of personnel, funding, and space are necessary to promote community-based activities in disaster management. Open space and community space for local activities could include centre to promote community-based activities for the betterment of the local services, which will lead to an increase in the community's total resilience. Each district's Disaster Management Centreshould be linked with other DMCs as part of a larger area collaboration. Furthermore, local organisations need to be linked.

In general, there has been a strong focus on search and rescue as a community initiative. While search and rescue is undoubtedly an important tool more emphasis and resources to strengthen buildings and motivate people to action to create safer living conditions is needed.

For effective disaster mitigation and management, a natural flow and linkage between activities during normal and emergency times needs to be designed. The following activities are recommended for this purpose:

Activity 2.1: Creation of community space for daily activities

Activity 2.2: Preparation of disaster mitigation tools at the community level

Activity 2.3: Promotion and implementation of retrofitting of buildings as a community initiative

Activity 2.4: Enhancement of networking with disaster management centres

Strategy 3: Institutionalisation efforts:

For the sustainability of community-based disaster management, it is important to institutionalise efforts by creating citizen groups and leaders. Muhtar, an elected chief of the mahalle, can play a key role as a network hub between several stakeholders. Since Muhtars have access to both the channels of the district municipality and the provincial government through the Kaymakam, he could act as hub for the provincial government, district municipality, local institutions, and academic and private sectors.The Muhtar can also make use of their own human network.

Some mahalles in the old city consist of a few thousand residents, whereas most mahalles have over ten thousand residents. Disaster management activities are effective in smaller units, where residents can recognise the units as their own and share and pursue common interests among the residents. Thus, a smaller unit than the mahalle, such as neighborhood, street, or apartment complex is recommended to be identified in a disaster management framework. It is also recommended that pertinent activities as be defined per the different units. Especially in Istanbul, collective housings are common and apartment complexes can be the smallest unit for community-based activities.

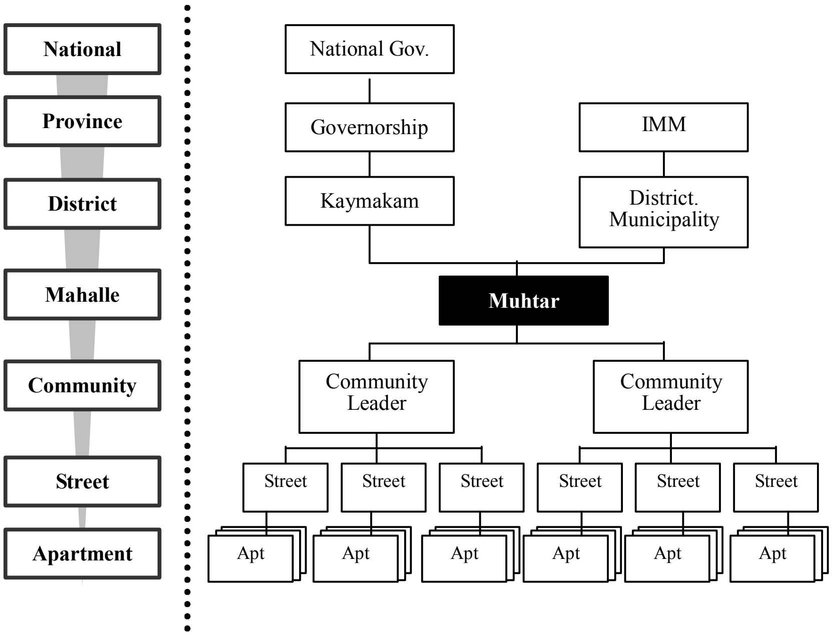
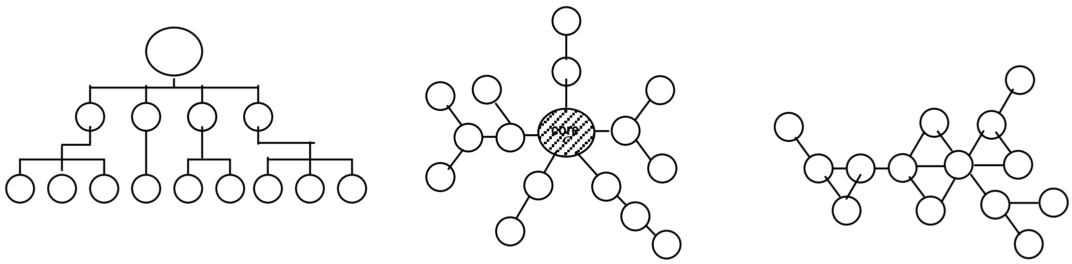


Figure 5.6.2 Organisational Structure of Network with the Muhtar as a Hub

Self-reliant social organisations based on human networks of the local area are a key driving force. It is ideal in terms of sustainability for these organisations to work on steadily improving local social welfare and living conditions, while inlcuding disaster management aspects.

To institutionalise community-based self-reliant organisations, first, three types of organisational structures can be identified: namely, the umbrella, core and network. In the umbrella structure, a vertical chain of command is strengthened and a strong representative organisation coordinates all the organisations below. In the network structure, there is no hierarchy, but each organisation is inter-related with one another. The core structure can be described as one between the network and umbrella structures. A core organisation is acts as a hub to combine all the organisations. The organisation structure type a community choses depends on the style of existing organisations and the intervention of the district municipality of the area, but an important issue is how to inter-link the community activities effectively among community-based organisations and public authorities.



Umbrella Hub Network

Figure 5.6.3 Different Structural Frameworks for Local Organisations

It is important to tap into university professors and professional society members, such as those belonging to chambers, for advice. It is recommended that district municipalities institutionalise a system of providing access to such professionals as part of community-based activities upon request.

The following activities are recommended for this purpose:

Activity 3.1: Identify smaller units than the mahalle, such as neighborhoods or streets to serve as potential disaster management units

Activity 3.2: Enhance activities at the neighbourhood level within each mahalle

Activity 3.3: Identify different stakeholders in the community and strengthen the network

Activity 3.4: Define role sharing and specify the responsibilities of each stakeholder

Activity 3.5: Enhance professional inputs for community-building and planning

Chapter 6. Urban Conditions for Earthquake Disaster Management Consideration

6.1. Data Related to Natural Conditions

6.1.1. Topography

(1) Topographic Map

a. Maps

Large-scale topographic data was necessary for the Study as basic data for the GIS database. This data was also necessary for the evaluation of slope stability.

1:1,000 scale paper maps and their corresponding 3D digital CAD files were created in Microstation format and then aggregated to 1:5,000 scale maps (472 sheets) by the Directorate of Photogrammetry, IMM in 1995 and 1997. Features are categorised into 62 levels. These series of maps cover the entire IMM jurisdiction area except Adalar District.

Another series of maps compiled in 1987 covers the Adalar District. This series consists of 1:1,000 scale paper maps and their corresponding digital CAD files.

İSKİ's 1:50,000 maps, are used for areas outside of those covered in the IMM maps.

Table 6.1.1 shows the topographic maps used by the Study Team. Their area covered by these maps is shown in Figure 6.1.1.

Table 6.1.1 Topographic Maps Used by the Study Team

Data	Source	Scale	Covering Area	Area by Sheet (km^2)	Year	Number of Sheet	Total Area (km^2)
Topographic Map	Directorate of Photogrammetry, IMM	1,5:000	IMM Except Adalar	5.8	1995 – 1997	472	2,754
Topographic Map	Directorate of Photogrammetry, IMM	1:1,000	Adalar	0.37	1987	69	25
			Bakırköy port		1995	1	0.37
			Same as 1:5,000			3,899	1,422
					1997	2,926	1,066
Topographic Map "İçmesuyu ve Atıksu Hatları, Barajlar, İçmesuyu ve Atıksu Havzaları	Directorate of Mapping Works, İSKİ	1:50,000	All the Study Area	1,538	2000	5	7,608

Source: JICA Study Team

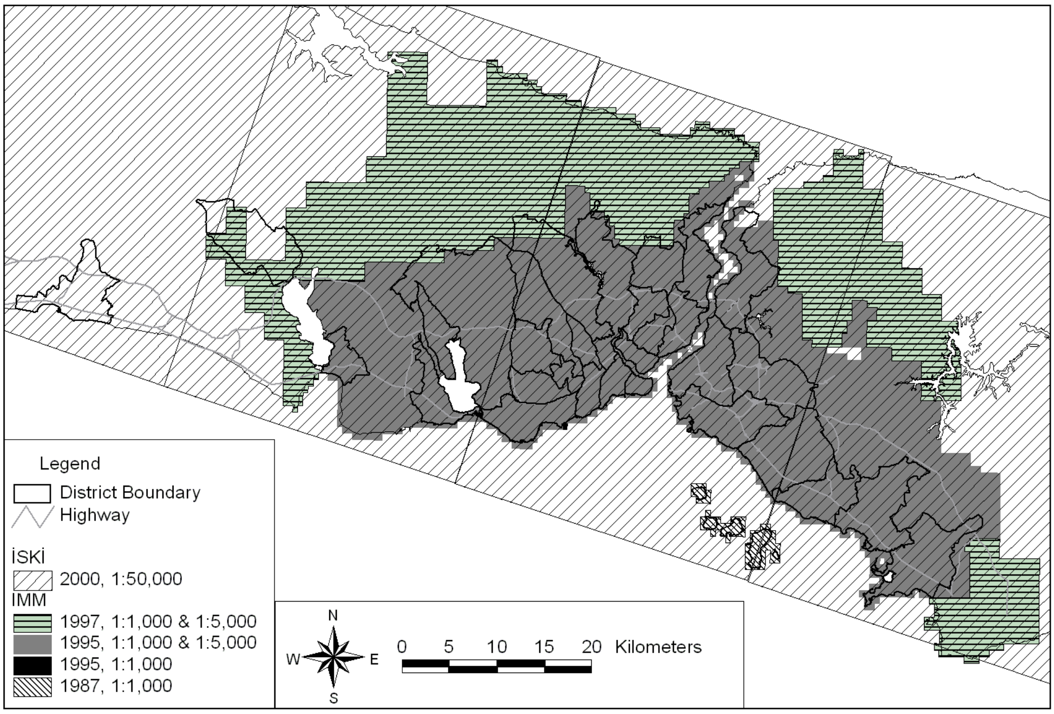


Figure 6.1.1 Area Covered by Topographic Maps Used by the Study Team

Source: IMM (1987, 1995 and 1997), ISKI (2000)

b. Datum

The geodetic datum used in İstanbul is "European 1950" (ED50).

c. Projection

Three projections, as shown in Table 6.1.2, are commonly used in İstanbul.

"UTM, 3 Derece" is normally used for IMM's large-scale data, such as 1:1,000 and 1:5,000 scale maps, because the central meridian (30° East) is near İstanbul and the distortion is smaller than "UTM, 6 Derece." The western parts of the Çatalca Municipality and Silivri Municipality areas are sometimes separated into the next western zone, of which the central meridian is 27° East.

The Study Team developed a GIS database on "UTM, 3 Derece."

Table 6.1.2 Projections Used in Istanbul

Name	Factors	
UTM, 3 Derece	Alias Name	"UTM, 3 degree" "UTM, İstanbul"
	Projection	Universal Transverse Mercator
	Central Meridian	30° E for the area between 28.5° E and 31.5° E (IMM, Büyükçekmece and eastern part of Çatalca), 27° E for the area between 25.5° E and 28.5° E (Silivri and western part of Çatalca)
	Reference Latitude	0
	Scale Factor	1.0000
	False Easting	500,000
	False Northing	0
UTM, 6 Derece	Alias Name	"UTM, Zone 35"
	Projection	Universal Transverse Mercator
	Central Meridian	27° E
	Reference Latitude	0
	Scale Factor	0.9996
	False Easting	500,000
	False Northing	0
Cadastral	Projection	Unknown
	Distance Units	Meter

d. DTM and Slope Gradient Data

For the DTM and slope analysis, the Study Team used IMM's 1:1,000 digital maps as base data. Elevation data of the 1:1,000 maps were processed to generate 50 m grid DTM data and 50m grid slope gradient data. An elevation map was compiled and is shown in

Figure 6.1.3. A slope gradient distribution map was compiled and is shown in

Figure 6.1.4.

(2) Topography of the Study Area

One of the most obvious features of the topography of Istanbul is the Bosphorus Strait, which separates Istanbul as part of both Asia and Europe. Both sides of the strait show steep mountainous topography while the other area of Istanbul is on relatively gentle hill topography. Another distinctive topographic feature is that no major plane is spread out in Istanbul. Generally, most of the rivers in Istanbul flow in a north-south direction on the European side and a NE-SW direction on the Asian side. These directions are perpendicular to the Marmara Sea shoreline. Locations of dividing ridges of the Marmara Sea in the south and the Black Sea in the north are different on both the European and Asian sides. It is near Black Sea on the European side and near the Marmara Sea on the Asian side. This difference causes a difference of the shape of the urbanised area on both sides. On the European side, the urbanised area goes inland while it remains seaside on the Asian side. The general topography of Istanbul is, thus, characterised by a gentle to medium configuration.

Elevation of the Study Area varies from 0 to 500m and elevation of most of the urbanised area is less than 150m. Elevation of the valley is almost less than 50m and the river gradient is relatively low. The gradient of the ground surface is varies from 0 to approximately 100% and the gradient of most of the urbanised area is less than 10%. In the northeast of the European side and the north of the Asian side, the ground surface gradient is over 10%. In the west of the European side and most of Asian side, the ground surface gradient of both sides of the valleys is 10 to 15%. In the northeast of the European side and the north of Asian side, the ground surface gradient of both sides of valleys exceeds 30%.

(3) Slope Gradient Condition

Figure 6.1.2 and Table 6.1.3 show the slope gradient distribution summarised by district and the calculated slope gradients. Districts Adalar, Beykoz, and Sariyer show the steepest slope prevailing areas. The slope area ratio of gradient less than 10% make up 30% of these districts.

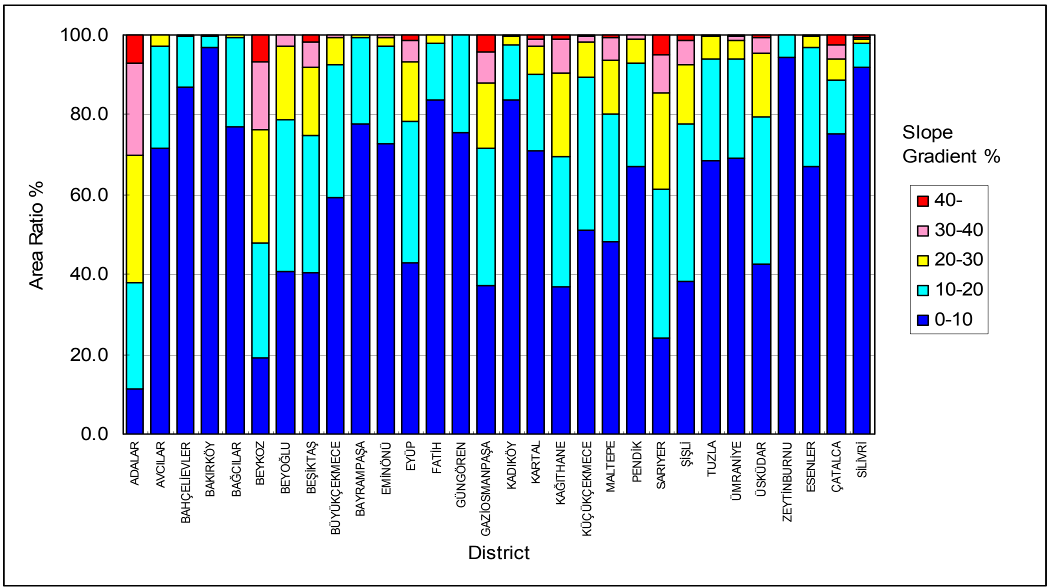


Figure 6.1.2 Slope Gradient Distribution for Each District

Note: Compiled by the JICA Study Team

Table 6.1.3 Area Ratio of Slope Gradient in Each District

District	Slope Gradient % Category				
	0-10	10-20	20-30	30-40	40 and over
Adalar	11.2	26.6	32.1	23.0	7.1
Avcilar	71.6	25.5	2.7	0.2	0.0
Bahçelievler	86.7	13.1	0.2	0.0	0.0
Bakirköy	96.7	3.2	0.2	0.0	0.0
Bağcilar	76.8	22.5	0.6	0.1	0.0
Beykoz	19.1	28.7	28.3	17.1	6.7
Beyoğlu	40.9	38.0	18.4	2.6	0.1
Beşiktaş	40.5	34.4	17.0	6.2	1.8
Büyükçekmece	59.2	33.5	6.7	0.6	0.0
Bayrampaşa	77.7	21.7	0.5	0.0	0.0
Eminönü	72.8	24.3	2.3	0.5	0.0
Eyüp	42.9	35.5	14.8	5.4	1.4
Fatih	83.7	14.3	1.9	0.1	0.0
Güngören	75.6	24.3	0.1	0.0	0.0
Gaziosmanpaşa	37.1	34.4	16.3	7.9	4.2
Kadiköy	83.7	13.8	2.2	0.3	0.0
Kartal	70.9	19.1	7.2	1.8	0.9
Kağithane	37.0	32.7	20.7	8.5	1.2
Küçükçekmece	51.1	38.1	8.9	1.6	0.4
Maltepe	48.3	31.9	13.4	5.5	0.9
Pendik	67.1	25.7	6.1	0.9	0.2
Sariyer	24.2	37.3	24.0	9.8	4.8
Şişli	38.4	39.2	15.1	5.8	1.6
Tuzla	68.4	25.4	5.7	0.4	0.0
Ümraniye	69.1	24.7	4.6	1.2	0.4
Üsküdar	42.5	37.0	15.8	4.0	0.7
Zeytinburnu	94.4	5.4	0.1	0.0	0.0
Esenler	67.0	29.7	2.9	0.2	0.1
Çatalca	75.2	13.4	5.4	3.6	2.4
Silivri	91.7	6.3	1.0	0.4	0.7

Note: Compiled the JICA Study Team

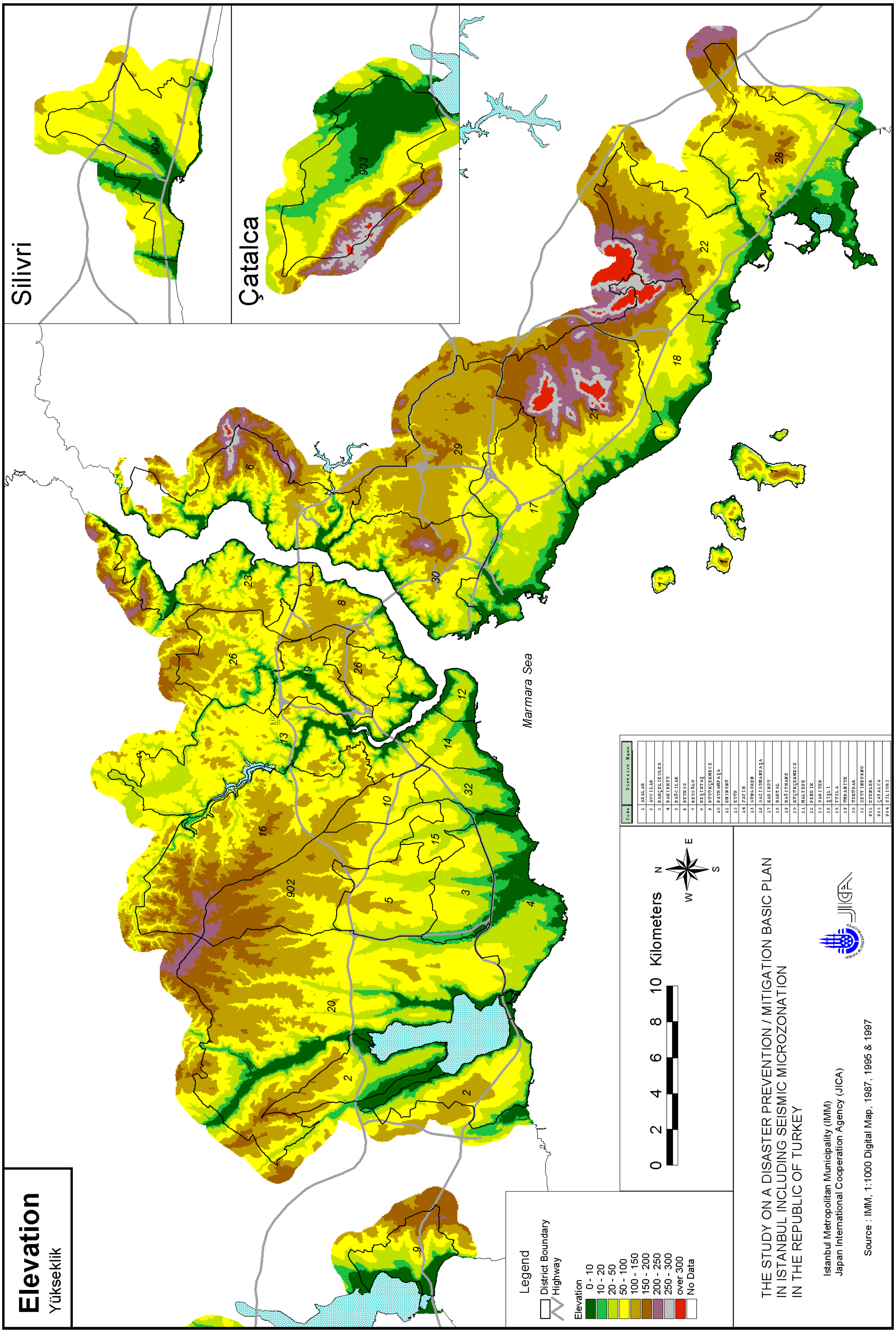


Figure 6.1.3 Elevation Map

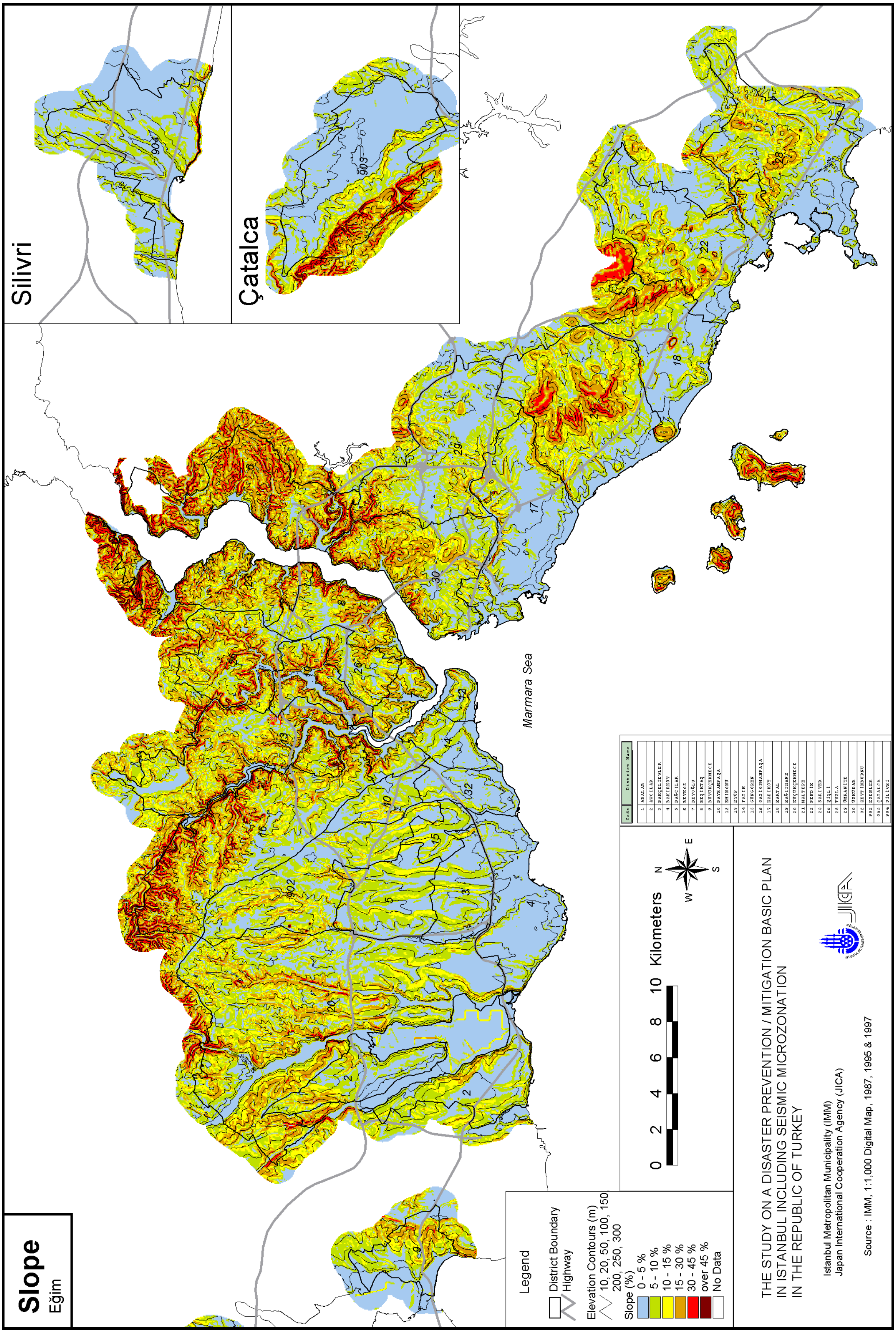


Figure 6.1.4 Slope Gradient

6.1.2. Geological Data

(1) Geological Map

The 1:50,000 scaled geological map of the Study Area was compiled by Prof. Dr. F.Y.Oktay and Dr. R.H.Eren in 1994. This map was later digitised by the City Planning Dept. of the Counterpart Agency in 1995. The reduced scale version of this map is illustrated in

Figure 6.1.5.

The Counterpart Agency later significantly improved this basic map by conducting supplemental geological surveys and by adding available borehole, geophysical exploration, and observation data. These maps were later reduced to a 1:5,000 scale in digital form. The JICA Study Team compiled these maps into GIS format, as shown in

Figure 6.1.6.

For the additional three districts, digital 1:25.000 scaled geological maps of M.T.A. (General Directorate of Mineral Research and Exploration Institute) were used. These maps were transformed into GIS format by the JICA team (

Figure 6.1.7).

Geological cross-sections were compiled through the mutual collaboration of the Study Team and the Counterpart Agency. These cross-sections are based on 1:5,000 geological maps and prepared for each 1,000 m grid system. Details are explained in Chapter 7 and crosssections are attached in the Supporting Report.

(2) General Geology

The stratigraphical column of Istanbul and the Kocaeli peninsulas have been divided into lithostratigraphical units: namely, groups and formations (Oktay ve Eren, 1994). The oldest rock units in Istanbul and its neighborhood were formed in the Paleozoic era According to this classification, the oldest units of the Paleozoic era are named the “Istanbul” group. The Triassic sequence is named the “Gebze” group, the Upper Cretaceous-Lower Eocene age sediments are named the “Darıca” group, the Eocene age sediments are named the “Çatalca” group, the Oligocene aged basin fills are named the “Terkos” group, and the Upper Miocene age Paratethian sequence are named the“Halkalı” group, accordingly. Young sediments are not divided into lithostratigraphical units. Among these, only the Late Quaternary basin fills are named (“Kuşdili Formation”). The stratigraphical classification is summarised in Table 6.1.4.

Table 6.1.4 Stratigraphical Classification in Istanbul

EGE	GROUP	FORMATION	THICKNESS (m)	SYMBOL	EXPLANATION
Current		Dolgu	30	Yd	Waste, Antique rubble and made grounds
Quaternary-Current		Alüvyon	15	Qa	Loose pebbles-sand-clays
Late Quaternary (Holosen)		Kuşdili	70	Kşf	Clay with sand and pebble lenses
Quaternary		Alüvyon Yelpazeleri	30	Q (Suf)	Loose boulders-pebbles-sands-clays
Upper Miocene	Halkalı	Bakırköy	40	Baf	Mactra-bearing limestone-marl-clay intercalation
Upper Miocene		Güngören	175	Gnf	Grey coloured clays with sand lenses
Upper Miocene		Çukurçeşme	50	Çf	Loose boulders-pebbles-sands-clays
Middle Miocene		Çamurluhan	100	Çmf	Clays-marl alternation with lensoidal conglomerate-pebbly sandstone-sandstone and limestone intercalations
Oligocene	Terkos	Karaburun/Gürpınar	900	Kbf/Güf	Conglomerates-limestones, marls, coal seams, tuffs / Tuffites sandstones, clays
Middle Eocene-Oligocene	Çatalca	Ceylan	50	Cef	Mudstone with marl and clastic limestone intercalations
		Soğucak	200	Sf	Reefal and fore-reef carbonates
		Hamamdere	600	Haf	Limestone-marl alternation
Upper Cretase-Lower Eocene	Darıca	Şemsettin/Sarıyer	300	Şf/Saf	Micrite-marl-mudstone-tuffite alternation / Andesite, basalts and agglomerate intercalation
		Kutluca	56	Ktf	Limestones with Rudists
		Hereke Pudingi	75	Hpf	Micrites-Dolomitic limestones with dolomite intercalations
Triassic	Gebze	Tepecik	140	Tef	Halobian shales
		Hereke	800	Hf	Dolomitic limestone, limestones
		Erikli	40	Ef	Yellowish coloured sandy limestones and sandstones
		Kapaklı	1000	Kaf	Red continental clasties
		Kocatarla		Kof	Basalts
Lower Carboniferous	İstanbul	Trakya	1500	Trf	Grey shales with turbidite sandstone and conglomerates
Lower Carboniferous		Baltalimanı	30	Blf	Radiolarian black cherts
Middle-Upper Devonian		Tuzla	100	Tf	Nodular limestones
Lower-Middle Devonian		Kartal	750	Kf	Shales with calciturbidite intercalations
Silürian-Lower Devonian		Dolayoba	500	Df	Limestones (biyolitite, biosparite, biomicrite)
Middle Ordovisiyen		Gözdağ	700	Gf	Laminated grey shales with quartz arenite lenses
Middle Ordovisiyen		Aydos	310	Af	Quartz arenites with quartz conglomerate lenses
Lower Ordovisian		Kurtköy	150	Kuf	Lensoidal conglomerates-sandstones-shales

References for Section 6.1.2:

Çağlayan M. A., Yurtsever A., 1998, Maden Tetkik Vearama Genel Müdürlüğü Türkiye Jeoloji Haritaları No. 20, 21, 22, 23, Jeoloji Etütleri Dairesi Ankara

Oktay F. Y., Eren R. H., 1994, Geology of Istanbul Megapolitan Area, Istanbul Greater City Municipality, Directorate of Reconstruction, Department of City Planning

Jeologi / Jeoteknik Etüd Raporu – İstanbul Avrupa Yakası Güneyi 1/5000 Ölçekli İmar Planalarına Esas, 2001, T. C. İstanbul Büyükşehir Belediyesi, Planlama ve İmar Daire Başkanlığı, Zemin ve Deprem İnceleme Müdürlüğü

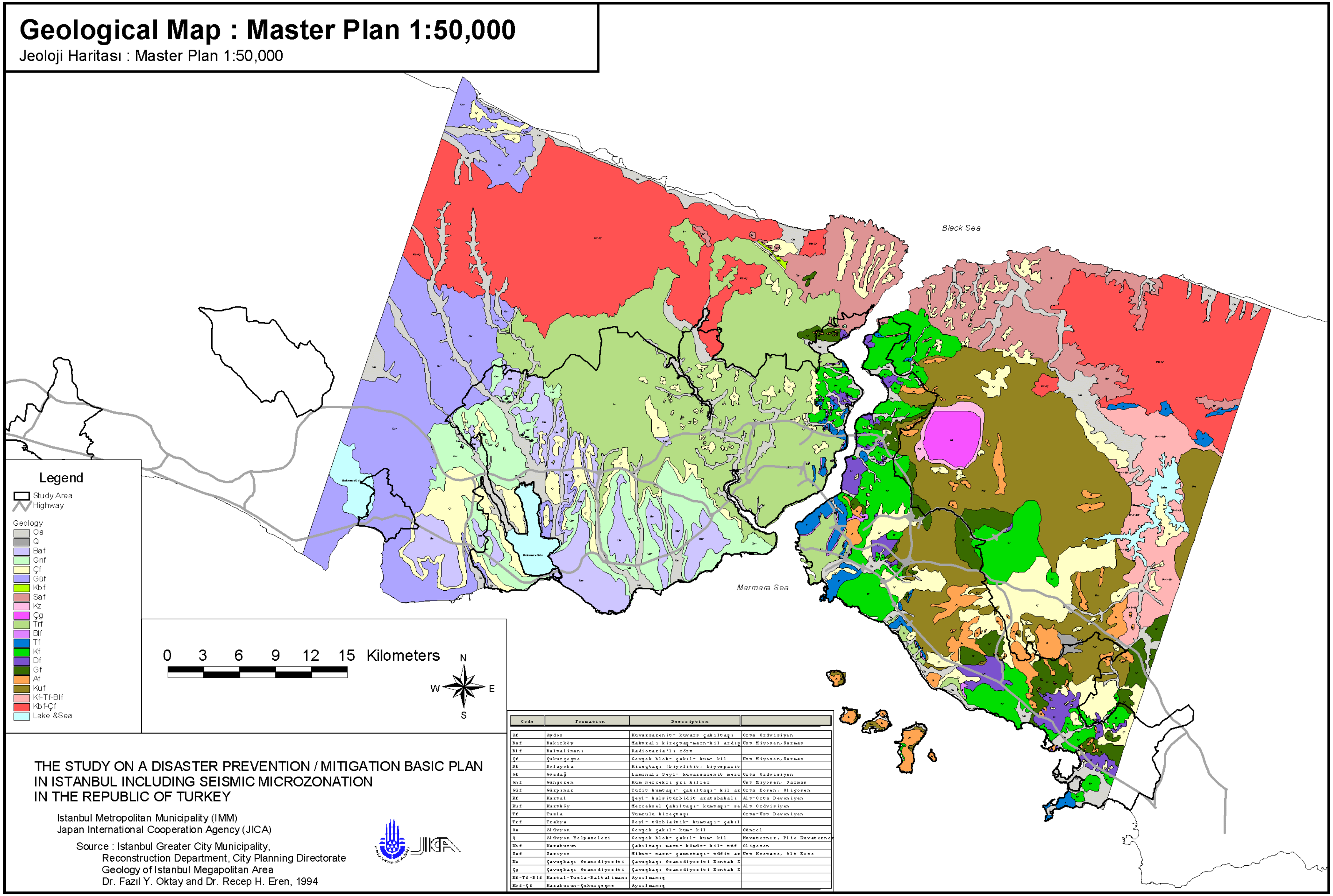


Figure 6.1.5 Geological Map (IMM Master Plan, 1:50,000)

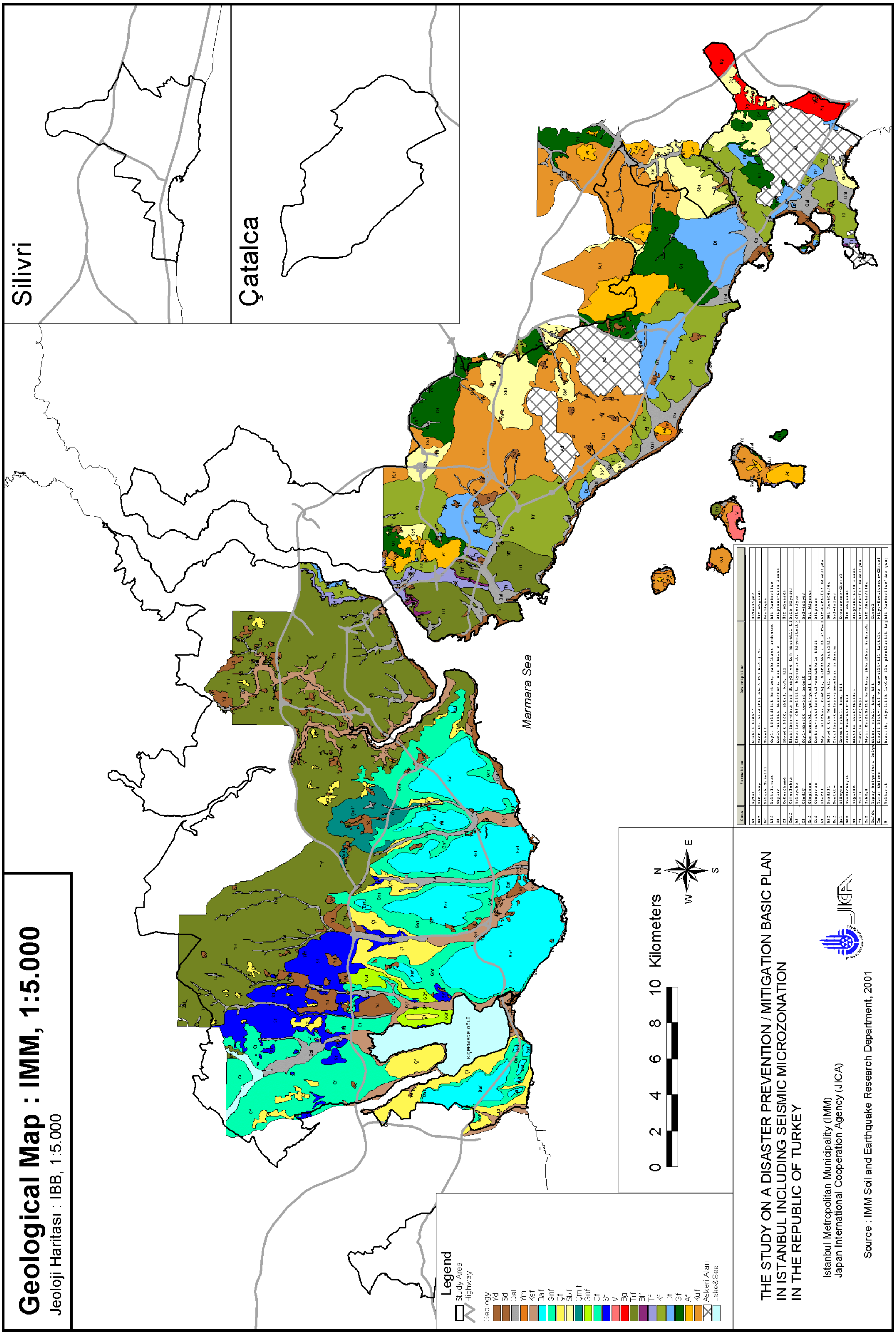


Figure 6.1.6 Geological Map (IMM, 1:5,000)

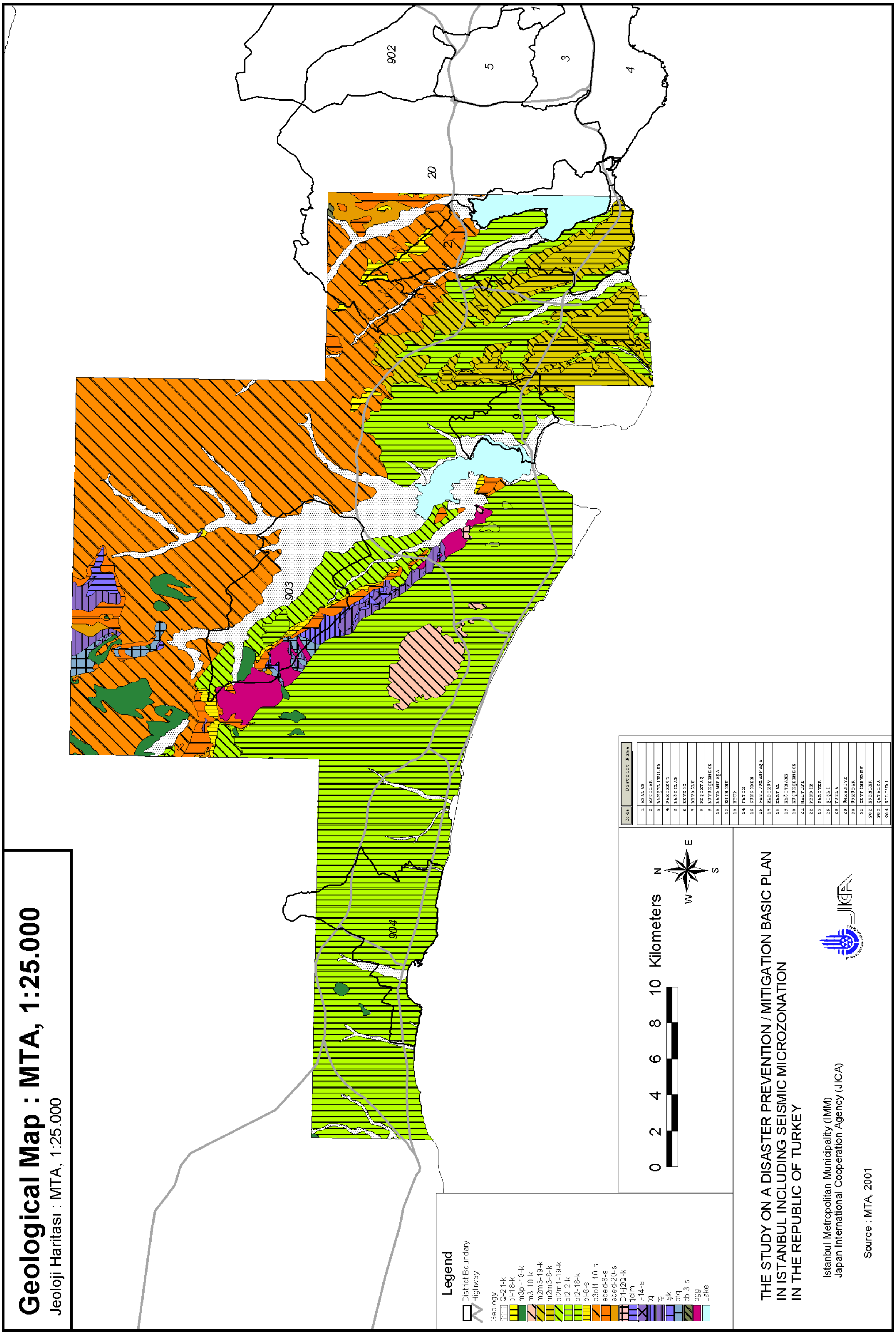


Figure 6.1.7 Geological Map (MTA, 1:25,000)

6.1.3. Geotechnical Data

(1) Soil Classification Map

Recently, the Counterpart Agency compiled 1:5,000 scale soil classification maps of Istanbul. The final report on the European side is already published and the report on the Asian side is now under final compilation. These maps are directly applied in building construction control and city planning. The 1:5,000 topographical and geological maps are used for mapping and the ground is categorised as shown in Table 6.1.5. Categorisation of the European side and the Asian side is different in detail, while the overall categorisation is almost similar. Surface geology and ground surface gradients are basic parameters for the detailed categorisation.

Table 6.1.5 Ground Classification of Istanbul City

Area	Category	Usage Limitations
European Side	YU	Suitable for settlement area
	AJ	Detailed geotechnical study required
	SA	Not suitable for settlement
	ÖA	Construction prohibited without precaution
Asian side	YU	Suitable for any kind of construction
	YÖUA	Stability study required
	AJE	Detailed geotechnical study required
	YUOA	Planning can be done for special purpose construction

Source: Department of Soil and Earthquake Research, Istanbul Metropolitan Municipality 2001

(2) Boring, Soil, and Geophysical Data

The Counterpart Agency has their archive for existing soil investigations and geophysical survey reports. All boring logs, laboratory tests, and survey results were collected and analyzed in the Study. Table 6.1.6 shows the summary of the data.

Table 6.1.6 Quantity of Available Boring Logs Data

	Number of Boreholes	Total Length (m)
European Side	1063	2832.86
Anatolia Side	703	27780.45
JICA Survey Borings	48	10596.46
Total	1814	41209.77

Source: JICA Study Team

Additional borings and geophysical surveys were carried out by the Study Team mainly to grasp shallow and deep Vs structures throughout the Istanbul area, especially on the European side where thick Tertiary formations prevail.

A suspension PS logging method developed in Japan was employed for the Study. It was carried out in boreholes and could obtain Vs at 1 m depths. Horizontal array microtremor measurements were also taken at the same locations of the PS logging to obtain deep Vs structures, up to the depth of approximately 500 m.

Simple borings and soil samplings were conducted in areas with prevailing alluvium deposits for the evaluation of liquefaction potential by in-situ and laboratory soil tests. Ground water levels were also monitored for the liquefaction potential analysis.

- Boring: 48 locations, total length 2826.85 m
- Standard penetration test: 1092 nos.
- Undisturbed and disturbed sampling: 59 nos.
- Laboratory test: 85 sets
- Natural water content, Atterberg's limit, grain size, unit weight and specific gravity
- Water standpipe installation and monitoring: 9 locations
- PS logging: 39 locations, total length 2288 m
- Horizontal array microtremor measurement: 40 locations

A location map of these existing and additional ground surveys is shown in

Figure 6.1.8. A geological database was developed through the Study. All of the borehole logs were digitised and stored into this database system and handed over to the Counterpart Agency.

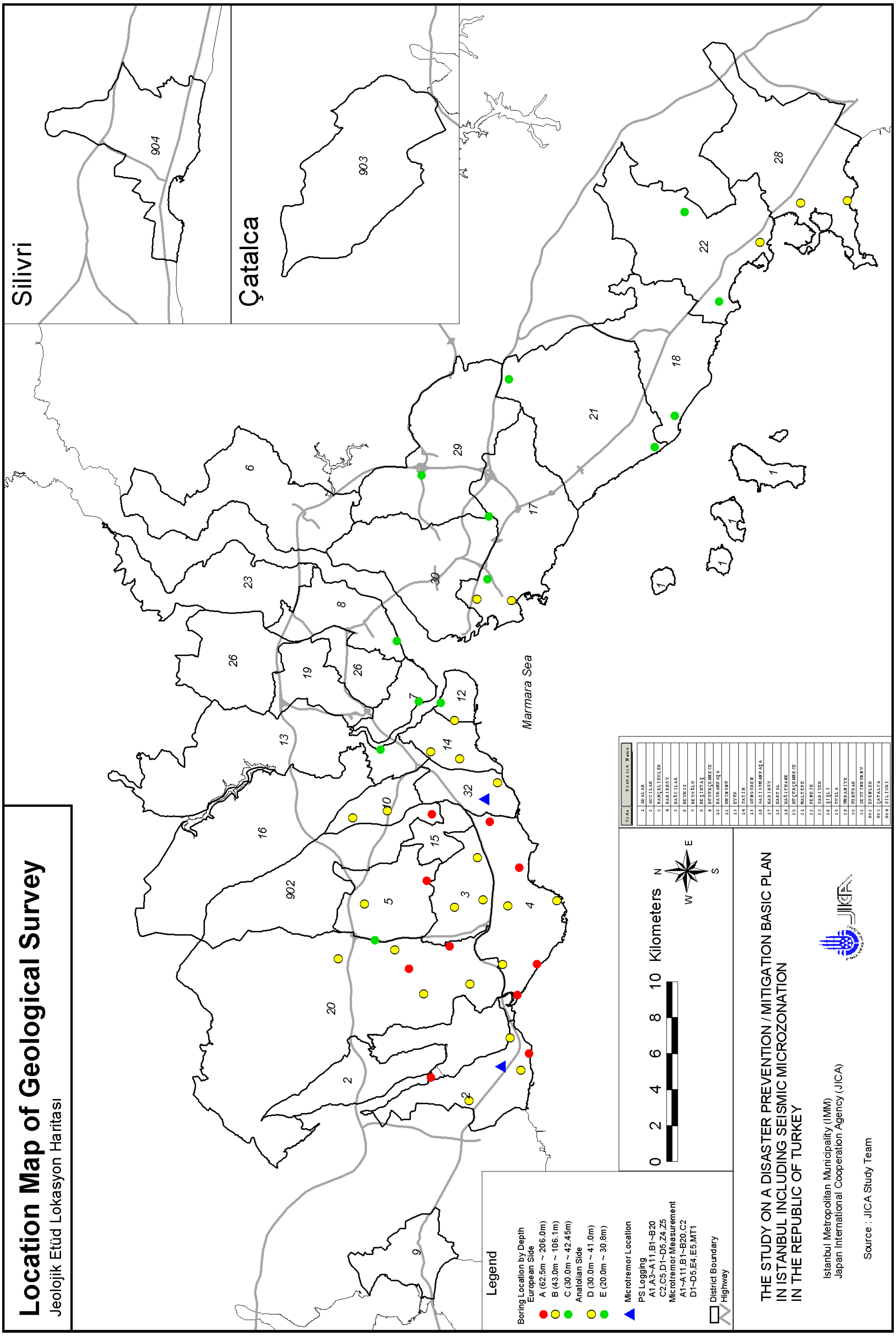


Figure 6.1.8 Location Map of Ground Survey

(3) Dynamic Property of Soil and Rock

The Department of Civil Engineering of the Istanbul Technical University is equipped with a dynamic soil test apparatus. Okur and Ansal (2001) studied undrained stress-strain behavior of low to medium plasticity clays obtained from earthquake regions in Turkey using this apparatus. Soil types are limited to normally consolidated to slightly overconsolidated clays and their proposed shear modulus and strain curves are reflected by the simple empirical equation as follows:

$$\frac{G}{G_{\max}} = \frac{35.09}{\dfrac{\gamma_a}{1 - 0.99\exp(-18.97 \times PI^{-1.27})} + 34.74}$$

where G refers to shear modulus, $G_{\max}$ refers to shear modulus at small strain, γ_a refers toshear strain amplitude, and PI refers to Plasticity Index.

In discussions with Prof. and Dr. A. Ansal, it was confirmed that a study on the dynamic deformation property of soils has recently been started and published information is limited. Furthermore, dynamic deformation properties of soft rocks, which prevail in the Study Area, have not been studied in detail yet.

References for Section 6.1.3:

Avcılar Belediesi, Avcılar İlçesi 1000 Hektarlık Alanın İmara Esas Jeolojic - Jeofizik - Jeoteknik Etüt Raporu, Nisan 2001 İstanbul.

Cihat Saglam, Bağcilar Belediyesi Genel Zemin, Arastirmalari ile imar Planlarina Esas Jeolojik Jetekik Etudler ve Deprem Risk Analizlerine Dair Rapor, haziran, 2000.

Istanbul-Beyoğlu Ilcesi, Imar Plani Revizyonuna Esas, Jeolojik-Jeoteknik Etut Raporu.S

T.C. Istanbul Büyükşehır Belediesi, Planlama ve İmar DarieBaşkanlığı, Zemin ve Deprem İnceleme Müdürlüğü, İstanbul Avrupa Yakası Güneyi 1/5000 Ölçekli İmar Planlarina Esas, Jeoloji / Jeoteknik Etüd Raporu, Ocak 2001, İstanbul.

V.Okul and A. Ansal (2001): Dynamic characteristics of clays under irregular cyclic loadings, XV ICSMGE TC4 Satellite Conference on “Lessons Learned from Recent Strong Earthquakes”, 25 August 2001, pp.267-270.

6.1.4. Earthquake Related Data

(1) Tectonic Setting

The tectonic framework of the Anatolian peninsula is characterised by the collision of the Arabian and African plates with the Eurasian plate. The Arabian plate is moving northward relative to Eurasia at a rate of about 25mm/year, and the African plate is also moving northward at a rate of about 10mm/year. The Arabian plate collides into the southeast margin of Anatolian micro plate, forcing anti-clockwise rotation of the Anatolian micro plate, accommodated by right-lateral slip on the NAF (North Anatolian Fault). Recent GPS data show that the relative motion between the westward moving Anatolian micro plate and the Eurasian plate across the NAF fault is around 18 to 25 mm/year. The crustal deformation in the convergence zone is complex; many normal faults and graben exist from west of Anatolian peninsula to the Aegean Sea.

(2) Seismic Setting

Istanbul lies on an active seismic zone ranging from Java – Myanmar – Himalaya – Iran – Turkey and Greece, where many large earthquakes have occurred in the past as shown in Figure 6.1.9.

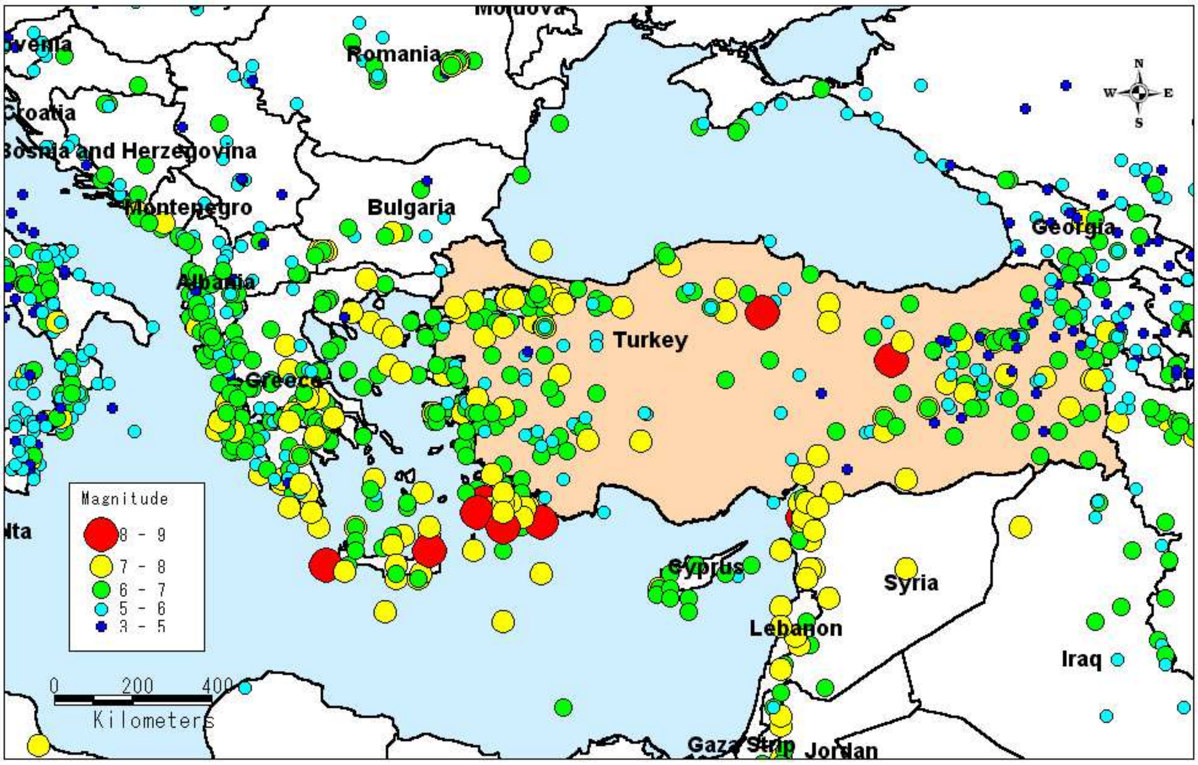


Figure 6.1.9 Hazardous Earthquakes around Turkey, Compiled from Utsu (1990)

Based on world wide historical catalogues, such as that of Utsu (1990), Istanbul (Constantinople) has suffered damage due to earthquakes repeatedly. Table 6.1.7 shows a summary of damaging earthquakes occurring in Istanbul before the 20th century. The seismic intensity in Istanbul for some earthquakes is estimated by the damage mentioned quite precisely in existing literature. Istanbul has experienced earthquakes equal or greater than intensity nine at least 14 times in historical years. This means Istanbul has suffered damage due to earthquakes every 100 years, on average.

Among the earthquakes listed above, three earthquakes caused serious damage to Istanbul as summarised below (based on Ambraseys and Finkel,1991):

1509/ 09/ 10; M = 7.7

On this date, a destructive earthquake caused considerable damage throughout the Marmara Sea area, from Gelibolu to Bolu and from Edirne and Demitoka to Bursa. **Damage was particularly heavy in Istanbul, where many mosques and other buildings, part of the city walls, and about 1000 houses were destroyed, and 5000 people were killed**. Many houses and public buildings sustained various degrees of damage in Demitoka, Gelibolu, Iznik, and Bolu. The shock was felt within a radius of 750 km and was followed by a tsunami in the eastern part of the Marmara Sea.

1766/ 05/ 22; M = 6.5

On this date, a destructive earthquake in the eastern part of the Marmara Sea caused heavy damage, extending from Rodosto (Tekirdağ) to İzmit and to the south coast of the Sea from Mudanya to Karamürsel. Damage to buildings and tall structures were reported from as far as Gelibolu, Edirne, İzmit, and Bursa. **In Istanbul, many houses and public buildings collapsed, killing 880 people.** Part of the underground water supply system was destroyed. The Ayvad Dam located in upper Kağithane, north of Istanbul, was damaged, and in the vicinity of Sultanahmet, the roof of an underground cistern caved in. The earthquake was associated with a tsunami, which was particularly strong along the Bosphorus.

1894/ 07/ 10; M = 6.7

On this date, a destructive earthquake in the Gulf of İzmit and further to the east caused extensive damage in the area between Silivri, Istanbul, Adapazarı and Katırlı. Maximum effects were reported from the region between Heybeliada, Yalova, and Sapanca where most villages were totally destroyed with great loss of life. The shock caused the Sakarya River to flood its banks and the development of mud volcanoes. In Adapazarı, 83 people were killed and another 990 in the Sapanca area. **In Istanbul, damage was widespread and, in some places, very serious. Many public buildings, mosques, and houses were shattered and left on the verge of collapse, while most of the older constructions fell down, killing 276 and injuring 321 people.** Three of the dams for the water supply of Istanbul were badly damaged. The shock was associated with a tsunami, which, at Yeşiıköy, had a height of 1.5 m and caused the failure of submarine cables.

Table 6.1.7 Historical Earthquakes Affecting Istanbul

Year	Month	Day	Latitude	Longitude	Magnitude	Tsunami observed	Damaged area	Damage extent	Intensity at Istanbul
427			40.5	28.5			Turkey:Istanbul	severe	10
438			40.8	29	6.6		Turkey:Istanbul		9
440	10	26	41	29			Turkey:Istanbul	severe	7
441							Turkey:Istanbul	severe	
447	11	8	40.2	28	7.3	Yes	Turkey:Marmara Sea,Istanbul	severe	9
477	9	25	41	29	7.0		Turkey:Istanbul	severe	10
533	11	29	36.1	37.1			Syria:Aleppo(Halab)/Turkey:Istanbul	extreme	
541	8	16	40.7	39	6.6		Turkey:Istanbul		9
553	8	15	40.7	29.3	7.0		Turkey:Istanbul	severe	10
555	8	16	41	29	7.6	Yes	Turkey:Izmit(Nicomedia),Istanbul	some	
557	10	6	41	29			Turkey:Istanbul		
557	12	14	41.8	29	7.2	Yes	Turkey:Istanbul	severe	10
732			41	29			Turkey:Istanbul		
740	10	26	40.7	29.3	7.3	Yes	Turkey:Marmara Sea,Istanbul,Izmit	severe	
815	8		41	29			Turkey:Istanbul		
865	5	16	40.8	28	6.7		Turkey:Istanbul		9
957	10	26				Yes	Turkey:Istanbul		
975	10	26				Yes	Turkey:Istanbul,Thracian coast	some	
989	10	26	40.9	29.3	7.3		Turkey:Istanbul/Greece	some	
1037	12	18	41	29.5			Turkey:Buccellariis,Istanbul	some	
1063	9	23	40.8	28.3	7.0		Turkey:Istanbul		9
1082	12	6	40.5	28.5			Turkey:Istanbul (1083?)	some	10
1087	12	6	40.9	28.9	6.5		Turkey:Istanbul		9
1346							Turkey:Istanbul	some	
1419	5	11	41	28.6			Turkey:Istanbul	considerable	9
1490			41	29			Turkey:Istanbul		
1509	9	14	40.8	28.1	7.7	Yes	Turkey:Tsurlu,Istanbul	severe	10-11
1556	3	10	41	29			Turkey:Istanbul		
1556	5	10	41	29			Turkey:Rosanna near Istanbul	moderate	
1646	4	5				Yes	Turkey:Istanbul	some	
1659			41	29			Turkey:Istanbul		
1719	3	6					Turkey:Istanbul,Villanova	some	
1719	5	25	40.8	29.5	7.0		Turkey:Istanbul,Izmit	severe	
1754	9	2					Turkey:Istanbul,Izmit/Egypt:Cairo	some	
1766	5	22	40.8	29	6.5	Yes	Turkey:Istanbul	some	9-10
1856	2	22	41.3	36.3	6.1		Turkey:Karpan?,Korgo?,Istanbul	limited	
1894	7	10	40.6	28.7	6.7	Yes	Turkey:Geiwe,Istanbul,Adapazari	limited	

Source: Utsu(1990)

(3) Earthquake Catalogues

The following five earthquake catalogues were collected:

(a) Ayhan, E., E. Alsan, N. Sancaklı and S. B. Üçer: An Earthquake Catalogue for Turkey and Surrounding Areas, 1881 – 1980, KOERI, Boğazıçi University.

(b) Kalafat, D., G. Öz, M. Kara, Zç Öğütçü, Kç Kılıç, A. Pınar and M. Yılmazer (2000): An Earthquake Catalogue for Turkey and Surrounding Areas, 1981 – 1997, M>=4.0, KOERI, Boğazıçi University.

(c) Kalafat, D. (personal communication): Earthquake Information around Istanbul from 2100 B.C. to 1900 A.D., KOERI, Boğazıçi University.

(d) Kalafat, D. (personal communication): Earthquake Information around Istanbul from 1900 to 2000, KOERI, Boğazıçi University.

(e) Ambraseys, N.N., and C.F. Finkel, 1991, Long-term Seismicity of Istanbul and the Marmara Sea Region, Terra Nova, 3.

Catalogues (a) and (b) are catalogues for Turkey and surrounding areas with respect to earthquakes of magnitude less than 4.0. On the other hand, sources (c) and (d) are for Istanbul and the surrounding areas. For historical years (i.e., before 1900), the main source of data was “Soysal, H., S. Sipahiou., D. Kolk., Y. Altok (1981). Tkiye ve vresinin tarihsel deprem katalo. (M. 2100 - M.S. 1900), TUBAK, Project No. TBAG 341, 1981.” Catalogue data for the instrumental period (i.e., after 1900) was mainly obtained from “Catalogue of Earthquakes, UNDP/UNESCO Survey of the Seismicity of the Balkan Region, UNESCO Project Office, Skopje, 1974,” Bulletins of International Seismological Centre, 1964-1987,” and KOERI. Source (e) is a paper on long-term seismicity of the Marmara Sea, and the magnitudes and locations of historical earthquakes in this area are evaluated. Most of the work on this subject refers to this paper.

Figure 6.1.10 shows the epicentral distribution of historical earthquakes from 32 A.D. to 1897, according to Ambraseys and Finkel (1991). Many earthquakes have occurred in and around the Marmara Sea area, especially in the eastern area including İzmit Bay. Three earthquakes, namely those occurring in 1509, 1766, 1894, which seriously affected Istanbul are indicated in the figure. It is remarkable that no hazardous earthquakes occur in the northern land area than Marmara Sea.

Figure 6.1.11 is the distribution of instrumentally observed earthquakes with a magnitude over 5 from 1905 to 2001. There are three earthquakes with magnitudes greater than 7, 1912 (Ms = 7.3), 1964 (Ms = 7.0) and the 1999 İzmit Earthquake (Ms =7 .8, Mw = 7.4). There are no earthquakes with a magnitude greater than 6 in the northern half of the Marmara Sea.

Figure 6.1.12 is the distribution of all instrumentally observed earthquakes from 1905 to 2001. The high activity seen from the eastern end of the Marmara Sea to İzmit Bay can be attributed to the aftershocks of the 1999 İzmit Earthquake. Along the northern coast of the Marmara Sea, the western half shows high seismicity; however, the eastern shows low seismicity. Most of the events that occur inland have magnitudes less than 3.

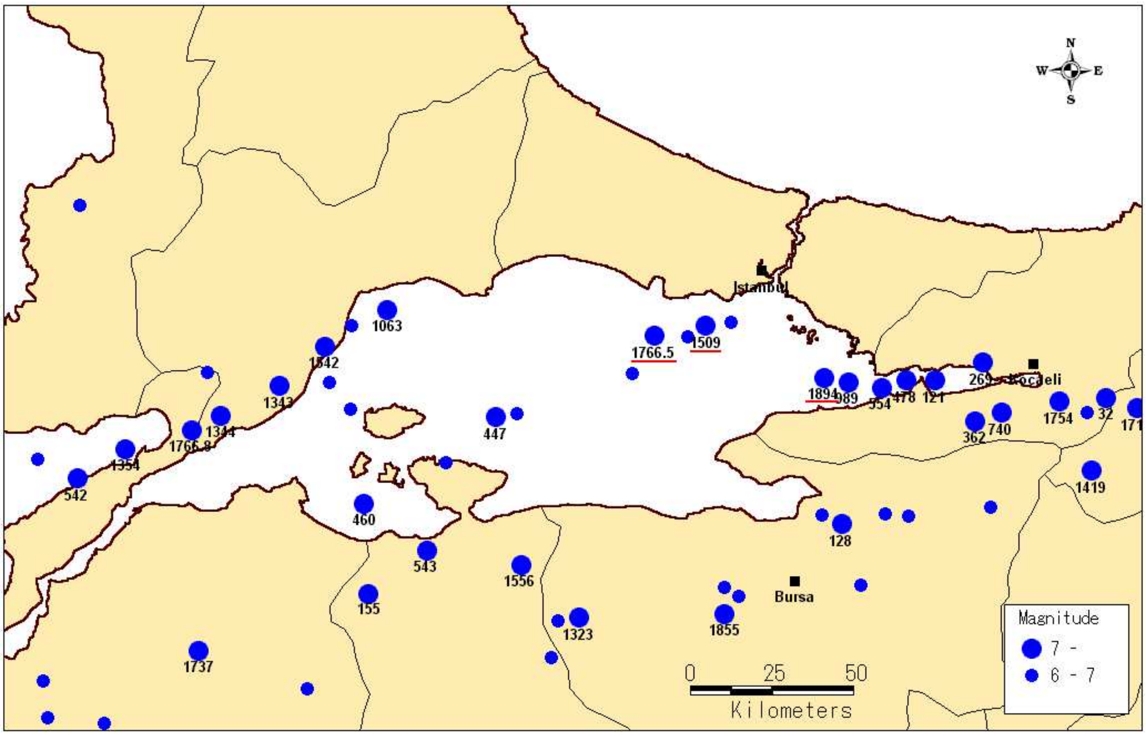


Figure 6.1.10 Epicentral Distribution of Historical Earthquakes, 32 A.D. – 1896

Source: Ambraseys and Finkel (1991)

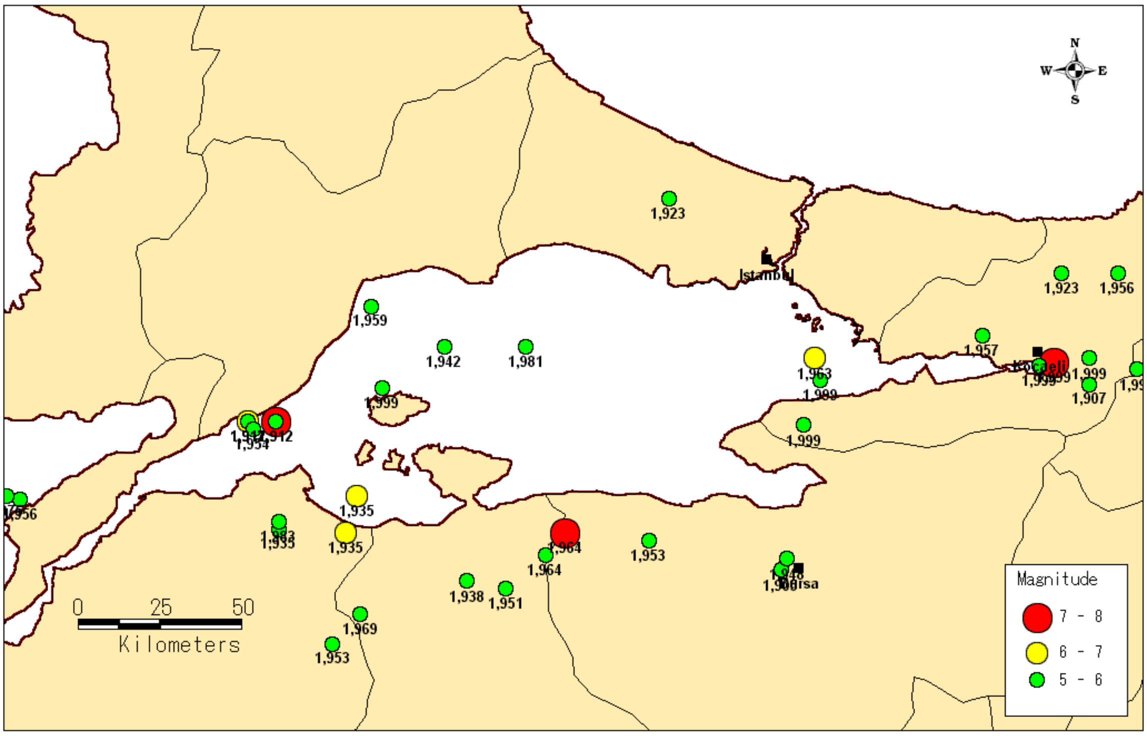


Figure 6.1.11 Epicentral Distribution of Earthquakes, M>=5, 1905 – 2001

Source: D. Kalafat

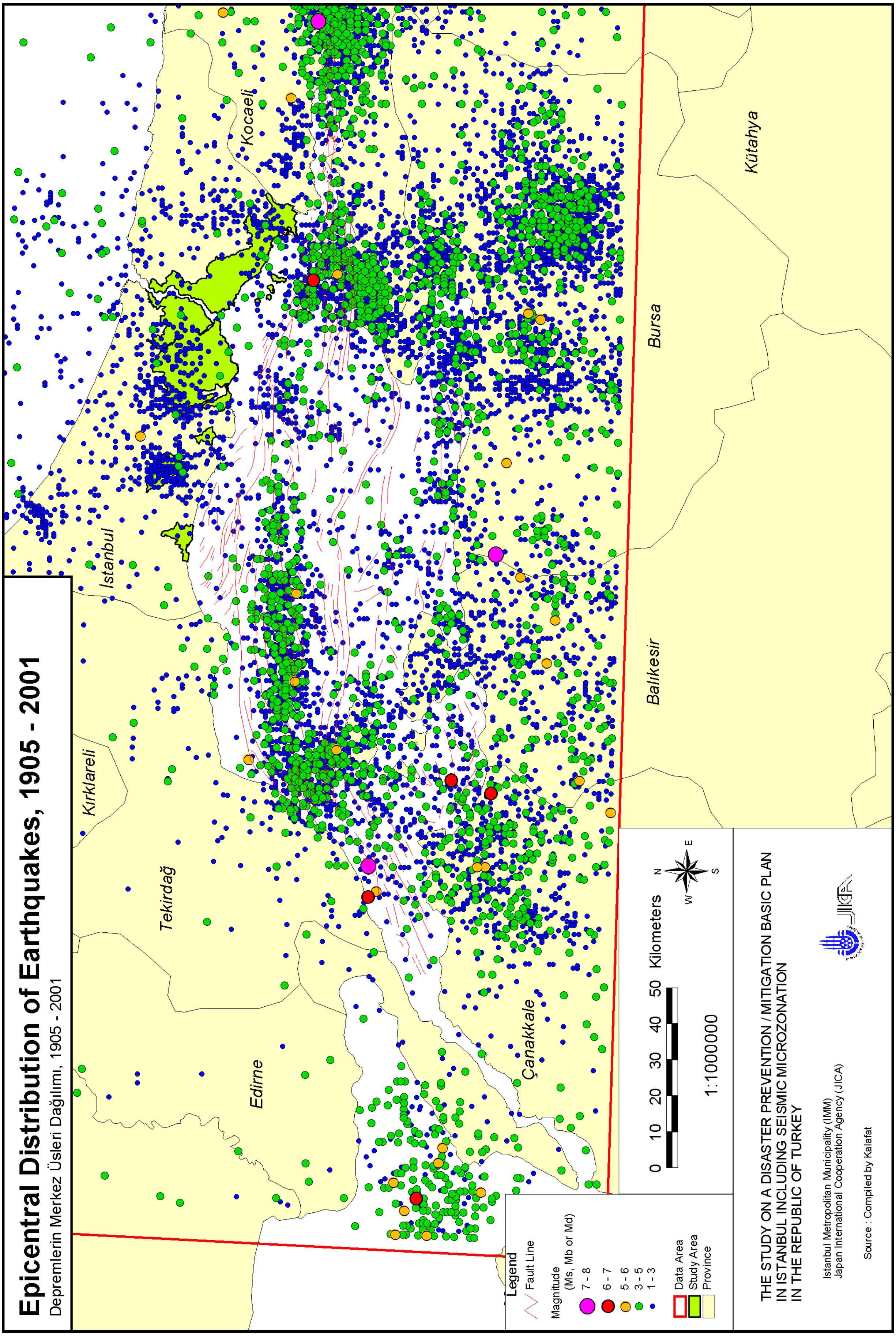


Figure 6.1.10 Epicentral Distribution of Historical Earthquakes, 32 A.D. – 1896

(4) Strong motion records

The following three organisations have permanent strong ground motion stations around Istanbul.

- KOERI : Kandilli Observatory and Earthquake Research Institute, Boğaziçi Universıty
- ITU : Istanbul Technical University
- ERD : Earthquake Research Department of General Directorate of Disaster Affairs

The ASCII digitally formatted strong motion wave records database was collected and contains over 1000 events from 1976. Figure 6.1.13 and Figure 6.1.14 show the strong motion stations and the distribution of events included in the waveform database, respectively. These records are used in the stage of earthquake motion analysis. Figure 6.1.15 shows the location of strong motion stations on a geological map.

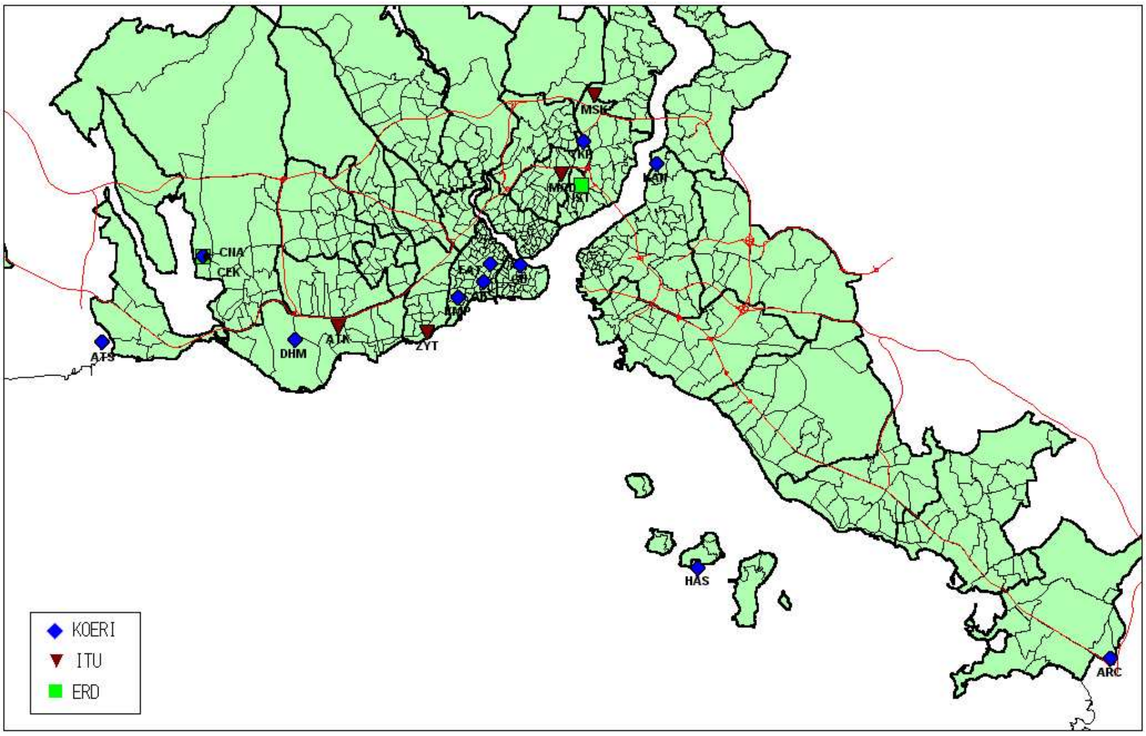


Figure 6.1.13 Location of Strong Motion Stations

Note: Compiled by the JICA Study Team

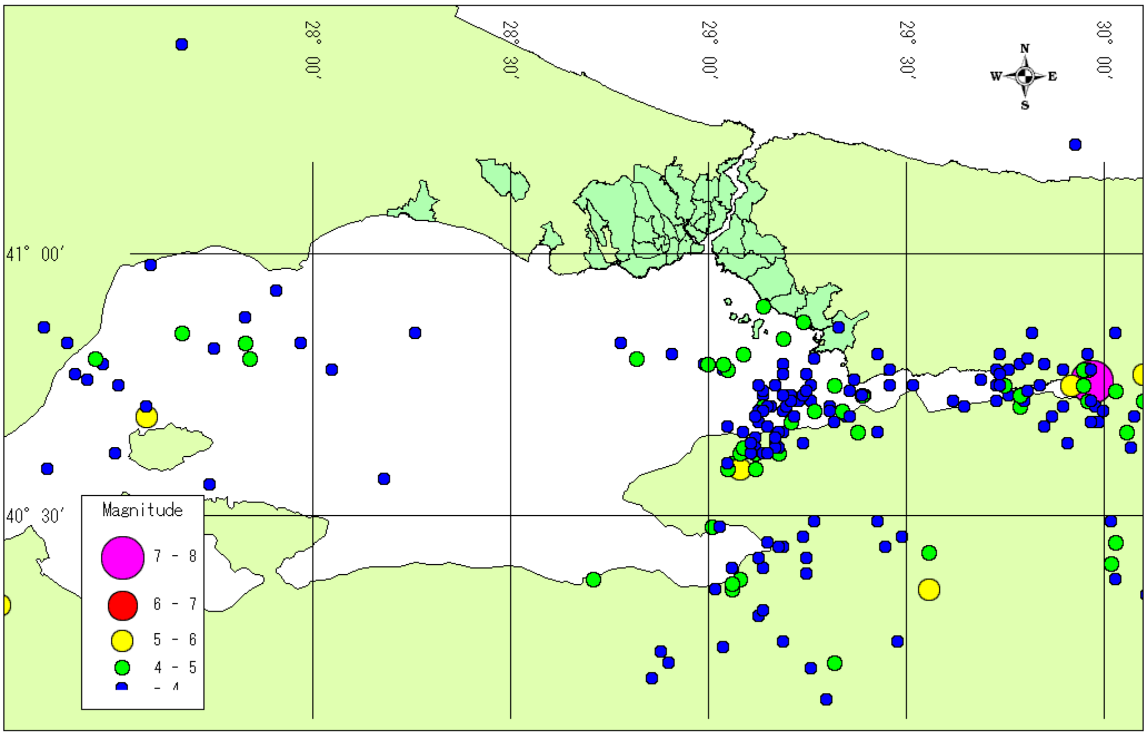


Figure 6.1.14 Distribution of Earthquakes with Strong Motion Record

Source: Özbey et al. (2001), Compiled by the JICA Study Team

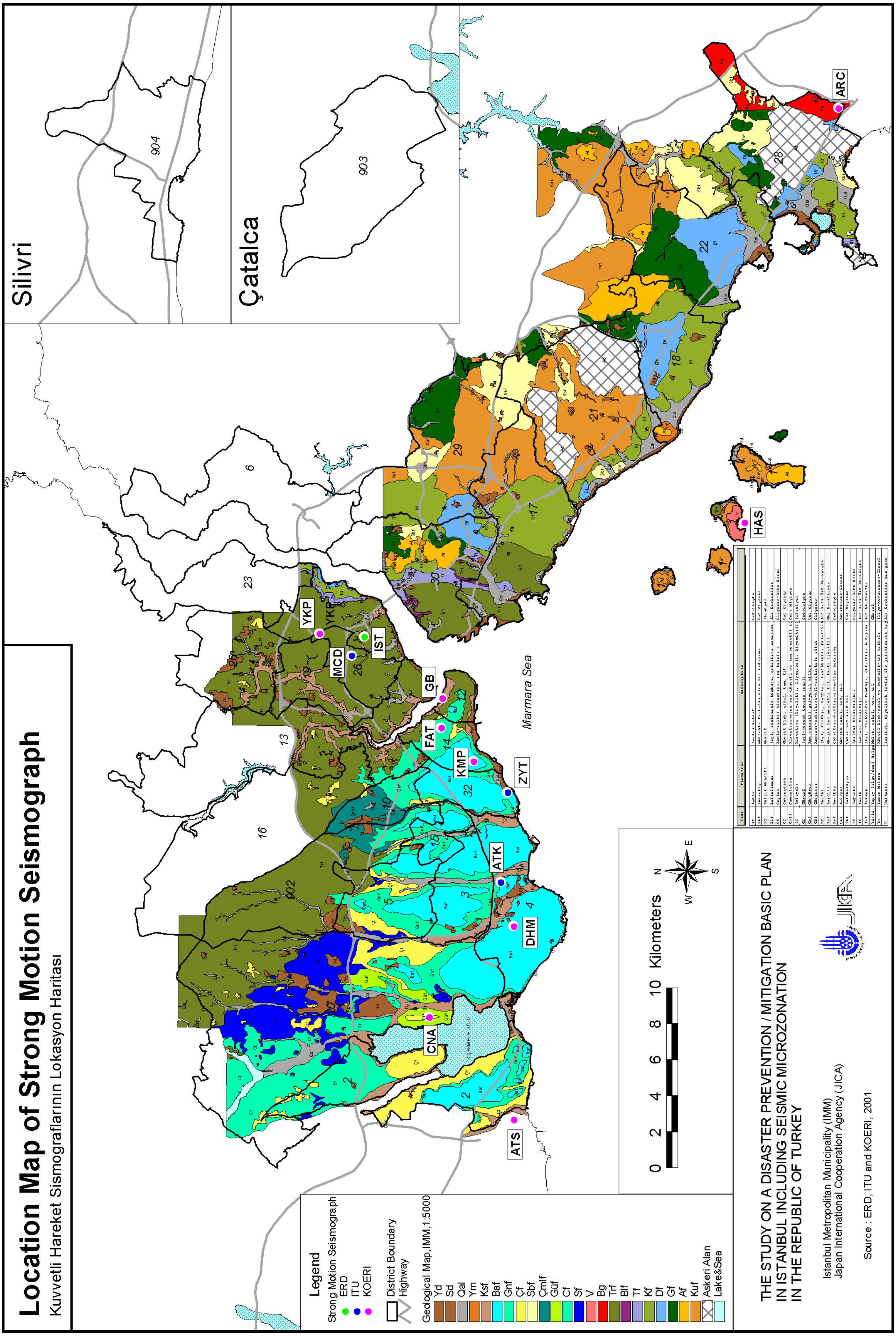


Figure 6.1.13 Location of Strong Motion Stations

References for Section 6.1.4:

Ambraseys, N.N., and C.F. Finkel, 1991, Long-term seismicity of Istanbul and the Marmara Sea region, Terra Nova, 3.

Ayhan, E., E. Alsan, N. Sancaklı and S. B. Üçer: An earthquake catalogue for Turkey and surrounding area, 1881 – 1980, KOERI, Boğazıçi University.

Kalafat, D. (personal communication): Between B.C.2100 – A.D.1900 Years Earthquake Information around Istanbul, KOERI, Boğazıçi University.

Kalafat, D. (personal communication): Between 1900 – 2000 Years Earthquake Information around Istanbul, KOERI, Boğazıçi University.

Kalafat, D., G. Öz, M. Kara, Zç Öğütçü, Kç Kılıç, A. Pınar and M. Yılmazer (2000): An earthquake catalogue for turkey and surrounding area, 1981 – 1997, M>=4.0, KOERI, Boğazıçi University.

Özbey, C., Y Fahjan, M. Erdik and E. Safak,2001, Strong Ground Motion Database for 18 August, 1999 Kocaeli and 12 November, 1999 Düzce Earthquakes, KOERI, Boğazıçi University.

Utsu, T., 1990, Table of world hazardous earthquakes.

6.1.5. Earthquake Damage Data for Risk Assessment

The information related to past earthquake damage is important in establishing the damage estimation method. It is also used to evaluate the estimated damage for scenario earthquakes. From the beginning of the Study, the Study Team gathered information on building damage in Istanbul due to the August 17, 1999 Izmit Earthquake.

Figure 6.1.16 shows the damage ratio distribution of buildings due to the Izmit Earthquake. The data source is the damaged building list compiled by the Governorship of the Istanbul Disaster Management Centre. The list contains the number of collapsed, heavily damaged, and moderately damaged buildings and the number of households in each building in each mahalle. In the Study Area, the number of collapsed buildings is 77, heavily damaged buildings are 305 and moderately damaged buildings are 1724 in total. It can be recognised from these figures that not only the well known Avcilar area but also the Büyükçekmece and Bağcılar areas were damaged.

The building damage distribution in Avcilar is more precisely mapped. The Avcilar District Office has noted the damage grade of each damaged building and mapped the results in 1/5,000 scale. Figure 6.1.17 shows the damage ratio for each 500 m square grid. The total number of buildings, including undamaged buildings, foreach grid is determined from the 1/5,000 map of IMM.

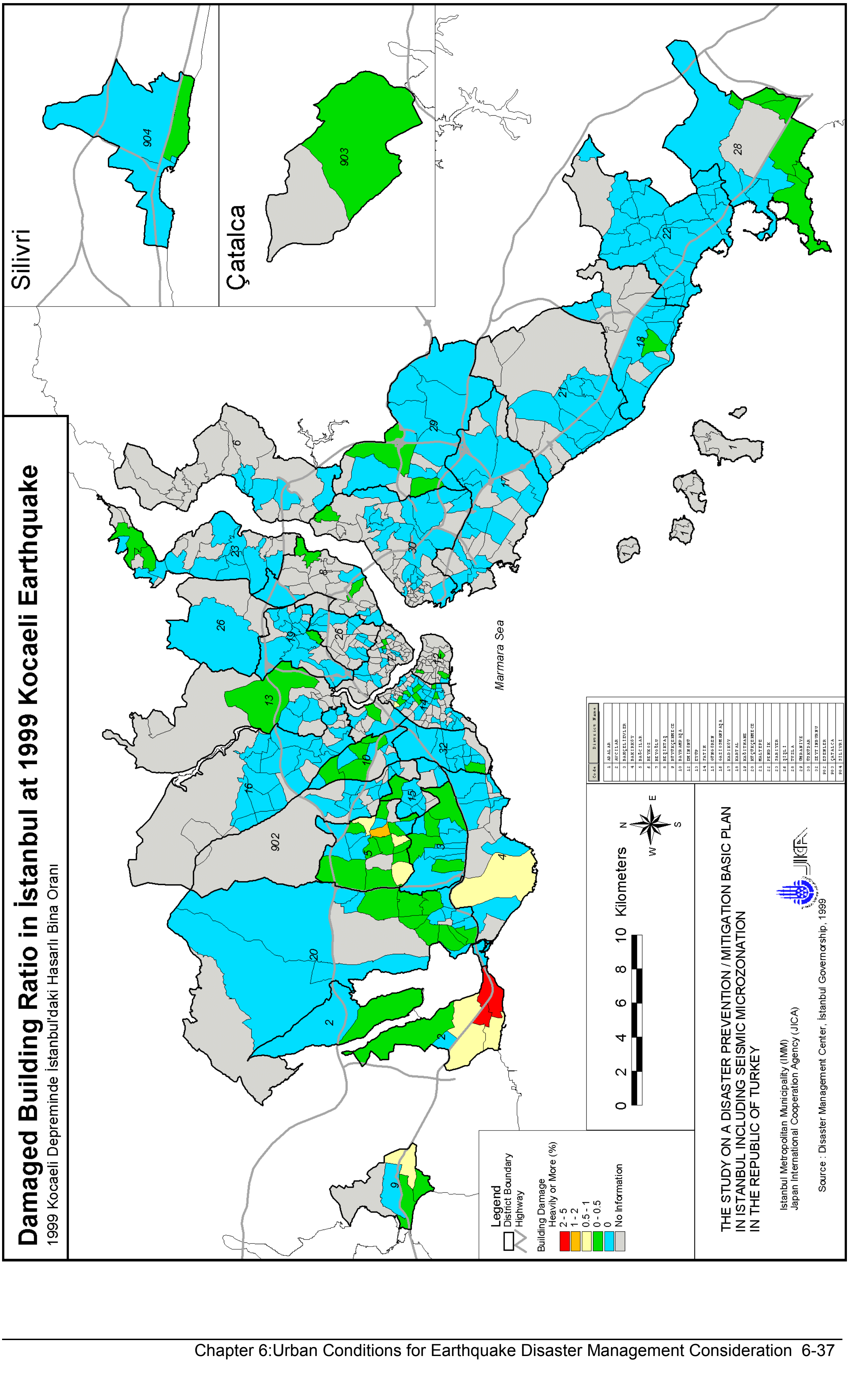


Figure 6.1.16 Building Damage Ratio by Izmit Earthquake - Heavy Damage or Greater

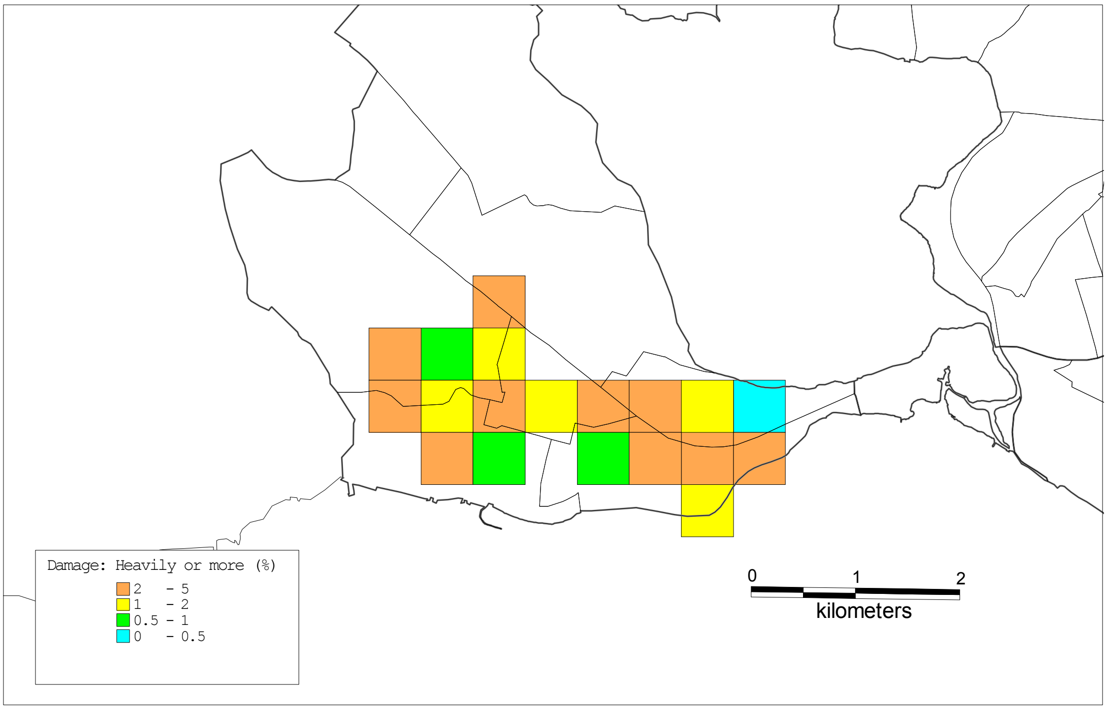


Figure 6.1.17 Building Damage Ratio by Izmit Earthquake in Avcilar – Heavy Damage or GreaterSource: Avcilar District Office, Compiled by the JICA Study Team

6.2. Data Related to Social Conditions

6.2.1. Population Data

According to the Population Census of 2000 by the State Institute of Statistics of the Prime Ministry (hereinafter referred to as SIS), the total population of Istanbul within its 27 districts and additional 3 districts (Büyükçekmece, Silivri and Çatalca) is 8,831,766 and its population density is 89 persons/hector. Population distribution by each mahalle is shown in Table 6.2.1.

Table 6.2.1 Population Distribution by District

District Code	District Name	No. of Mahalle	Area (ha)	No. of Mahalle more than		Highest Population Density		Population (Persons)	Population Density (persons / ha)	Population Density (persons / building)
				density of 500 persons / ha	density of 700 persons / ha	Density (persons/ha)	Mahalle Code			
1	ADALAR	11	1,100	0	0	80	1	17,738	16	3
2	AVCILAR	9	3,861	0	0	304	6	231,799	60	17
3	BAHÇELİEVLER	11	1,661	5	2	711	8	469,844	283	24
4	BAKIRKÖY	15	2,951	0	0	321	11	206,459	70	21
5	BAĞCILAR	22	2,194	3	0	673	16	557,588	254	15
6	BEYKOZ	19	4,156	0	0	132	5	182,864	44	6
7	BEYOĞLU	45	889	5	2	935	22	234,964	264	9
8	BEŞİKTAŞ	23	1,811	1	0	621	15	182,658	101	13
9	BÜYÜKÇEKMECE	6	1,474	N/A	N/A	N/A	N/A	34,737	24	10
10	BAYRAMPAŞA	11	958	0	0	466	4	237,874	248	12
12	EMİNÖNÜ	33	508	0	0	394	10	54,518	107	4
13	EYÜP	20	5,050	0	0	450	12	232,104	46	9
14	FATİH	69	1,045	25	3	864	56	394,042	377	12
15	GÜNGÖREN	11	718	6	2	870	7	271,874	378	26
16	GAZİOSMANPAŞA	29	5,676	2	0	548	23	667,809	118	12
17	KADIKÖY	28	4,128	0	0	365	11	660,619	160	17
18	KARTAL	20	3,135	0	0	211	19	332,090	106	14
19	KAĞITHANE	19	1,443	5	0	643	4	342,477	237	12
20	KÜÇÜKÇEKMECE	23	12,173	0	0	399	15	589,139	48	13
21	MALTEPE	21	5,530	0	0	284	2	345,662	63	14
22	PENDİK	29	4,731	0	0	192	23	372,553	79	9
23	SARIYER	23	2,774	0	0	234	9	212,996	77	7
26	ŞİŞLİ	28	3,543	4	0	616	8	271,003	76	12
28	TUZLA	11	4,998	0	0	119	8	100,609	20	7
29	ÜMRANİYE	14	4,561	0	0	298	904	443,358	97	10
30	ÜSKÜDAR	54	3,783	5	1	738	40	496,402	131	12
32	ZEYTİNBURNU	13	1,149	6	1	833	13	239,927	209	15
902	ESENLER	18	3,890	8	2	745	13	388,003	100	17
903	ÇATALCA	2	5,263	0	0	3	901	15,624	3	6
904	SİLİVRİ	5	3,828	0	0	226	902	44,432	12	5
Total		642	98,981	75	13	-	-	8,831,766	89	12

Note: N/A indicates that population data is not sub-divided by Mahalle; therefore, population data cannot be separated.

Source: Population Census 2000, SIS

Gaziosmanpaşa has the largest population counted at 667,809, and Kadiköy has the second largest population counted at 660,619. The district that has the smallest population is Çatalca, having 15,624. Within 27 districts in Istanbul, Adalar has the smallest population. The population in each mahalle is shown in

Figure 6.2.1.

Population density by mahalle is also calculated, based on the Population Census 2000 compiled by SIS.

Figure 6.2.2 shows population density by mahalle, and, thus, reflecting the the characteristics of congested areas. The average population density within the Study Area is 89 persons/ha. Güngören has the largest population density counted at 378 persons/ha and Fatih follows counted at 377 person/ha. On the contrary, Adalar, Büyükçekmece, Çatalca, and Silivri each have a rather small population density counted at 16 persons/ha, 24 persons/ha, 3 persons/ha and, 12 persons/ha, respectively.

As shown in Table 6.2.1, Fatih has 25 mahalles that have a population density of more than 500 persons/ha. In Table 6.2.2 a list of mahalles that have a population density of more than 500 persons/ha is provided for reference.

Table 6.2.2 List of Mahalles with Population Density Greater than 500 persons/ha

District Name	Mahalle Name	Area (ha)	Population	Population Density (persons/ha)
BAHÇELİEVLER	HÜRRİYET	57	40,385	707
	SOĞANLI	96	60,481	630
	SİYAVUŞPAŞA	81	57,692	711
	ZAFER	108	62,016	573
	ŞİRİNEVLER	108	55,563	513
BAĞCILAR	YENİGÜN	29	19,628	673
	YILDIZTEPE	61	32,596	533
	FATİH	62	35,328	570
BEYOĞLU	ÇUKUR	5	4,741	928
	FİRUZAĞA	10	5,488	526
	KADIMEHMET	14	8,056	576
	KALYONCU KULLUĞU	5	4,525	935
	YENİŞEHİR	11	5,982	567
BEŞİKTAŞ	MURADİYE	9	5,865	621
FATİH	ABDİ ÇELEBİ	10	6,710	646
	ALİ FAKİH	14	8,572	627
	ARABACI BEYAZIT	16	9,340	580
	BEYCEĞİZ	11	7,000	623
	CAMBAZİYE	16	8,109	514
	DERVİŞALİ	19	11,793	628
	HACI HAMZA	17	8,673	502
	HAMAMİ MUHİTTİN	8	4,843	640
	HAYDAR	12	5,983	501
	HIZIR ÇAVUŞ	5	3,446	659
	HOCAÜVEYS	24	13,503	557
	İBRAHİM ÇAVUŞ	14	8,777	630
	İSKENDERPAŞA	11	5,750	504
	KOCAMUSTAFAPAŞA	6	3,821	627
	KASIM GÜNANİ	9	5,651	625
	KATİP MUSLİHİTTİN	8	4,590	545
	KEÇECİ KARABAŞ	12	9,000	744
	KOCADEDE	11	6,036	555
	MELEKHATUN	14	9,891	717
	MUHTESİP İSKENDER	14	8,868	653
	MÜFTÜ ALİ	12	10,351	864
	NEVBAHAR	17	8,940	514
	SANCAKTAR HAYRETTİN	13	7,258	548
	SİNANAĞA	17	10,398	622
	UZUNYUSUF	16	10,781	687
GÜNGÖREN	AKINCILAR	26	20,689	805
	GÜNEŞTEPE	73	43,222	593
	MERKEZ	79	43,852	558
	GÜVEN	32	18,085	571
	HAZNEDAR	35	22,024	628
	M.ÇAKMAK	35	30,440	870

District Name	Mahalle Name	Area (ha)	Population	Population Density (persons/ha)
GAZİOSMANPAŞA	HÜRRİYET	47	25,248	538
	ŞEMSİPAŞA	35	19,348	548
KAĞITHANE	ÇELİKTEPE	52	28,600	551
	GÜLTEPE	20	12,627	643
	HARMANTEPE	29	18,568	633
	ORTABAYIR	37	20,904	560
	YAHYA KEMAL	30	16,028	530
ŞİŞLİ	BOZKURT	18	10,570	587
	DUATEPE	14	7,512	545
	ESKİŞEHİR	18	11,318	616
	FERİKÖY	24	12,912	532
ÜSKÜDAR	ARAKİYECİ HACI CAFER	10	6,481	643
	SOLAK SİNAN	10	5,855	562
	TABAKLAR	6	4,522	738
	TAVAŞİ HASANAĞA	7	4,277	622
	VALİDE-İ ATİK	13	6,893	518
ZEYTİNBURNU	ÇIRPICI	38	25,081	663
	GÖKALP	29	17,012	592
	NURİPAŞA	36	22,130	623
	VELİEFENDİ	40	24,564	611
	YENİ DOĞAN	16	8,816	564
	YEŞİLTEPE	21	17,621	833
ESENLER	DAVUTPAŞA	21	13,958	670
	FATİH	49	34,825	706
	KARABAYIR	69	42,464	620
	KAZIM KARABEKİR	50	30,452	615
	MENDERES	44	29,840	676
	MİMAR SİNAN	17	10,887	632
	NENE HATUN	50	37,209	745
	ORUÇ REİS	66	36,715	553

Source: Population Census 2000, SIS

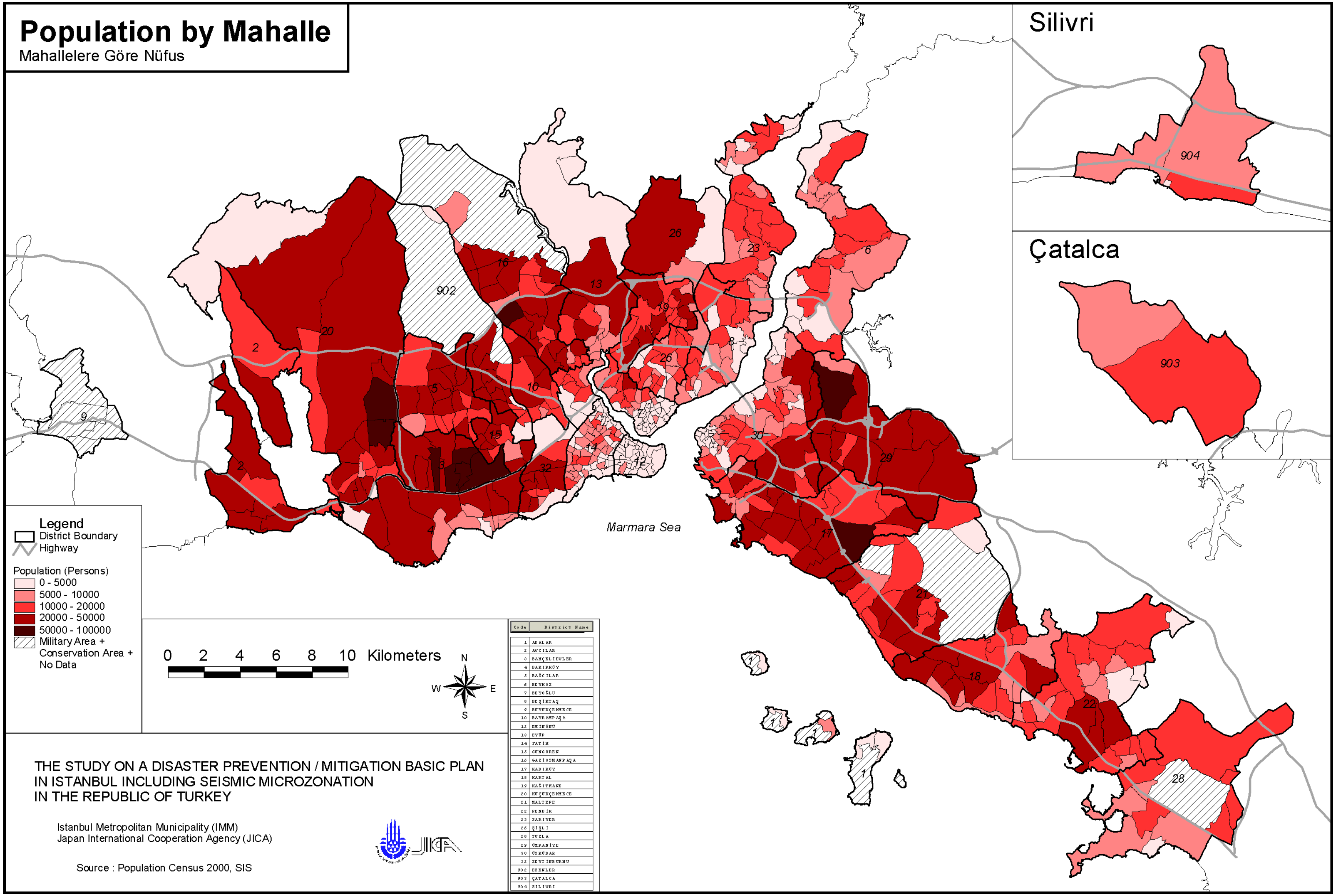


Figure 6.2.1 Population Distribution

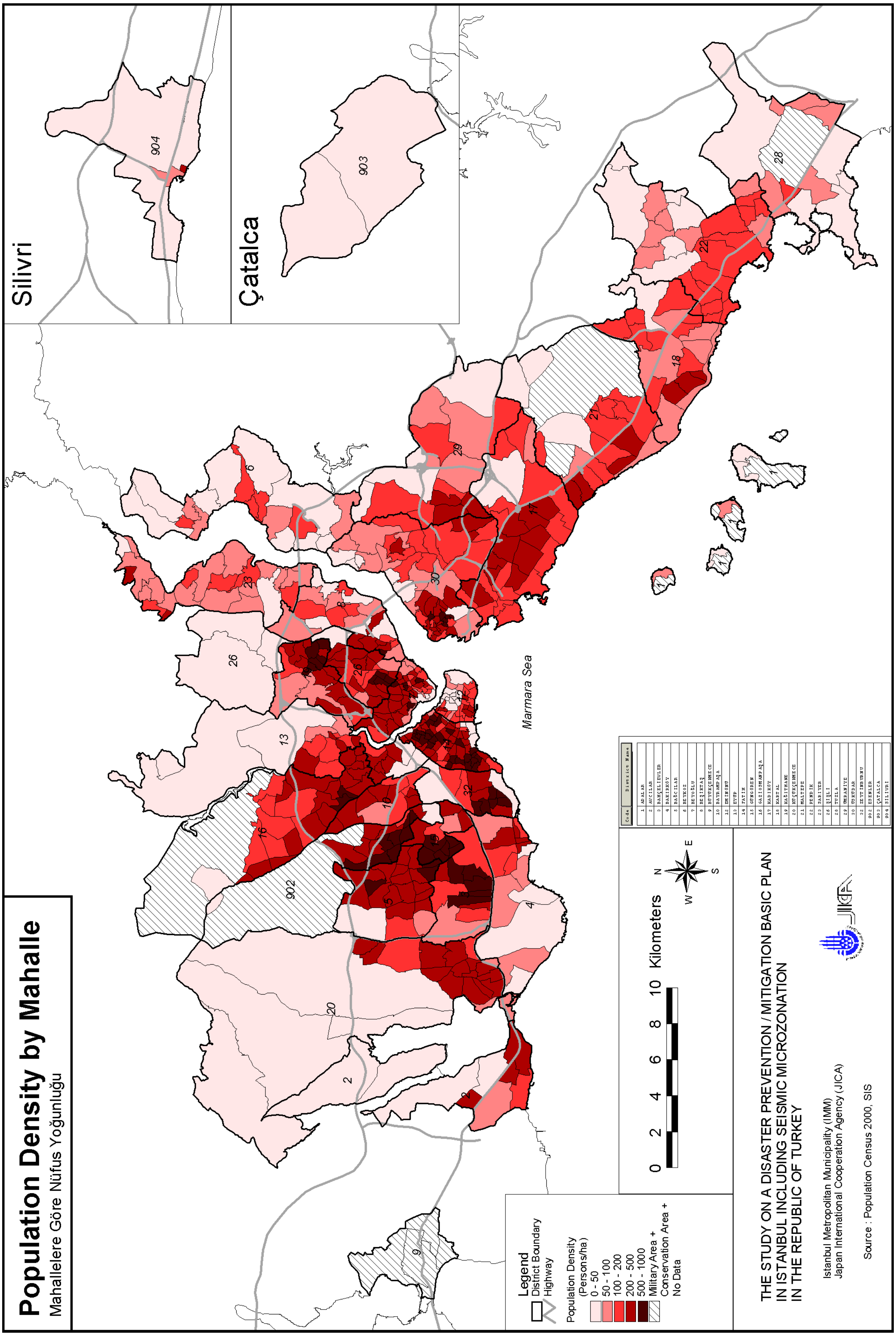


Figure 6.2.2 Population Density

6.2.2. Building Data

Building data within the Study Area is indispensable to the execution of damage estimation through seismic microzonation. The Study Team requested census data gathered by the SIS and received the data on the 16th of January 2002. The received data consisted of 1) structure type, 2) construction year, and 3) number of stories of each building, and these items were necessary to carry out the damage estimation within the Study. This data was obtained from a very comprehensive census and missing data are very few (for instance, among the total 724,609 buildings within the Study Area 0.9% of the structural type entries, 1.3 % of the construction year entries, and 0.4% of the number of stories entries are unknown. Therefore, these errors will not be taken into account in the Study. Table 6.2.3 shows the number of buildings and building density (buildings/ha) for each district.

Table 6.2.3 Building Distribution by District

District Code	District Name	Area (ha)	Population	Buildings	Building Density (Buildings/ha)
1	ADALAR	1,100	17,738	6,517	6
2	AVCILAR	3,861	231,799	14,030	4
3	BAHÇELİEVLER	1,661	469,844	19,690	12
4	BAKIRKÖY	2,951	206,459	10,067	3
5	BAĞCILAR	2,194	557,588	36,059	16
6	BEYKOZ	4,156	182,864	28,280	7
7	BEYOĞLU	889	234,964	26,468	30
8	BEŞİKTAŞ	1,811	182,658	14,399	8
9	BÜYÜKÇEKMECE	1,474	34,737	3,347	2
10	BAYRAMPAŞA	958	237,874	20,195	21
12	EMİNÖNÜ	508	54,518	14,149	28
13	EYÜP	5,050	232,104	25,716	5
14	FATİH	1,045	394,042	31,946	31
15	GÜNGÖREN	718	271,874	10,655	15
16	GAZİOSMANPAŞA	5,676	667,809	56,483	10
17	KADIKÖY	4,128	660,619	38,615	9
18	KARTAL	3,135	332,090	24,295	8
19	KAĞITHANE	1,443	342,477	28,737	20
20	KÜÇÜKÇEKMECE	12,173	589,139	45,816	4
21	MALTEPE	5,530	345,662	25,311	5
22	PENDİK	4,731	372,553	39,877	8
23	SARIYER	2,774	212,996	30,781	11
26	ŞİŞLİ	3,543	271,003	22,576	6
28	TUZLA	4,998	100,609	14,726	3
29	ÜMRANİYE	4,561	443,358	43,473	10
30	ÜSKÜDAR	3,783	496,402	43,021	11
32	ZEYTİNBURNU	1,149	239,927	15,573	14
902	ESENLER	3,890	388,003	22,700	6
903	ÇATALCA	5,263	15,624	2,573	0
904	SİLİVRİ	3,828	44,432	8,534	2
	Total	98,981	8,831,766	724,609	7

Source: Building Census 2000, SIS

As indicated, according to the 2000 Building Census by SIS, the total number of buildings within the Study Area is counted at 724,609 buildings.

Figure 6.2.3 shows building distribution by mahalle and

Figure 6.2.4 shows duilding density by mahalle. In detail, Gaziosmanpaşa has the highest number of buildings in Istanbul, counted at 56,483. However, its area is rather large and its building density is 10 buildings/ha. Similar to their population distribution, the additional 3 districts have a low number of buildings.

Concerning building density, Fatih and Beyoğlu have the highest population density at 31 persons/ha and 30 persons/ha, respectively. On the contrary, Çatalca has the lowest population density in the Study Area.

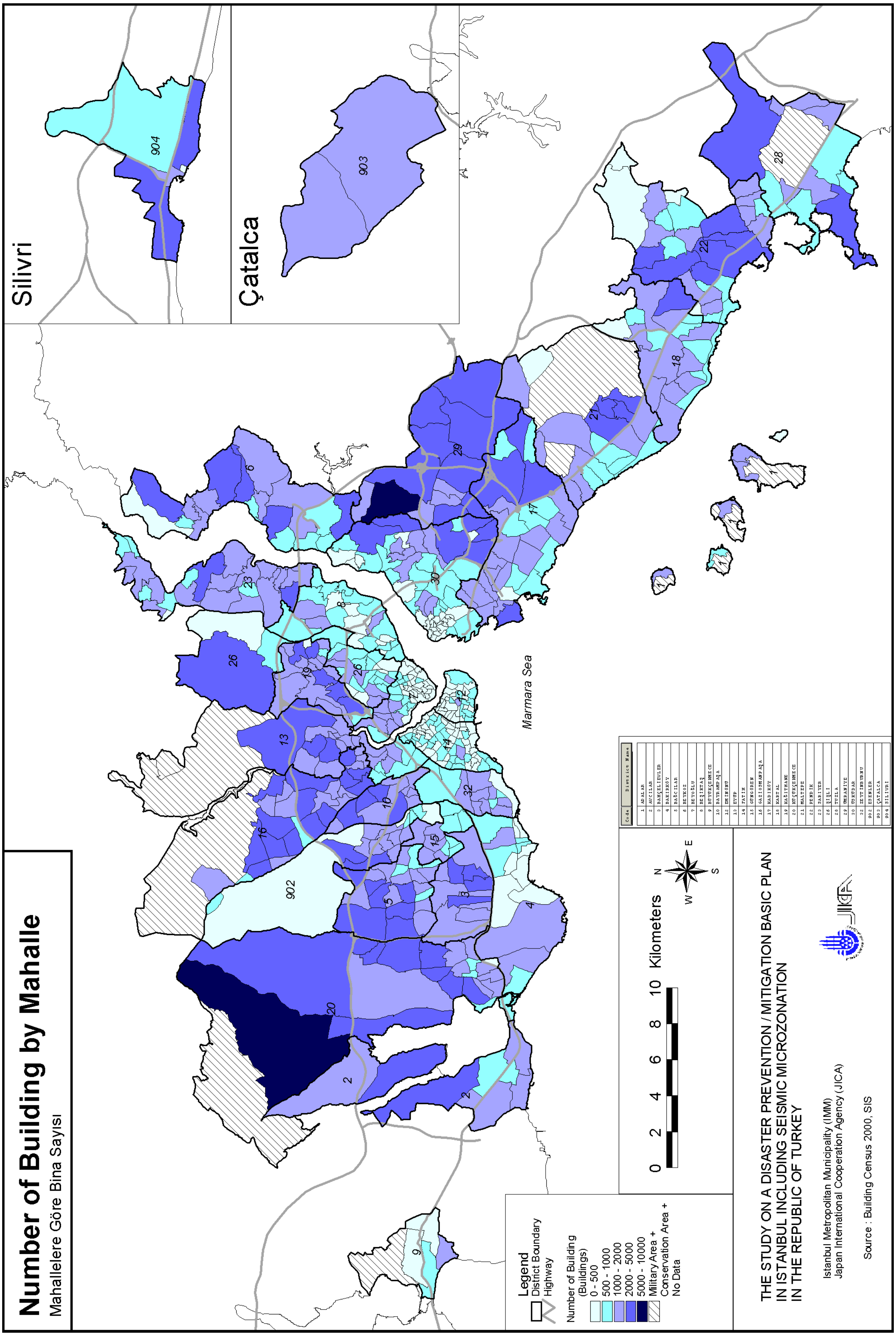


Figure 6.2.3 Building Distribution by Mahalle

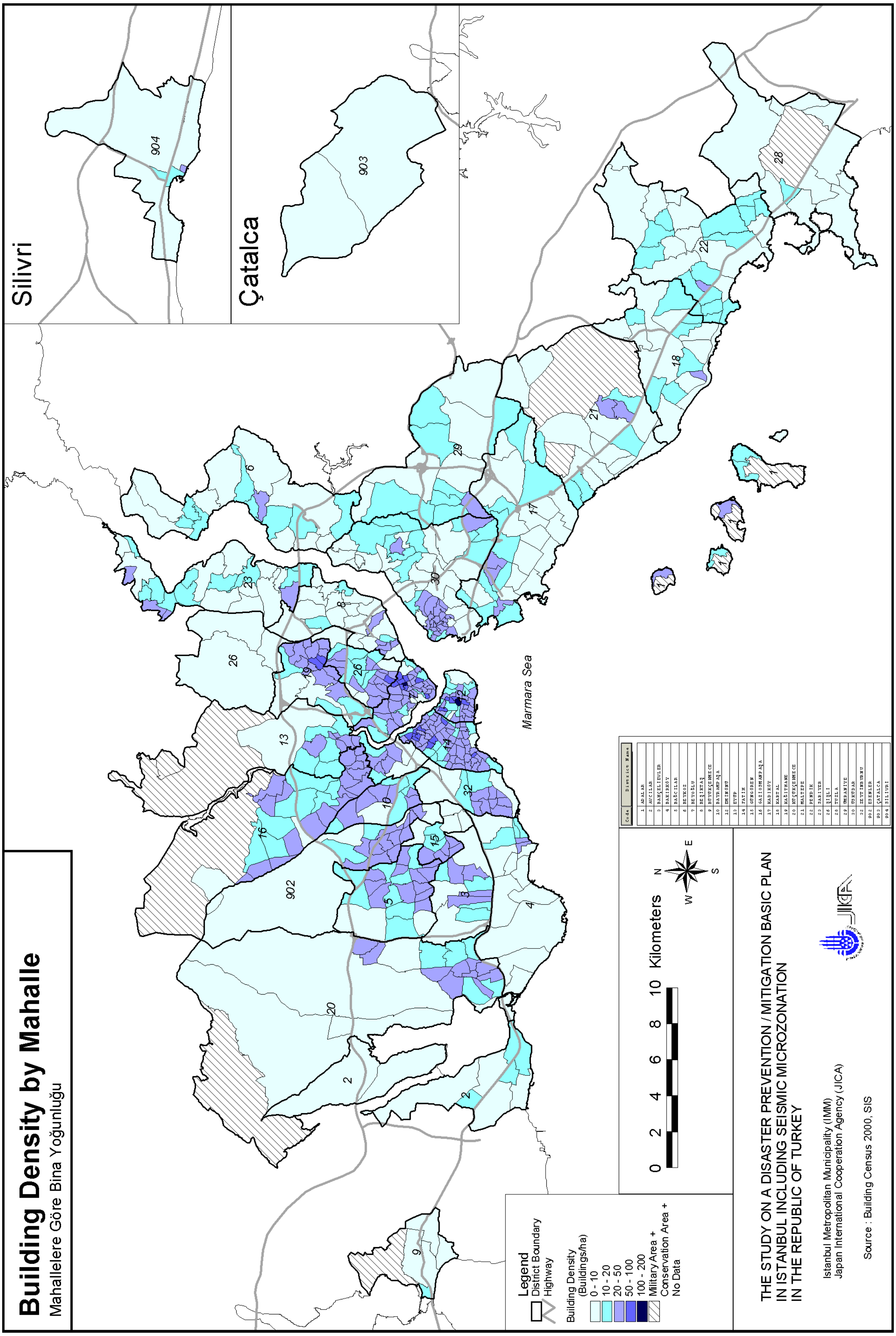


Figure 6.2.4 Building Density by Mahalle

(1) Structure Types

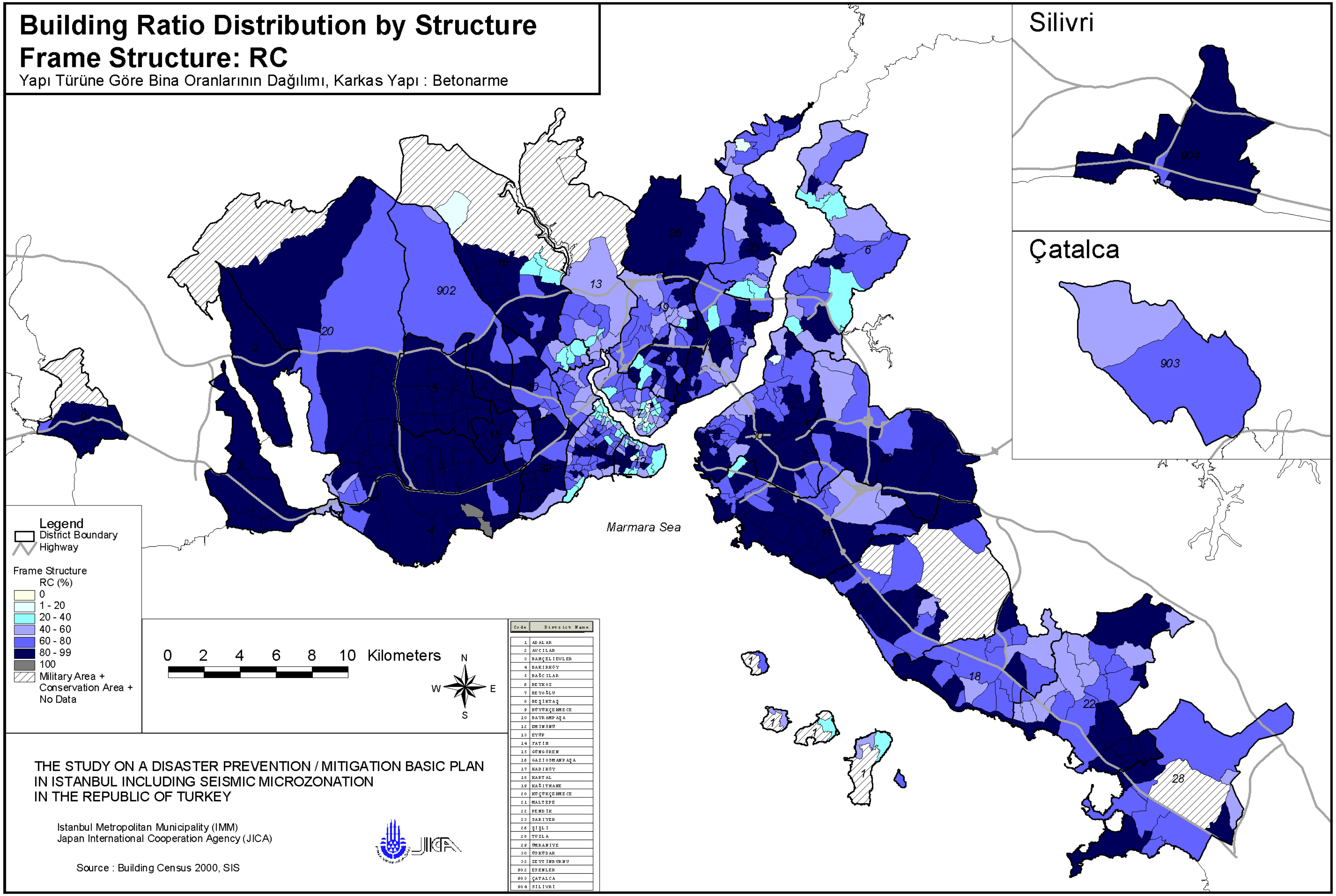
In the 2000 Building Census, building structures were divided into several types. For framed structures, two parts are recognised. One pertains to the framing of the building (i.e., 1: steel frame, 2: RC frame, 3: wood frame, and 4: other frame) and the other pertains to infill wall materials (1: steel plate, 2: concrete block, 3: briquette, 4: brick, 5: wood, 6: stone, and 7: sun dried brick). Combinations of these parts can exist and they form a variety of building structure types. According to discussions with Dr. Professor Nuray Aydonoglu, the difference of infill wall material cannot be used to classify the difference in building strength; therefore, the infill wall material was not taken into consideration in this project and data are aggregated using the frame, or skeleton, type. Another type of structure is masonry. For masonry structures, materials are classified into six (6) categories: 1) briquette, 2) brick, 3) wood, 4) stone, 5) sun dried brick, and 6) others. Due to the questionable nature of wood masonry, the number of buildings in this category is merged into the "wood frame" category.

Table 6.2.4 shows the breakdown of type of structure by district. In fact, within the Study Area, the ratio of RC frame structures is 74.4% and of briquette/brick masonry is 21.7%; therefore, 96.1% of structures are made up of these two types. Newly developed areas in the last three decades that are mainly made up of RC structuresare Avcilar, Bahçelievler, Bağcilar, Büyükçekmece, Gaziosmanpaşa, and Esenler, with 90% of its building stock made up of RC structures. On the contrary, the building stock in old towns such as Adalar, Beyoğlu, Eminönü and Fatih is more than 30% masonry structures. Most masonry structures are made of briquette and brick, and it is remarkable that in Eminönü, 19% of the bulding stock is comprised of stone masonry buildings.

Figure 6.2.5 shows the building distribution ratio of RC structures by mahalle and

Figure 6.2.6 shows the building distribution ratio of masonry structures (briquette and brick) by mahalle.

District Code	District Name	Structure (No of Buildings)										Structure (Percentage)									
		FS (Steel)	FS (RC)	FS (Wood)	FS (Other)	MS (Briquette, Brick)	MS (Stone)	MS (Sun dried brick)	MS (Other)	Other (Full shear wall)	Other (Prefabric)	FS (Steel)	FS (RC)	FS (Wood)	FS (Other)	MS (Briquette, Brick)	MS (Stone)	MS (Sun dried brick)	MS (Other)	Other (Full shear wall)	Other (Prefabric)
1	ADALAR	8	2,767	1,021	9	2,606	59	11	9	0	13	0.1	42.5	15.7	0.1	40.1	0.9	0.2	0.1	0.0	0.2
2	AVCILAR	13	13,165	22	1	759	26	6	2	1	20	0.1	93.9	0.2	0.0	5.4	0.2	0.0	0.0	0.0	0.1
3	BAHÇELİEVLER	13	18,957	17	1	543	11	1	2	20	55	0.1	96.6	0.1	0.0	2.8	0.1	0.0	0.0	0.1	0.3
4	BAKIRKÖY	20	8,851	235	1	731	35	1	1	1	50	0.2	89.2	2.4	0.0	7.4	0.4	0.0	0.0	0.0	0.5
5	BAĞCILAR	20	34,116	13	2	1,710	15	33	5	0	17	0.1	94.9	0.0	0.0	4.8	0.0	0.1	0.0	0.0	0.0
6	BEYKOZ	106	17,034	559	3	10,153	133	3	46	0	6	0.4	60.7	2.0	0.0	36.2	0.5	0.0	0.2	0.0	0.0
7	BEYOĞLU	75	13,762	1,018	11	10,354	922	53	7	1	12	0.3	52.5	3.9	0.0	39.5	3.5	0.2	0.0	0.0	0.0
8	BEŞİKTAŞ	11	9,985	707	43	3,204	276	9	12	3	20	0.1	70.0	5.0	0.3	22.5	1.9	0.1	0.1	0.0	0.1
9	BÜYÜKÇEKMECE	1	3,127	19	1	146	15	0	0	0	8	0.0	94.3	0.6	0.0	4.4	0.5	0.0	0.0	0.0	0.2
10	BAYRAMPAŞA	9	15,324	17	4	4,548	35	10	0	0	25	0.0	76.7	0.1	0.0	22.8	0.2	0.1	0.0	0.0	0.1
12	EMİNÖNÜ	25	7,397	792	19	3,040	2,655	5	14	1	35	0.2	52.9	5.7	0.1	21.7	19.0	0.0	0.1	0.0	0.3
13	EYÜP	20	15,225	459	1	9,190	246	17	2	3	71	0.1	60.3	1.8	0.0	36.4	1.0	0.1	0.0	0.0	0.3
14	FATİH	32	19,336	1,815	3	9,573	662	38	20	2	54	0.1	61.3	5.8	0.0	30.4	2.1	0.1	0.1	0.0	0.2
15	GÜNGÖREN	10	10,058	7	2	471	4	0	6	0	5	0.1	95.2	0.1	0.0	4.5	0.0	0.0	0.1	0.0	0.0
16	GAZİOSMANPAŞA	25	40,486	37	3	15,615	54	39	3	0	14	0.0	71.9	0.1	0.0	27.7	0.1	0.1	0.0	0.0	0.0
17	KADIKÖY	58	30,730	537	13	6,237	223	63	18	302	30	0.2	80.4	1.4	0.0	16.3	0.6	0.2	0.0	0.8	0.1
18	KARTAL	38	17,594	410	2	5,864	191	10	7	1	68	0.2	72.7	1.7	0.0	24.2	0.8	0.0	0.0	0.0	0.3
19	KAĞITHANE	42	19,187	19	3	9,251	11	9	1	56	8	0.1	67.1	0.1	0.0	32.4	0.0	0.0	0.0	0.2	0.0
20	KÜÇÜKÇEKMECE	40	38,452	148	3	6,239	146	14	82	140	18	0.1	84.9	0.3	0.0	13.8	0.3	0.0	0.2	0.3	0.0
21	MALTEPE	73	19,708	57	0	4,953	81	17	5	9	59	0.3	79.0	0.2	0.0	19.8	0.3	0.1	0.0	0.0	0.2
22	PENDİK	102	28,027	153	5	10,855	93	26	31	95	70	0.3	71.0	0.4	0.0	27.5	0.2	0.1	0.1	0.2	0.2
23	SARIYER	20	19,270	884	19	9,661	288	41	10	2	13	0.1	63.8	2.9	0.1	32.0	1.0	0.1	0.0	0.0	0.0
26	ŞİŞLİ	24	16,240	392	5	5,456	148	107	3	4	9	0.1	72.5	1.8	0.0	24.4	0.7	0.5	0.0	0.0	0.0
28	TUZLA	139	11,302	109	73	2,849	50	11	28	1	61	1.0	77.3	0.7	0.5	19.5	0.3	0.1	0.2	0.0	0.4
29	ÜMRANİYE	24	32,029	129	6	10,823	73	11	2	100	25	0.1	74.1	0.3	0.0	25.0	0.2	0.0	0.0	0.2	0.1
30	ÜSKÜDAR	38	33,748	1,172	30	7,096	348	54	70	3	53	0.1	79.2	2.8	0.1	16.7	0.8	0.1	0.2	0.0	0.1
32	ZEYTİNBURNU	21	13,736	18	2	1,583	51	11	3	15	20	0.1	88.8	0.1	0.0	10.2	0.3	0.1	0.0	0.1	0.1
902	ESENLER	21	21,051	48	2	1,425	32	22	3	0	2	0.1	93.1	0.2	0.0	6.3	0.1	0.1	0.0	0.0	0.0
903	ÇATALCA	2	1,434	102	1	823	118	13	1	0	6	0.1	57.4	4.1	0.0	32.9	4.7	0.5	0.0	0.0	0.2
904	SİLİVRİ	7	6,879	75	1	1,292	67	124	5	0	40	0.1	81.0	0.9	0.0	15.2	0.8	1.5	0.1	0.0	0.5
Total		1,037	538,977	10,991	269	157,050	7,068	759	398	760	887	0.1	74.4	1.5	0.0	21.7	1.0	0.1	0.1	0.1	0.1



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 6.2.5 Building Distribution by Structure Type (Frame Structure: RC)

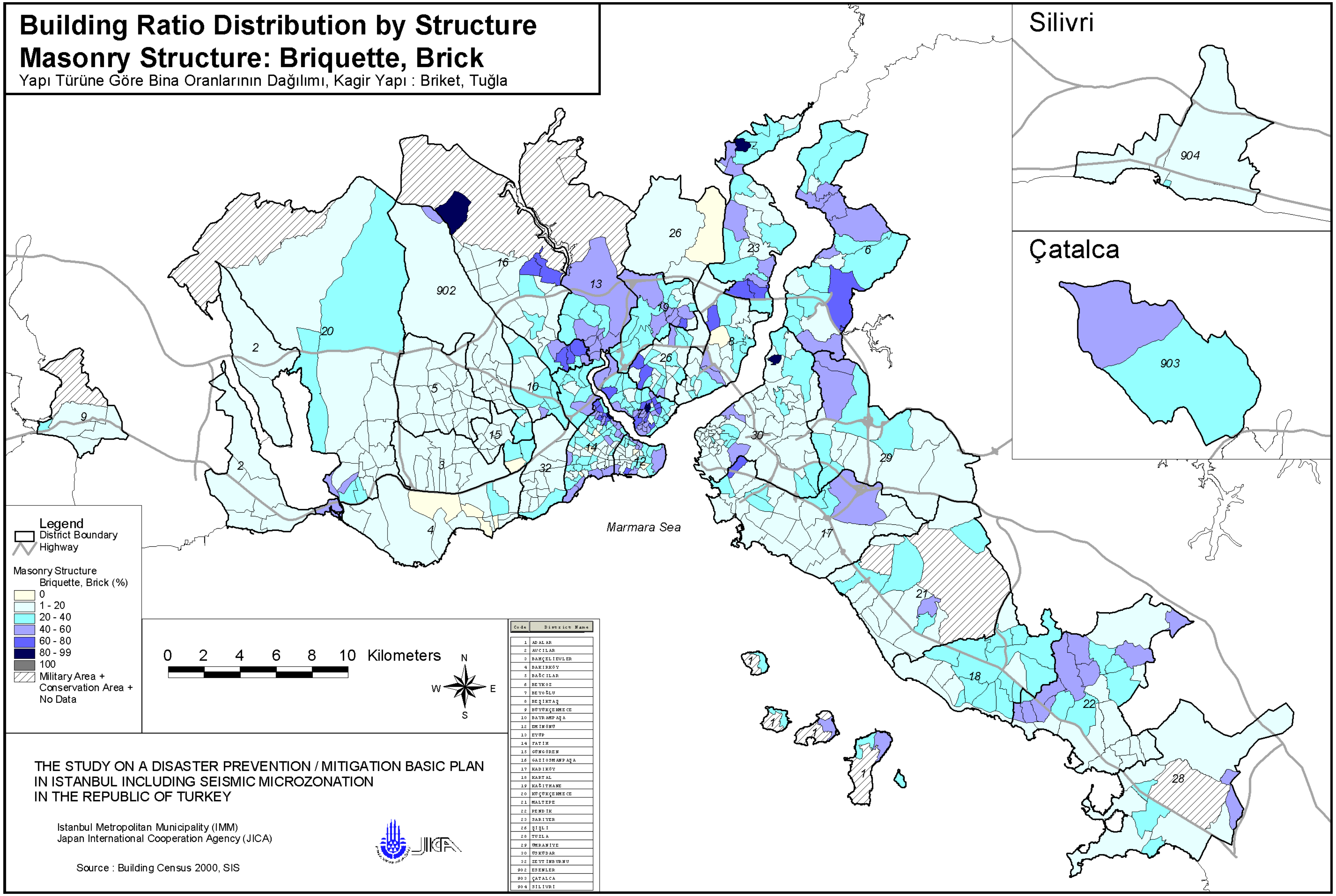


Figure 6.2.6 Building Distribution by Structure Type (Masonry Structure: Briquette, Brick)

(2) Building Construction Year Data

In the 2000 Building Census, the construction year data is divided into fourteen categories: 1) 1923 and before, 2) 1924-1929, 3) 1930-1939, 4) 1950-1959, 5) 1960-1969, 6) 1970-1979, 7) 1980-1989, 8) 1980-1989, 9) 1990-1995, 10) 1996, 11) 1997, 12) 1998, 13) 1999, and 14) 2000. The original data was aggregated into 6 categories: 1) 1949 and before, 2) 1950-1959, 3) 1960-1969, 4) 1970-1979, 5) 1980-1989, and 6) 1990 and after. Table 6.2.5 summarises construction year data of buildings by district.

Table 6.2.5 Building Construction Year by District

District Code	District Name	Construction Year (No. of Buildings)						Construction Year (Percentage)					
		1949 and before	1950-1959	1960-1969	1970-1979	1980-1989	1990 and after	1949 and before	1950-1959	1960-1969	1970-1979	1980-1989	1990 and after
1	ADALAR	1,910	719	845	969	1,185	813	29.7	11.2	13.1	15.0	18.4	12.6
2	AVCILAR	24	71	197	1,105	3,928	8,690	0.2	0.5	1.4	7.9	28.0	62.0
3	BAHÇELİEVLER	15	51	468	3,398	7,453	8,096	0.1	0.3	2.4	17.4	38.3	41.6
4	BAKIRKÖY	359	439	1,292	2,886	2,740	2,166	3.6	4.4	13.1	29.2	27.7	21.9
5	BAĞCILAR	26	50	321	4,826	15,604	14,982	0.1	0.1	0.9	13.5	43.6	41.8
6	BEYKOZ	1,170	755	2,727	7,150	11,063	4,982	4.2	2.7	9.8	25.7	39.7	17.9
7	BEYOĞLU	8,113	2,679	3,576	4,084	3,709	4,052	31.0	10.2	13.6	15.6	14.1	15.5
8	BEŞİKTAŞ	1,783	1,842	1,792	3,509	3,068	2,247	12.5	12.9	12.6	24.6	21.5	15.8
9	BÜYÜKÇEKMECE	22	55	113	301	1,552	1,269	0.7	1.7	3.4	9.1	46.9	38.3
10	BAYRAMPAŞA	27	341	2,977	5,721	6,302	4,538	0.1	1.7	15.0	28.7	31.7	22.8
12	EMİNÖNÜ	6,016	1,369	1,949	2,554	1,389	615	43.3	9.9	14.0	18.4	10.0	4.4
13	EYÜP	1,474	2,353	4,860	6,074	5,937	4,670	5.8	9.3	19.2	23.9	23.4	18.4
14	FATİH	7,067	3,303	5,589	8,785	4,187	2,323	22.6	10.6	17.9	28.1	13.4	7.4
15	GÜNGÖREN	6	51	426	2,216	4,275	3,556	0.1	0.5	4.0	21.0	40.6	33.8
16	GAZİOSMANPAŞA	307	2,810	4,222	9,582	14,897	24,383	0.5	5.0	7.5	17.0	26.5	43.4
17	KADIKÖY	1,140	1,459	4,250	11,735	11,885	7,657	3.0	3.8	11.1	30.8	31.2	20.1
18	KARTAL	205	405	2,053	5,873	9,385	6,251	0.8	1.7	8.5	24.3	38.8	25.9
19	KAĞITHANE	57	704	5,481	8,316	6,934	6,911	0.2	2.5	19.3	29.3	24.4	24.3
20	KÜÇÜKÇEKMECE	149	396	2,528	6,801	12,613	22,133	0.3	0.9	5.7	15.2	28.3	49.6
21	MALTEPE	158	284	1,645	4,900	9,027	9,068	0.6	1.1	6.6	19.5	36.0	36.2
22	PENDİK	197	394	1,792	5,167	14,174	17,748	0.5	1.0	4.5	13.1	35.9	45.0
23	SARIYER	1,783	1,418	2,635	6,575	10,746	7,250	5.9	4.7	8.7	21.6	35.3	23.8
26	ŞİŞLİ	2,379	2,639	4,111	4,656	3,939	4,550	10.7	11.8	18.5	20.9	17.7	20.4
28	TUZLA	183	141	389	1,582	4,605	7,588	1.3	1.0	2.7	10.9	31.8	52.4
29	ÜMRANİYE	64	183	962	4,894	13,279	23,203	0.2	0.4	2.3	11.5	31.2	54.5
30	ÜSKÜDAR	2,094	1,273	3,559	9,525	12,334	13,692	4.9	3.0	8.4	22.4	29.0	32.2
32	ZEYTİNBURNU	208	513	1,148	2,443	4,815	6,254	1.4	3.3	7.5	15.9	31.3	40.7
902	ESENLER	27	83	919	4,409	8,901	8,221	0.1	0.4	4.1	19.5	39.5	36.4
903	ÇATALCA	211	94	234	551	705	728	8.4	3.7	9.3	21.8	27.9	28.9
904	SİLİVRİ	270	102	275	1,201	2,589	4,063	3.2	1.2	3.2	14.1	30.5	47.8
Total		37,444	26,976	63,335	141,788	213,220	232,699	5.2	3.8	8.9	19.8	29.8	32.5

Source: Building Census 2000, SIS

According to the data, up to 1969, the number of buildings in Istanbul was only 127,755 (17.9 % of the total number of buildings in the year 2000). Also, development in Istanbul rapidly increased after 1970, with the construction of mostly RC frame structures. It can be considered that this wave of construction contributed to the construction of rather low quality buildings, especially residential buildings.

In the Study, construction year data is used to visualise the urban development pattern in Istanbul (

Figure 6.2.7 to

Figure 6.2.12). These figures clearly show urban development in Istanbul.

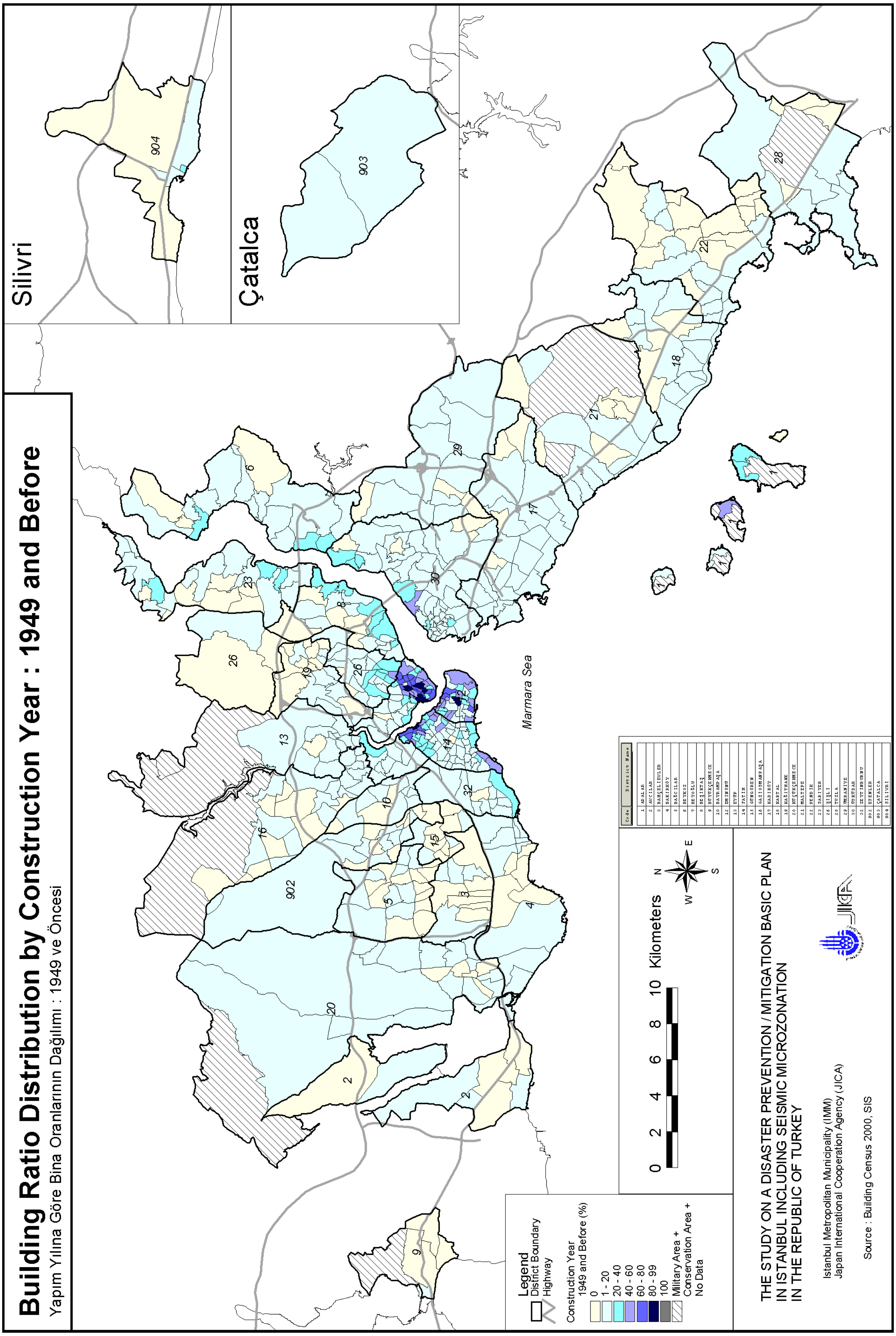


Figure 6.2.7 Building Distribution by Construction Year (1949 and before)

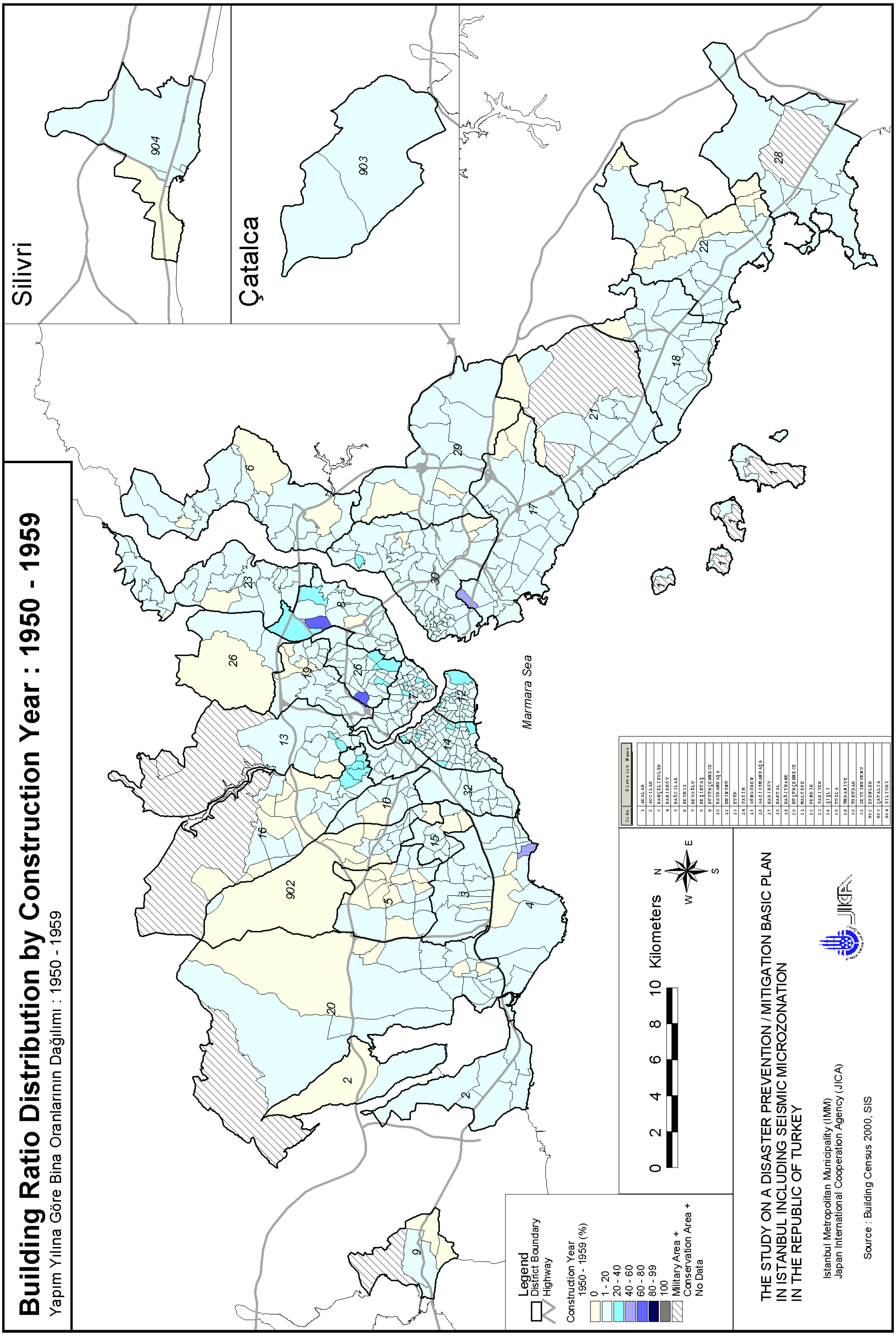


Figure 6.2.8 Building Distribution by Construction Year (1950-1959)

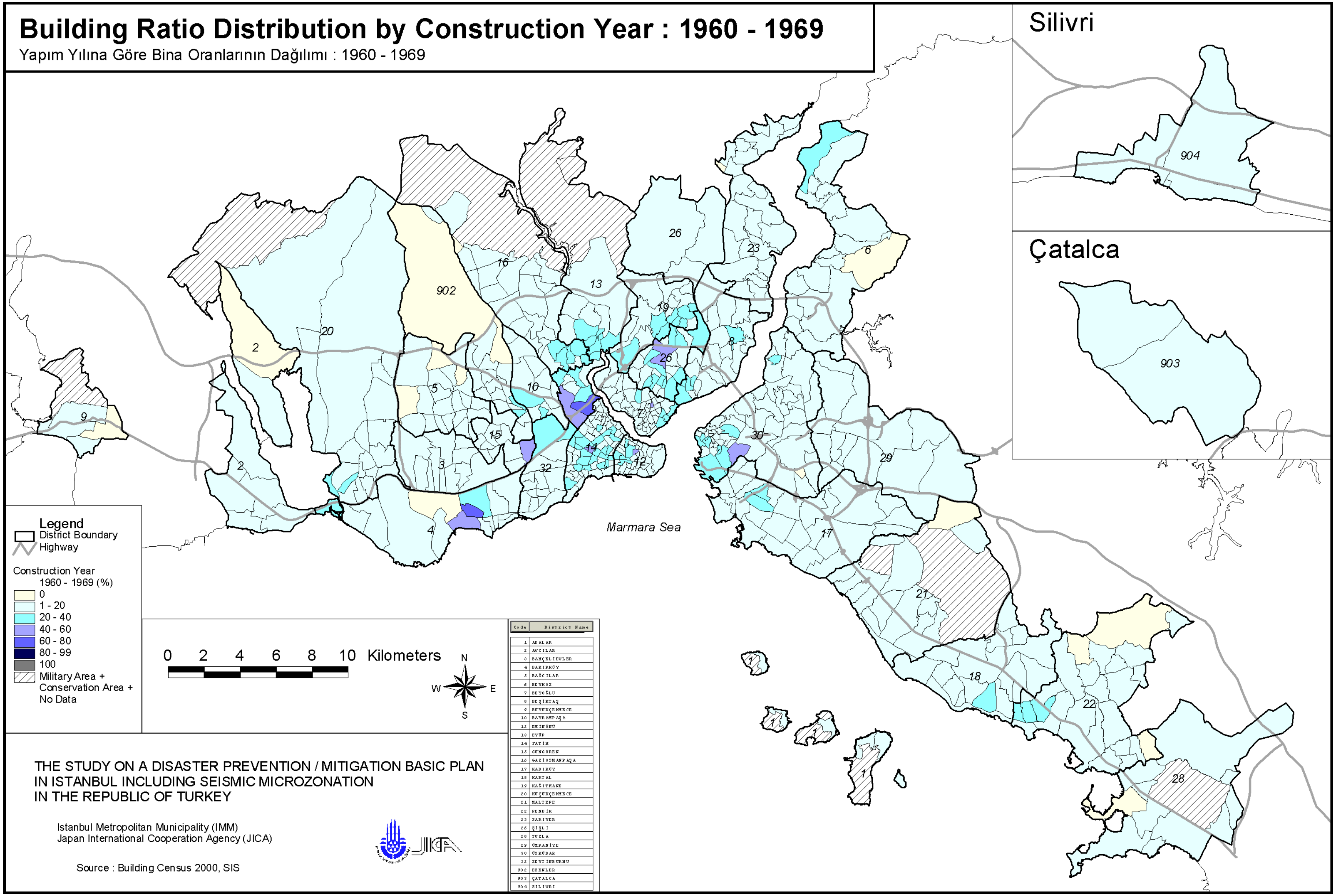


Figure 6.2.9 Building Distribution by Construction Year (1960-1969))

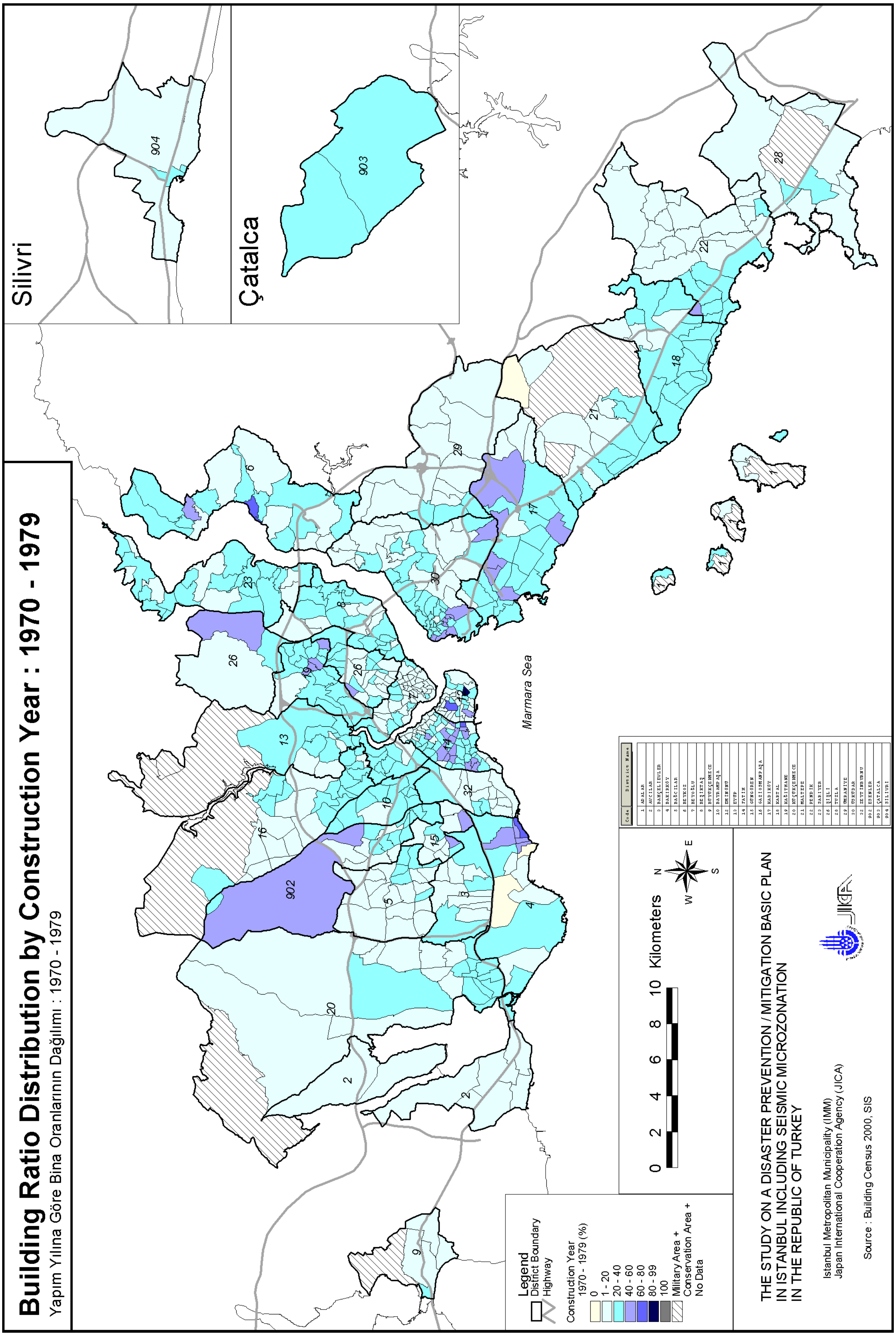


Figure 6.2.10 Building Distribution by Construction Year (1970-1979)

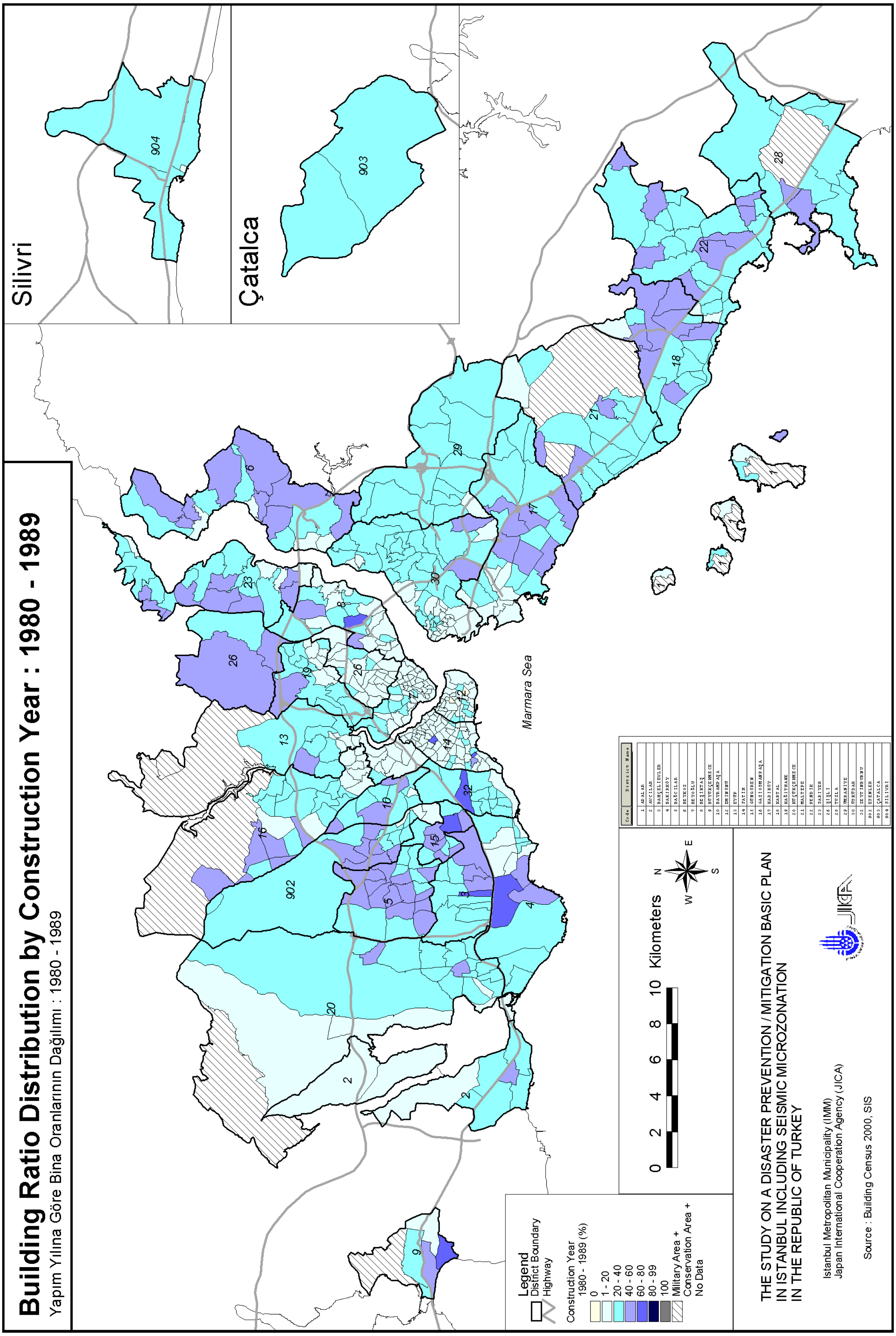


Figure 6.2.11 Building Distribution by Construction Year (1980-1989)

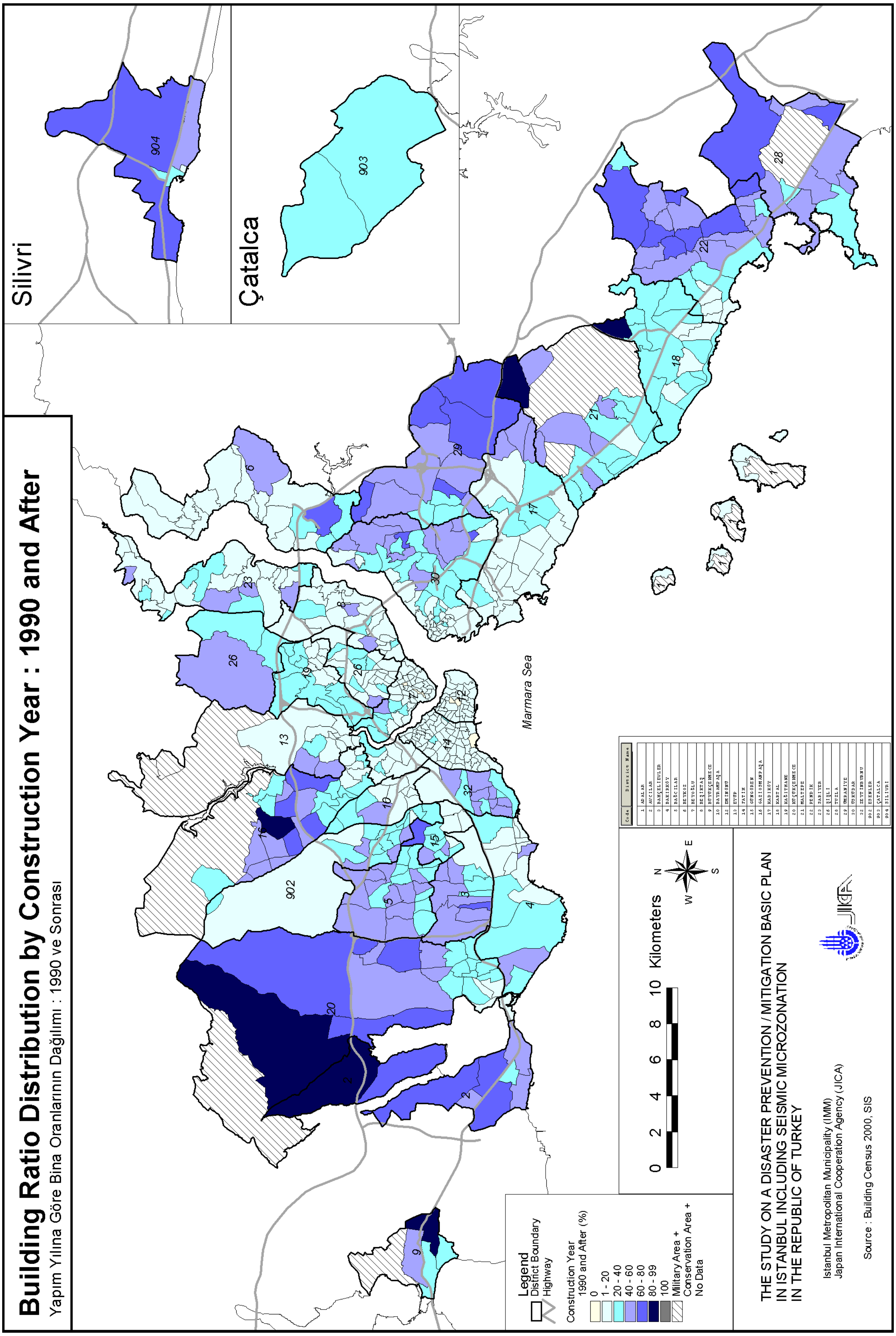


Figure 6.2.12 Building Distribution by Construction Year (1990 and after)

(3) Number of Stories

In the 2000 Building Census, data on the number of stories for buildings is also included. In the questionnaire used, it was indicated that attics and basements had to be included in the assessment of the number of stories for each building; thus, the actual number of storeys above ground is not certain, and this is true especially for office and commercial buildings. However, there was no compelling reason to collect the actual information and, in the study, the existing data was used. In the future, it is recommended that the difference in the actual number of stories above ground and the number collected through the census should be indicated separately, if census data will be used to update data in the future. Table 6.2.6 shows a summary of building height by district. For the damage estimation carried out in this study, data on the number of stories are classified into four (4) categories: 1) 1-3 stories, 2) 4-7 stories, 3) 8-15 stories, and 4) 16 stories and over.

Table 6.2.6 Number of Building Stories by District

District Code	District Name	No. of Stories (No of Buildings)				No. of Stories (Percentage)			
		1-3	4-7	8-15	16 and over	1-3	4-7	8-15	16 and over
1	ADALAR	5,294	1,214	0	0	81.3	18.7	0.0	0.0
2	AVCILAR	4,901	8,745	348	1	35.0	62.5	2.5	0.0
3	BAHÇELİEVLER	3,559	14,027	1,972	0	18.2	71.7	10.1	0.0
4	BAKIRKÖY	3,147	6,514	323	18	31.5	65.1	3.2	0.2
5	BAĞCILAR	13,224	22,222	541	8	36.7	61.7	1.5	0.0
6	BEYKOZ	25,036	2,733	67	0	89.9	9.8	0.2	0.0
7	BEYOĞLU	11,961	13,806	608	7	45.3	52.3	2.3	0.0
8	BEŞİKTAŞ	6,020	7,692	629	23	41.9	53.6	4.4	0.2
9	BÜYÜKÇEKMECE	1,242	2,059	19	0	37.4	62.0	0.6	0.0
10	BAYRAMPAŞA	7,170	12,842	112	0	35.6	63.8	0.6	0.0
12	EMİNÖNÜ	7,886	5,713	486	1	56.0	40.6	3.5	0.0
13	EYÜP	19,380	6,153	44	0	75.8	24.1	0.2	0.0
14	FATİH	11,765	19,655	304	0	37.1	62.0	1.0	0.0
15	GÜNGÖREN	1,383	8,472	733	1	13.1	80.0	6.9	0.0
16	GAZİOSMANPAŞA	30,299	25,754	319	0	53.7	45.7	0.6	0.0
17	KADIKÖY	16,134	17,063	4,961	188	42.1	44.5	12.9	0.5
18	KARTAL	13,980	9,017	1,224	10	57.7	37.2	5.1	0.0
19	KAĞITHANE	14,145	13,883	681	1	49.3	48.4	2.4	0.0
20	KÜÇÜKÇEKMECE	25,527	18,843	1,217	31	56.0	41.3	2.7	0.1
21	MALTEPE	14,318	10,087	779	6	56.8	40.0	3.1	0.0
22	PENDİK	27,614	11,544	557	2	69.5	29.1	1.4	0.0
23	SARIYER	24,245	6,320	106	0	79.0	20.6	0.3	0.0
26	ŞİŞLİ	8,858	11,454	2,106	31	39.5	51.0	9.4	0.1
28	TUZLA	10,922	3,709	40	1	74.4	25.3	0.3	0.0
29	ÜMRANİYE	30,525	12,508	306	29	70.4	28.8	0.7	0.1
30	ÜSKÜDAR	24,113	18,292	369	0	56.4	42.8	0.9	0.0
32	ZEYTİNBURNU	4,471	10,448	558	20	28.9	67.4	3.6	0.1
902	ESENLER	7,509	14,742	401	0	33.1	65.1	1.8	0.0
903	ÇATALCA	2,084	453	2	0	82.1	17.8	0.1	0.0
904	SİLİVRİ	6,363	2,069	81	0	74.7	24.3	1.0	0.0
Total		383,075	318,033	19,893	378	52.9	43.9	2.7	0.1

Source: Building Census 2000, SIS

By observing the building stories data, it is evident that buildings with up to 4 stories account for 52.9% of the total number of buildings within the Study Area. By district, these buildings (1-4 stories) make up 70% of the buildings in the districts of Adalar, Beykoz, Eyüp, Sariyer, Tuzla, Ümraniye, Çatalca, and Silivri. These districts are mostly low-density areas with a population density of less than 100person/ha. On the contrary, Bahçelievler, Kadiköy, and Şişli have a rather large number of high-story buildings. In fact, 9.4% to 12.9% of the buildings in these districts were buildings with more than 16 stories

Building story information was also input into GIS.

Figure 6.2.13 to

Figure 6.2.16 show the building distribution by number of stories for each of the classified categories.

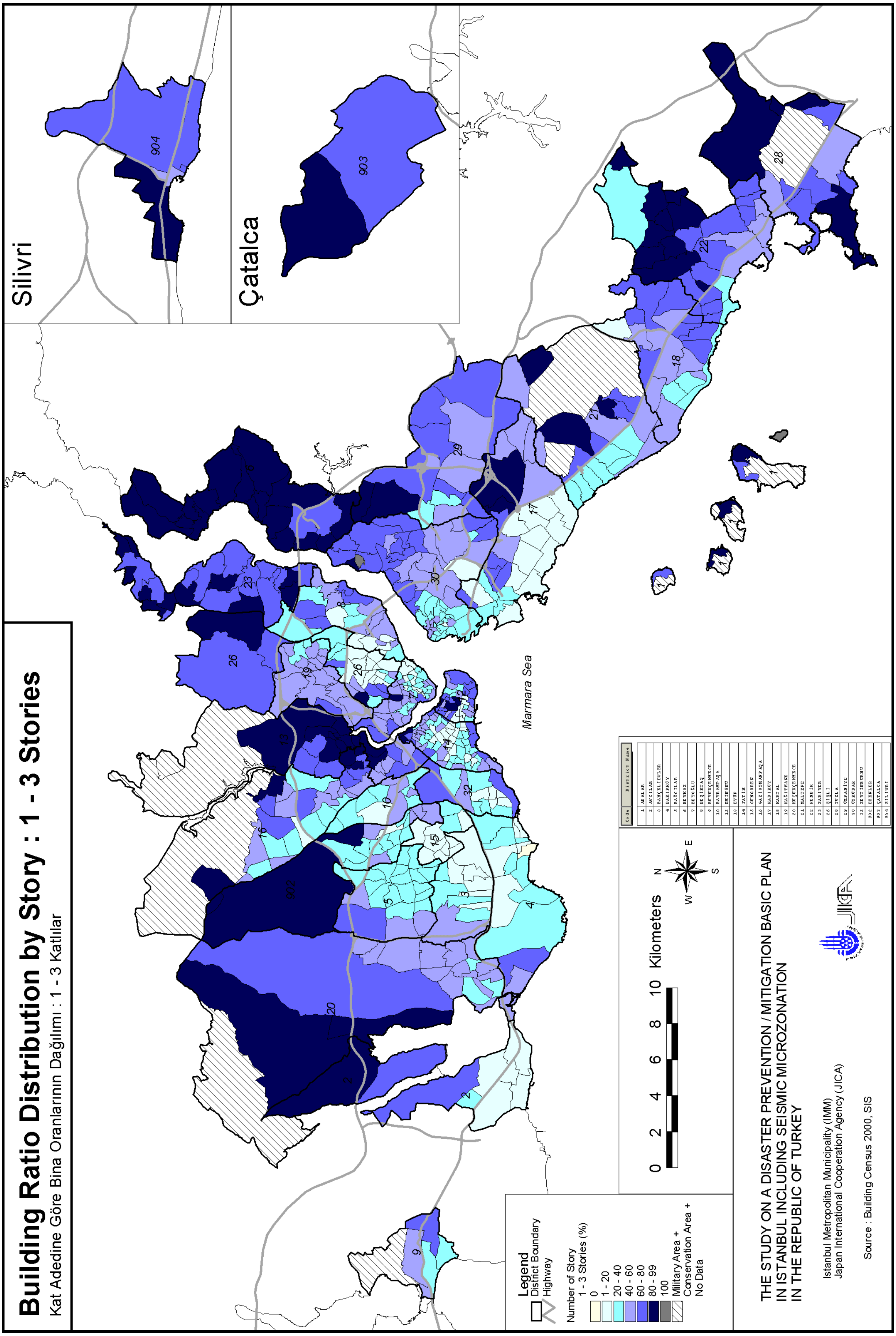


Figure 6.2.13 Building Distribution by Number of Stories (1-3 Stories)

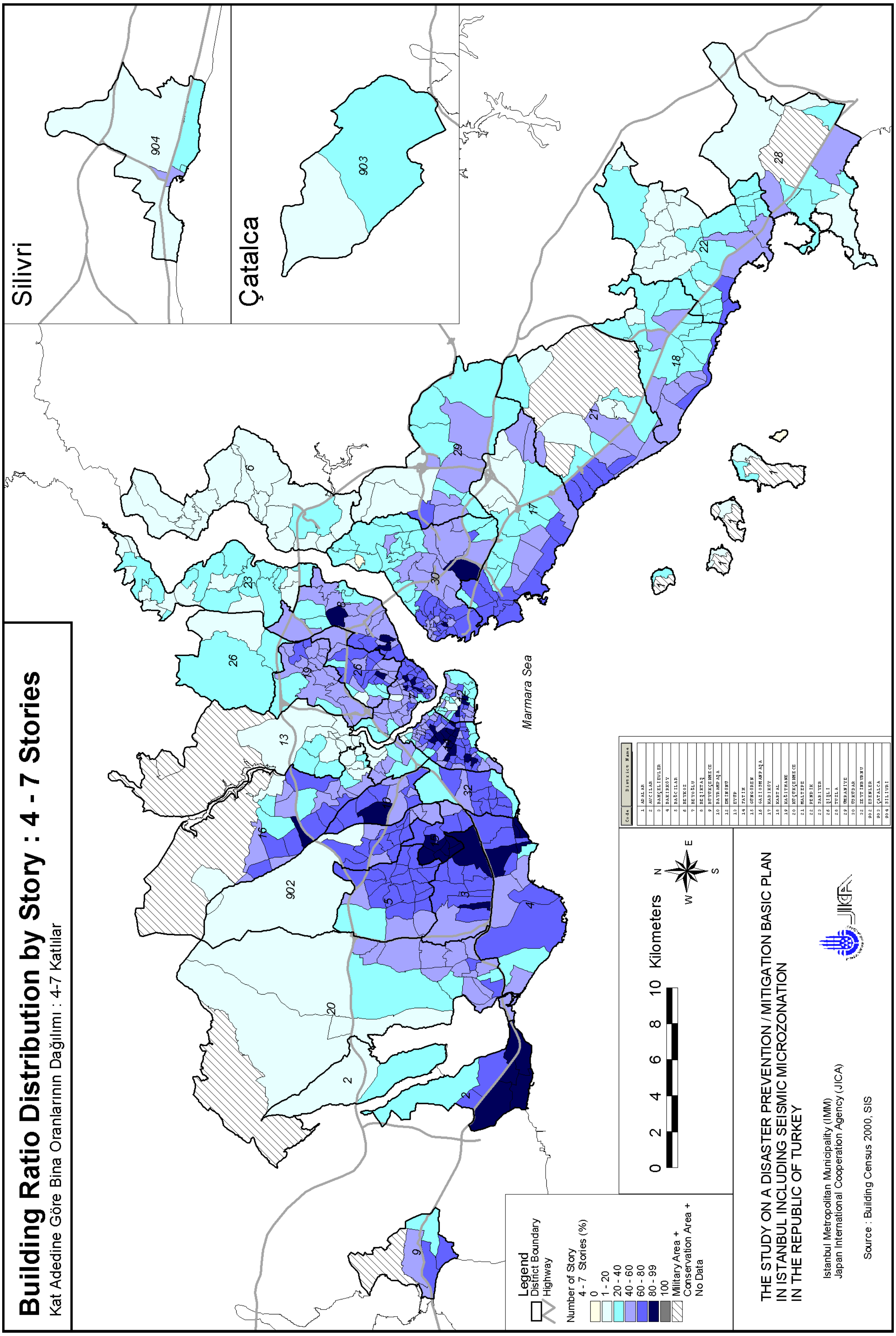


Figure 6.2.14 Building Distribution by Number of Stories (4-7 Stories)

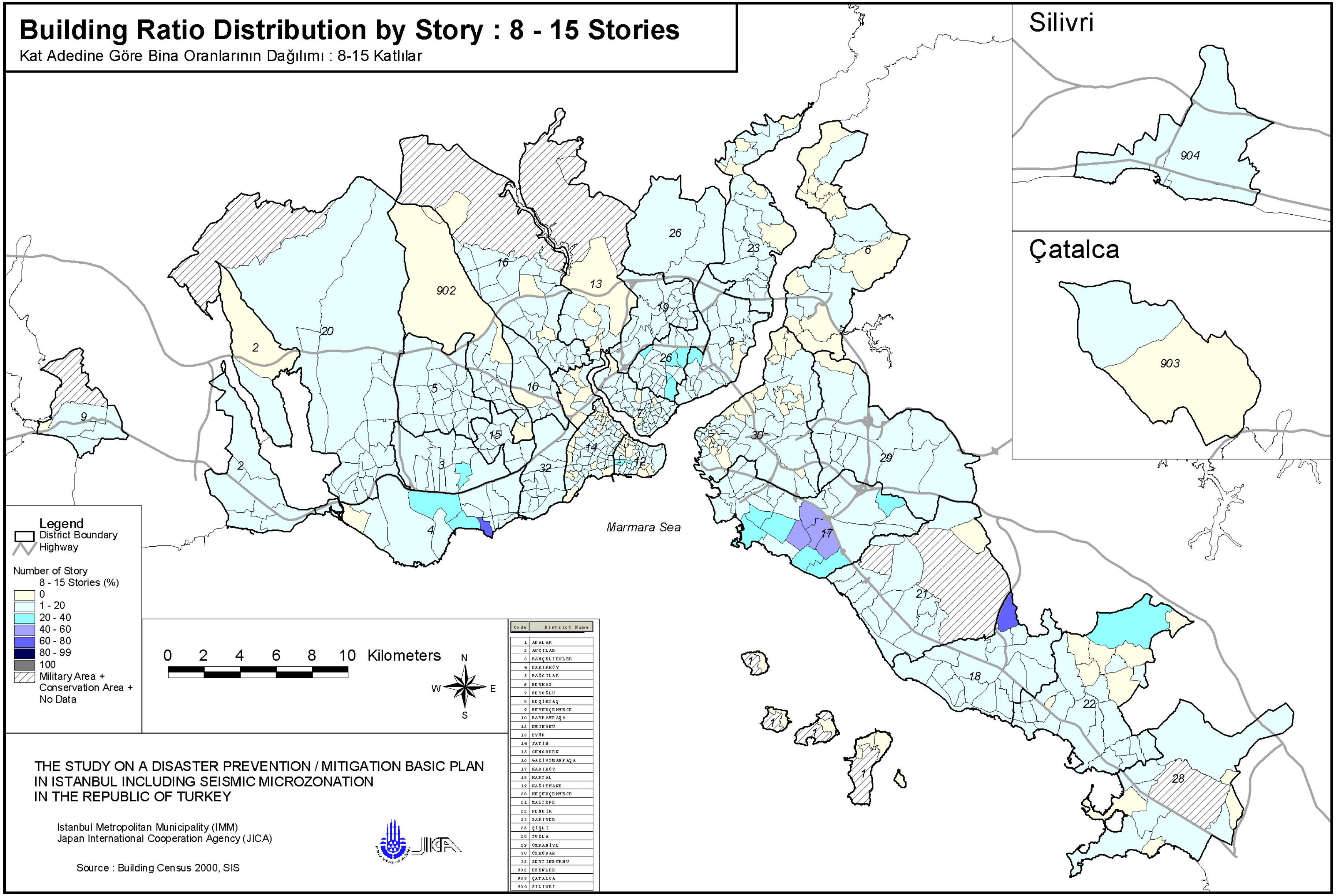


Figure 6.2.15 Building Distribution by Number of Stories (8-15 Stories)

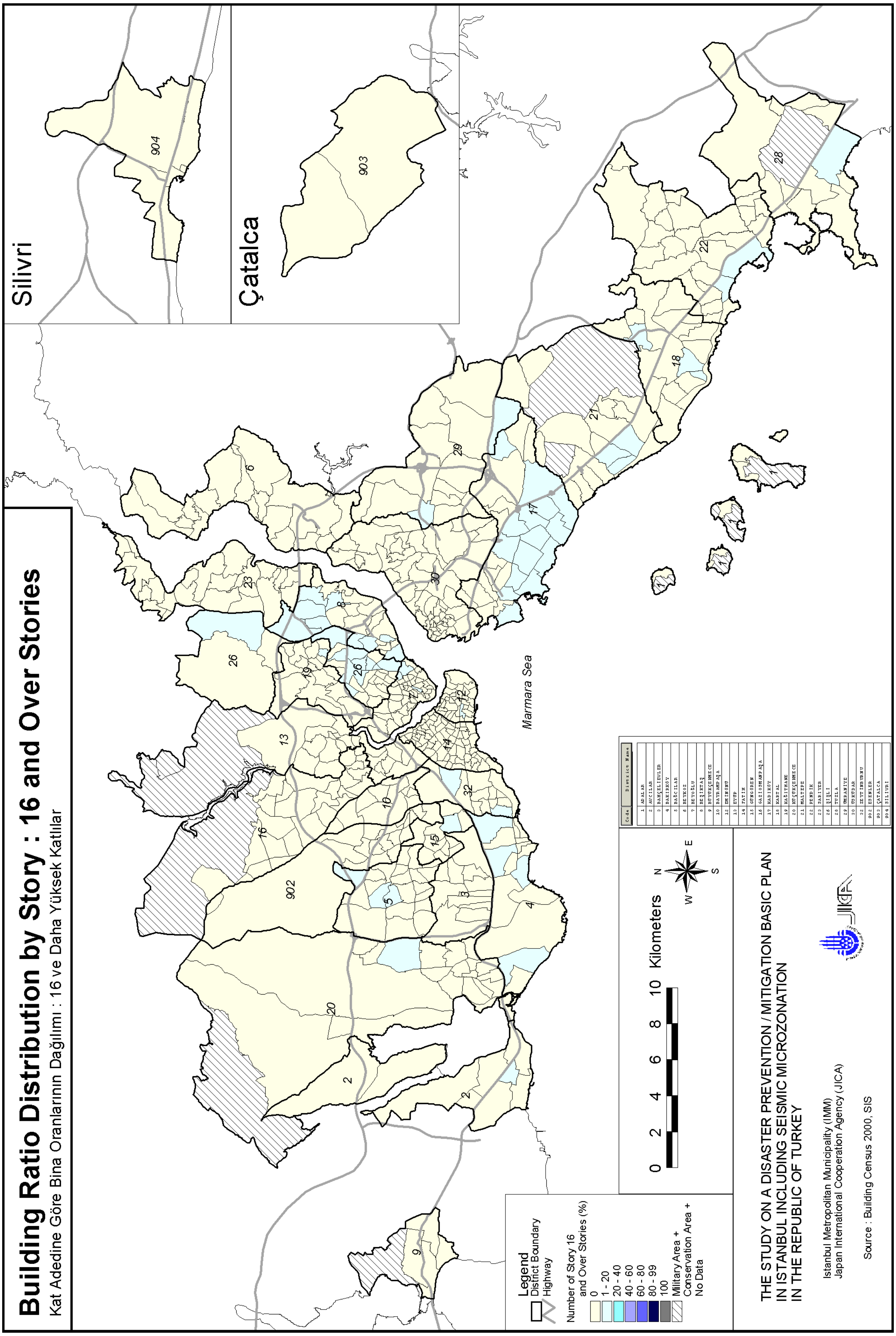


Figure 6.2.16 Building Distribution by Number of Stories (16 Stories and Over)

6.2.3. Road Data

The road network in Istanbul is the most important infrastructure for transportation, which maintains the urban life of the city. The road network also functions as a lifeline and communication system, since lifelines and communication facilities are located underneath roads. Therefore, there are two aspects to consider when it comes to the effects of an earthquake disaster on the road network. One aspect includes the damages on each individual structure, and the other aspect includes the dysfunction of the entire network system due to damage to individual structures. Furthermore, the road network plays an important role in activities of evacuation, fire fighting operation, and medical service, as well as in the transportation of relief supplies and rehabilitation activities.

From this point of view, it is essential to fully grasp the current status and function of the road network in order to carry out earthquake disaster prevention and reconstruction plans. It is also important to attempt to assess potential damages to the road network by an earthquake.

(1) Collected Data

Road data in the Study Area were collected from topographical maps of scale 1/5,000. The collected and compiled data cover a range of wide principal roads to narrow streets. Narrow streets could cause significant difficulties if they are blocked by collapsed buildings. Furthermore, principal wide roads are important not only as potential evacuation routes, but also as routes for the transportation of relief goods and routes used in rehabilitation activities.

(2) Current State of the Road Network in the Study Area

a. Analysis of Road Length and Road Density

Data was collected for approximately 13,700 km of road. Widths of roads are valid in accordance to their characterisitics, such as traffic capacity and area connectivity.

In this study, roads were classified into following three categories:

1) Roads having a width of more than 16 m and functioning as principal roads for an extended area (

2) Figure 6.2.17)

3) Roads having a width of 7-15 m and functioning as a secondary road of the principal network (

4) Figure 6.2.18)

5) Roads having a width of 2-6 m and functioning as a city street (

6) Figure 6.2.19).

Table 6.2.7 shows a summary of road length by width for each district. Table 6.2.8 shows road density per unit area (ha) and road density per person for the three categories of roads in each district.

- The ratio of narrow streets (2-6 m) to total length exceeds the other two categories. The ratio to total length is 64.7 %, the ratio to area is 89.5 m/ha, and the ratio to persons is 1.00 m/person, on average.
- Roads with width of 7-15 m show ratios of 29.9 %, 41.4 m/ha and 0.46 m/person, respectively.
- Roads with widths of more than 16 m show 3.5 %, 4.9 m/ha and 0.05m/person, respectively.

Thus, in the Study Area, the density of narrow streets is extremely high and this narrow road network makes up the transportation system that is very important in the daily lives of citizens. Also, these narrow roads are those to which attention must be given with regards to earthquake disaster prevention, since these narrow streets are the most vulnerable to potential blocking due to building collapses.

Moreover, the density of roads directly correlates to land usage of the area.

Figure 6.2.21 shows the density of roads (m/ha) for each district. It shows that the density is rather high in residential areas and, also, that narrow streets are dense in these areas.

b. Road Network in Study Area

In the Study Area, two highways running from east to west form the principal road axis. Highways running from north to south also form a principal road axis, and these connect the two east-west highways. Therefore, the road network system connecting an extended area is almost completed. Both sides of the Straits of Bosphorus are connected by two east-west highways, which play a major role in east-west transportation of people and goods.

Principal roads more than 16m wide, except highways, extend in east-west and north-south directions. These roads function as connector roads to the highways and the principal roads of adjacent areas.

Roads 7-5 m wide are distributed in and around residential areas. These roads function as connector roads to the principal roads. They also work serve as sub-principal roads to the principal roads in their region that do not function as wide area network roads.

Streets 2-6 m wide do not function as principal roads.

Table 6.2.7 Summary of Road Length by Width for Each District

District		Road Length by Width					Road Length Ratio		
		w < 6	7< w < 15	16 < w	N/A	Total	w < 6	6 < w < 15	16 < w
Code	Name	(m)	(m)	(m)	(m)	(m)	(%)	(%)	(%)
1	ADALAR	99,022	23,778	147	0	122,947	80.5	19.3	0.1
2	AVCILAR	269,529	116,037	25,517	20,702	431,785	62.4	26.9	5.9
3	BAHÇELİEVLER	185,643	165,880	16,811	4,430	372,762	49.8	44.5	4.5
4	BAKIRKÖY	168,905	140,382	30,135	10,127	349,549	48.3	40.2	8.6
5	BAĞCILAR	344,580	190,211	11,025	15,830	561,646	61.4	33.9	2.0
6	BEYKOZ	429,220	99,796	6,973	19,675	555,665	77.2	18.0	1.3
7	BEYOĞLU	178,216	47,568	14,339	963	241,087	73.9	19.7	5.9
8	BEŞİKTAŞ	165,920	134,243	15,919	10,336	326,418	50.8	41.1	4.9
9	BÜYÜKÇEKMECE	71,499	45,020	6,361	9,987	132,868	53.8	33.9	4.8
10	BAYRAMPAŞA	119,838	84,005	18,479	12,973	235,296	50.9	35.7	7.9
12	EMİNÖNÜ	71,743	29,207	11,087	5,662	117,699	61.0	24.8	9.4
13	EYÜP	322,735	129,096	20,783	15,748	488,362	66.1	26.4	4.3
14	FATİH	196,096	57,976	13,718	285	268,076	73.1	21.6	5.1
15	GÜNGÖREN	66,512	112,883	5,377	1,143	185,916	35.8	60.7	2.9
16	GAZİOSMANPAŞA	609,456	213,975	27,748	10,381	861,559	70.7	24.8	3.2
17	KADIKÖY	394,559	298,476	30,496	9,517	733,047	53.8	40.7	4.2
18	KARTAL	323,302	255,500	21,912	11,784	612,499	52.8	41.7	3.6
19	KAĞITHANE	216,051	112,712	12,880	2,394	344,036	62.8	32.8	3.7
20	KÜÇÜKÇEKMECE	863,115	354,648	25,025	13,436	1,256,224	68.7	28.2	2.0
21	MALTEPE	464,426	252,413	18,276	5,305	740,421	62.7	34.1	2.5
22	PENDİK	561,643	155,510	14,981	8,876	741,010	75.8	21.0	2.0
23	SARIYER	388,241	92,382	7,991	7,912	496,527	78.2	18.6	1.6
26	ŞİŞLİ	301,116	134,316	24,049	15,081	474,562	63.5	28.3	5.1
28	TUZLA	383,206	141,423	18,657	14,874	558,160	68.7	25.3	3.3
29	ÜMRANİYE	659,072	291,135	27,831	4,374	982,412	67.1	29.6	2.8
30	ÜSKÜDAR	498,332	221,470	27,608	9,423	756,833	65.8	29.3	3.6
32	ZEYTİNBURNU	112,752	98,426	15,591	8,507	235,275	47.9	41.8	6.6
902	ESENLER	395,479	99,421	13,214	8,951	517,065	76.5	19.2	2.6
903	ÇATALCA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
904	SİLİVRİ	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Total	**8,860,208**	**4,097,889**	**482,930**	**248,689**	**13,699,706**	-	-	-
	Average	-	-	-	-	-	**64.7**	**29.9**	**3.5**

Source: Compiled by the JICA Study Team

Table 6.2.8 Summary of Road Density for Each District

District		Area	Road Density (m/ha)				Population	Road Density (m/person)			
			Road Width (m)			Total		Road Width (m)			Total
			< 6	7 - 15	16 <			< 6	7 - 15	16 <	
Code	Name	(ha)	(m/ha)	(m/ha)	(m/ha)	(m/ha)	(persons)	(m/person)	(m/person)	(m/person)	(m/person)
1	ADALAR	1,100	90.1	21.6	0.1	111.8	17,738	5.58	1.34	0.01	6.93
2	AVCILAR	3,861	69.8	30.1	6.6	111.8	231,799	1.16	0.50	0.11	1.86
3	BAHÇELİEVLER	1,661	111.8	99.9	10.1	224.4	469,844	0.40	0.35	0.04	0.79
4	BAKIRKÖY	2,951	57.2	47.6	10.2	118.5	206,459	0.82	0.68	0.15	1.69
5	BAĞCILAR	2,194	157.1	86.7	5.0	256.0	557,588	0.62	0.34	0.02	1.01
6	BEYKOZ	4,156	103.3	24.0	1.7	133.7	182,864	2.35	0.55	0.04	3.04
7	BEYOĞLU	889	200.4	53.5	16.1	271.1	234,964	0.76	0.20	0.06	1.03
8	BEŞİKTAŞ	1,811	91.6	74.1	8.8	180.3	182,658	0.91	0.73	0.09	1.79
9	BÜYÜKÇEKMECE	1,474	48.5	30.5	4.3	90.1	34,737	2.06	1.30	0.18	3.82
10	BAYRAMPAŞA	958	125.0	87.7	19.3	245.5	237,874	0.50	0.35	0.08	0.99
12	EMİNÖNÜ	508	141.2	57.5	21.8	231.7	54,518	1.32	0.54	0.20	2.16
13	EYÜP	5,050	63.9	25.6	4.1	96.7	232,104	1.39	0.56	0.09	2.10
14	FATİH	1,045	187.6	55.5	13.1	256.4	394,042	0.50	0.15	0.03	0.68
15	GÜNGÖREN	718	92.6	157.1	7.5	258.8	271,874	0.24	0.42	0.02	0.68
16	GAZİOSMANPAŞA	5,676	107.4	37.7	4.9	151.8	667,809	0.91	0.32	0.04	1.29
17	KADIKÖY	4,128	95.6	72.3	7.4	177.6	660,619	0.60	0.45	0.05	1.11
18	KARTAL	3,135	103.1	81.5	7.0	195.4	332,090	0.97	0.77	0.07	1.84
19	KAĞITHANE	1,443	149.7	78.1	8.9	238.5	342,477	0.63	0.33	0.04	1.00
20	KÜÇÜKÇEKMECE	12,173	70.9	29.1	2.1	103.2	589,139	1.47	0.60	0.04	2.13
21	MALTEPE	5,530	84.0	45.6	3.3	133.9	345,662	1.34	0.73	0.05	2.14
22	PENDİK	4,731	118.7	32.9	3.2	156.6	372,553	1.51	0.42	0.04	1.99
23	SARIYER	2,774	140.0	33.3	2.9	179.0	212,996	1.82	0.43	0.04	2.33
26	ŞİŞLİ	3,543	85.0	37.9	6.8	133.9	271,003	1.11	0.50	0.09	1.75
28	TUZLA	4,998	76.7	28.3	3.7	111.7	100,609	3.81	1.41	0.19	5.55
29	ÜMRANİYE	4,561	144.5	63.8	6.1	215.4	443,358	1.49	0.66	0.06	2.22
30	ÜSKÜDAR	3,783	131.7	58.5	7.3	200.1	496,402	1.00	0.45	0.06	1.52
32	ZEYTİNBURNU	1,149	98.1	85.7	13.6	204.8	239,927	0.47	0.41	0.06	0.98
902	ESENLER	3,890	101.7	25.6	3.4	132.9	388,003	1.02	0.26	0.03	1.33
903	ÇATALCA	5,263	N/A	N/A	N/A	N/A	15,624	N/A	N/A	N/A	N/A
904	SİLİVRİ	3,828	N/A	N/A	N/A	N/A	44,432	N/A	N/A	N/A	N/A
	Total	**98,981**	**-**	**-**	**-**	**-**	**8,831,766**	**-**	**-**	**-**	**-**
	Average	**-**	**89.5**	**41.4**	**4.9**	**138.4**	**-**	**1.00**	**0.46**	**0.05**	**1.55**

Source: Compiled by the JICA Study Team

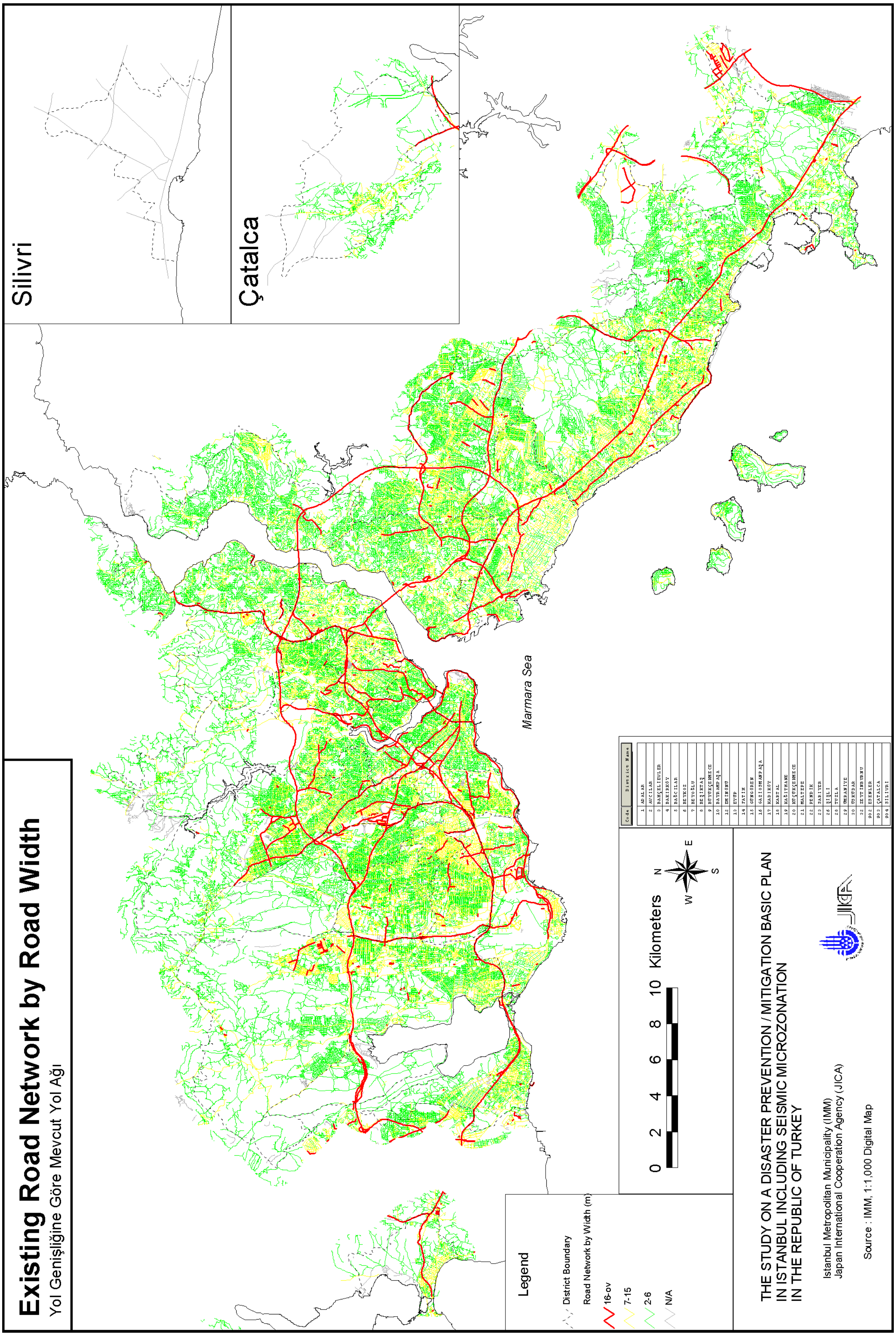


Figure 6.2.17 Existing Road Network by Road Width

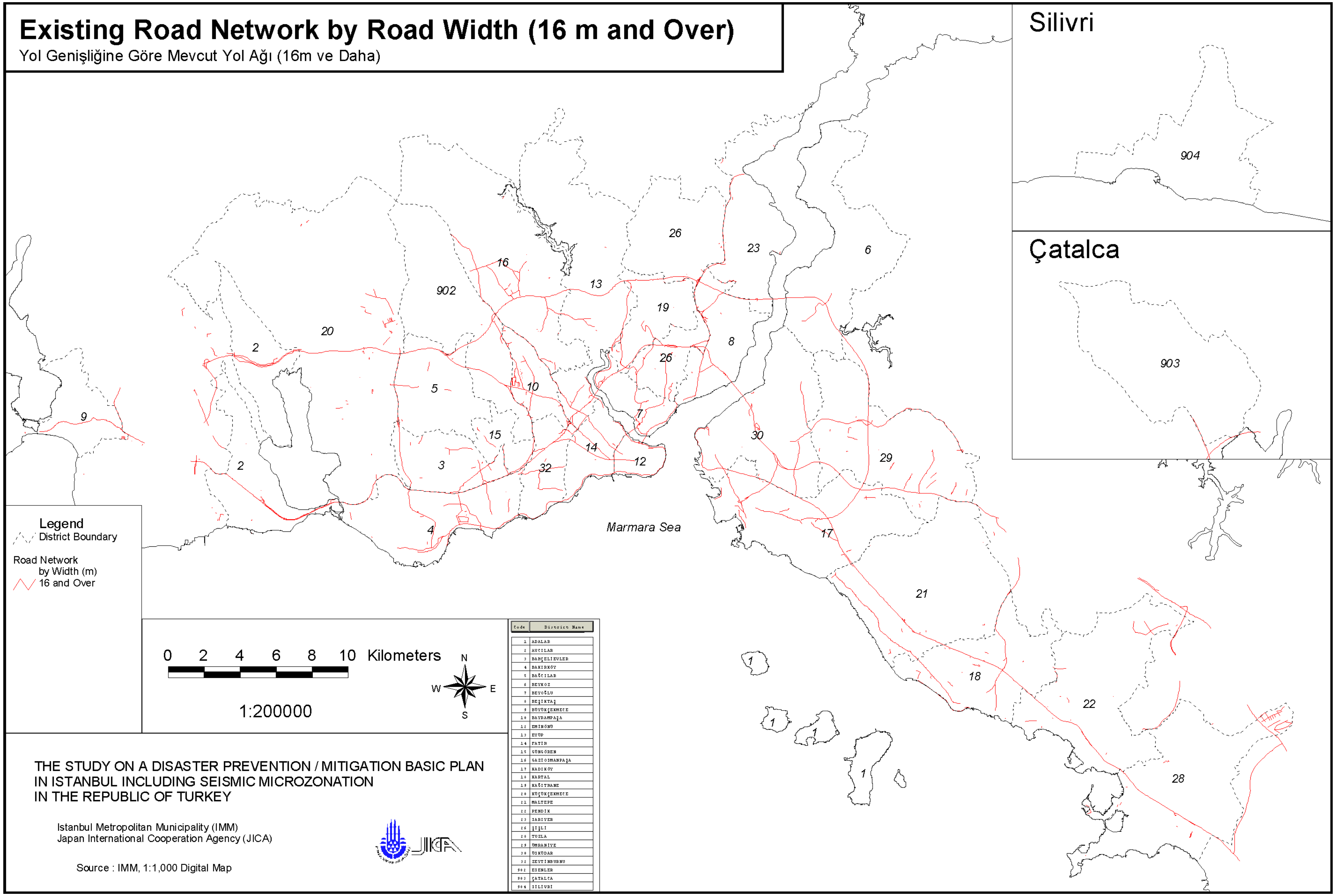


Figure 6.2.18 Existing Road Network by Road Width (16 m and Over)

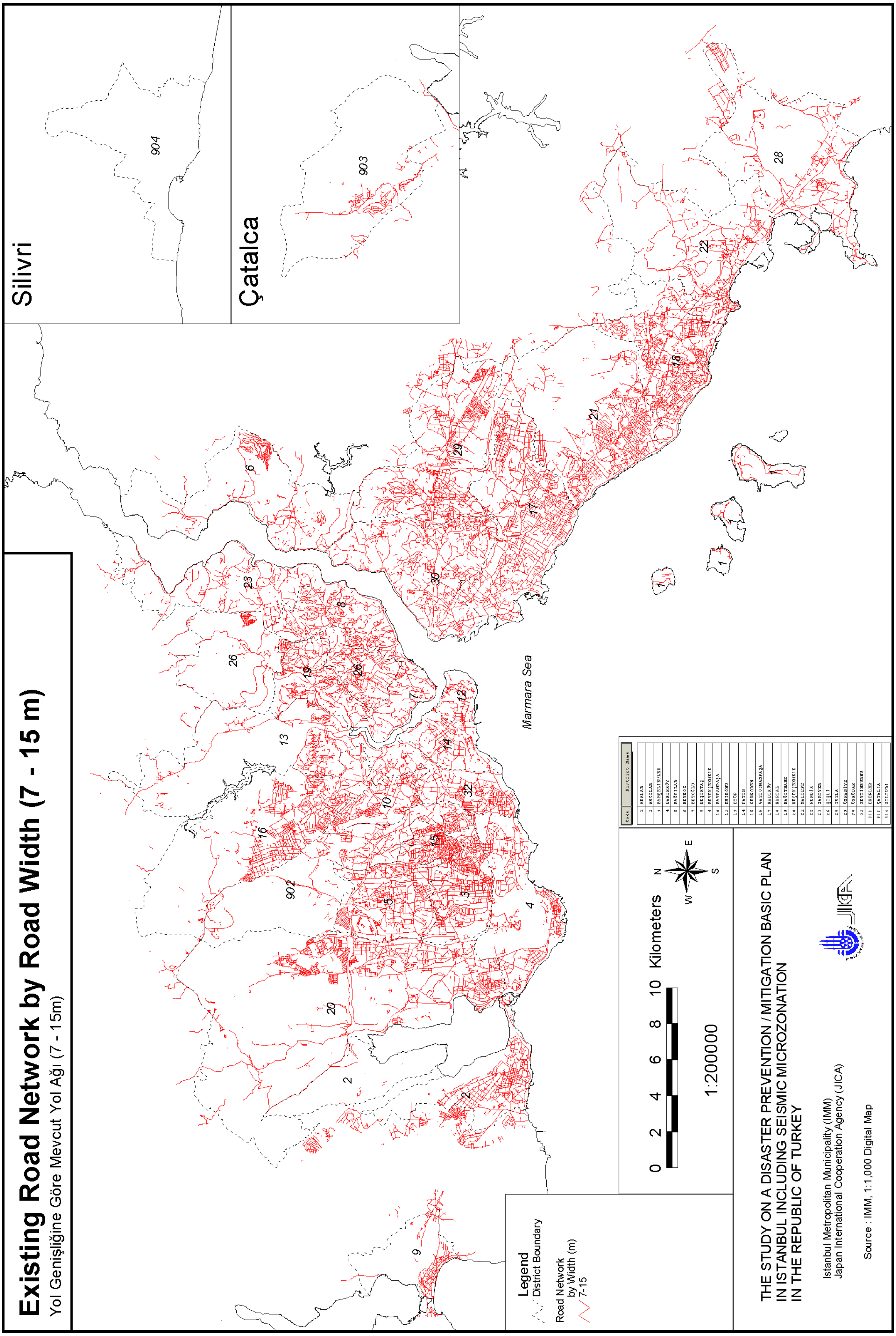


Figure 6.2.19 Existing Road Network by Road Width (7-15 m)

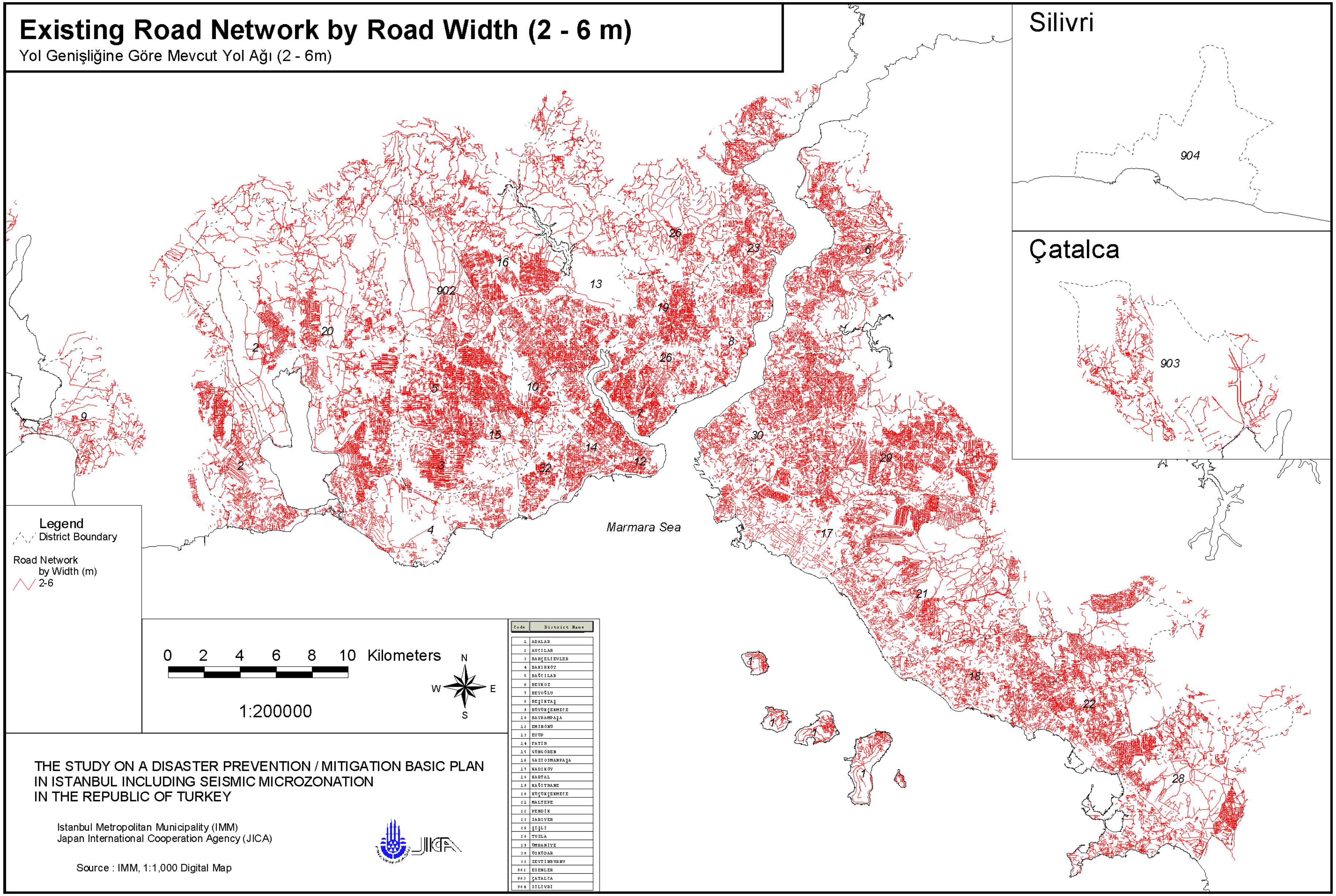


Figure 6.2.20 Existing Road Network by Road Width (2-6 m)

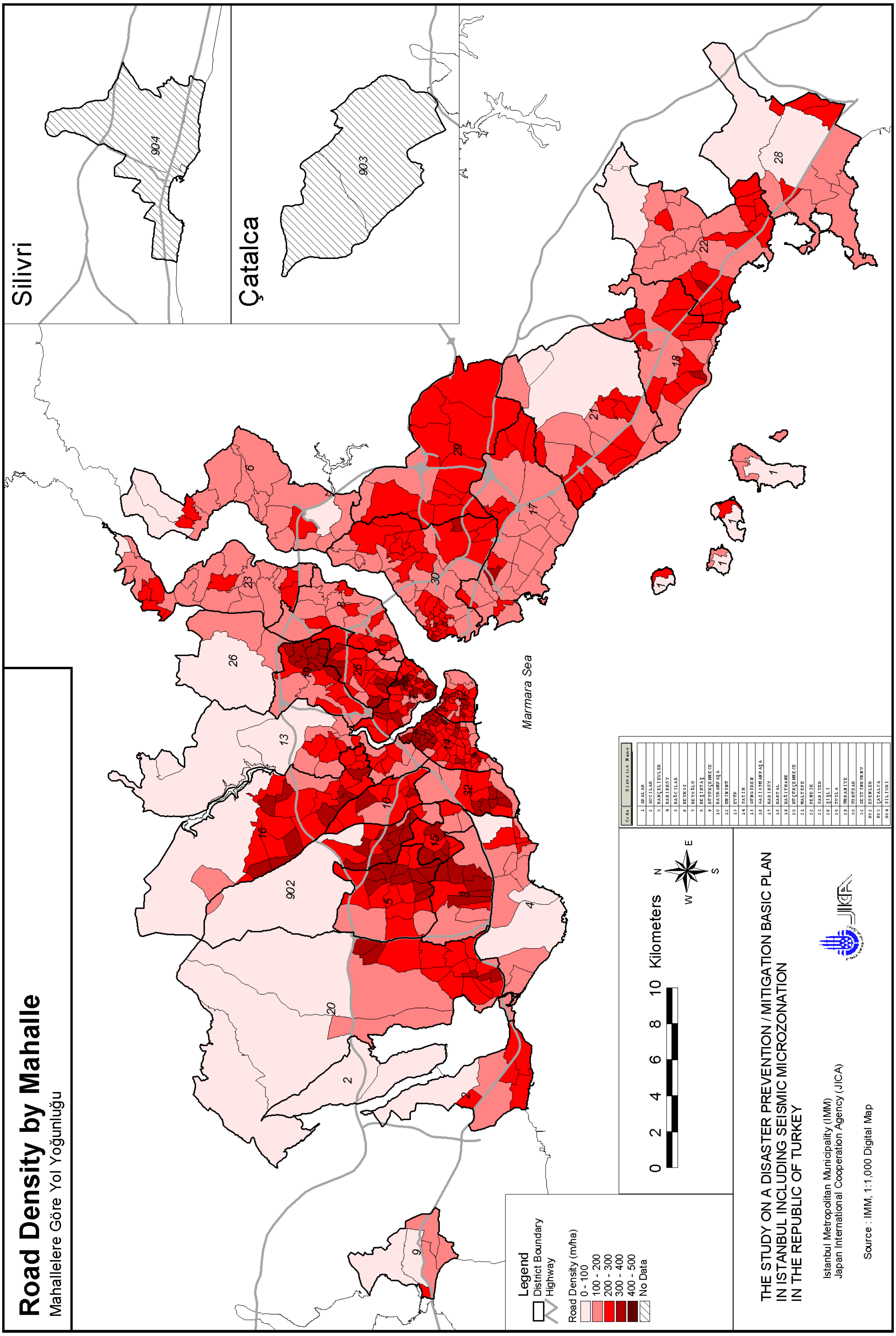


Figure 6.2.21 Road Density by District

6.2.4. Bridge Data

(1) General

The collapse of a bridge at the time of an earthquake stops the flow of all vehicles, including emergency vehicles such as ambulances, fire engines, etc. In the Study, data on all bridges in Istanbul was collected to analyze their vulnerability.

For the Study, it was necessary to obtain information on bridges including their location, construction year, girder type, bearing type, height of abutment, structure, etc. Table 6.2.9 is created from original data received from the 17th Regional Highway, Ministry of Transportation and Communication. Using the Ministry's original data as a basis, the Study Team modified the data to fit the format designed for the Study.

(2) Relevant Organisation for Bridges

The following are relevant organisations in charge of designing, constructing, and maintaining bridges.

1) Highway Bridges

- 17th Regional Highway - E80 (from Edirne to Ümraniye), E5 (all routes in Istanbul)
- 1st Regional Highway – E80 (from Ümraniye to Tuzla)

2) Road Bridges

- IMM Construction Works Department (bridges constructed after 1994)
- IMM Infrastructure Coordination Department (bridges constructed after 1994)
- IMM Road Maintenance Department (bridges other than those mentioned above)
- IMM Transportation Department (location of each bridge)

3) Railway Bridges

- TCDD National Railway (all railway bridges)

4) Metro Bridges

- IMM Directorate of Technical Works

(3) Data Set-up

Some of these relevant organisations have limited information on their respective bridges; therefore, it was necessary to consider a way to create data required for the Study. Basic data was supplied by the relevant organisations, and the Study Team conducted its own inventory out in the field to supplement the data these organisations supplied.

Table 6.2.9 shows the list of bridges received from relevant organisations and the inventory taken by the Study Team.

Figure 6.2.22 shows the location of all bridges with data attributes.

Table 6.2.9 List of Bridges

Organisation	Girder Type						Type of Bearing			Max. Height of Abut./Pier			Material of Abut./Pier			Foundation Type	
	1 Span		2 or More Spans														
	Arch/Rigid Frame	Simple	Simple	Continuous	More than 1 Continuous	Combination Of Continuous & Simple	Fall Prevention Device	Normal	M M	less than 5 m	5 to 10 m	more than 10m	Reinforced Concrete	Steel/Tentative	Masonry	Pile	Spread
17th Reg.Hwy.	0	12	202	120	2	0	0	0	336	1	269	66	336	0	0	76	260
	336						336			336			336			336	
1th Reg.Hwy.	0	0	8	38	1	2	0	0	49	0	0	49	49	0	0	1	48
	49						49			49			49			49	
IBB-construction Dept.	0	5	7	3	0	0	0	0	15	0	14	1	13	0	2	-	-
	15						15			15			15			-	
IBB-Infra. Coord.Dept.	1	17	11	1	0	0	0	0	29	18	11	1	28	2	0	22	8
	30						29			30			30			30	
IBB Maintenance Dept.	13	41	20	44	10	5	0	0	120	105	26	2	133	0	0	—	—
	133						120			133			133			—	
IBB Metro	0	12	3	0	0	5	0	0	20	8	12	0	20	0	0	6	14
	20						20			20			20			20	
TCDD Railway – Asian side	13	20	5	1	0	0	0	16	10	13	26	0	31	1	7	—	—
	39						26			39			39			—	
TCDD Railway - European side	2	18	17	0	0	0	0	26	9	15	22	0	37	0	0	-	-
	37						35			37			37			—	

Note: Compiled by the JICA Study Team

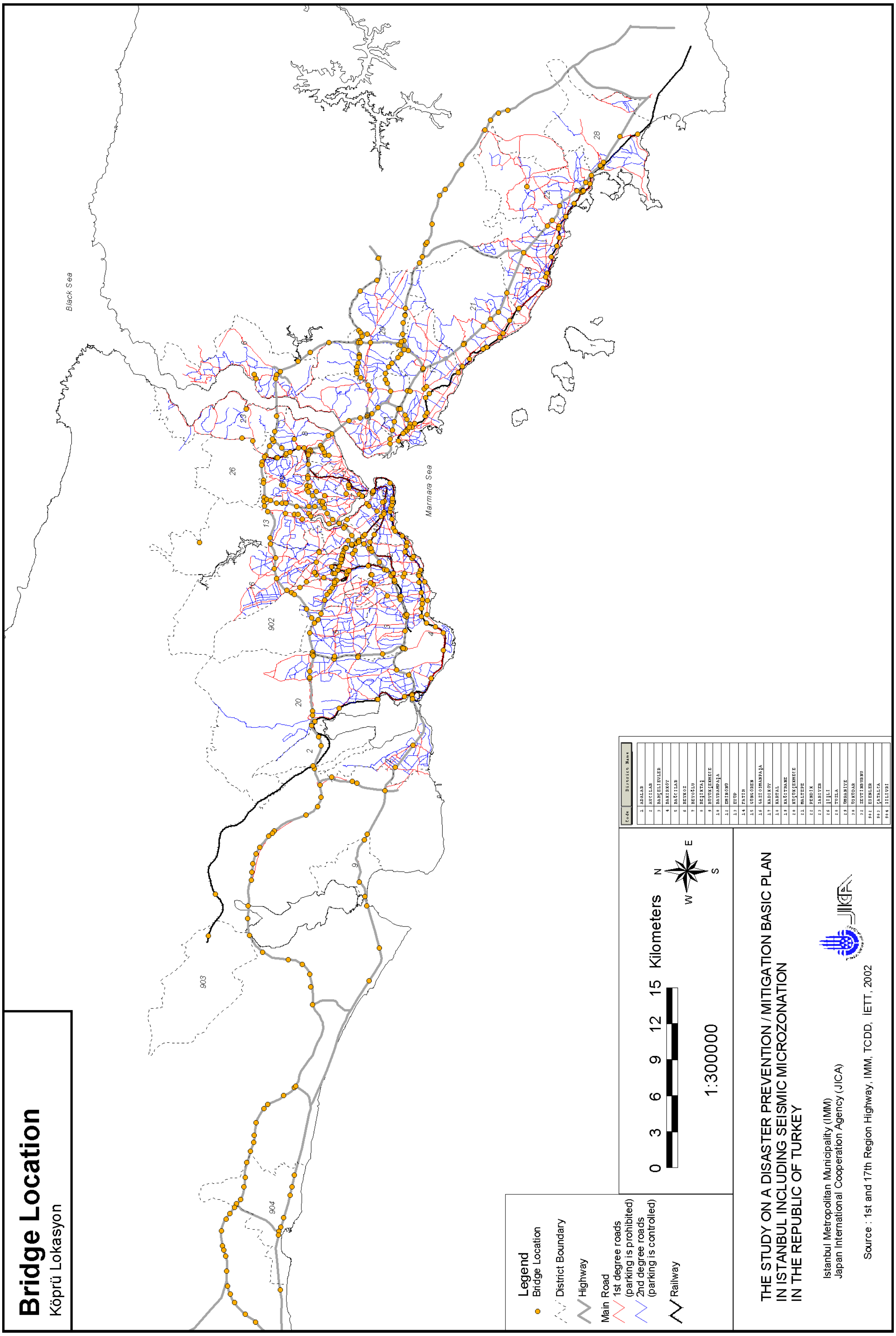


Figure 6.2.22 Bridge Locations

(4) Structural Feature of Bridges by Transportation Type

a. Motorway Bridges

Structure Type

Many overpass bridges have a simple support structure. Bridges with more than 2 spans are also simply supported as shown in Photo 1. Precast, prestressed concrete girders are mainly used and neoprene bearings are used as shown in Photo 2. Continuous bridges are also built on neoprene bearings. These bearings do not seem to be fixed to the superstructure and substructure. Continuous bridges are used as viaducts as shown in Photo 3. Many continuous bridges are cast-in-place, since the practice of connecting precast girders is notstandard in Turkey. Neoprene bearings are also used for continuous bridges.

Superstructure

Many motorway bridges are concrete bridges. Since steel bridges are so expensive, they are mainly used for curb alignment, in locations where the space for the substructure is restricted, or for cases in which quick construction is required.

Substructure

RC piers (wall type) are mainly employed as the intermediate pier of a simply supported 2-span overpass bridge. Some bridges have RC ramen type piers. Almost all bridges have reversed T-type abutments, and pier abutments are rarely used.

Foundation

The JICA study team asked relevant departments to the foundation type of their respective bridges. The Study Team confirmed the foundations of bridges of the 1st and 17th Regional Highway. Spread foundations existed in 77% of the 17th Regional Highway bridges (226 out of 336), and 98% of the 1st Regional Highway bridges (49 out of 50).Pile foundations accounted for the rest.

Unseating Prevention Structure

Unseating prevention structures were not found in almost all bridges covered in the field survey, and seat width, in most cases, was about 50cm.

b. TCDD Railway Bridges

Structure Type

Many bridges are simple span structures with two abutments or simply supported structures with 2 spans as shown in Photo 4. Steel rollers are the common bearing type. Both side abutments, but not the intermediate piers, bear lateral forces. No viaducts were observed on the European side. However, a multi-span, simply supported, gerber girder viaduct was found on the Anatolian side as shown in Photo 5. Several arched overpass bridges (stone masonry) can also be seen on the Anatolian side (Photo 6).

Superstructure

Similar to railway bridges, many TCDD bridges adopt a steel structure. Many I-beam and some truss bridges can be seen. Bridges with a span greater than 20 m tend to use truss girders. Other bridges with a span of less than 10 m have box culverts.

Substructure

Simple span bridges have a reversed T-type abutment, like motorway bridges. According to the collected data from TCDD, bridges on the Anatolian side are relatively old (constructed in 1912). Some bridges are masonry as shown in Photo 2.4.8. Many intermediate piers of 2 span, simply supported bridges adopt wall type piers. Some of these piers have RC rigid frame structures.

Foundation

According to TCDD technical information, spread foundations are used for bridges on the Anatolian side. Actually, some arch bridges, which usually have solid ground foundations, can be seen in this area.

Unseating Prevention Structure

Unseating prevention structures were not found in the Study Team's field observation. Seat widths were generally wider than that of motorway bridges. Seat widths were estimated as more than 70 cm.

c. IMM Metro Bridges

Structure Type

There are some viaducts whose length are more than several hundred meters as shown in Photo 9. The total length of these viaducts account for a considerable rate of gross railway bridge length. Viaduct structures are multi-span and simply supported, and their bearing material is neoprene. Other bridges are mainly simple beam bridges with a span of less than 20 m that pass over a road or cross a river.

Superstructure

Compared with the TCDD bridges, IMM Metro bridges are relatively new. These bridges were constructed circa 1990. Hence, relatively new techniques, such as the use of PC, precast and prestressed girders, were adopted. Steel girders are used for bridges with a long span or skewed angle, instances in which precast prestressed girders cannot be adopted.

Substructure

Metro bridges commonly have viaducts of RC rigid frames (ramen) with two pillars. Wall type piers are employed for skewed bridges as shown in Photo 2.4-10.

Foundation

Pile foundations are adopted for viaducts of several hundred-meter lengths.

Unseating Prevention Structure

Unseating prevention structures were not observed in the field observation. Seat widths were almost equal to that of motorway bridges, and seat widths were observed as about 50 cm.

(5) Structural Character by Route and Area

a. TEM

Anatolian Side

No viaducts were observed on the Anatolian side. Many PC overpass bridges were observed, but few subterranean bridges with substructures of two abutments were seen.

Standard overpass bridges are shown in Photo 11. Girders are precast, prestressed, and box beam as shown in Figure 6.2.23. Their structure type is 2 spans and simply supported. Since these bridges were constructed from 1990 to 1991, these bridges are relatively new. Judging from these bridges' proportions, this type of bridge seems to be constructed properly and strongly. Seat width of wall type pier is 50 cm. This value is relatively small compared to the value that is regulated by specifications for highway bridges.

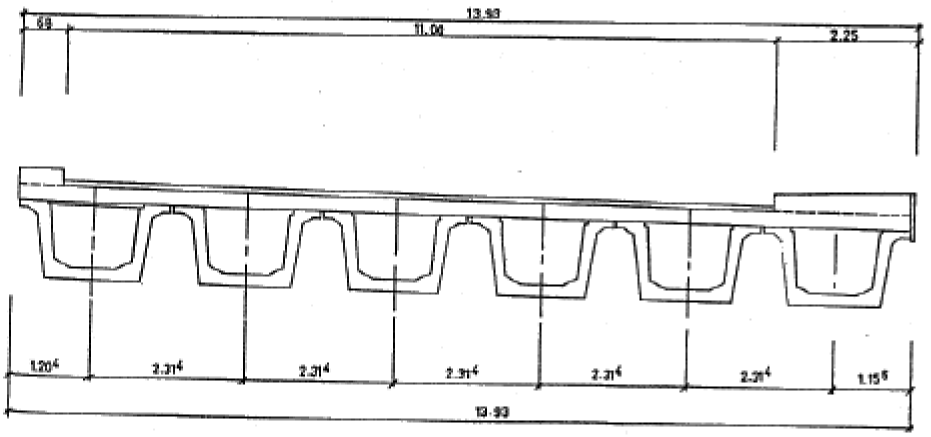


Figure 6.2.23 Typical Cross-section of Precast, Prestressed, Simple Box Beam

European Side

Overpass bridges on the European side have a similar structure type as those on the Anatolian side. The skew angle of bridges is shown in Photo 2.4-11. Superstructures are precast, prestressed, simple box beam, and the seat width does not seem to be expanded on account of skew angles.

Many viaducts were observed in this area. The bridge in Photo 2.4-12 is a multi-span, simply supported bridge and its bearing material is neoprene. The protrusions from the top of the substructure are a feature of this bridge whose purpose could not be confirmed. It is assumed that these projections are to prevent the collision of girders against each other during an earthquake. their bearing material is neoprene, and the bearing footings do not seem to be fixed to the superstructure or substructure.

b. E5

Anatolian Side

the number of bridge on the Anatolian side is much less than that of TEM. Bridges that do exist are mainly 2 span, simply supported bridges.

European Side

Many precast, prestressed, concrete girder structures can be found in TEM. In E5, many bridges have a superstructure that is characterised by post-tensioned continuous plate girders(Figure 6.2.24).

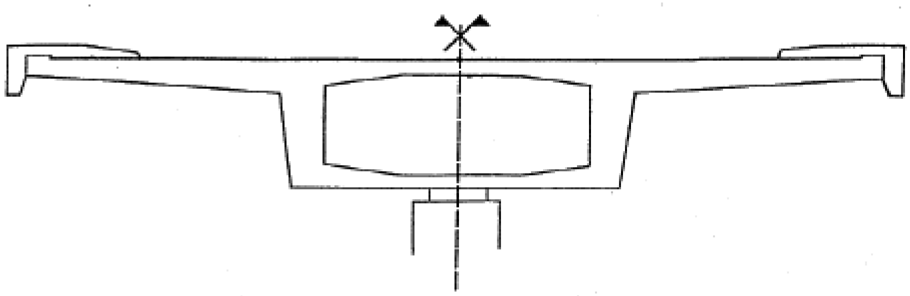


Figure 6.2.24 Post-tensioned Continuous Plate Girder

c. Old City

Photo 13 shows an example of a prestressed, concrete rigid frame. The superstructure is made up of post-tensioned, continuous plate girders. Overhang slabs are supported by abutments, and pier heights are irregular due to vertical liners. Therefore, there is a potential for the concentration of lateral forces in short columns in the event of an earthquake.

Photo 14 shows a steel bridge that is multi-span and simply supported. A large device is installed on the superstructure and substructure. This device seems to be the unseating prevention structure. In spite of curb alignment, a simple support is adopted. It might be installed in order to stabilise the superstructure. As the result of a detailed observation, the quality of bridge manufacturing, especially the quality of the welding, was observed as not high, since it is a relatively old bridge.

d. Bridges with High Pier

Photo 15 shows the approaching bridge to the first Bosphorus bridge. It is a multi-span, simply supported, prestressed concrete bridge. The size of the substructure seems to be rather thin against the heavy concrete superstructure.

Photo 16 shows a bridge overpassing Golden Horn Bay. It is multi-span continuous bridge. Its superstructure consists of steel box girders and its bearing plate is metal. Statically indeterminate forces are small due to its high pier, so it could have multi-point fixed support.

e. Steel Bridges

Photo 17 shows a continuous, steel girder bridge with curb alignment. Each box girder is equipped with two (2) bearing plates and the substructure is RC. This substructure is very thin, and an even lighter steel serves as the superstructure.

The substructure of the bridge in Photo 18 is a steel pier. To improve stability of superstructure, the bridge seat is widened.

The bridge in Photo 19 has a very wide superstructure in the transverse direction, and this bridge length (861 m) is the longest in the Study Area. Space between the right and left pier is also wide, so that a road could pass under the bridge. The bridge's two girders are connected by cross beams. Compared to the superstructure size, the substructure size seems small.

f. Pedestrian Bridges

Compared to motorway bridges, the ratio of steel pedestrian bridges seems to be higher than that of concrete bridges. Steel pedestrian bridges can mainly be seen in E5 and other arterial roads. Almost all steel bridges are of continuous girders, and their substructure is

RC. Their superstructure hangs over the end of the substructure, which prevents the girders from falling during an earthquake.

Mainly concrete bridges can be seen in TEM. A standard pedestrian bridge is shown in Photo 20. Many of the same type of bridges can be seen in TEM, and, thus, they are considered the standard bridge type in TEM. Their superstructure is concrete and they are multi-span and simply supported. Their bearing plate is neoprene, and their bidge seat length is estimated to be 50 cm.

Photo 6.2.1

Photo 6.2.2

Photo 6.2.3

Photo 6.2.4

Photo 6.2.5

Photo 6.2.6

Photo 6.2.7

Photo 6.2.8


Photo 6.2.9


Photo 6.2.10


Photo 6.2.11


Photo 6.2.12


Photo 6.2.13


Photo 6.2.14


Photo 6.2.15


Photo 6.2.16


Photo 6.2.17


Photo 6.2.18


Photo 6.2.19


Photo 6.2.20


Photo 6.2.21


Photo 6.2.22


Photo 6.2.23


Photo 6.2.24

g. Considerations

The present condition of bridges in the Study Area is mentioned from many points of view. On the basis of the present condition, problems of bridges in the Study Area are observed as follows:

1) Simply supported bridges are adopted not only for overpass bridges, but also for viaducts, and the clearance between girders is narrow. Therefore, girders have the potential to collide with each other easily, and there is high possibility of collapse in case of an earthquake.

2) Observed seat length is relatively short compared to Japanese standard specifications for highway bridges, and even for cases where the superstructure is at a skewed angle, the seat length is not extended beyond the standard value.

3) In most cases, neoprene bearing plates did not seem to be fixed to the superstructure or substructure. Thus, there is a high possibility of residual deformation after an

earthquake. Girders can collide with each other and there is the possibility of collapse due to an earthquake with large accelerations.

4) Many bridges do not have unseating prevention structures.

5) Compared to the scale of bridge superstructures, there are several substructures whose sizes seem to be relatively small.

h. Further Tasks

Necessary data for the damage analysis of bridges based on Katayama's method have been collected in this survey. Although unseating prevention structures were not observed in the site survey, it is said that some bridges have unseating prevention structures. The existence of unseating prevention structures is one of the most important items for damage assessment of bridges. In the next survey, it will be necessary to reconfirm existence of unseating prevention structures. Further data for assessment, such as ground data and seismic intensity, will be added to the bridge inventory.

6.2.5. Lifeline Data

In the Study, lifeline damage estimations are also undertaken. The importance of this damage estimation is that, by relaying the maximum potential damage, advance preparation of emergency supplies for a quick recovery can be ensured and the strengthening of resulting weak areas can be pursued. In this study, following 5 lifelines are included:

- Gas
- Water and Sewage
- Electricity
- Telecommunications

(1) Gas

In Istanbul, the natural gas distribution service is provided by IGDAŞ for both the European and Anatolian sides of the city. Among lifeline-related companies and organisations, IGDAŞ has made the most progress in digitising their network using GIS, since they are awarethat gas linescan cause the most serious damage and danger to the city during an earthquake. Their database is comprehensive and contains important and necessary information, such as pressure regulation valve locations, main pipe network, distribution pipe network, and other related attributes. However, the data received from IGDAS does not include information on the systems in Büyükçekmece. Çatalca and Silivri, which are not serviced by IGDAŞ. The data for these areas has already been integrated to the database preparied in this project and is ready to analyze. In addition, the Study Team has already calculated the length of pipes by type and width of pipes for each mahalle zone.

Figure 6.2.25 shows the existing network of gas distribution in Istanbul.

(2) Water and Sewage

Water supply service and sewage is provided by ISKI for the entire Study Area except for Silivri, where their own water supply service is provided. ISKI is also managing their network using GIS; however, at the moment, not all of the network attributes (e.g., pipe type/diameter information, joint type information, etc.) are available. In the Study, the number of damage points will be estimated for each mahalle depending on the data quality. Therefore, pipeline data is necessary for transmission lines from the water resource area to purification plants and for distribution pipelines from purification plants to service areas.

Figure 6.2.26 and

Figure 6.2.27 illustrate service networks for water and sewage, respectively.

(3) Electricity

Electricity service is separated into two parts, electricity supply is operated by TEAŞ. This service is separate for the two sides of the city (TEAŞ European side and TEAŞ Anatolian Side), and electricity distribution is operated by BEDAŞ (European Side) and AKTAŞ (Anatolian Side). Therefore, to complete an assessment of the electricity network in Istanbul, data from each company had to be integrated. However, each company had data in different formats or no data was available, and this created a delay of setting up data. In reality, electricity companies did not have digitised maps; therefore, the Study Team started to digitise all received hard copy network information.

Figure 6.2.28 shows existing high voltage electricity lines based on the data received from TEAŞ. The received data also did not cover the additional 3 districts. For Bedaş and Aktaş, the Study Team received statistical tables prepared by their own service district. In the next phase, the Study Team will calculate the length of cables in each mahalle.

(4) Telecommunications

Turk Telecom provides telecommunication service for Turkey in its entirety. In Istanbul, their jurisdiction areas are separated into two parts: one is for the European side and the other is for the Anatolian side. Recently, at the beginning of this year, by order of the central office of Turk Telecom, the project to set up GIS network data for the fiber optic cable network has been started. It is expected to be completed soon and a request has been made for Turk Telecom to supply the data after its completion. Soon after the data is received from Turk Telecom, the Study Team will integrate this data into the database.

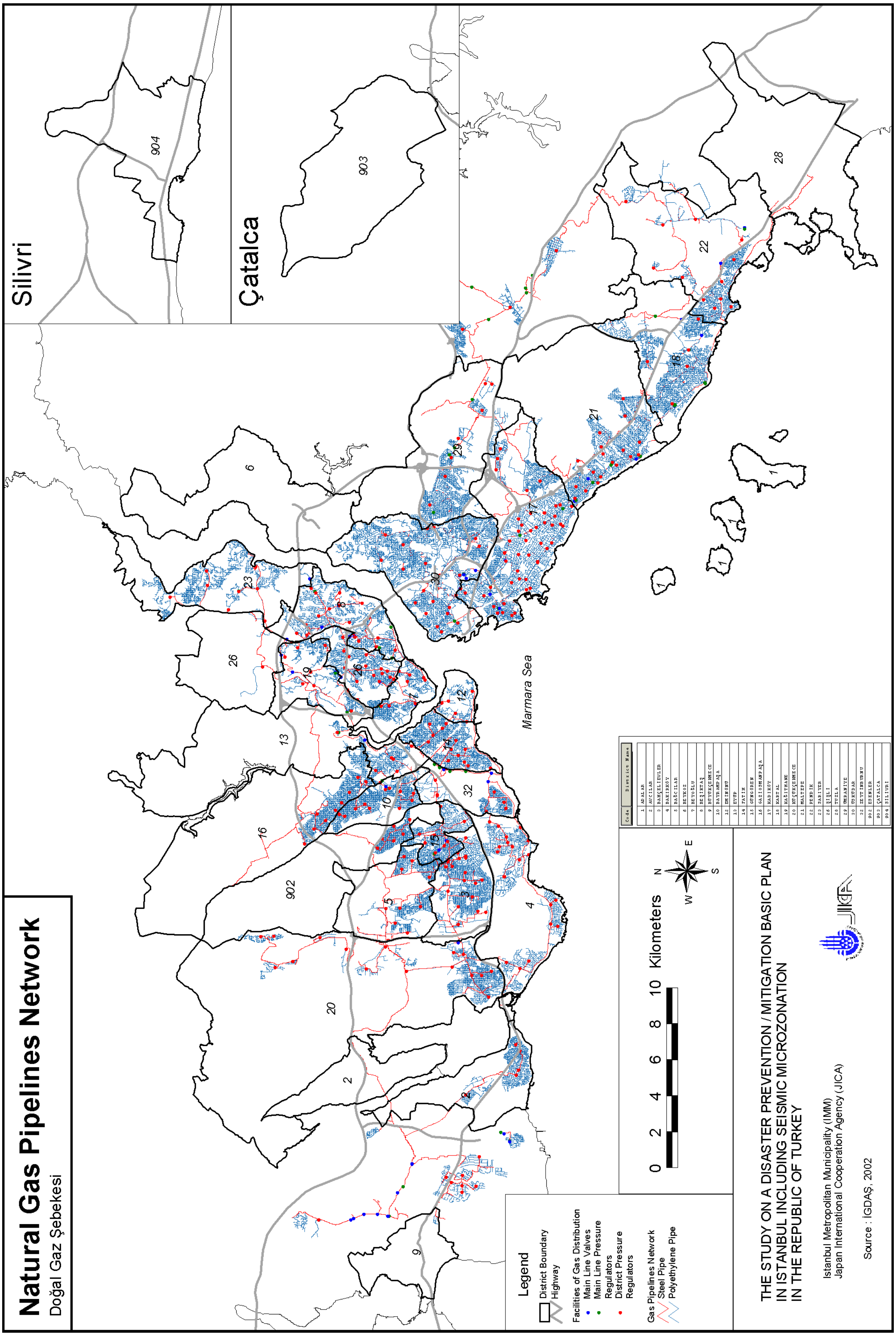


Figure 6.2.25 Gas Distribution Network

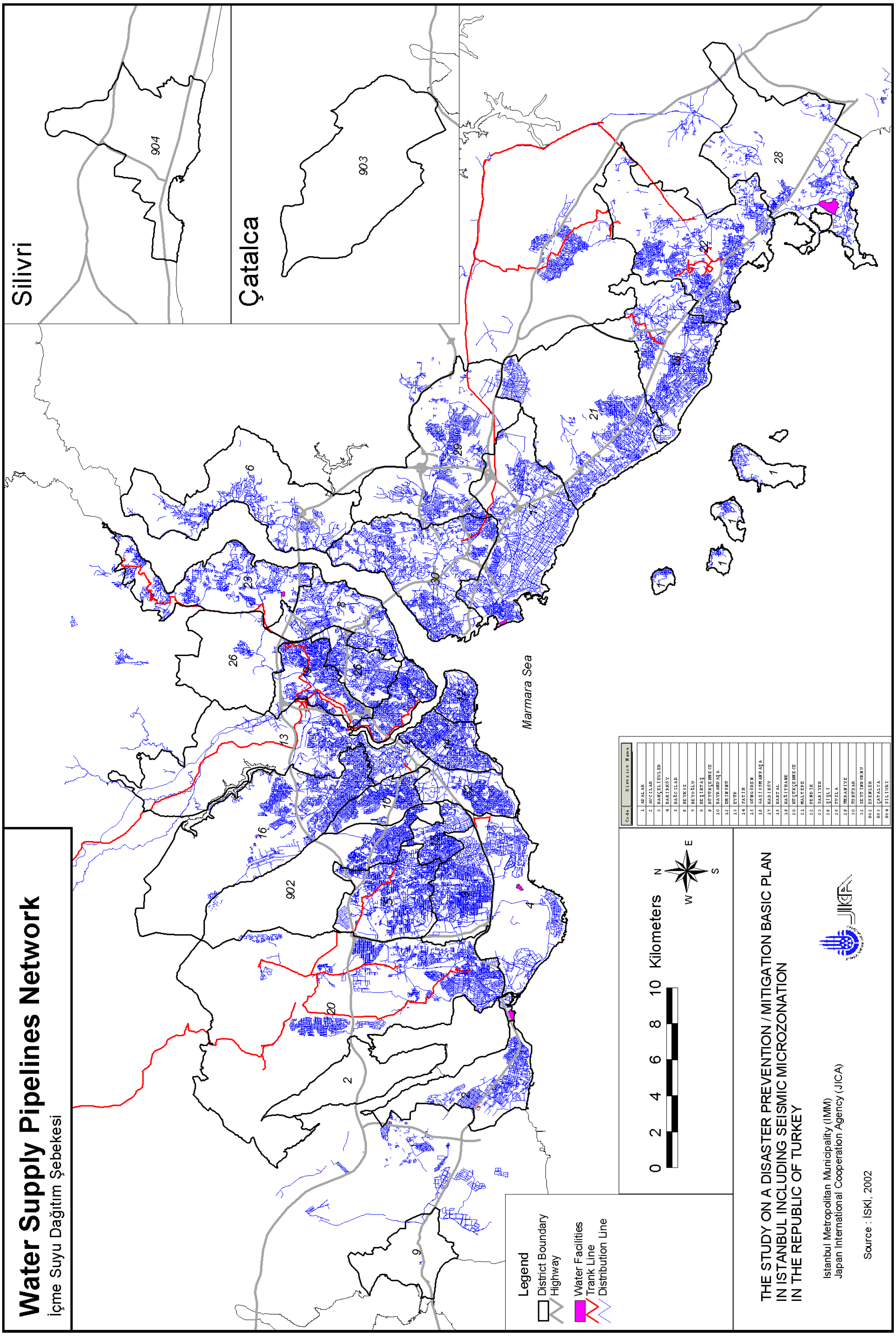


Figure 6.2.26 Water Distribution Network

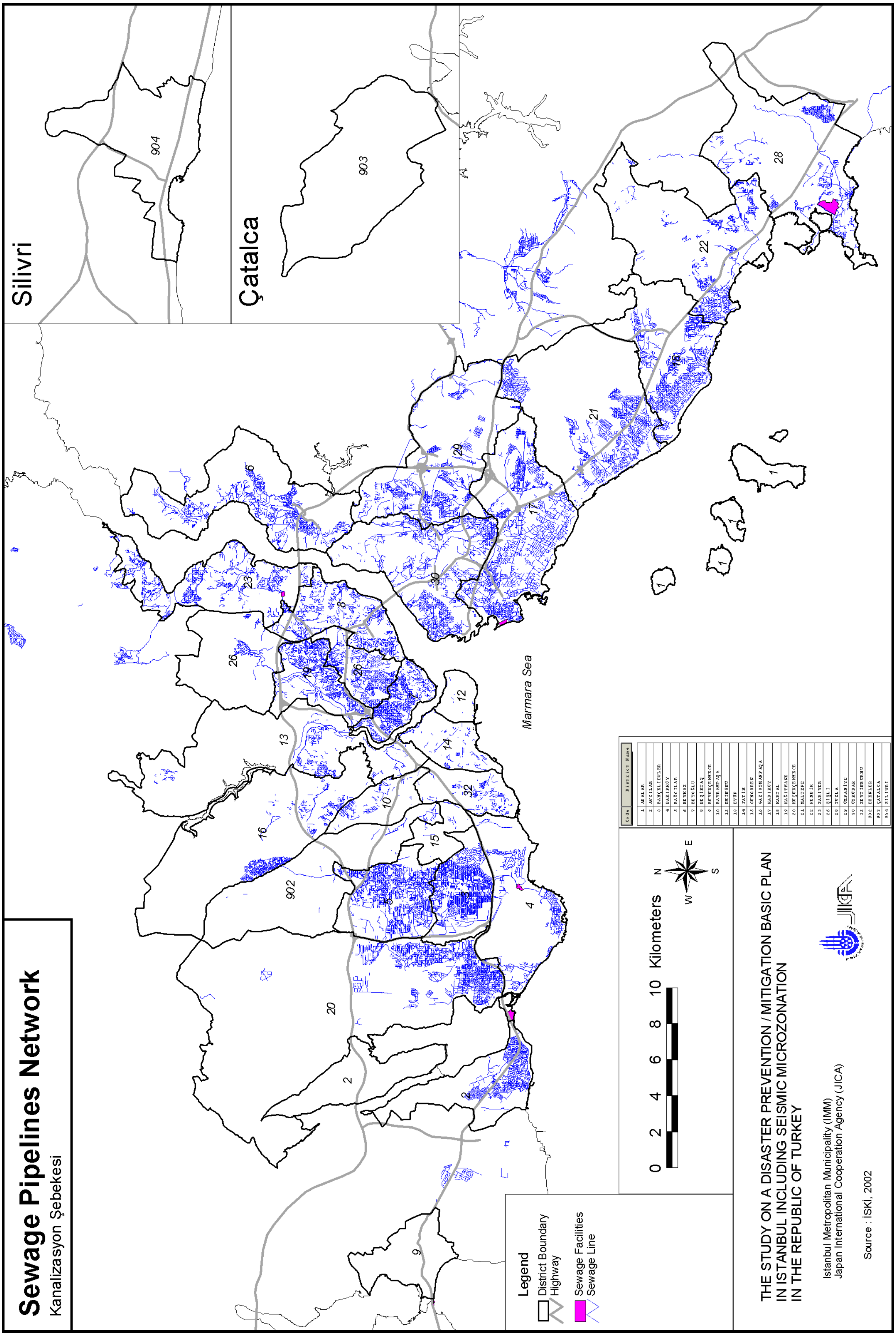


Figure 6.2.27 Sewage Network

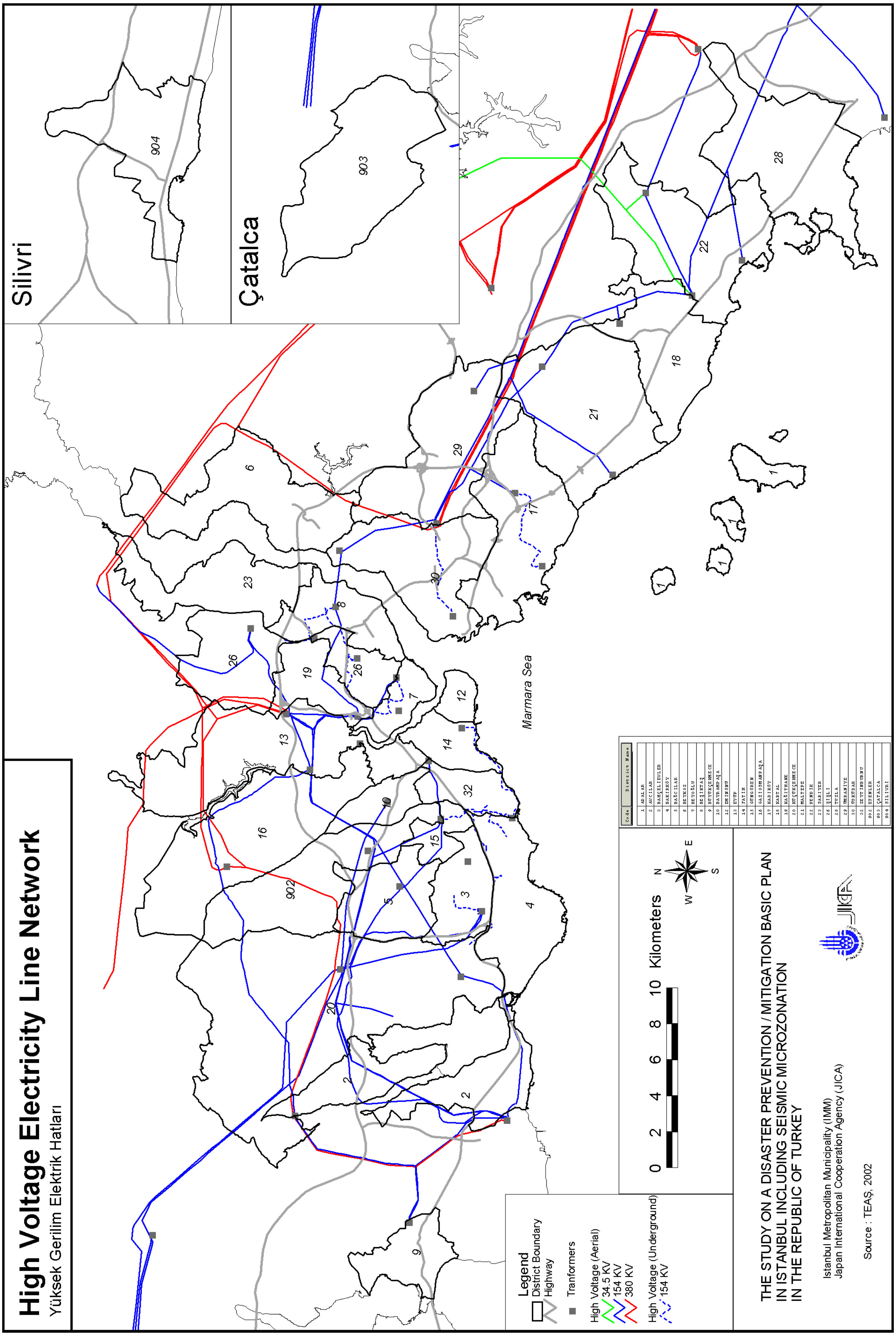


Figure 6.2.28 High Voltage Electricity Network

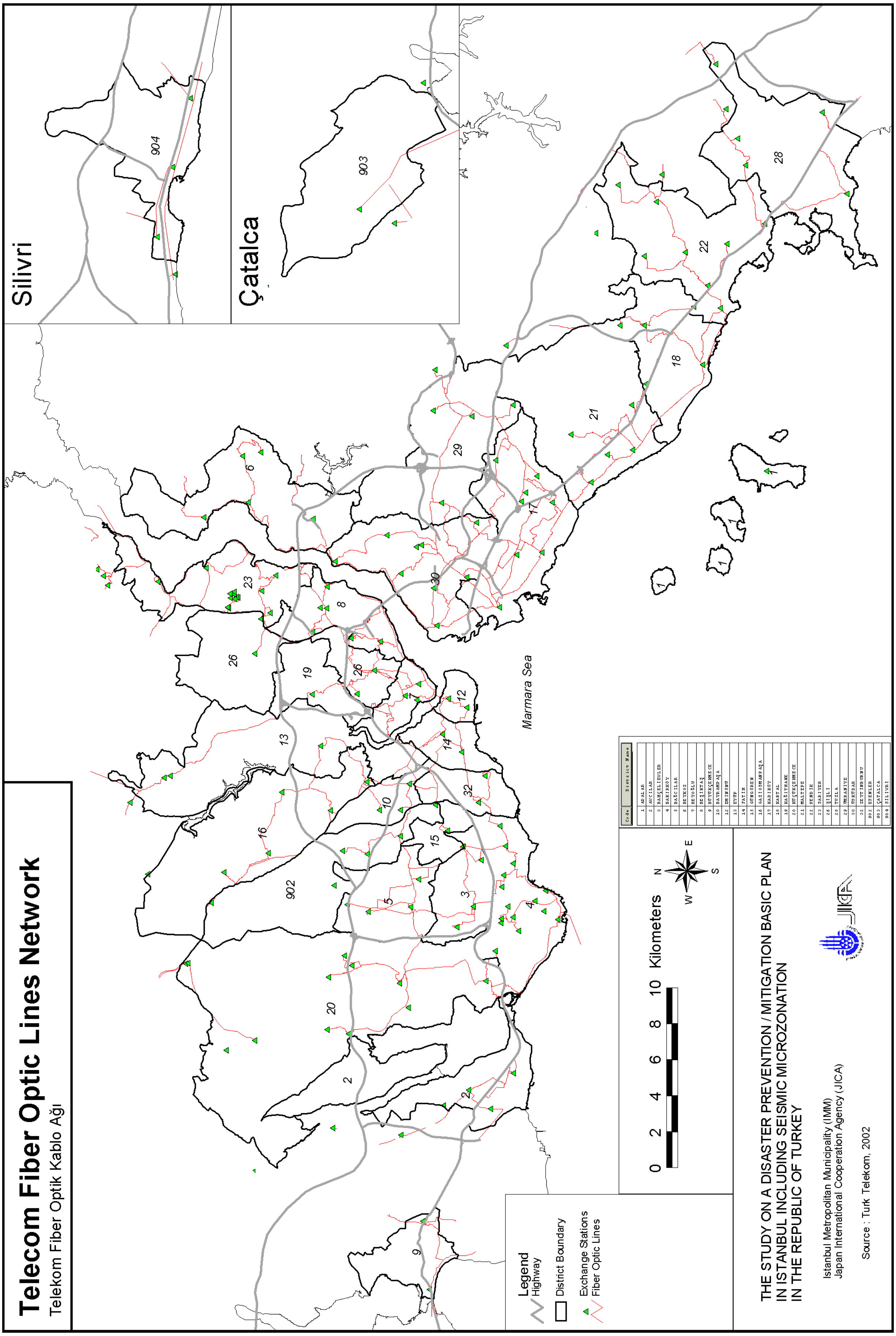


Figure 6.2.29 Telecom Fiber Optic Lines Network

6.2.6. Major Urban Facilities Data

(1) Educational Facilities

The current situation for the educational facilities was examined based on the data obtained from the provinces in May 2002. The numbers of primary schools and high schools, population, and holding capacity per school in each district in the Study Area are summarized in Table 6.2.10. Total numbers of primary school and high school for each district are stated in

Figure 6.2.30.

Table 6.2.10 Numbers of Primary Schools, High schools, Population per School for Each District in the Study Area

Code	District	Primary School			High School			Total	Population	Population per School
		Public	Private	Sub Total	Public	Private	Sub Total			
1	ADALAR	5	1	6	1	1	2	8	17,738	2,217
2	AVCILAR	22	1	23	8	1	9	32	231,799	7,244
3	BAHÇELİ EVLER	36	11	47	17	9	26	73	469,844	6,436
4	BAKIRKÖY	28	12	40	13	5	18	58	206,459	3,560
5	BAĞCILAR	50	4	54	17	7	24	78	557,588	7,149
6	BEYKOZ	48	2	50	8	1	9	59	182,864	3,099
7	BEYOĞLU	26	6	32	13	18	31	63	234,964	3,730
8	BEŞİ KTAŞ	29	15	44	14	8	22	66	182,658	2,768
9	BÜYÜKÇEKMECE	50	8	58	9	9	18	76	34,737	457
10	BAYRAMPAŞA	22	0	22	12	0	12	34	237,874	6,996
12	EMİ NÖNÜ	9	3	12	11	1	12	24	54,518	2,272
13	EYÜP	43	3	46	10	0	10	56	232,104	4,145
14	FATİ H	51	7	58	17	11	28	86	394,042	4,582
15	GÜNGÖREN	20	4	24	8	6	14	38	271,874	7,155
16	GAZİ OSMANPAŞA	79	4	83	17	2	19	102	667,809	6,547
17	KADIKÖY	74	20	94	26	17	43	137	660,619	4,822
18	KARTAL	50	6	56	21	4	25	81	332,090	4,100
19	KAĞTHANE	46	1	47	12	0	12	59	342,477	5,805
20	KÜÇÜKÇKMECE	61	5	66	17	7	24	90	589,139	6,546
21	MALTEPE	41	5	46	14	9	23	69	345,662	5,010
22	PENDİ K	56	2	58	13	0	13	71	372,553	5,247
23	SARIYER	40	15	55	10	9	19	74	212,996	2,878
26	Şİ ŞLİ	30	13	43	16	10	26	69	271,003	3,928
28	TUZLA	25	2	27	8	1	9	36	100,609	2,795
29	ÜMRANİ YE	71	5	76	19	4	23	99	443,358	4,478
30	ÜSKÜDAR	66	17	83	22	21	43	126	496,402	3,940
32	ZEYTİ NBURUNU	21	1	22	14	1	15	37	239,927	6,485
902	ESENLER	24	2	26	3	1	4	30	388,003	12,933
903	ÇATALCA	46	0	46	6	0	6	52	15,624	300
904	Sİ Lİ VRİ	39	2	41	8	1	9	50	44,432	889
Total		1,208	177	1,385	384	164	548	1,933	8,831,766	-
Average		-	-	-	-	-	-	64	294,392	4,569

Source: Provincial Disaster Management Center

More than 100 schools, both primary and high schools, are located in Kadıköy(137 schools), Üsküdar(126 schools), and Gaziosmanpaşa(102 schools). Districts with less than 30 schools are Esenler(30 schools), Eminönü(24 schools), and Adalar(8 schools). An average of 64 schools are located in each district.

Population density per school was calculated by dividing district's population by the total number of schools in the district. Çatalca(300 persons/school), Büyükçekmece(457 persons/school), and Silivri(889 persons/school) are the districts with density of less than 1,000 persons per school. Districts with the density greater than 7,000 persons/school are Bağcılar(7,149 persons/school), Güngören(7,155 persons/school), Avcılar(7,244 persons/school), and Esenler(12,933 persons/school). Over all the average for the Study Area is 4,569 persons/school. The maximum difference can be observed from between Çatalca and Esenler; the density in Esenler is 43 times higher than that in Çatalca.

The ratios of the numbers of schools to population in each district are shown in

Figure 6.2.31. The figure shows that the population per school is relatively smaller in the 3 cities located in the west of the City of Istanbul and higher in the districts west to Eyüp-Fatih area except Bakırköy.

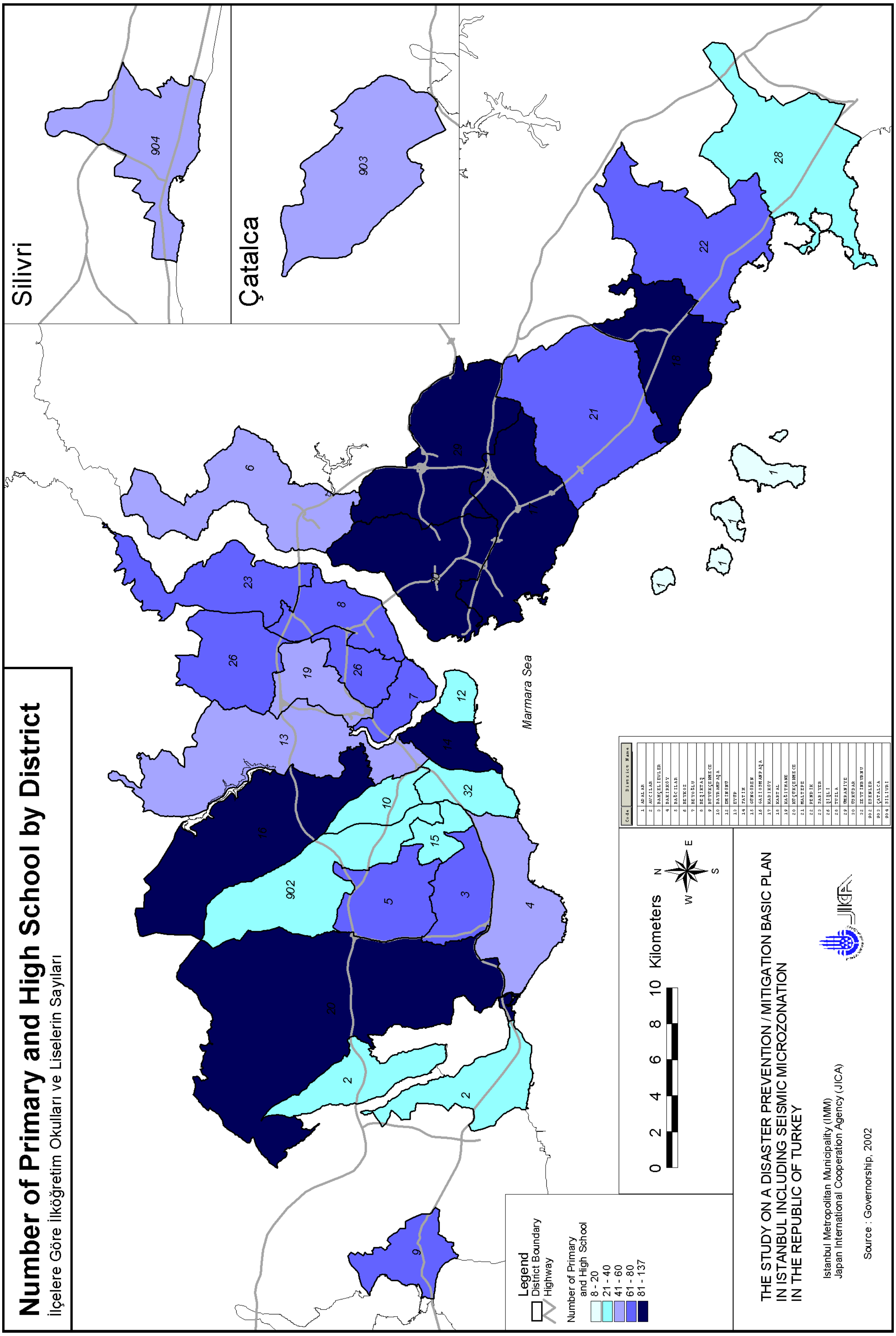
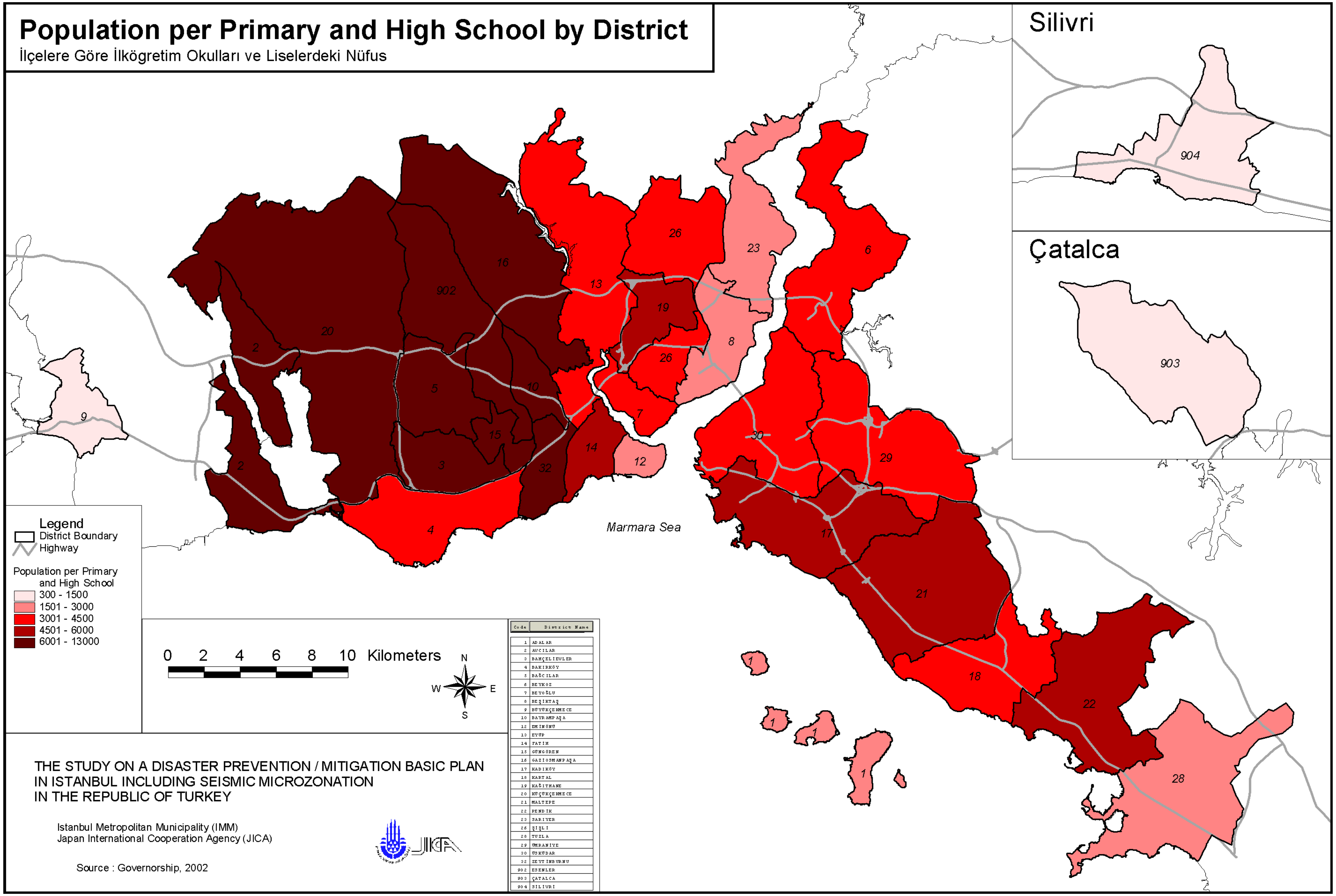


Figure 6.2.30 Number of Primary and High School by District



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 6.2.31 Population per Primary and High School by District

The province anticipates using total of 280 schools in Istanbul as emergency shelters/temporary housings. Table 6.2.11 shows available floor areas of schools, populations, and population densities to clarify usability of the schools for the purpose.

Table 6.2.11 Floor Areas of Schools and Populations

Code	District	Primary and High School	School Buildings Planned as Temporary Housing		Population	Area per Population (m^2 / person)
			Number	Available Floor Area (m^2)		
1	ADALAR	8	6	6,568	17,738	0.37
2	AVCILAR	32	5	18,980	231,799	0.08
3	BAHÇELİ EVLER	73	14	20,447	469,844	0.04
4	BAKIRKÖY	58	4	9,300	206,459	0.05
5	BAĞCILAR	78	9	10,816	557,588	0.02
6	BEYKOZ	59	8	7,135	182,864	0.04
7	BEYOĞLU	63	3	6,131	234,964	0.03
8	BEŞİ KTAŞ	66	3	6,677	182,658	0.04
9	BÜYÜKÇEKMECE	76	17	89,142	34,737	2.57
10	BAYRAMPAŞA	34	4	10,472	237,874	0.04
12	EMİ NÖNÜ	24	12	51,868	54,518	0.95
13	EYÜP	56	4	19,220	232,104	0.08
14	FATİ H	86	3	12,200	394,042	0.03
15	GÜNGÖREN	38	4	18,774	271,874	0.07
16	GAZİ OSMANPAŞA	102	16	40,419	667,809	0.06
17	KADIKÖY	137	9	24,825	660,619	0.04
18	KARTAL	81	16	25,746	332,090	0.08
19	KAĞITHANE	59	8	17,772	342,477	0.05
20	KÜÇÜKÇKMECE	90	18	103,705	589,139	0.18
21	MALTEPE	69	7	36,990	345,662	0.11
22	PENDİ K	71	16	56,364	372,553	0.15
23	SARIYER	74	4	6,310	212,996	0.03
26	Şİ ŞLİ	69	5	9,176	271,003	0.03
28	TUZLA	36	9	13,520	100,609	0.13
29	ÜMRANİ YE	99	25	60,996	443,358	0.14
30	ÜSKÜDAR	126	14	45,075	496,402	0.09
32	ZEYTİ NBURUNU	37	5	23,358	239,927	0.10
902	ESENLER	30	6	20,156	388,003	0.05
903	ÇATALCA	52	18	18,643	15,624	1.19
904	Sİ Lİ VRİ	50	8	17,785	44,432	0.40
Total		1,933	280	808,570	8,831,766	-
Average		64	9	26,952	294,392	0.09

Source: Provincial Disaster Management Center

The districts where schools with floor area greater than 1 m^2 per person are located are Büyükçekmece(2.57m^2) and Çatalca(1.19m^2). Unit floor area per person less than 0.03 m^2 is observed in Beyoğlu(0.03 m^2), Fatih(0.03 m^2), Saryer(0.03 m^2), Sisli(0.03 m^2), and Bağcılar(0.02 m^2). Over all the average of floor area per person, which would be served as a temporary housing space, is 0.09 m^2. The maximum difference is shown in between Büyükçekmece and Bağcılar: the unit floor area for Büyükçekmece is 129 times larger than that for Bağcılar.

Figure 6.2.32 illustrates the available floor are school per person for each district. The figure indicates that the districts with available floor area per person less than the average are located mostly in the European side of the Study Area.

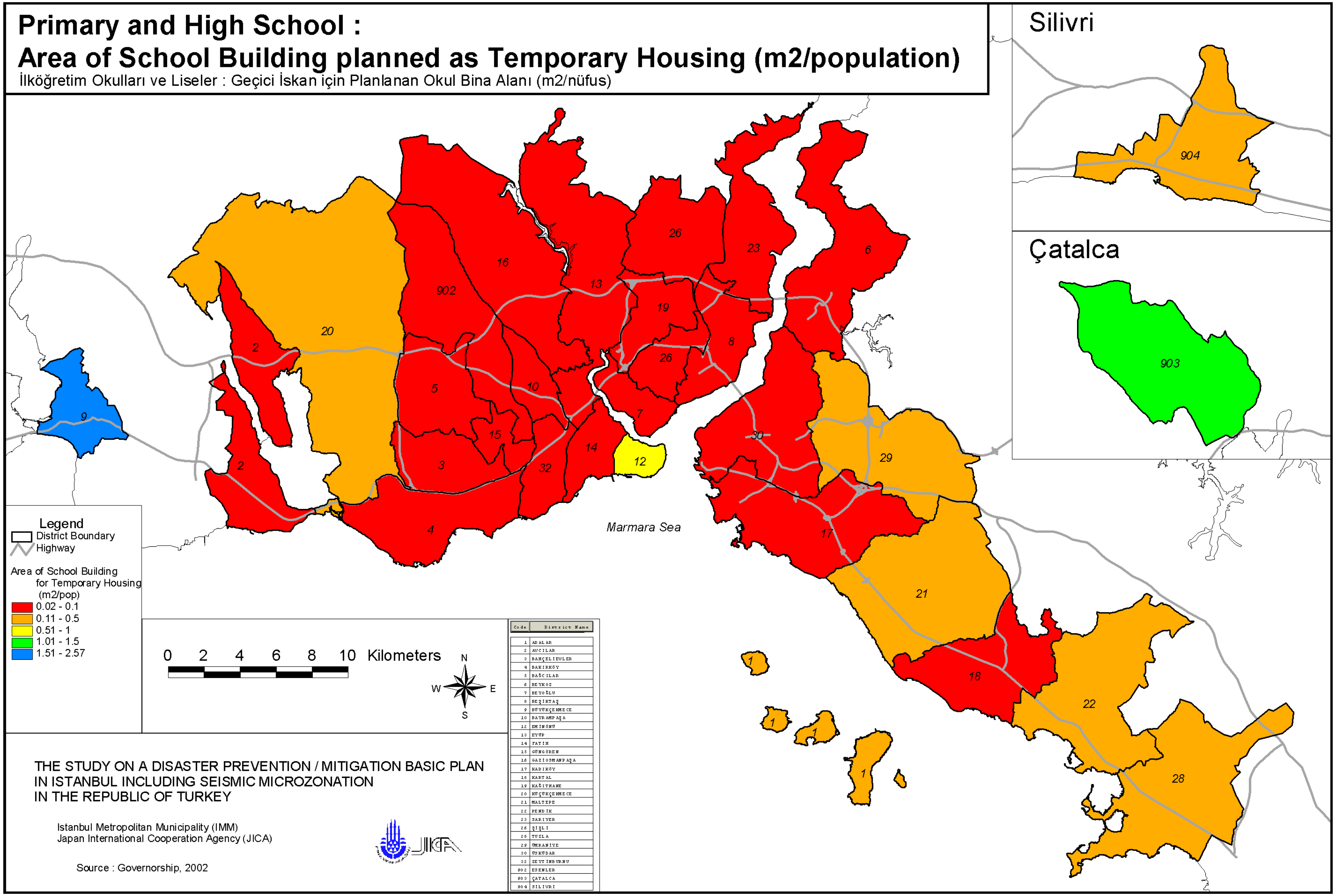


Figure 6.2.32 Primary and High School : Area of School Building Planned as Temporary Housing (m2/population)

(2) Medical Facilities

Current Situation for the medical facilities is examined based on the data obtained from the provinces in May 2002. The numbers of hospitals and policlinics are summarized in Table 6.2.12. The total numbers of hospitals and policlinics for each district are stated in

Figure 6.2.33.

Table 6.2.12 Numbers of Hospitals and Policlinics for Each District

Code	District	Hospital						Policlinic			Total
		Public	Private	SSK	Univesity	Public Corporation	Sub Total	Public	Private	Sub Total	
1	ADALAR	2					2			0	2
2	AVCILAR		5				5		6	6	11
3	BAHÇELİEVLER	1	11				12			0	12
4	BAKIRKÖY	3	6	1			10		10	10	20
5	BAĞCILAR		4				4	1	22	23	27
6	BEYKOZ	2		1			3	1	5	6	9
7	BEYOĞLU	2	6				8		15	15	23
8	BEŞİKTAŞ		4				4			0	4
9	BÜYÜKÇEKMECE	1	3				4			0	4
10	BAYRAMPAŞA	1	4	1			6	2	10	12	18
12	EMİNÖNÜ	2	1				3	2	5	7	10
13	EYÜP	1	2	1			4		10	10	14
14	FATİH	1	9	2	4		16	1	15	16	32
15	GÜNGÖREN		5	1			6		1	1	7
16	GAZİOSMANPAŞA	1	10				11			0	11
17	KADIKÖY	1	15	3		1	20		42	42	62
18	KARTAL	1	3		1	1	6		9	9	15
19	KAĞITHANE		3				3			0	3
20	KÜÇÜKÇKMECE		6				6		21	21	27
21	MALTEPE		4	1			5		2	2	7
22	PENDİK	1	4				5	1	10	11	16
23	SARIYER	3					3		15	15	18
26	ŞİŞLİ	1	15	3		2	21			0	21
28	TUZLA						0			0	0
29	ÜMRANİYE		4				4	1	23	24	28
30	ÜSKÜDAR	3	8	1	1	4	17		16	16	33
32	ZEYTİNBURUNU	2	4				6		10	10	16
902	ESENLER		3				3		11	11	14
903	ÇATALCA	1					1			0	1
904	SİLİVRİ	1	2				3			0	3
Total		31	141	15	6	8	201	9	24	267	468
Average		-	-	-	-	-	7	-	-	9	16

Source: Provincial Disaster Management Center
Note: SSK: Social Insurance Organization(Sosya Sigortalar Kurumu)

More than 30 medical facilities, both hospitals and policlinics, are located in Gaziosmanpaşa(62 facilities), Üsküdar(33 facilities), and Eyüp(32 facilities). Districts with less than or equal to 3 medical facilities are Kağıthane(3 facilities), Silivri(3 facilities), Adalar(2 facilities), Çatalca(1 facility), and Tuzla(0 facility). In an average 16 facilities are located in each district.

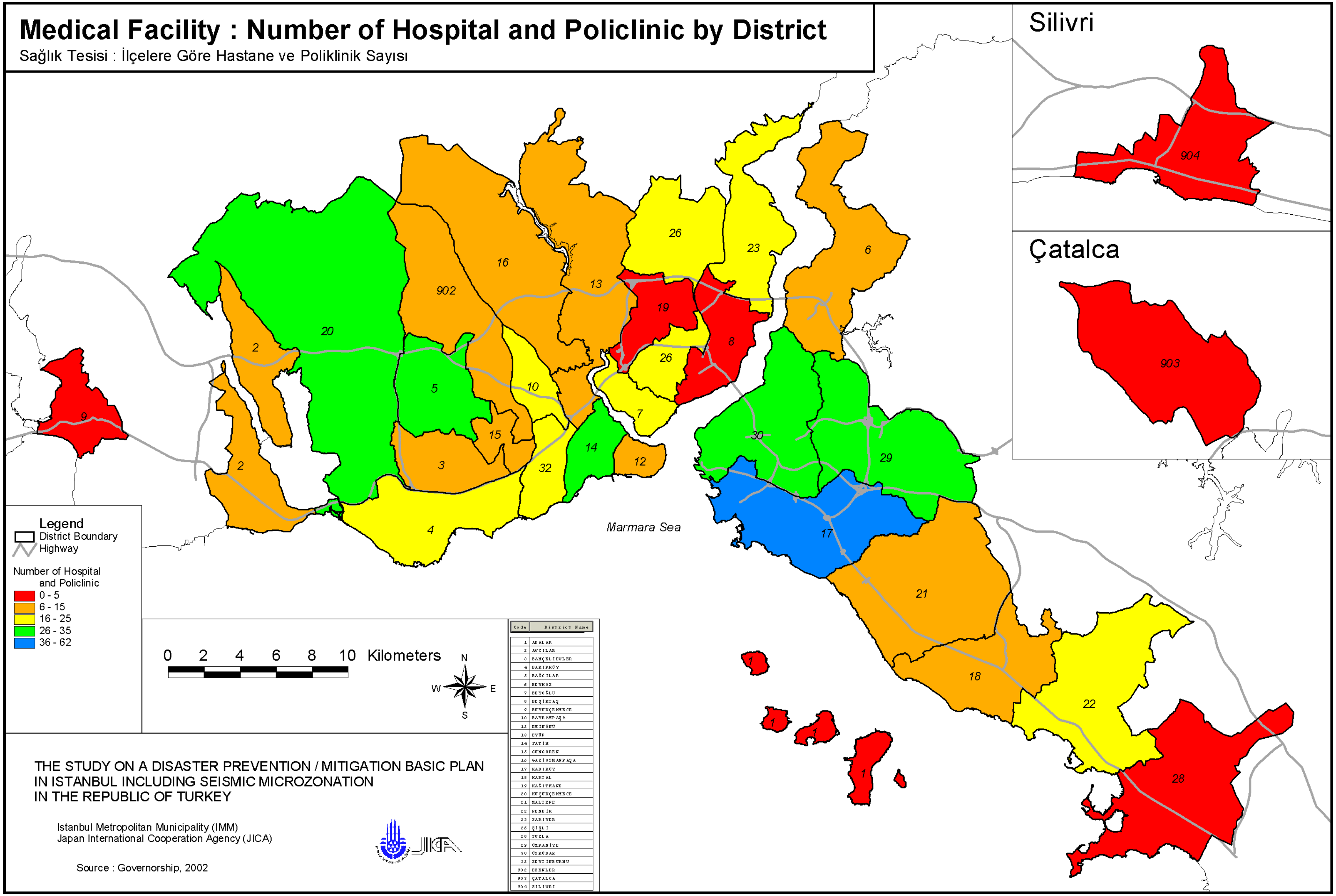


Figure 6.2.33 Medical Facility : Number of Hospital and Policlinic by District

Current situation with regards to the numbers of beds is examined based on the data obtained from the Ministry of Health in July 2002. The numbers of beds and of beds per population for each district are summarized in Table 6.2.13. The numbers of beds in the medical facilities for each district are stated in

Figure 6.2.34.

Table 6.2.13 Numbers of Beds and of Beds per Population in Each District

Code	District	Numbers of Beds	Population	Numbers of Beds per 100,000 people
1	ADALAR	685	17,738	3862
2	AVCILAR	323	231,799	139
3	BAHÇELİEVLER	1,126	469,844	240
4	BAKIRKÖY	4,229	206,459	2048
5	BAĞCILAR	177	557,588	32
6	BEYKOZ	300	182,864	164
7	BEYOĞLU	861	234,964	366
8	BEŞİKTAŞ	173	182,658	95
9	BÜYÜKÇEKMECE	134	34,737	386
10	BAYRAMPAŞA	259	237,874	109
12	EMİNÖNÜ	420	54,518	770
13	EYÜP	75	232,104	32
14	FATİH	1,081	394,042	274
15	GÜNGÖREN	207	271,874	76
16	GAZİOSMANPAŞA	491	667,809	74
17	KADIKÖY	1,127	660,619	171
18	KARTAL	918	332,090	276
19	KAĞITHANE	285	342,477	83
20	KÜÇÜKÇKMECE	334	589,139	57
21	MALTEPE	85	345,662	25
22	PENDİK	244	372,553	65
23	SARIYER	510	212,996	239
26	ŞİŞLİ	1,597	271,003	589
28	TUZLA	0	100,609	0
29	ÜMRANİYE	87	443,358	20
30	ÜSKÜDAR	2,036	496,402	410
32	ZEYTİNBURUNU	1,325	239,927	552
902	ESENLER	147	388,003	38
903	ÇATALCA	50	15,624	320
904	SİLİVRİ	147	44,432	331
Total		19,433	8,831,766	-
Average		648	294,392	220

Source: The Ministry of Health

More than 2,000 beds in the medical institution are located in Bakırköy(4,299 beds) and Üsküdar(2,036 beds). Districts with less than 100 beds are Ümraniye(87 beds), Maltepe(85 beds), Eyüp(75 beds), Çatalca(50 beds), Tuzla(0 bed). In an average 648 beds are located in each district.

More than 2,000 beds per 100,000 people are available in Adalar(3,862 beds) and Bakırköy(2,048 beds). Districts with less than 40 beds per 100,000 people are Esenler(38 beds), Bağcılar(32 beds), Eyüp(32 beds), Maltepe(25 beds), Ümraniye(20 beds), and Tuzla(0 bed).

On average 220 beds per 100,000 people are available in each district.

Numbers of beds per 100,000 people for the districts are shown in

Figure 6.2.35. According to the figure, there is a tendency that more numbers of beds per 100,000 people are available on the European side than on the Asian side. Many districts with less than 100 beds per 100,000 people are located in the inland areas of the European side.

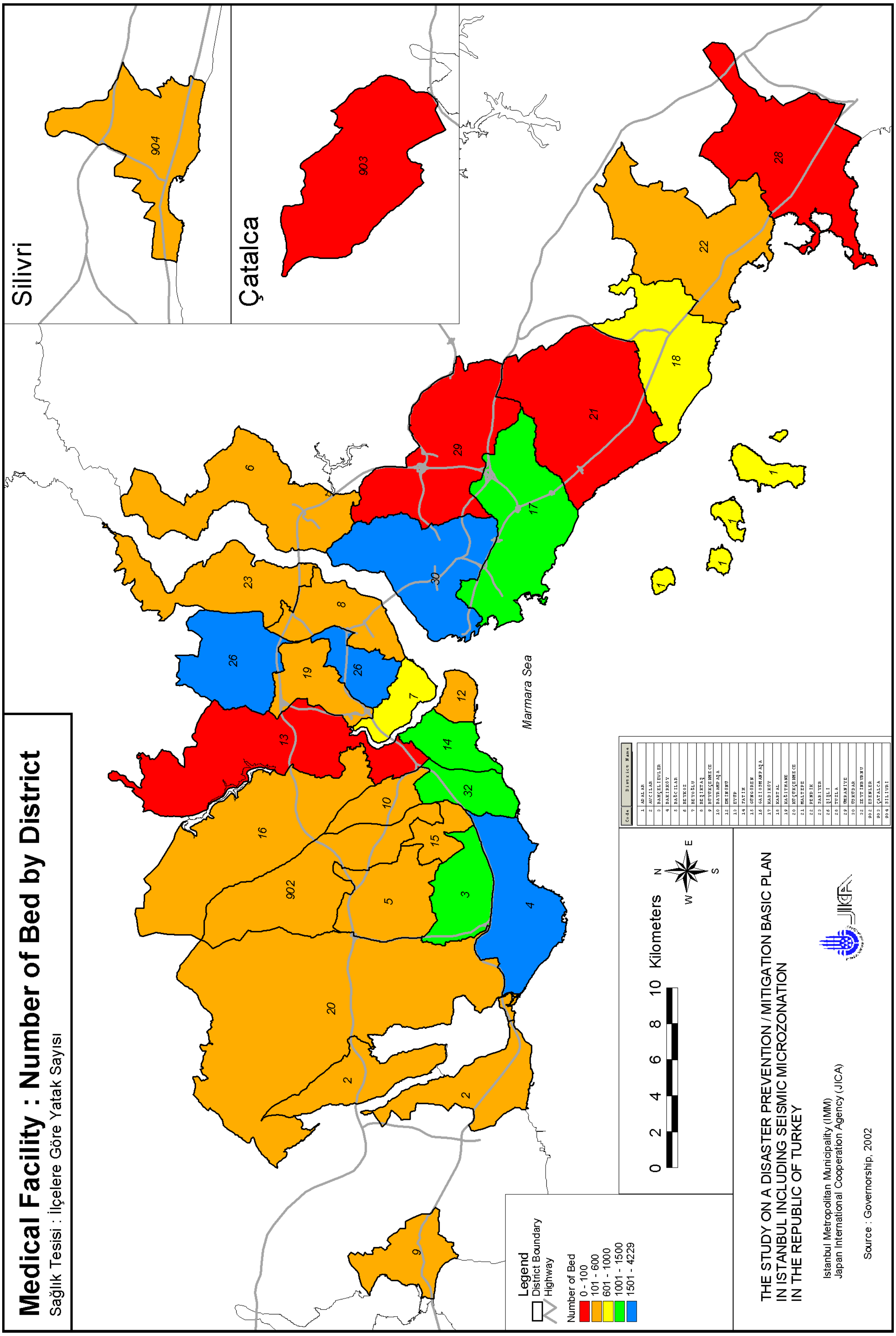


Figure 6.2.34 Medical Facility : Number of Bed by District

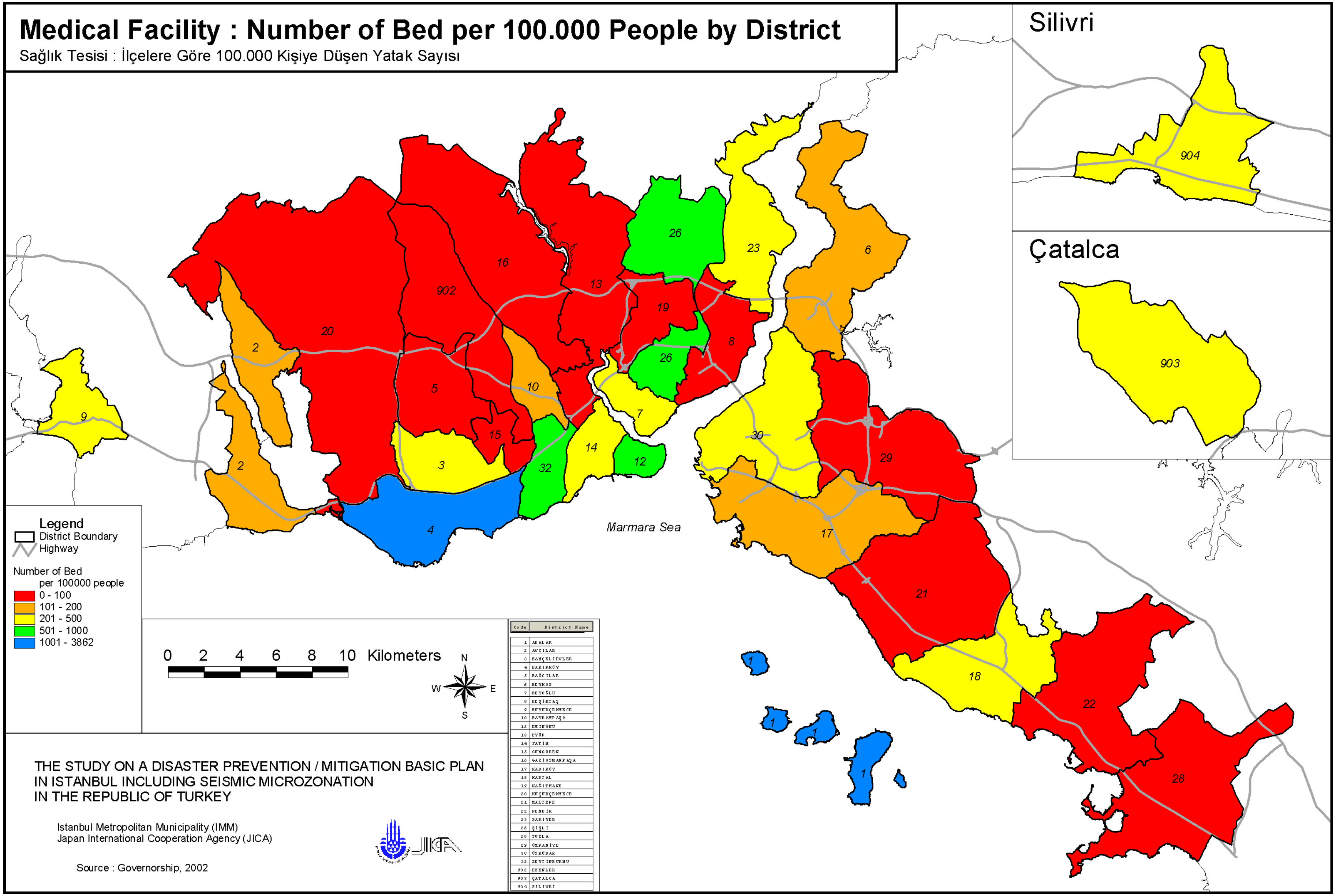


Figure 6.2.35 Medical Facility : Number of Bed per 100,000 People by District

(3) Fire Fighting Facilities

Current situation for the fire fighting facilities is examined based on the data obtained from the IMM Fire Department in May 2002. Table 6.2.14 shows numbers of facilities for each district.

Figure 6.2.36 shows locations of fire fighting facilities.

There is more than 1 fire fighting facility in most of the districts. According to the figure, many fire fighting facilities are located close to the first degree road designated by the IMM.

Table 6.2.14 Numbers of Fire Fighting Facilities for Each District

Code	District	Fire Fighting
1	ADALAR	4
2	AVCILAR	1
3	BAHÇELİ EVLER	1
4	BAKIRKÖY	1
5	BAĞCILAR	1
6	BEYKOZ	2
7	BEYOĞLU	0
8	BEŞİ KTAŞ	1
9	BÜYÜKÇEKMECE	1
10	BAYRAMPAŞA	2
12	EMİ NÖNÜ	0
13	EYÜP	2
14	FATİ H	1
15	GÜNGÖREN	1
16	GAZİ OSMANPAŞA	1
17	KADIKÖY	2
18	KARTAL	1
19	KAĞTHANE	2
20	KÜÇÜKÇKMECE	2
21	MALTEPE	1
22	PENDİ K	1
23	SARIYER	2
26	ŞİŞLİ	2
28	TUZLA	2
29	ÜMRANİ YE	1
30	ÜSKÜDAR	2
32	ZEYTİ NBURUNU	1
902	ESENLER	0
903	ÇATALCA	1
904	Sİ Lİ VRİ	1
Total		40

Source: IMM Fire Department

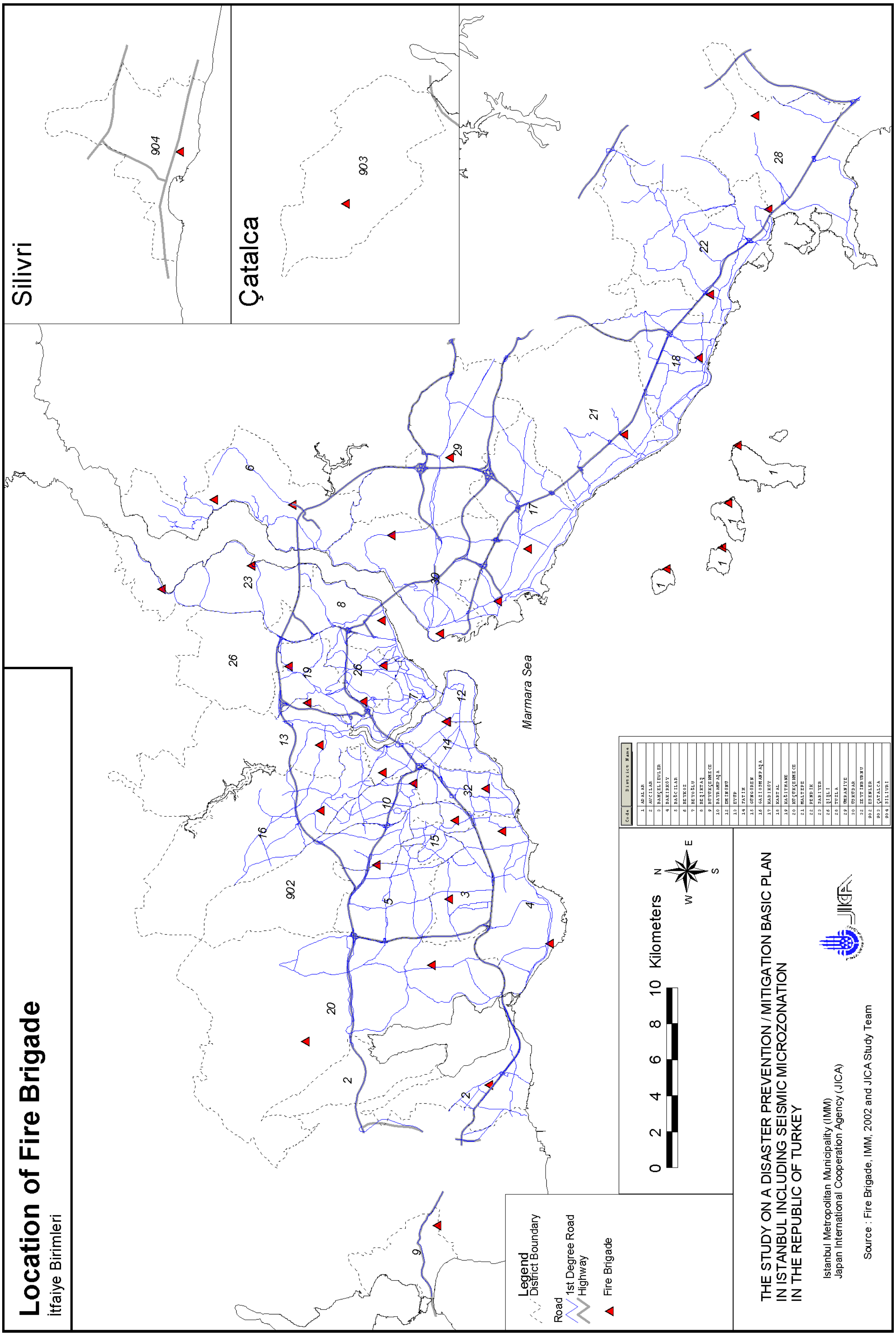


Figure 6.2.36 Location of Fire Brigade

(4) Security Facilities

Current situation for the security facilities is examined based on the data obtained from the province in May 2002. Table 6.2.15 shows the numbers of district polices (İlçe emniyet), polices, gendarmes (Jandarma), and other relating facilities for each district.

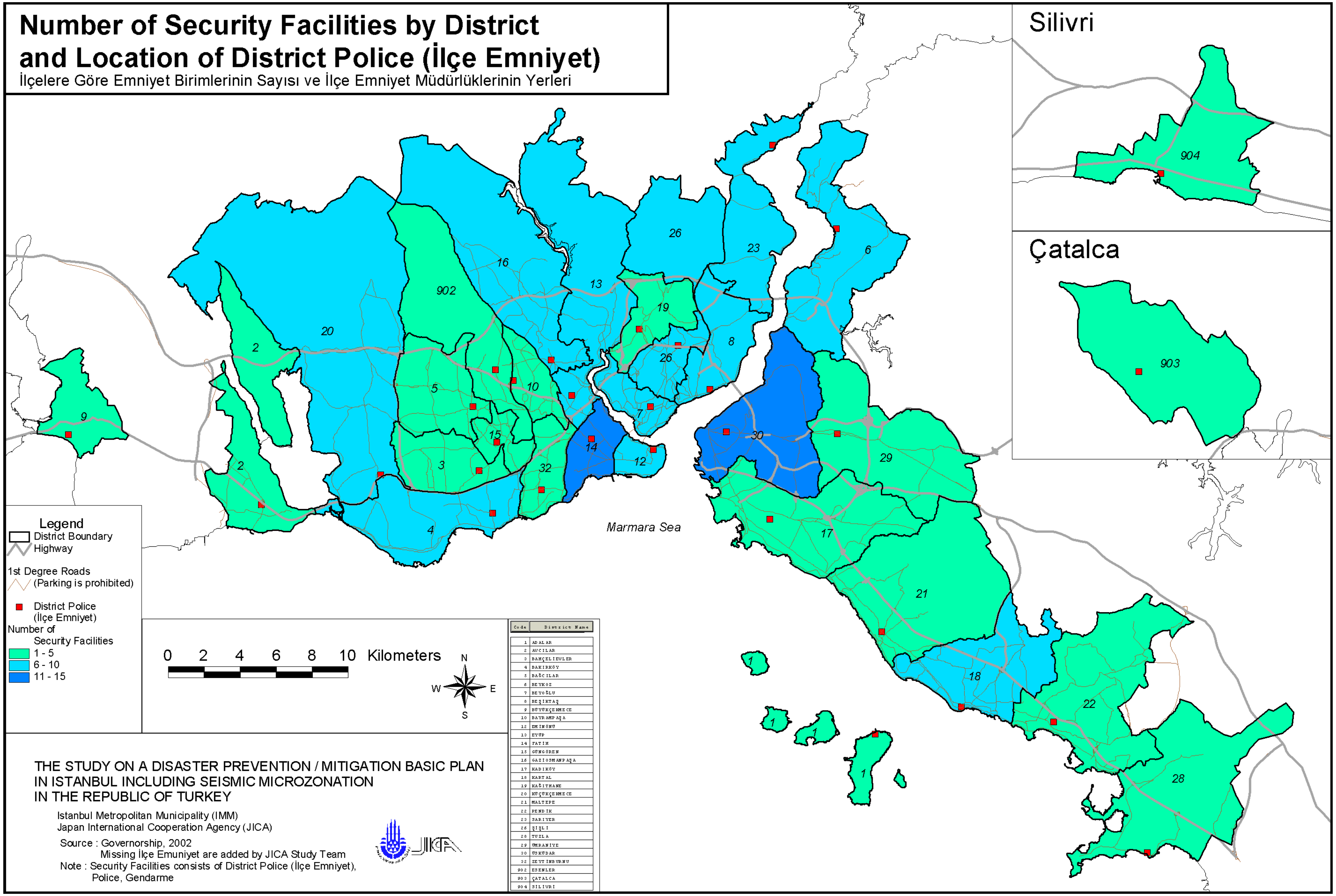
Table 6.2.15 Numbers of District Polices(İlçe Emniyet), Polices, Gendarmes(Jandalma) and Other Relating Facilities for Each District

Code	District	District Police	Police	Gendarme	Other	Total
1	ADALAR	1	0	0	0	1
2	AVCILAR	1	3	0	0	4
3	BAHÇELİ EVLER	1	3	0	0	4
4	BAKIRKÖY	1	6	2	1	10
5	BAĞCILAR	1	2	0	0	3
6	BEYKOZ	1	5	1	0	7
7	BEYOĞLU	1	5	0	0	6
8	BEŞİ KTAŞ	1	7	0	0	8
9	BÜYÜKÇEKMECE	1	1	1	0	3
10	BAYRAMPAŞA	1	2	1	0	4
12	EMİ NÖNÜ	1	6	0	0	7
13	EYÜP	1	5	1	0	7
14	FATİ H	1	13	0	1	15
15	GÜNGÖREN	1	3	0	0	4
16	GAZİ OSMANPAŞA	1	6	1	1	9
17	KADIKÖY	1	0	0	0	1
18	KARTAL	1	5	1	0	7
19	KAĞITHANE	1	4	0	0	5
20	KÜÇÜKÇKMECE	1	5	0	1	7
21	MALTEPE	1	4	0	0	5
22	PENDİ K	1	2	1	0	4
23	SARIYER	1	7	1	1	10
26	Şİ ŞLİ	1	7	1	0	9
28	TUZLA	1	1	0	1	3
29	ÜMRANİ YE	1	1	2	0	4
30	ÜSKÜDAR	1	9	1	0	11
32	ZEYTİ NBURUNU	1	2	0	1	4
902	ESENLER	1	1	0	0	2
903	ÇATALCA	1	0	0	0	1
904	Sİ Lİ VRİ	1	0	0	0	1
Total		30	115	14	7	166
Average		-	-	-	-	6

Source: Provincial Disaster Management Center

More than 10 buildings of security facilities are located in Fatih(15 buildings) and Üsküdar(11 buildings). In an average 6 security related buildings are located in each district.

Figure 6.2.37 shows numbers of buildings of security facilities for each district and locations of the district police (İlçe emniyet). According to the figure, the district police(İlçe emniyet) buildings are locating close the first degree road designated by IMM.



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 6.2.37 Number of Security Facilities by District and Location of District Police

(5) Governmental Facilities

Current situation for the governmental facilities is examined based on the data obtained from the province in May 2002. Table 6.2.16 shows numbers of ministerial, provincial, and municipal buildings for each district.

Table 6.2.16 Numbers of Buildings Belong to Ministry, Province, and Municipality for Each District

Code	District	Ministry	Province	Municipality	Total
1	ADALAR	0	1	1	2
2	AVCILAR	2	1	12	15
3	BAHÇELİ EVLER	7	1	11	19
4	BAKIRKÖY	21	1	11	33
5	BAĞCILAR	0	1	1	2
6	BEYKOZ	8	1	11	20
7	BEYOĞLU	26	1	8	35
8	BEŞİ KTAŞ	21	1	14	36
9	BÜYÜKÇEKMECE	1	1	8	10
10	BAYRAMPAŞA	3	1	6	10
12	EMİ NÖNÜ	10	2	5	17
13	EYÜP	19	1	14	34
14	FATİ H	11	1	28	40
15	GÜNGÖREN	1	1	3	5
16	GAZİ OSMANPAŞA	3	1	8	12
17	KADIKÖY	27	1	10	38
18	KARTAL	21	1	13	35
19	KAĞITHANE	3	1	4	8
20	KÜÇÜKÇKMECE	3	2	16	21
21	MALTEPE	3	1	3	7
22	PENDİ K	7	1	7	15
23	SARIYER	5	1	9	15
26	Şİ ŞLİ	10	1	4	15
28	TUZLA	7	1	8	16
29	ÜMRANİ YE	0	1	2	3
30	ÜSKÜDAR	0	1	1	2
32	ZEYTİ NBURUNU	8	1	2	11
902	ESENLER	2	1	8	11
903	ÇATALCA	0	1	1	2
904	Sİ Lİ VRİ	0	1	1	2
Total		229	32	230	491
Average		-	-	-	16

Source: Provincial Disaster Management Center

More than 35 buildings of governmental facilities are located in Fatih(40 buildings), Kadıköy (38 buildings), and Beşiktaş (36 buildings). In an average 16 buildings are located in each district.

Figure 6.2.38 shows numbers of buildings of governmental facilities and the locations of the central provincial offices (Kaymakamılık) and the municipality offices(Belediye) for each district. According to the figure, the central provincial offices (Kaymakamılık) and the municipality offices(Belediye) tend to be located close to the first degree road designated by IMM.

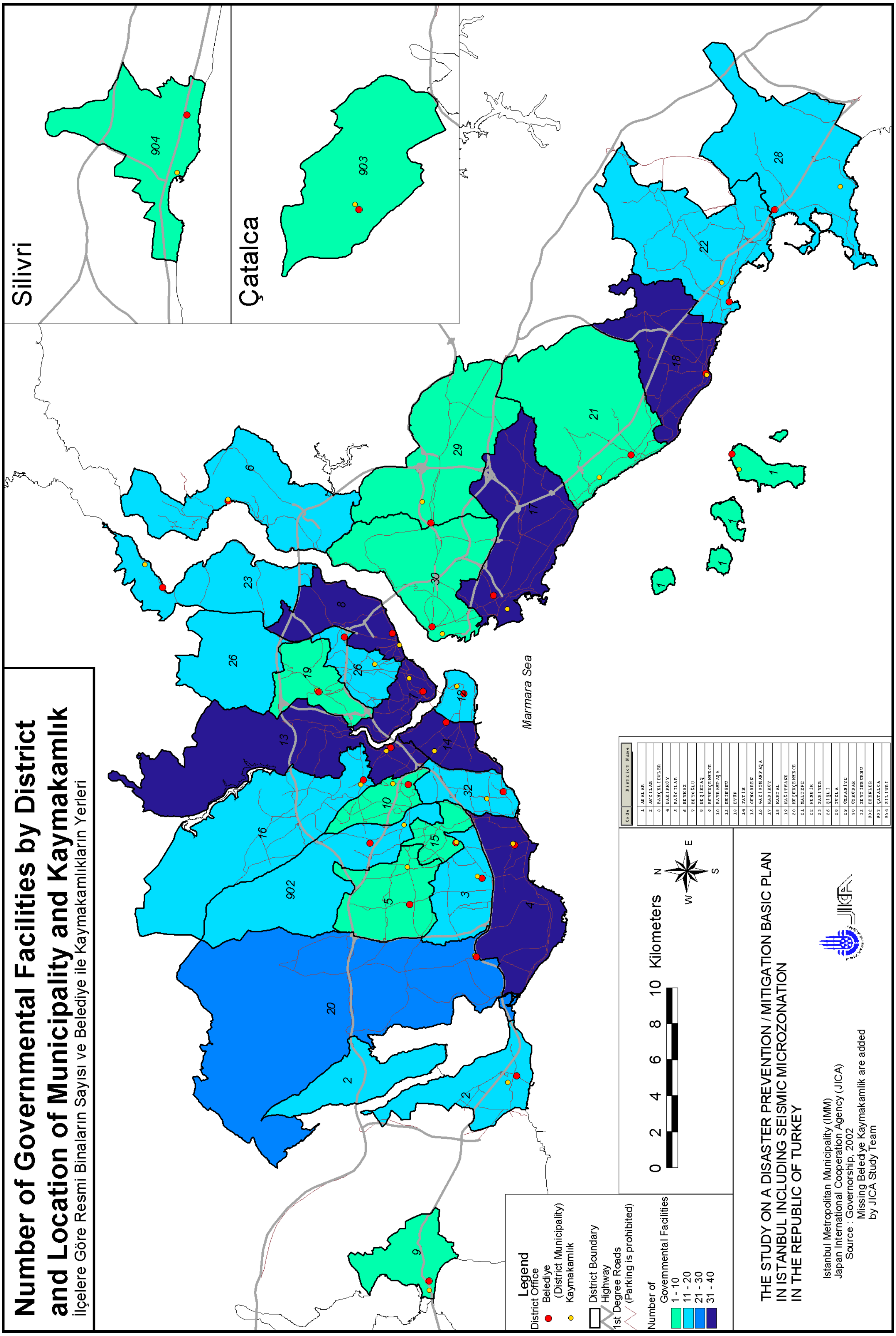


Figure 6.2.38 Number of Governmental Facilities by District and Location of Municipality and kaymakamlik

6.2.7. Hazardous Facility Data

During an earthquake, hazardous facilities may cause secondary disasters. It is imperative, therefore, to have a database to understand not only the distribution of hazardous facilities, but also to understand which critical facilities have high danger rates. The list of the 882 registered hazardous facilities (which are categorised as 1) large LPG storage, 2) paint/polish products factories, 3) Chemical Warehouses, 4) fuel/LPG filling stations, 5) fuel filling stations) was compiled by the Licensing Directorate of IMM. This data does not contain building information. In the Study, critical areas for fire outbreak were to be identified. Distribution based on Districts are summarized and shown in Table 6.2.17 and

Figure 6.2.39.

Table 6.2.17 Distribution of Hazardous Facility

District Code	District Name	Big LPG Storage	Factory of Paint/Polish Products	Warehouse of Chemical Products	Fuel/LPG Filling Facility	Fuel Filling Station	TOTAL
1	ADALAR	0	0	0	0	0	0
2	AVCILAR	3	0	10	4	0	17
3	BAHÇELİEVLER	7	0	11	16	2	36
4	BAKIRKÖY	0	0	17	2	0	19
5	BAĞCILAR	17	0	28	16	0	61
6	BEYKOZ	0	0	11	2	0	13
7	BEYOĞLU	4	1	14	1	2	22
8	BEŞİKTAŞ	7	0	10	1	0	18
9	BÜYÜKÇEKMECE	N/A	N/A	N/A	N/A	N/A	N/A
10	BAYRAMPAŞA	2	1	8	5	5	21
12	EMİNÖNÜ	4	0	3	0	0	7
13	EYÜP	6	7	10	4	2	29
14	FATİH	13	0	12	4	0	29
15	GÜNGÖREN	4	1	8	4	1	18
16	GAZİOSMANPAŞA	14	12	30	1	2	59
17	KADIKÖY	6	0	35	5	0	46
18	KARTAL	9	9	22	5	1	46
19	KAĞITHANE	15	7	10	7	5	44
20	KÜÇÜKÇEKMECE	9	10	16	6	2	43
21	MALTEPE	6	3	12	4	1	26
22	PENDİK	5	29	25	3	5	67
23	SARIYER	6	0	11	3	0	20
26	ŞİŞLİ	9	2	18	3	1	33
28	TUZLA	1	0	5	0	0	6
29	ÜMRANİYE	8	6	29	8	3	54
30	ÜSKÜDAR	2	0	20	11	0	33
32	ZEYTİNBURNU	6	3	19	6	1	35
902	ESENLER	0	0	10	2	0	12
903	ÇATALCA	N/A	N/A	N/A	N/A	N/A	N/A
904	SİLİVRİ	N/A	N/A	N/A	N/A	N/A	N/A
Total		163	91	404	123	33	814

Source: Licensing Directorate of IMM (2002)

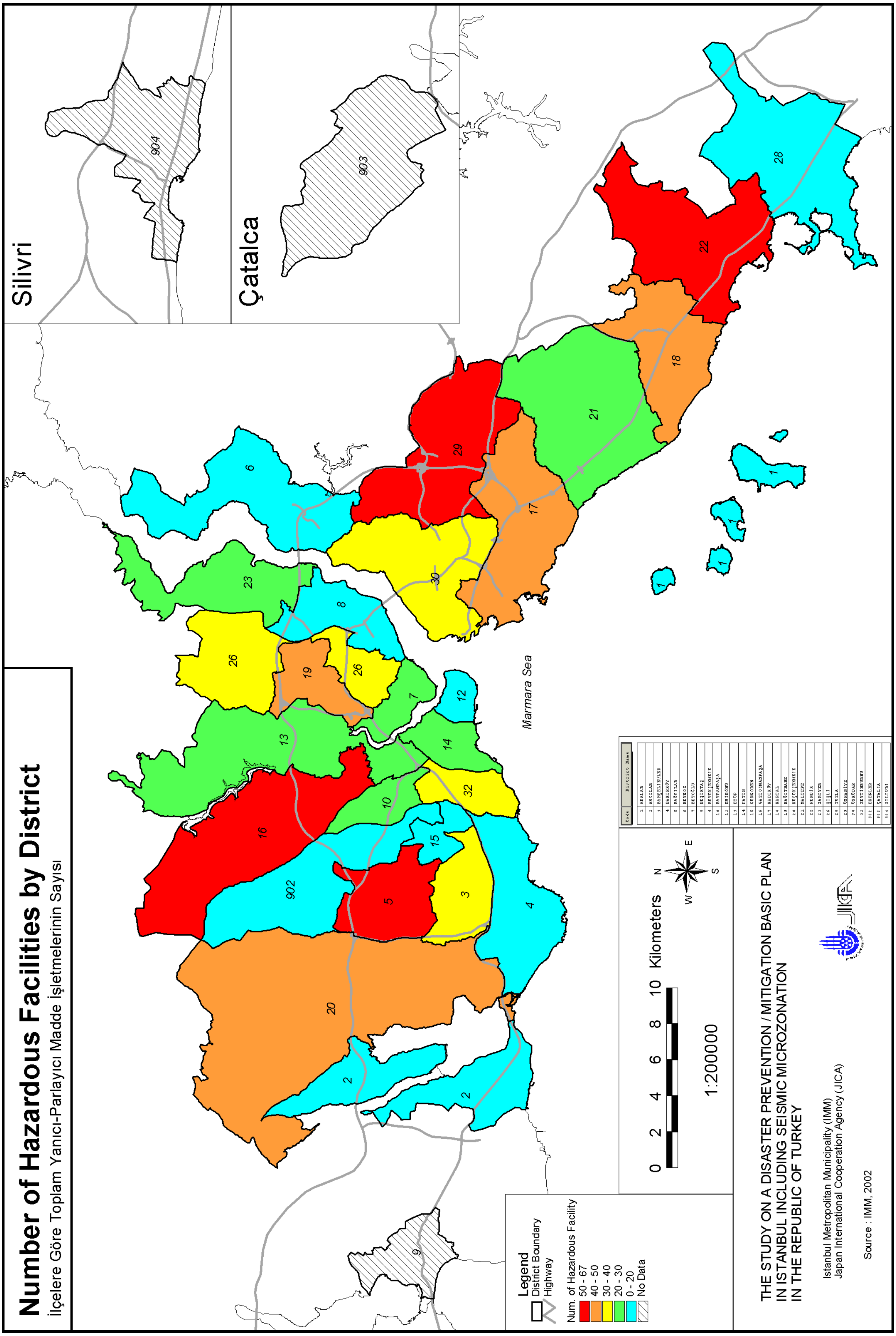


Figure 6.2.39 Number of Hazardous Facilities by District

Chapter 7. Earthquake Analysis

7.1. Scenario Earthquake

From the beginning of the study, many extensive discussions have occurred with relevant institutes/researchers in order to determine the scenario earthquakes. Based on these discussions and the recent amount of research work on the North Anatolian Fault (NAF), the scenario earthquakes were identified so that the appropriate damage estimation is taken into consideration in disaster prevention planning. The location of the NAF, in the Marmara Sea, was determined based on the most recent study result by CNRS-INSU, ITU, TÜBİTAK.

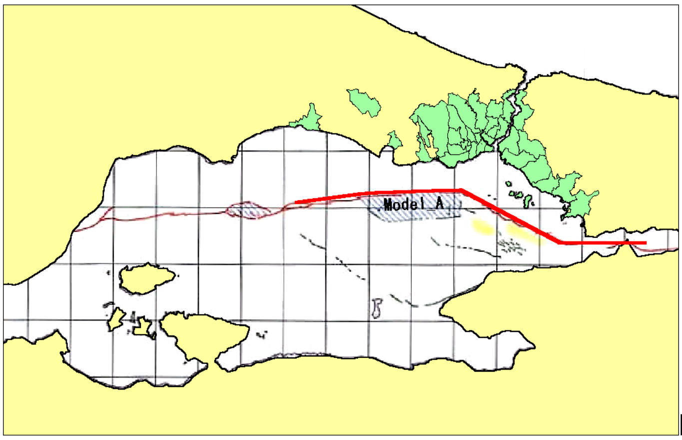
The following the four scenario earthquakes models were determined as show inFigure 7.1.1:

Model A: This section is about 120 km long from west of 1999 Izmit earthquake fault to Silivli. This model is the most probable model of these four scenario earthquakes because the seismic activity is progressing to the west. The moment magnitude (Mw) is assumed to be 7.5.

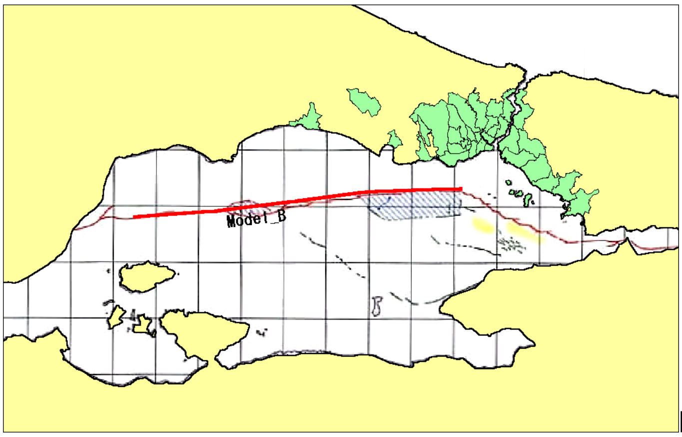
Model B: This section is about 110 km long from the eastern end of 1912 Murefte-Sarkoy earthquake fault to Bakılköy. The moment magnitude is assumed to be 7.4.

Model C: This model supposes a simultaneous break of the entire 170 km section of the NAF in the Marmara Sea. The moment magnitude is assumed to be 7.7. This is the largest magnitude that this area has ever experienced, as the maximum magnitude of historical earthquakes in the Marmara Sea area is 7.6. There is no evidence of a simultaneous break of the entire section in the past, though the eastern one-third did rupture on May 1766 and the rest on August 1766. If a rupture of the maximum length of the faults is assumed, this is the worst case within reason.

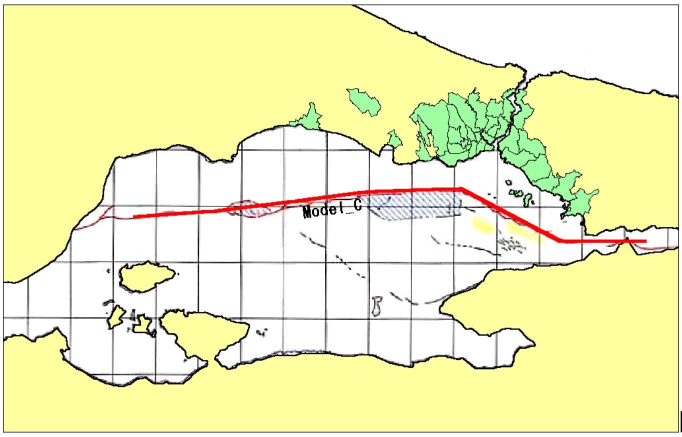
Model D: The continuous fault that was found in the north of the Marmara Sea follows the base of the northern steep slope of the Çinarcık Basin. A normal fault model was developed, which follows the northern slope of the Çinarcık Basin with reference to many recent researched works. The moment magnitude (Mw) was assumed to be 6.9 with the empirical formula for a normal fault.



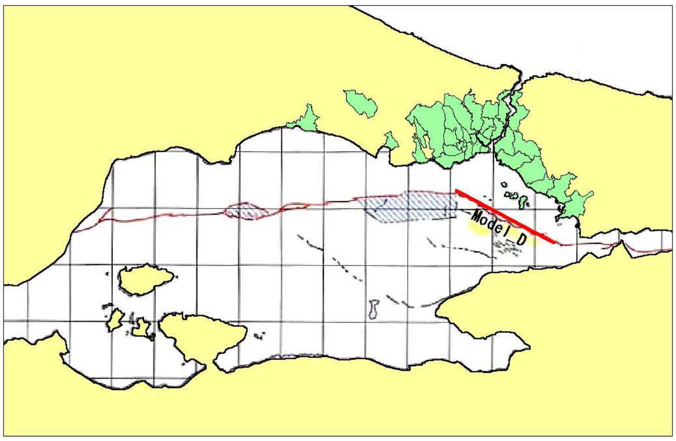
Model A



Model B



Model C



Model D

Figure 7.1.1 Scenario Earthquakes

The fault model scenario earthquake parameters were decided as shown in Table 7.1.1.

Table 7.1.1 Fault Model Parameters

	Model A	Model B	Model C	Model D
Length (km)	119	108	174	37
Moment magnitude (Mw)	7.5	7.4	7.7	6.9
Dip angle (degree)	90	90	90	90
Depth of upper edge (km)	0	0	0	0
Type	Strike-slip	Strike-slip	Strike-slip	Normal fault

7.2. Ground Motion

A flowchart of the earthquake analysis is shown in Figure 7.2.1. Based on the fault model, peak acceleration, peak velocity, and acceleration response spectrum are calculated with the selected empirical attenuation formula. Next, the amplification factor is multiplied to get the peak ground acceleration (PGA), peak ground velocity (PGV), and acceleration response spectrum (Sa) at the ground surface.

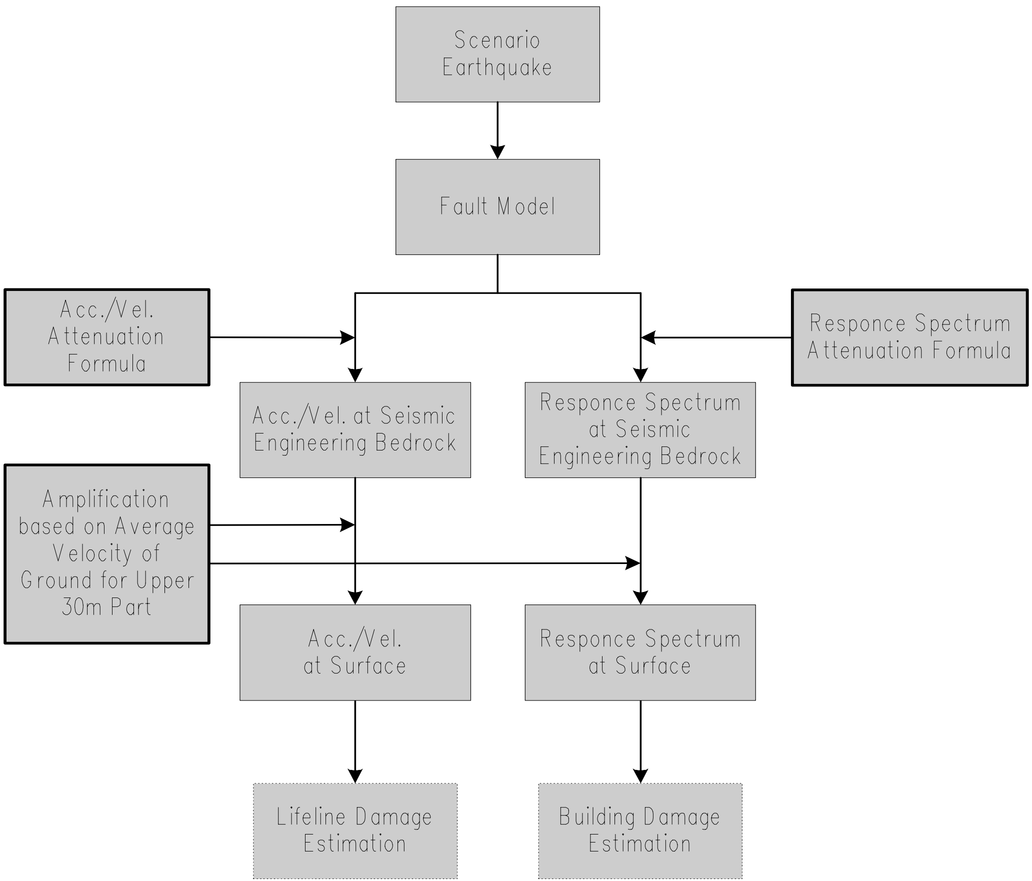


Figure 7.2.1 Flowchart of Earthquake Ground Motion Analysis

7.2.1. Bedrock Motion

Many researchers have proposed different empirical attenuation functions. The selection of the attenuation formula was conducted separately for the acceleration, velocity, and acceleration response spectrum. Formulae that explain the observed data during the August 17, 1999 Izmit Earthquake were selected. This decision was based on similarities between the Izmit Earthquake and the scenario earthquakes: namely, magnitude of the Izmit Earthquake is 7.4 and those of the scenario earthquakes are 6.9 to 7.7. The types of faults of all earthquakes are strike-slip, except that of Model D.

(1) Acceleration

Seven (7) attenuation formulae were studied and the formula by Boore *et al*. (1997) was selected for PGA analysis for Model A, B and C. Spudich *et al*. (1999) is used for Model D, which has a normal fault mechanism.

(2) Velocity

Four (4) attenuation formulae were studied, and the formula by Campbell (1997) was selected for PGV analysis. 200% of the estimated value obtained by this formula was used. For normal fault, there was no adequate attenuation function of PGV. Therefore, the PGV of Scenario Earthquake D could not be estimated.

(3) Acceleration Responce Spectrum (Sa, h=5%)

Four (4) attenuation formulae were studied, and the formula by Boore *et al*. (1997) was selected for the Sa analysis. 130% of estimated value obtained by this formula was used.

7.2.2. Subsurface Amplification

Subsurface amplification was evaluated by an amplification factor assigned to each site class. Classifications ranged from class A to E according to the average S wave velocity over the upper 30 m (AVS30) of the surface soil. This policy is based on the NEHRP (National Earthquake Hazards Reduction Program) “Recommended Provisions for Seismic Regulations for New Buildings and Other Structures,” (1997 edition, FEMA-302, 303; BSSC, 1997. This method takes the difference of ground class into consideration, as well as that of nonlinear effects during strong motion.

The amplification factor of acceleration response spectrum was defined at 0.2 seconds and 1.0 seconds. The amplification factor of site class B (760m/s < AVS30 ≤ 1500 m/s) was defined to be 1.0 at the seismic engineering bedrock.

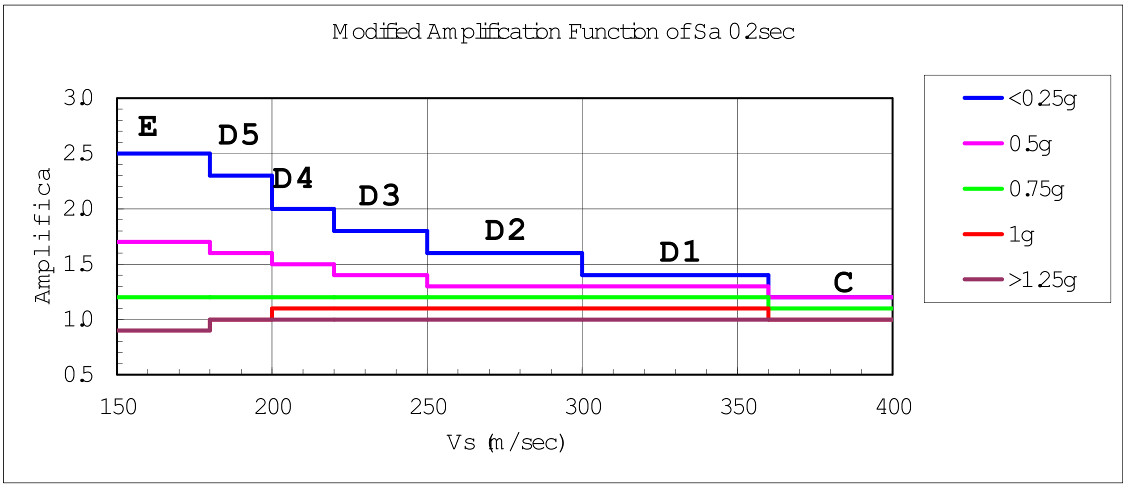
The difference between amplification factors of site class D and E was large. Therefore, in this study, site class D was divided into 5 sub-classes (D1 to D5). If enough data to decide on the subclasses was not available, the single site class D was used. Site classification and amplification factors are shown in Table 7.2.1 and Figure 7.2.2, respectively. The amplification of PGA and PGV were assumed to be identical to the amplification of Sa (h = 5%) at 0.2 seconds and Sa (h = 5%) at 1.0 seconds, respectively, according to Wald *et al.* (1999).

Table 7.2.1 Site Classification Applied in the Study

Site Class	Average S Wave Velocity Over Upper 30m
A	>1500m/sec
B	760 - 1500m/sec
C	360 - 760m/sec
D	180 - 360m/sec
D1	300 - 360m/sec
D2	250 - 300m/sec
D3	220 - 250m/sec
D4	200 - 220m/sec
D5	180 - 200m/sec
E	<180m/sec

Source: NEHRP

Note: AVS30 = Average S wave Velocity over the upper 30 m



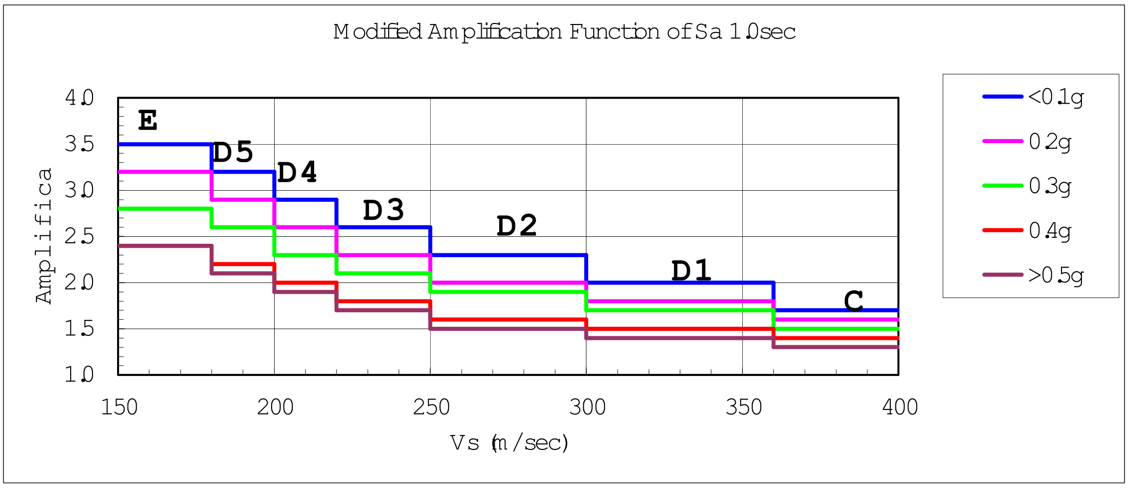


Figure 7.2.2 Modified Amplification Function

7.2.3. Ground Model

A square grid system of 500 m by 500 m dimensions was adopted for the ground motion calculation. Geological models were defined for each grid using geological maps, geological cross-sections, boring logs, and shear wave velocities. The ground modeling flowchart is shown in Figure 7.2.3.

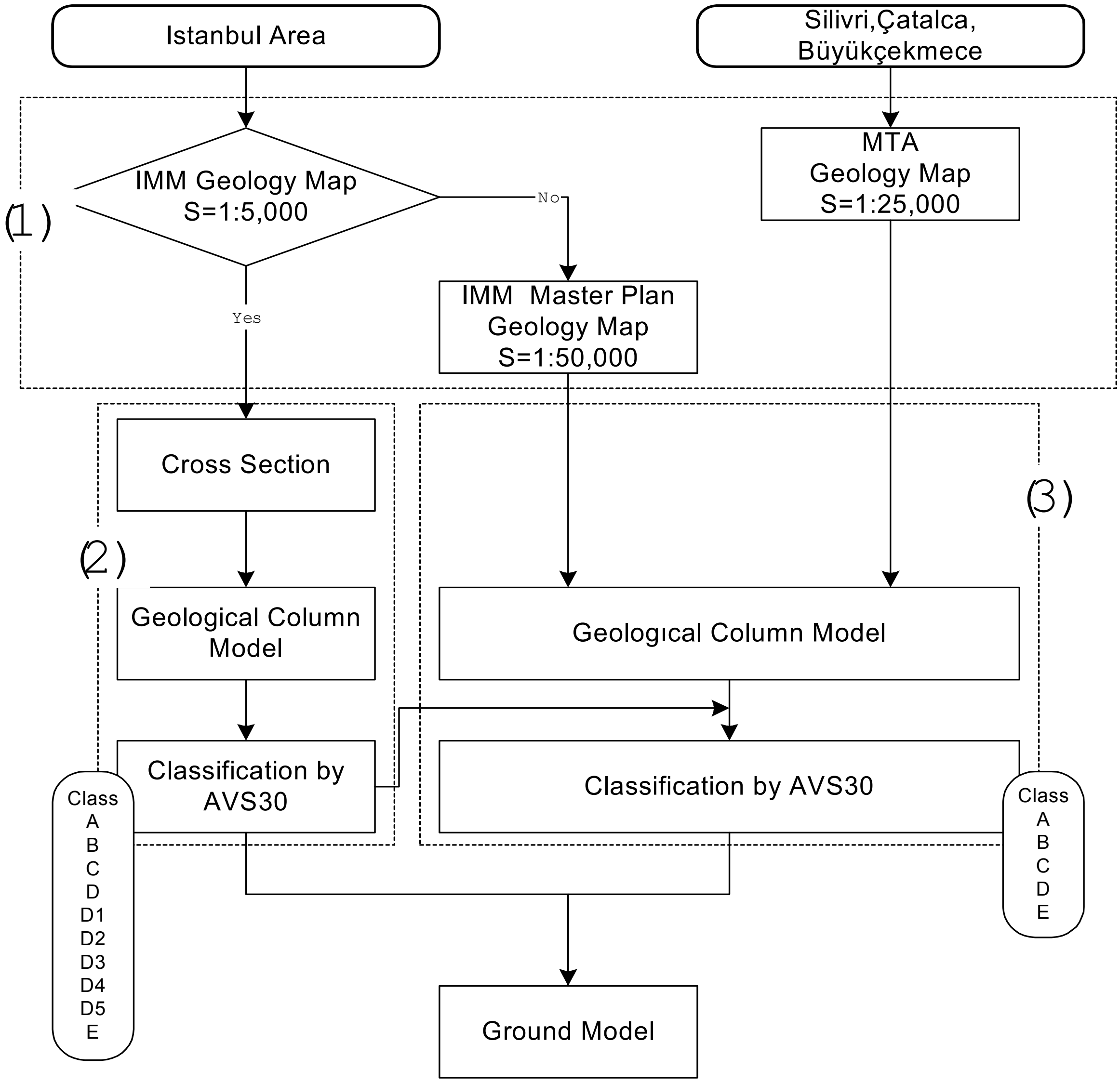


Figure 7.2.3 Flowchart of Ground Classification

Geological cross sections were prepared at1 km interval in areas for which 1:5000 geological maps were available. Geological models of the upper 30 meters of each 500 m grid were compiled. In other areas, only surface geology was used.

Shear wave velocities were measured comprehensively by suspension PS logging. Ground shear wave velocities for every 1 m-pitch of the boreholes were directly correlated to most of the geological units in the Study Area. Shear wave velocities for each geological unit were examined statistically in detail, considering 1) correlation to standard penetration test N value and 2) variation by measured depth or elevation. Determined shear wave velocities for each geological formation are tabulated in Table 7.2.2.

Table 7.2.2 Shear Wave Velocity of Geological Formation Applied in Earthquake Analysis

Geological Formation and sub-category			Average Shear Wave Velocity (m/sec)	Applied Shear Wave Velocity (m/sec)
Yd/Sd			280	150
Qal			240	220
Kşf			190	150
Ym			-	150
Baf	All data		430	-
	105m < Elevation		260	260
	51m < Elevation < 105m		470	470
	7m < Elevation < 51m		330	330
	Elevation <7m		600	600
Gnf	All data		340	-
	0m < Depth < 15m		260	260
	15m < Depth		360	360
Çf/Sbf			410	410
Çmlf			460	460
Güf	All data		440	-
	West of Küçükçekmece Gölü	All data	380	-
		-76m <Elevation	330	330
		-131m < Elevation < -76m	410	410
		Elevation < -131m	550	550
	East of Küçükçekmece Gölü	All data	480	-
		60m < Elevation	300	300
		-10m < Elevation < 60m	600	600
		-45m < Elevation < -10m	390	390
		Elevation < -45m	510	510
Cef			-	850
Sf			850	850
Trf			1310	1310
Kf			1360	1310
Df			2620	1310
Other Rock formations			-	1310

Using these values, average shear wave velocities of the upper 30 m of every 500 m grid model are calculated. Ground classification of each grid model was determined according to Table 7.2.1. In the area where 1:5,000 geological maps were not available, the classification shown in Table 7.2.3 was adopted. The compiled ground classification map is shown in Figure 7.2.4.

Table 7.2.3 Site Class Definition for Areas of IMM 1:50,000 Geological Maps and MTA 25,000 Geological Maps

Surface Geology	Site Class
Alluvium deposit layer	D
Tertiary layer	C
Rock formation	B

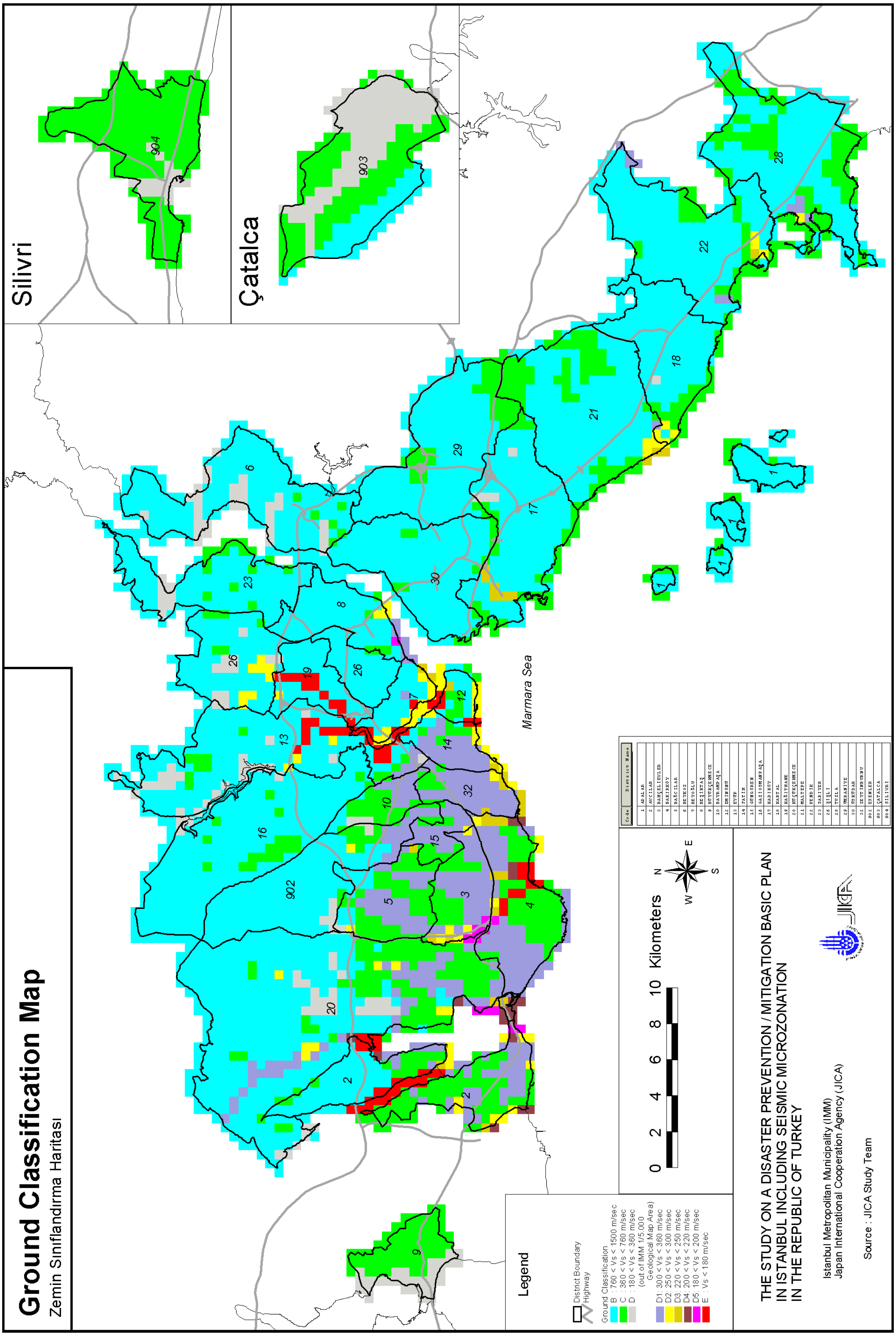


Figure 7.2.4 Ground Classification Map

7.2.4. Ground Motion by Scenario Earthquakes

(1) Peak Ground Acceleration (PGA)

The PGA distribution maps are shown in Figure 7.2.5 to Figure 7.2.8.

a. Model A

Acceleration exceeds over 400 gals on the seashore of the European side and in Adalar. The valley following north from Haliç also experiences accelerations of over 400 gals. Acceleration in Eminönü to Büyükçekmece ranges from 300 to 400 gals. In the majority of areas of the New City, Çatalca, and Silivri, acceleration ranges from 200 to 300 gals. The Asian side suffers less than 300 gals, except for the seaside areas.

b. Model B

The PGA distribution of the European side is similar to Model A. The majority of the Asian side area experiences accelerations of less than 200 gals, except Adalar, Kadıköy, and Üsküdar.

c. Model C

The seaside area of Bakırköy and part of Adalar experience accelerations of more than 500 gals. Accelerations of over 400 gals are estimated in Tuzla, Fatih to Avcılar, and the valley extending to the north from Haliç. The area with accelerations of 400 to 500 gals is a little wider to the north, compared to Model A. Every grid in this model experiences the largest observed PGA of the four scenario earthquakes.

d. Model D

A part of Adalar and Bakırköy experience accelerations of over 400gals. Bakırköy and part of Tuzla experience accelerations of 300 to 400 gals. Accelerations of 200 to 300 gals are experienced from Eminönü to Avcılar and on the Asian seashore.

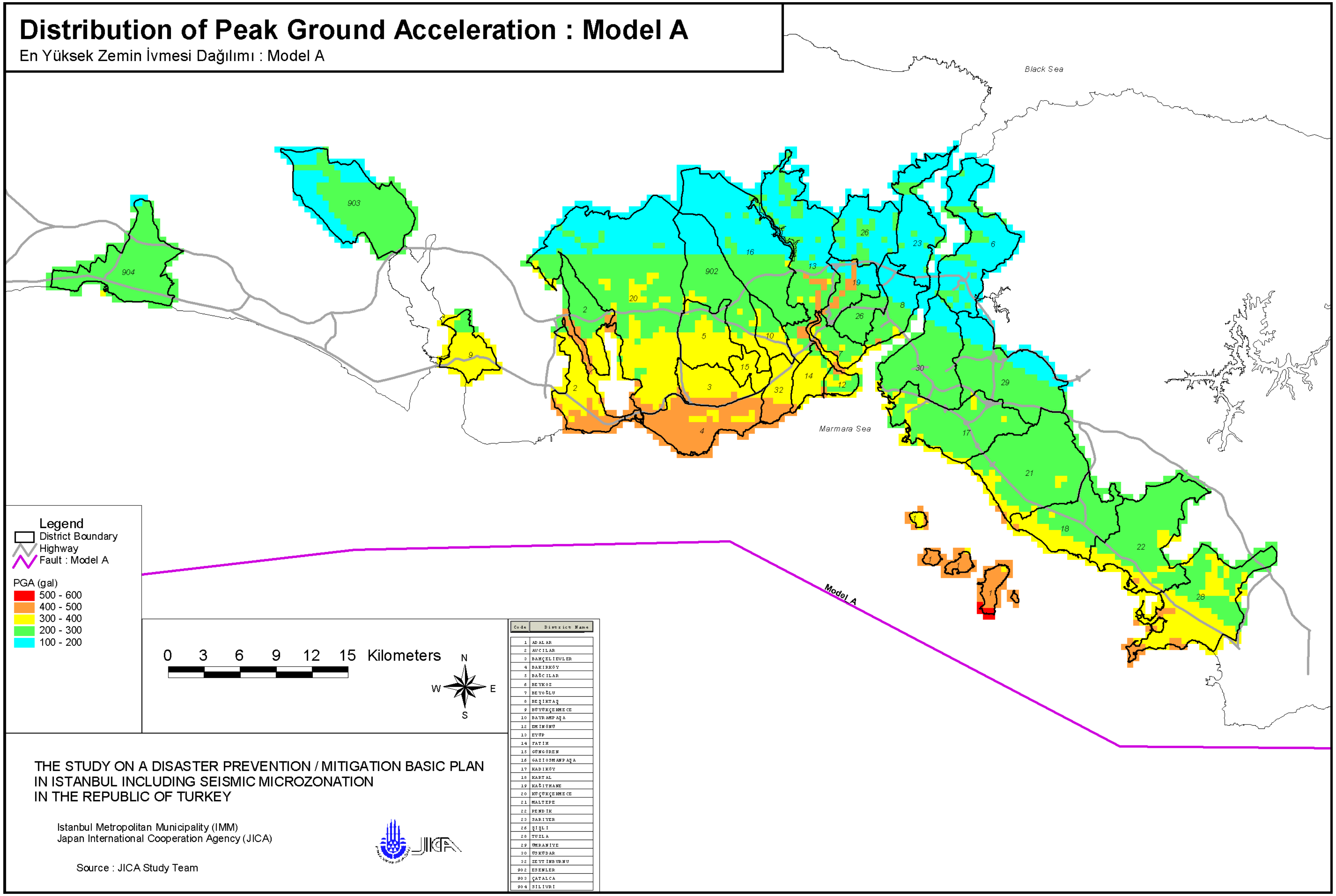


Figure 7.2.5 Distribution of Peak Ground Acceleration: Model A

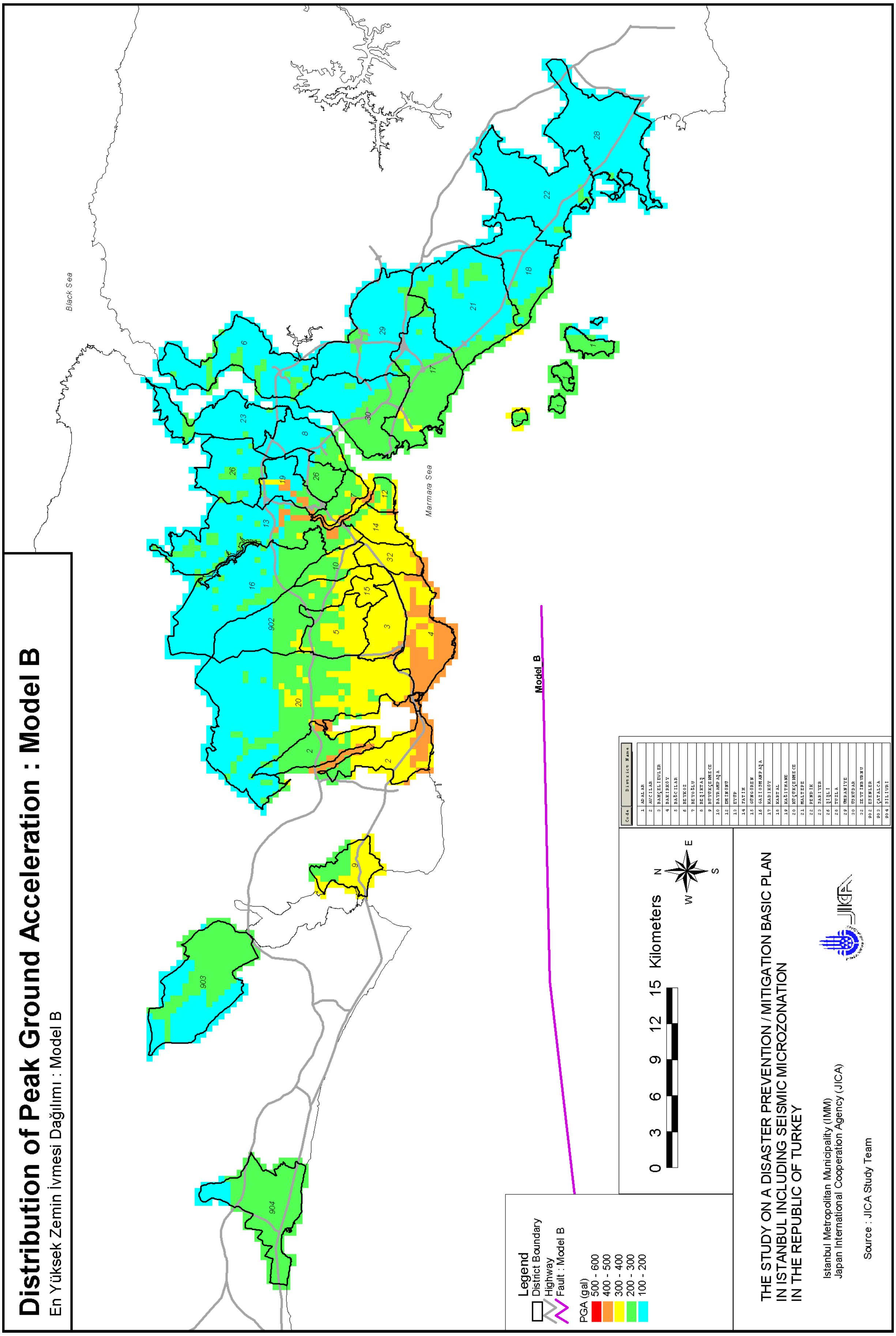


Figure 7.2.6 Distribution of Peak Ground Acceleration: Model B

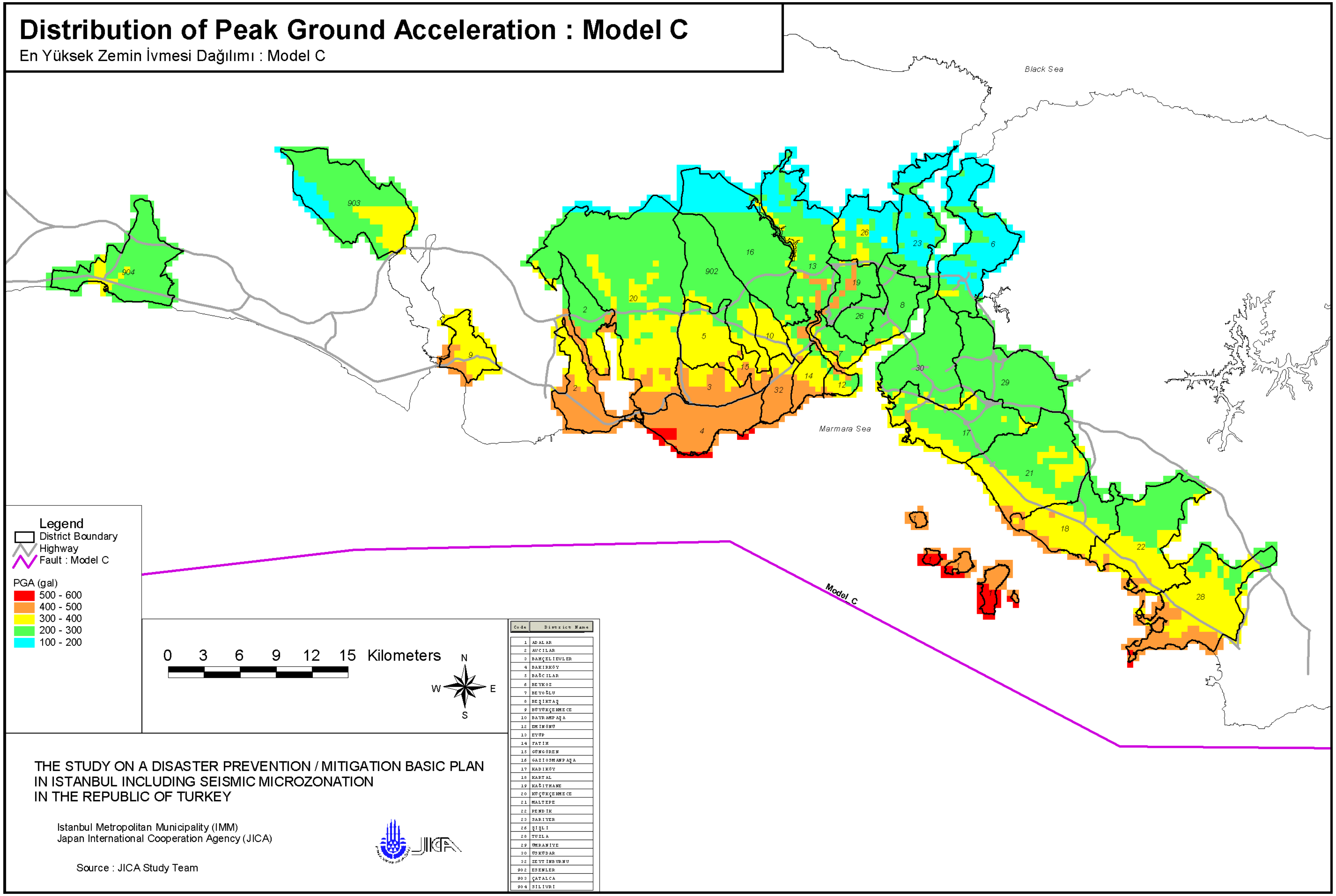


Figure 7.2.7 Distribution of Peak Ground Acceleration: Model C

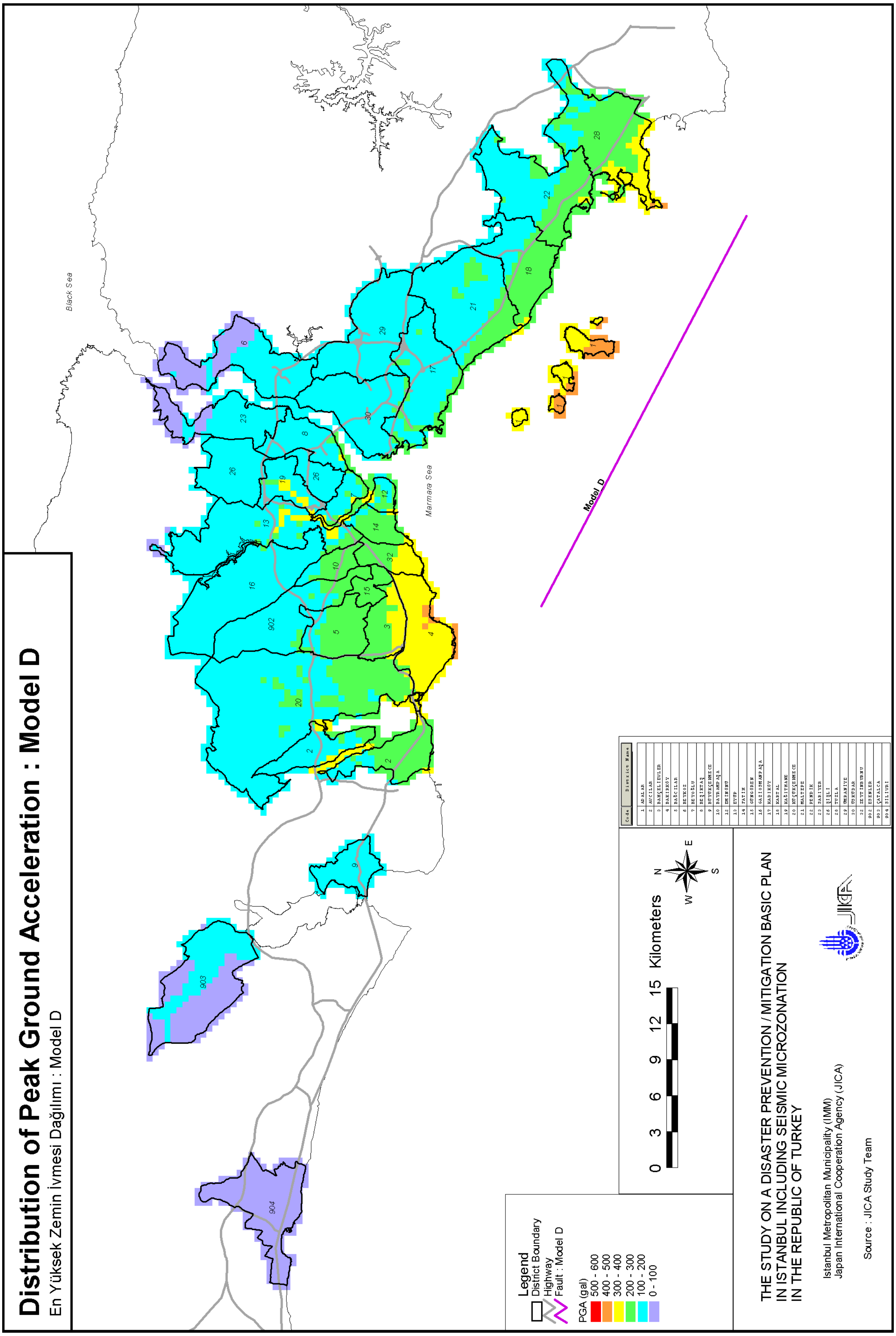


Figure 7.2.8 Distribution of Peak Ground Acceleration: Model D

(2) Peak Ground Velocity (PGV)

The PGV distribution maps are shown in Figure 7.2.9 to Figure 7.2.11. PGV of Model D was not estimated because an adequate attenuation function was not available for the normal fault.

Ground conditions (grid class site) influence PGV distribution more than they do PGA distribution. This difference is explained as follows:

- Short period, seismic motion components more strongly reflect PGA values, and long period seismic motion components more strongly reflect PGV values.
- The short period seismic motion is strongly affected by the non-linearity effect of soil because the scenario earthquake is large.
- The long period seismic motion (PGV) is not affected very much.

a. Model A

Grid classes D4, D5, and E on the European side experience velocities of over 80 kine. Grid classes D1, D2, and D3 in Fatih, Bayrampaşa, Bağcılar, Avcılar, and the southern districts on the European side experience velocities of 60 to 80 kine. The class C grid on the Asian seashore experience velocities of 40 to 60 kine.

b. Model B

The PGV distribution on the European side of Model B is somewhat similar to Model A. The majority of the Asian side, except the seaside from Maltepe to Tuzla and along the valley, experience velocities of less than 40 kine.

c. Model C

The area that experiences velocities of 40 kine is wider than that of Model A on the Asian side.

Every grid experiences the largest PGV among the three scenario earthquakes.

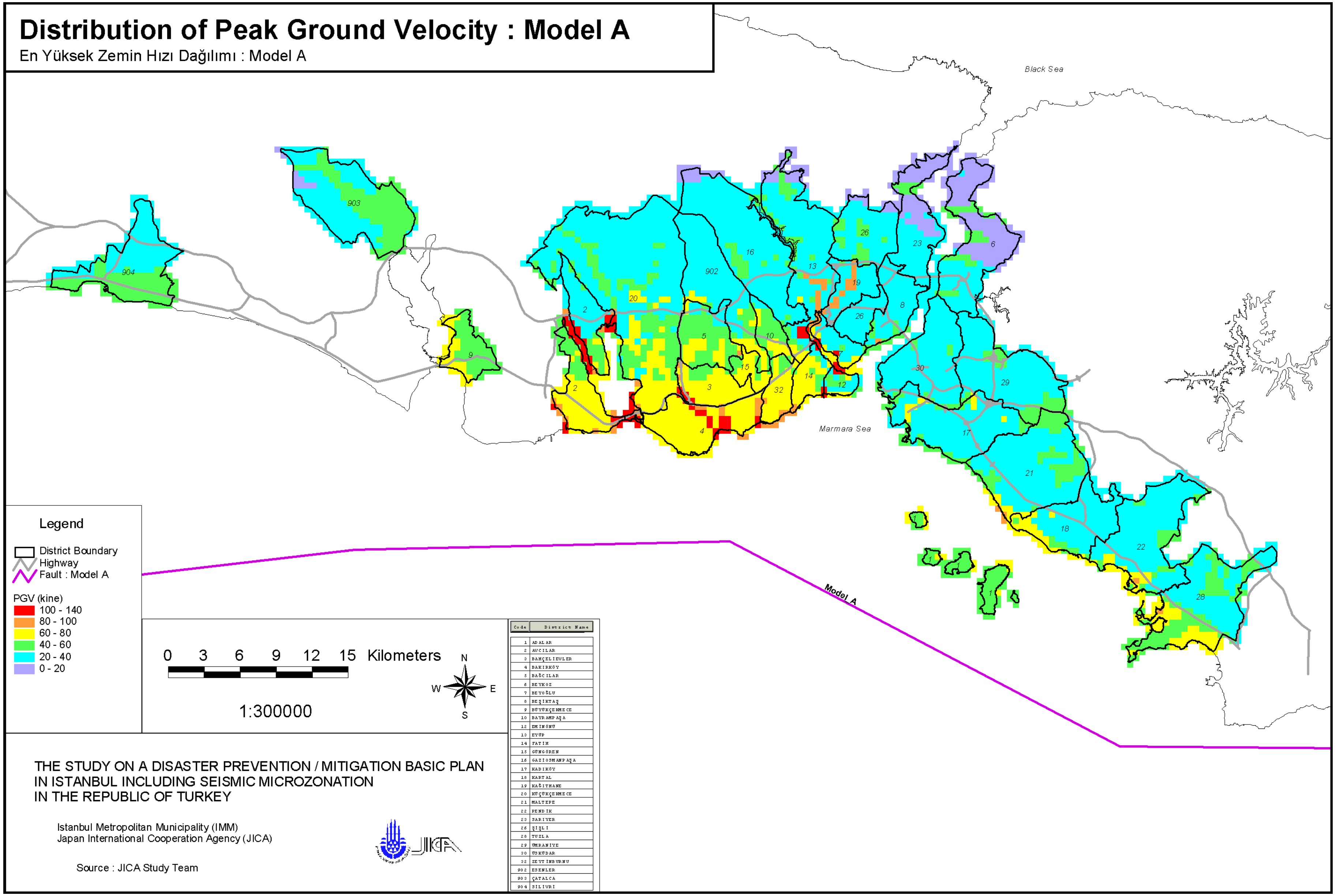


Figure 7.2.9 Distribution of Peak Ground Velocity: Model A

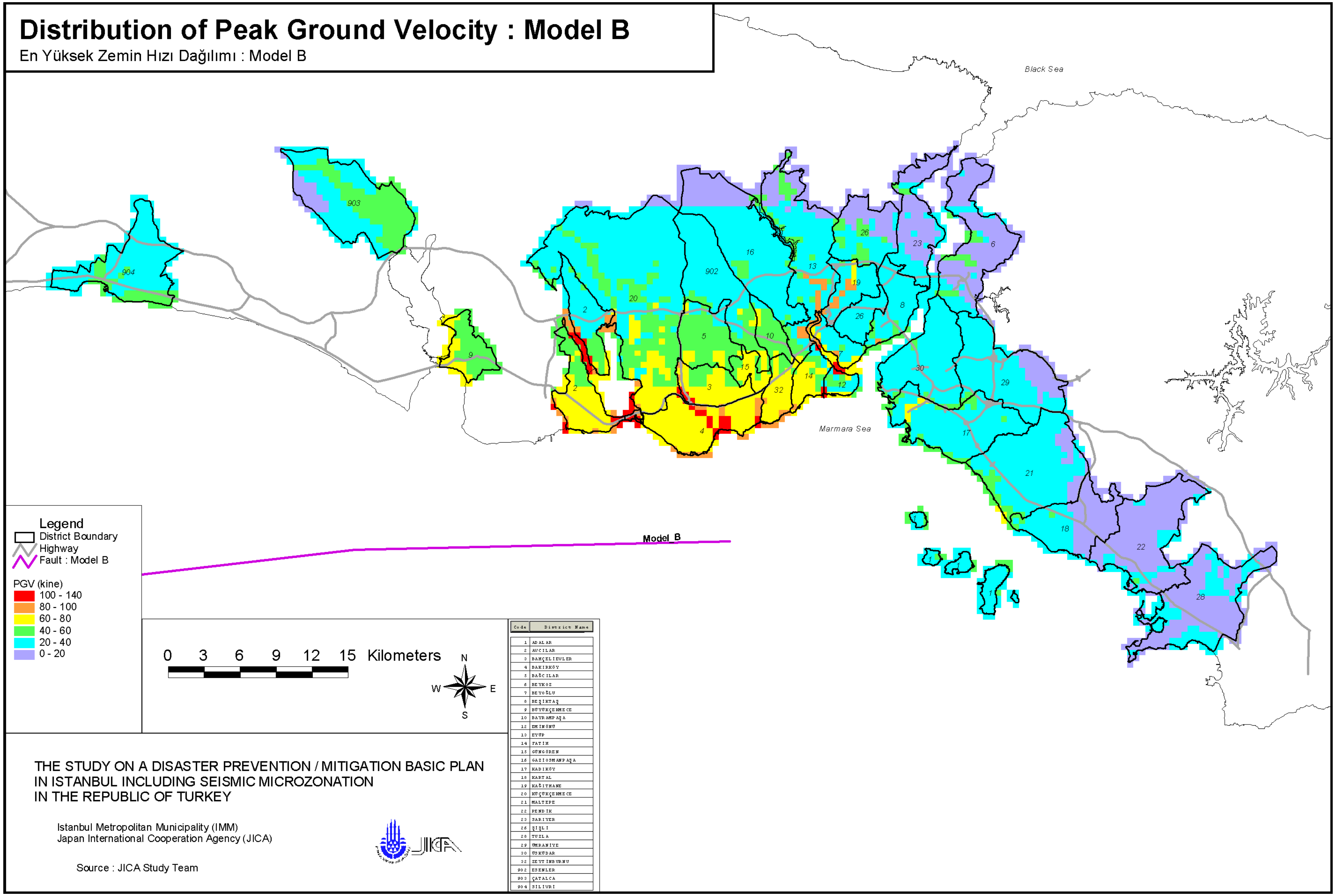


Figure 7.2.10 Distribution of Peak Ground Velocity: Model B

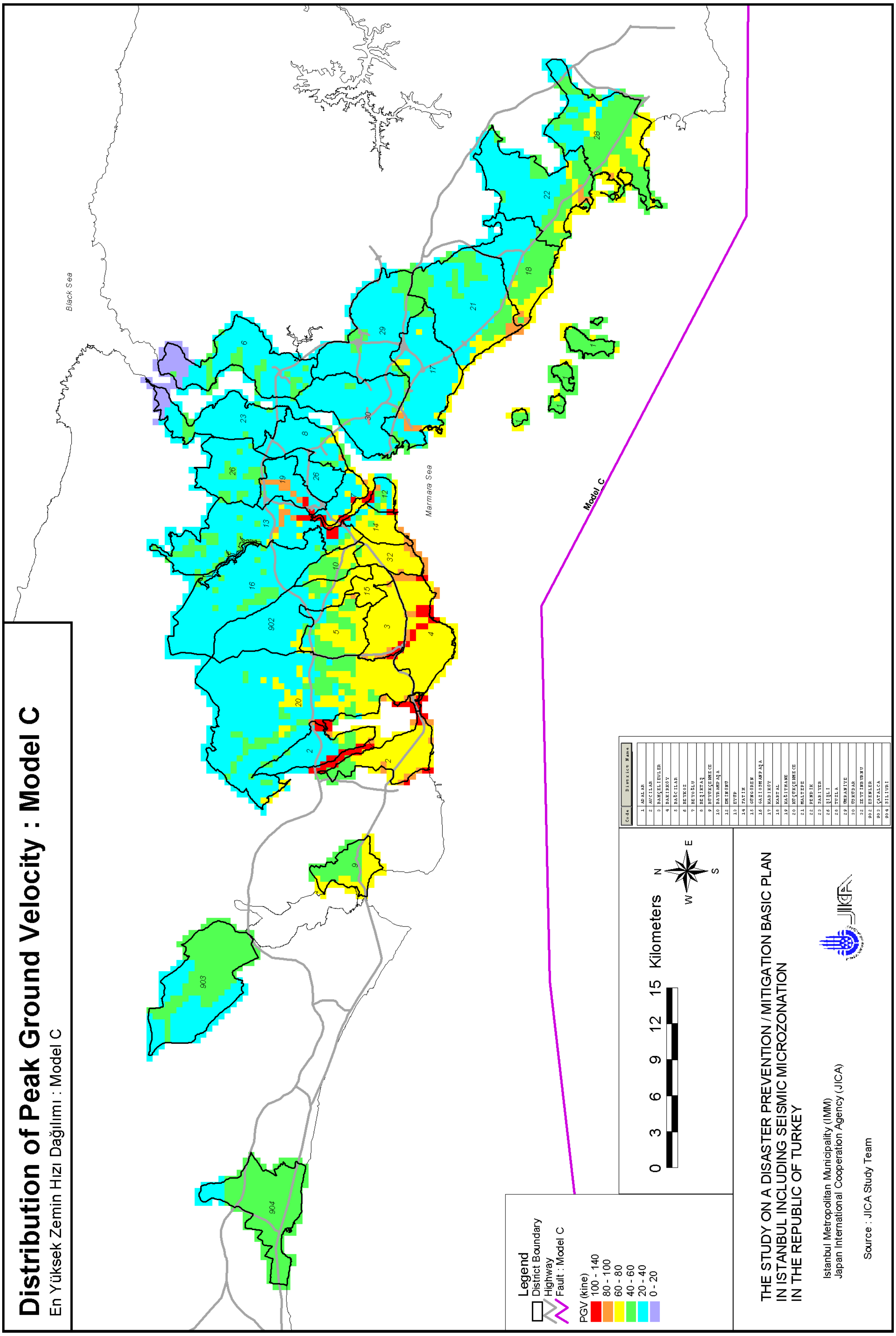


Figure 7.2.11 Distribution of Peak Ground Velocity: Model C

(3) Acceleration Response Spectrum (Sa, h=5%)

The 5% damped Sa values for the period of 0.1 to 2.0 seconds were calculated. The distribution maps of Sa at 0.2 sec and 1.0 sec are shown in Figure 7.2.12 to Figure 7.2.19.

a. Model A

0.2 sec: Sa values of 500 to 1000 gals are experienced from Eminönü to Büyükçekmece on the European side and on the seaside of the Asian side. Other areas experience 200 to 500 gals.

1.0 sec: Grid classes D and E at the seaside of Bakırköy experience over 500 gal. Eminönü to Büyükçekmece and the Asian seashore experience 200 to 500 gals.

b. Model B

The Sa distribution of the European side for Model B is similar to that for Model A. Almost the entire area on the Asian side experiences accelerations of 200 to 500 gals at 0.2 sec, and less than 200 gals at 1.0 sec.

c. Model C

0.2 sec: The Sa distribution for Model C is very similar to that of Model A.

1.0 sec: Almost all of Bakırköy experiences accelerations of over 500 gals, and the area with 200 to 500 gals is wider than that of Model A.

d. Model D

0.2 sec: The Sa distribution of Model D on the European side is similar to Model A. The majority of the Asian side experiences accelerations of 200 to 500 gals, except for the seaside.

1.0 sec: A part of Bakılköy experiences accelerations of over 500 gals. Bahçelievler and the southern district of the European side and seashore of the Asian side experience 200 to 500 gals. The majority of the study areas suffer less than 200 gals.

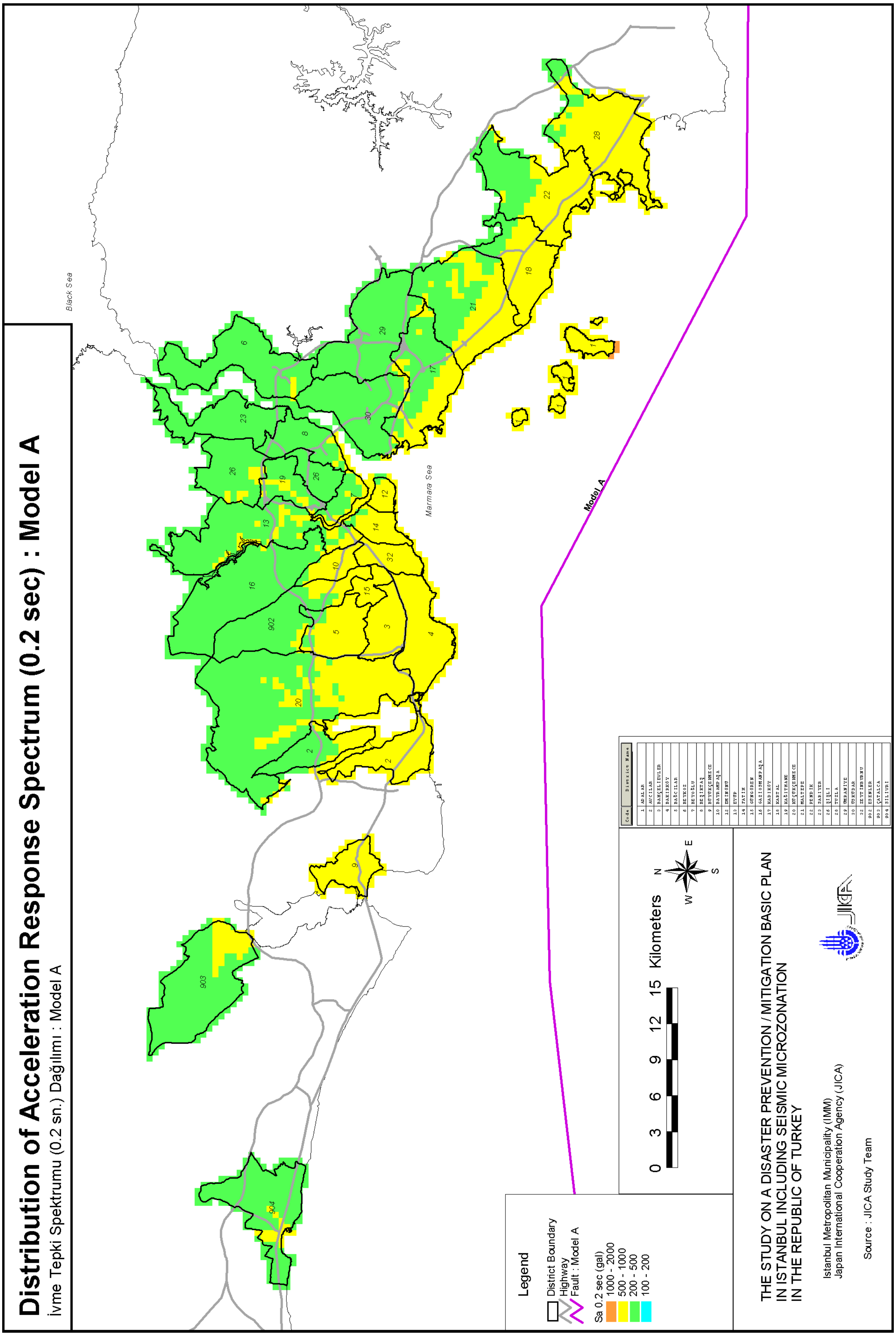


Figure 7.2.12 Distribution of Acceleration Response Spectrum (0.2 sec): Model A

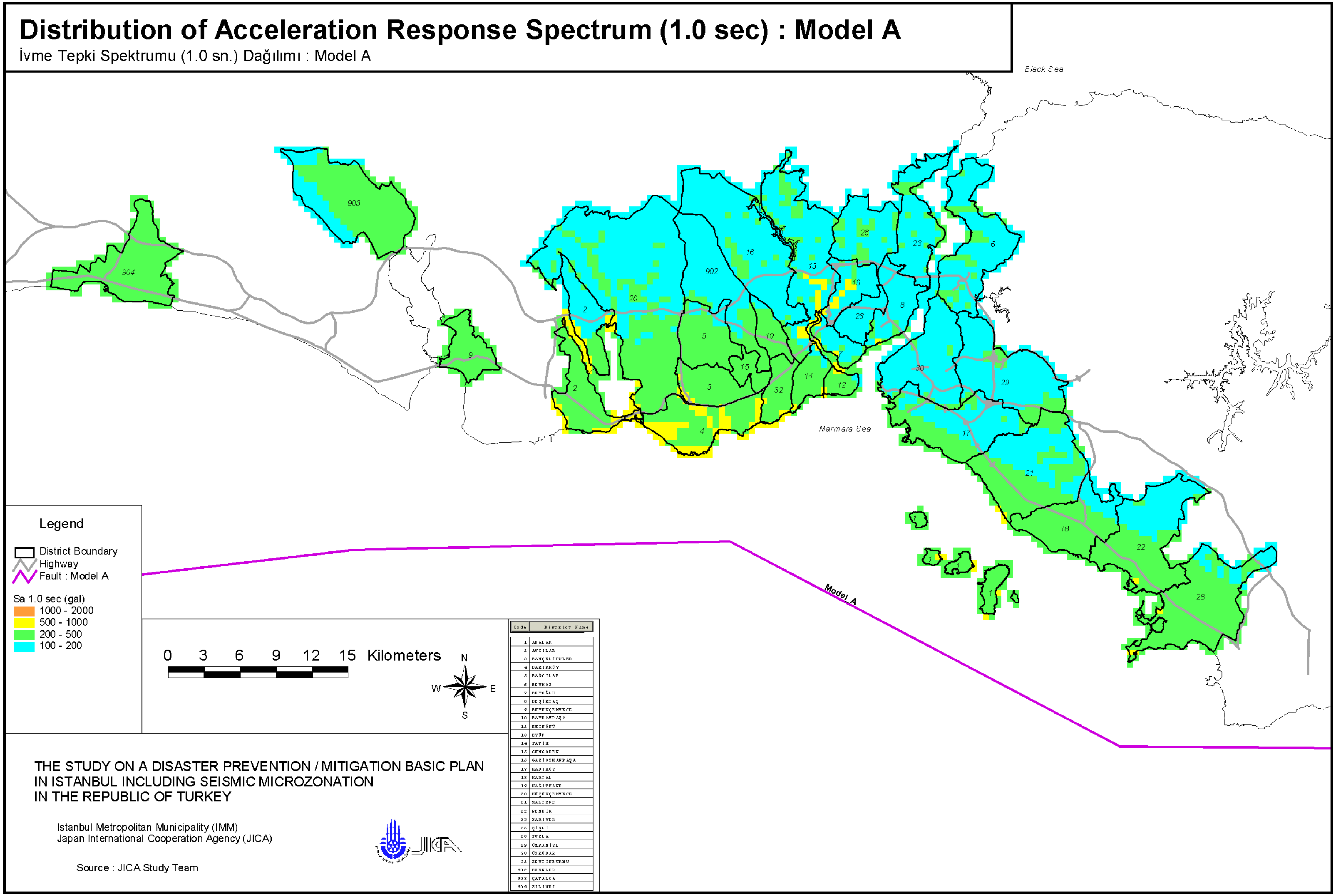


Figure 7.2.13 Distribution of Acceleration Response Spectrum (1.0 sec): Model A

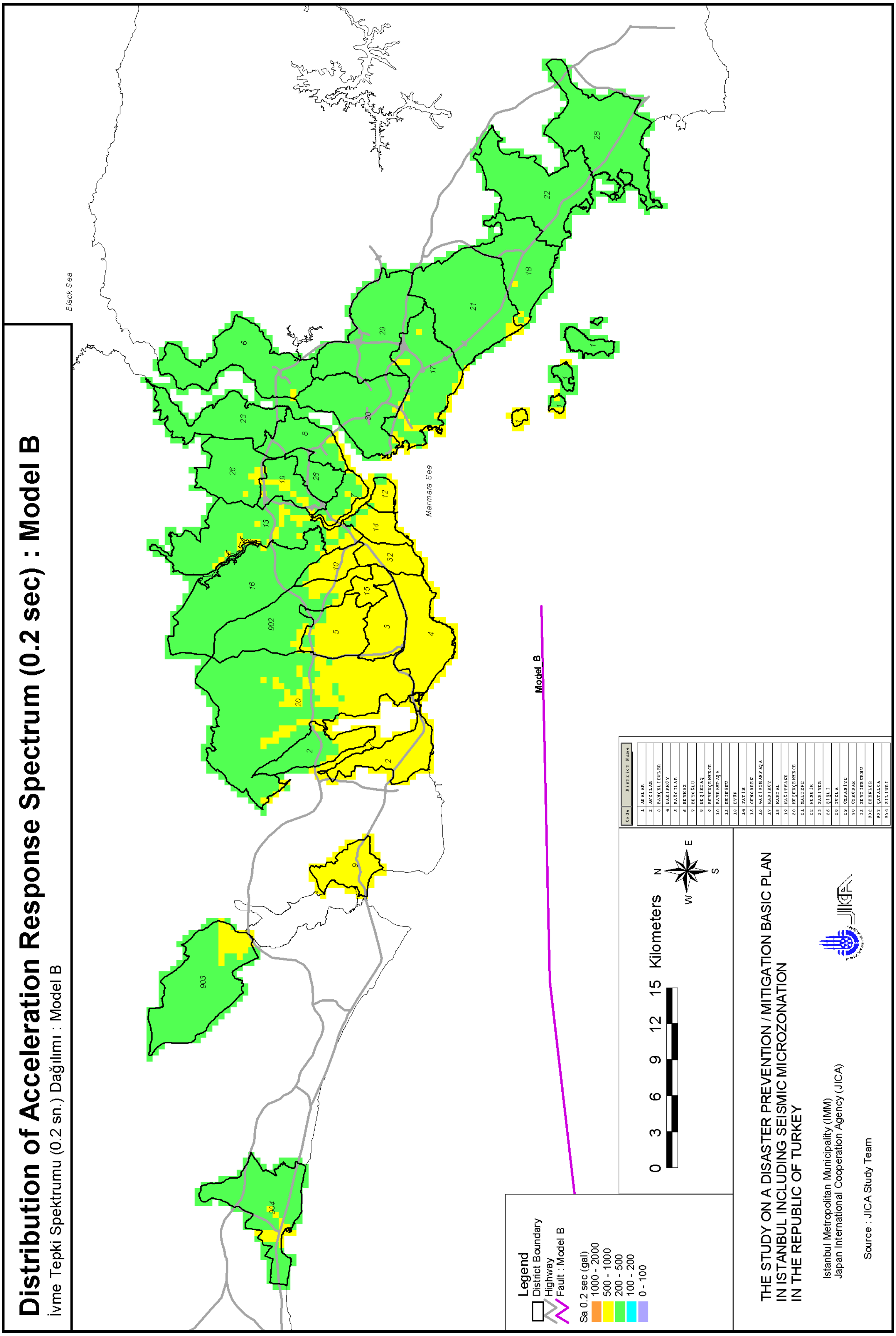


Figure 7.2.14 Distribution of Acceleration Response Spectrum (0.2 sec): Model B

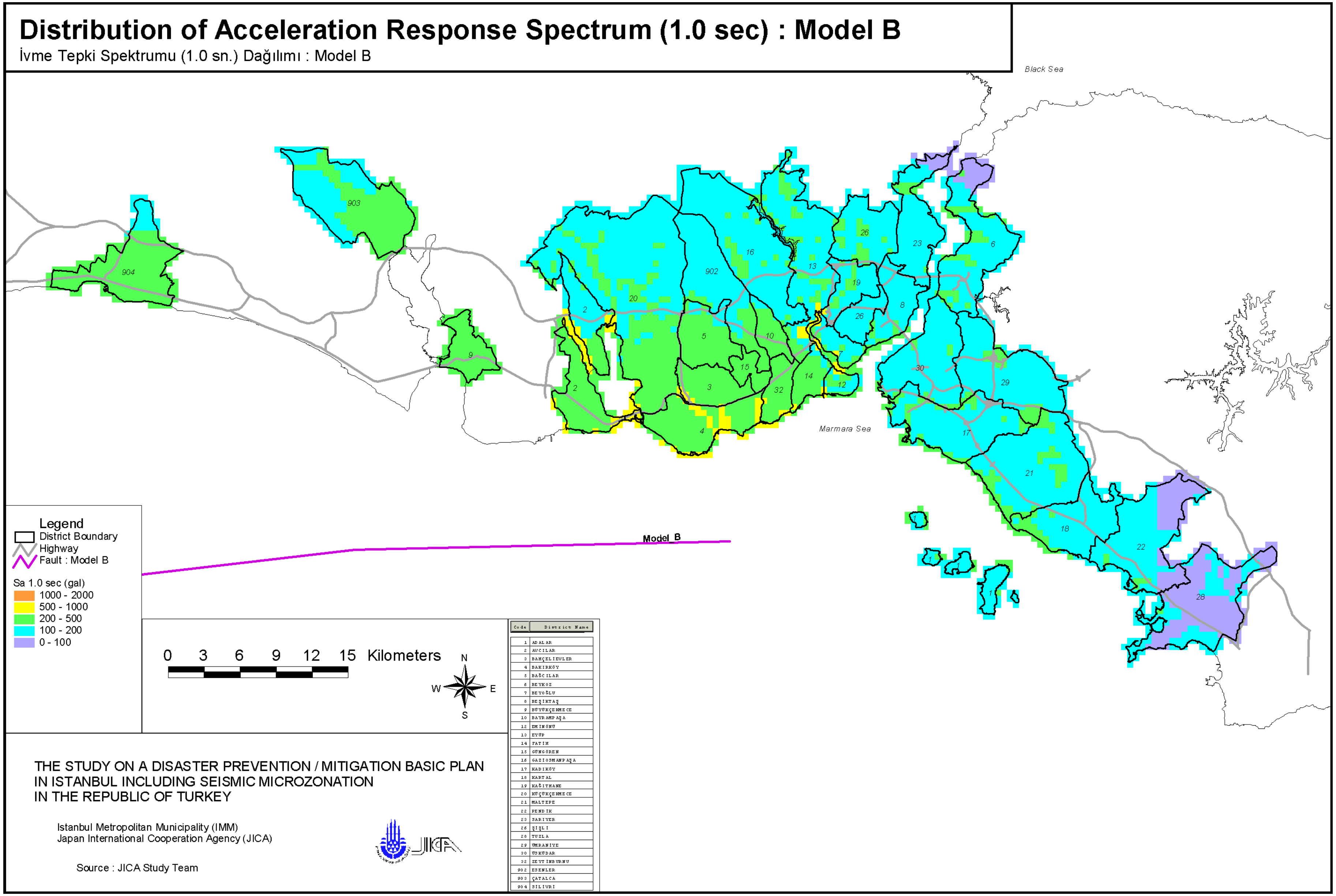


Figure 7.2.15 Distribution of Acceleration Response Spectrum (1.0 sec): Model B

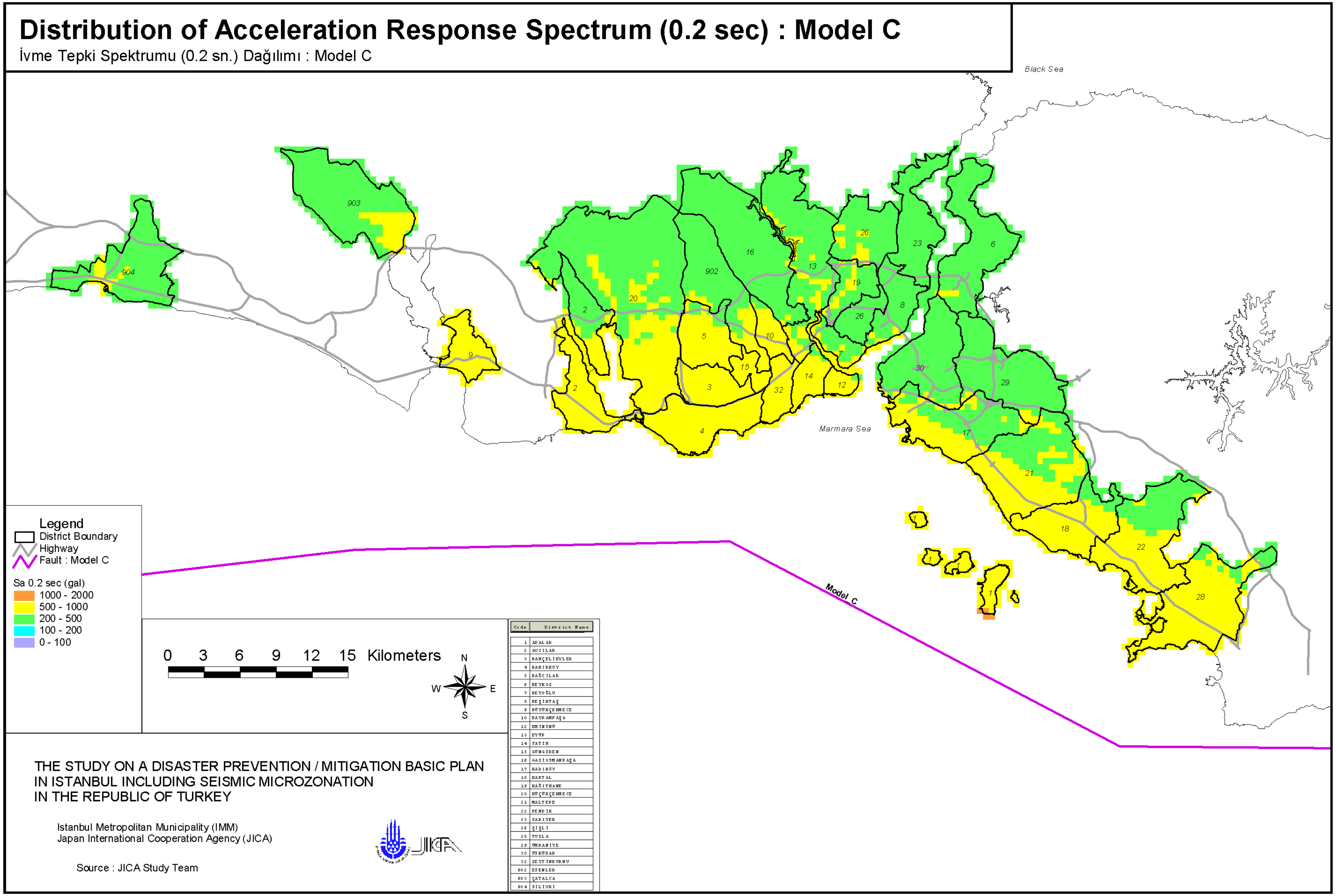
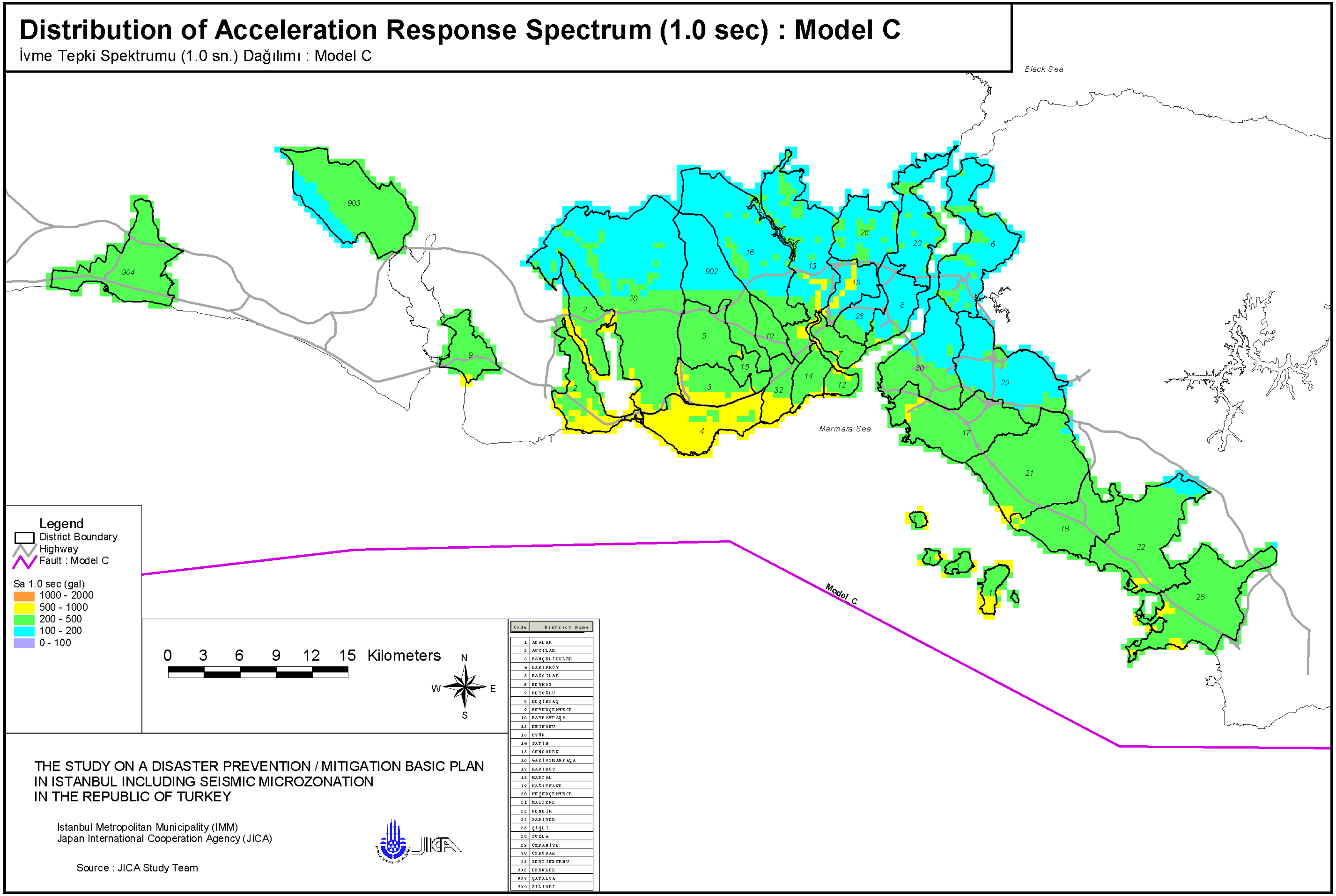


Figure 7.2.16 Distribution of Acceleration Response Spectrum (0.2 sec): Model C



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 7.2.17 Distribution of Acceleration Response Spectrum (1.0 sec): Model C

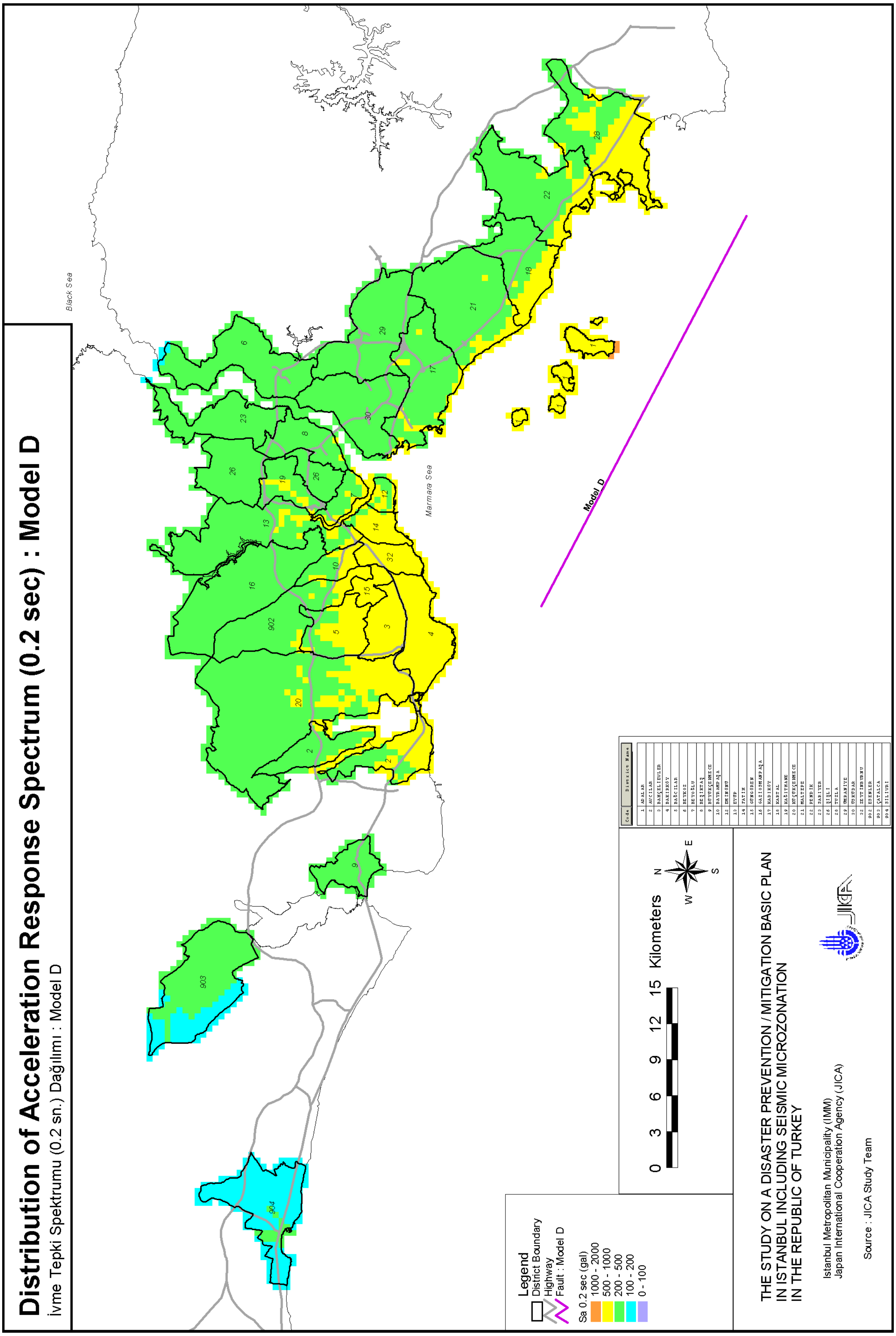
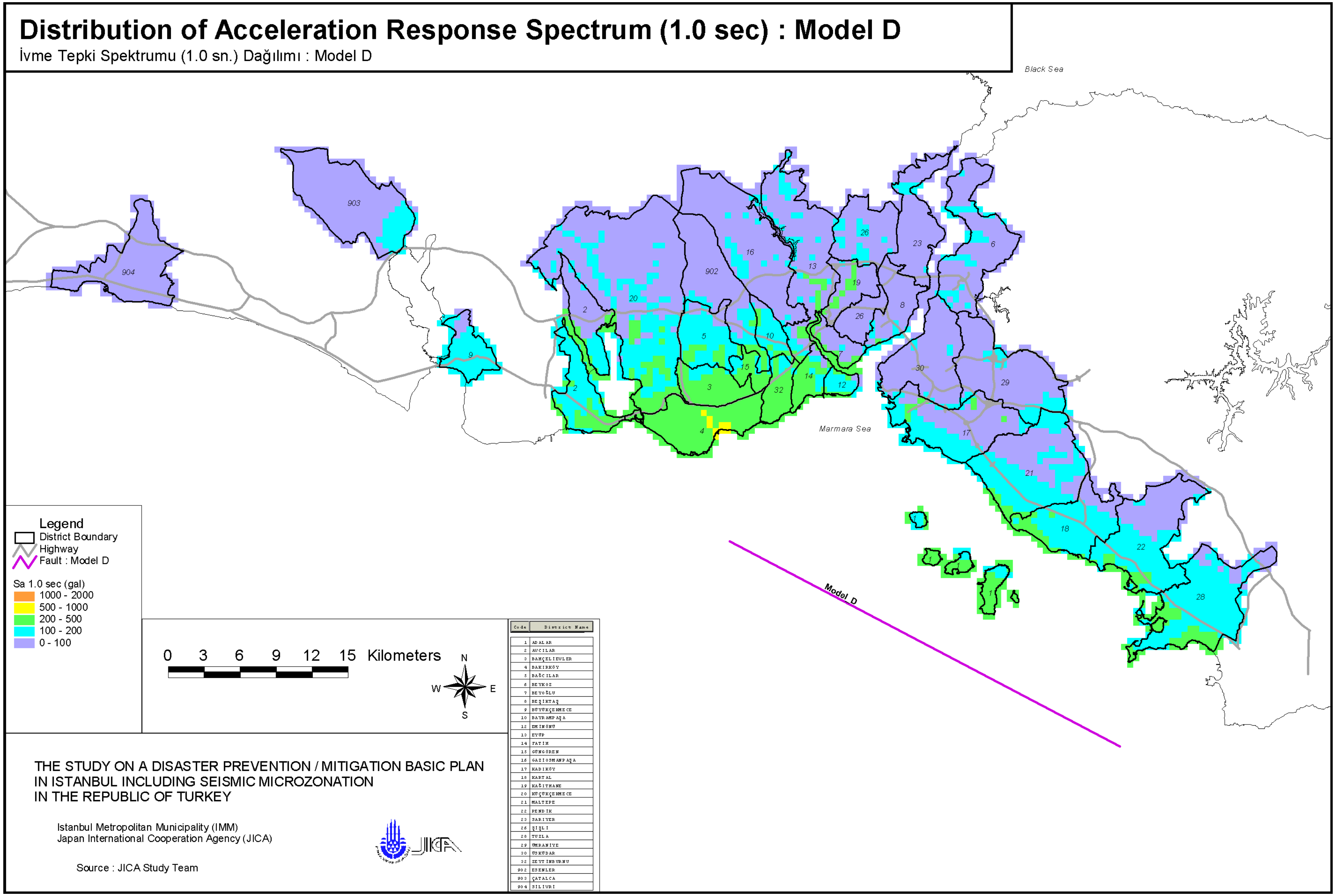


Figure 7.2.18 Distribution of Acceleration Response Spectrum (0.2 sec): Model D



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 7.2.19 Distribution of Acceleration Response Spectrum (1.0 sec): Model D

Acknowledgements

The earthquake analysis in this chapter was conducted under close discussions with Prof. Dr. Mustafa Erdik and researchers in the Department of Earthquake Engineering, KOERI (NOTE: write out acronym for KOERI). This is especially true of the method of subsurface amplification calculation, which is based on their suggestions. The Study Team expresses special thanks for their collaboration on the Study.

References for Section 7.2

Boore K.M., W.B. Joyner and T.E. Fumal, 1997, Equations for Estimating Horizontal Response Spectra and Peak Acceleration from Western North American Earthquakes: A Summary of Recent Work, Seism. Res. Lett., Vol. 68, No. 1, 128-153.

BSSC, 1997, NEHRP Provisions for Seismic Regulations for New Buildings and Other Structures 1997 Edition, Part 1: Provisions, FEMA 302, Federal Management Agency.

Campbell, K.W., 1997, Empirical Near-Source Attenuation Relationships for Horizontal and Vertical Components of Peak Ground Acceleration, Peak Ground Velocity, and Pseydo-Absolute Acceleration Response Spectra, Seism. Res. Lett., Vol. 68, No.1, 154-179.

Spudich, P., W.B. Joyner, A.G. Lindh, D.M. Boore, B.M. Magraris and J.B. Fletcher, 1999, SEA99: A Revised Ground Motion Prediction Relation for Use in Extensional Tectonic Regimes, Bull. Seism. Soc. Am., Vol. 89, No. 5.

Wald, D.J., V. Quitoriano, T.H. Heaton, H. Kanamori, C.W. Scrivner and C.B. Worden, 1999, TriNet "ShakeMaps": Rapid Generation of Peak Ground Motion and Intensity Maps for Earthquakes in Southern California, Earthquake Spectra, Vol. 15, No. 3, 537-555.

7.3. Evaluation of Liquefaction Potential

7.3.1. General

An evaluation of liquefaction potential is conducted in order to provide an overview of the distribution liquefaction potential over the area and its regional characteristics in the Study Area.

The following three grades are indicated as the liquefaction potential estimation in the "Manual for Zonation on Seismic Geotechnical Hazards" by TC4, ISSMFE (1993).

Method Grade 1: simple and synthetic analysis by using geological maps, topographical maps, and histories of disaster

Method Grade 2: a detailed analysis using site reconnaissance results, interviewing the local residents, etc.

Method Grade 3: a detailed analysis using geological investigation results and numerical analyses

It is considered that Method Grade 3 is appropriate in quality and content, compared to other estimation items of the Study. The main content of the evaluation of the liquefaction potential is the comparison of the soil strength with the seismic motion. Various procedures exist to determine these values. Soil properties are determined by simple physical property tests or detailed dynamic laboratory tests. Seismic motion is determined using only information on ground type of the area or an estimated waveform for target earthquakes. In the latter case, the waveform is used to obtain the maximum value of acceleration during an earthquake or time-dependent change of acceleration. The procedure should be determined considering the objective of the estimation. In cases where critical situations are estimated in designing important facilities, a point base analysis is to be used with detailed procedures. In this seismic microzoning study, soil strength and seismic motion are to be determined at the same levels of quality in the whole Study Area. Therefore, using some statistical method is appropriate.

The following information on soil properties and seismic motion was available in the Study:

Borehole logs with results of Standard Penetration Tests (SPT)

Physical soil properties

Peak ground acceleration for scenario earthquakes

Considering the above, a combination of the F_L method and the P_L method was used in the Study. This method is commonly used in Japan for practical purposes.

Manmade ground and quaternary deposits are the objective of the evaluation. A 500 m grid system, which is used in the earthquake analysis, is prepared for modeling.

Figure 7.3.1 shows the flow chart for a liquefaction potential analysis.

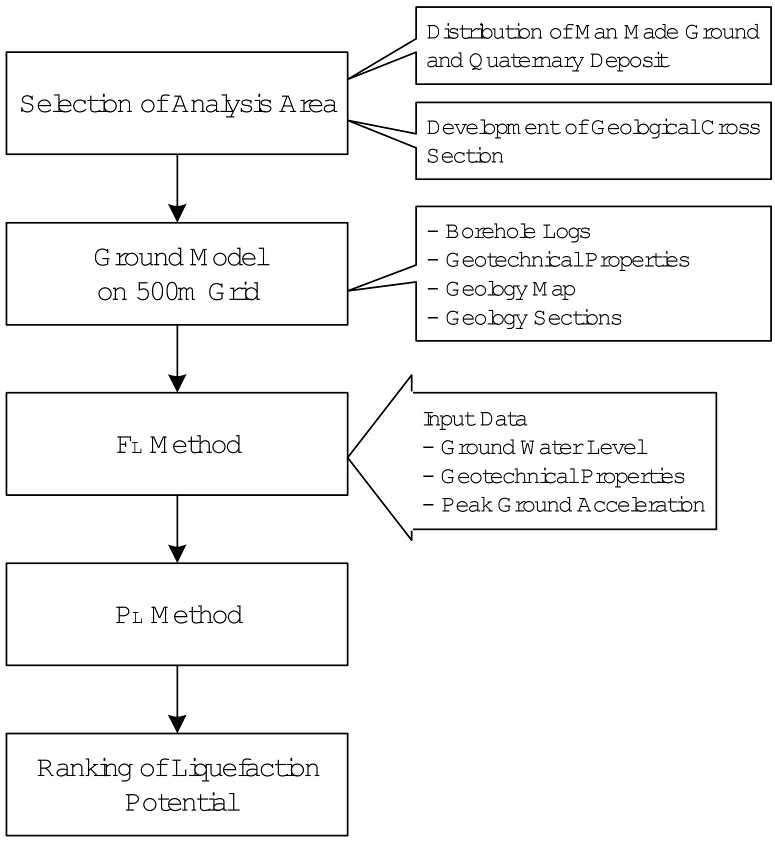


Figure 7.3.1 Flowchart of Liquefaction Analysis

7.3.2. Method of Calculation

The liquefaction potential for individual layers is analysed by the FL method. The whole liquefaction potential at the analysed point is evaluated by the PL method based upon the results of the FL method.

F_L Method (Japanese Design Specification of Highway Bridge, revised 1996)

Ground condition to be evaluated:

Quaternary sandy soil from ground surface to depth of 20 m

Groundwater table less than 10 m from ground surface

$F_L = R/L$

F_L: liquefaction resistance factor

$F_L \leq 1.0$: Judged as liquefied

$F_L > 1.0$: Judged as not liquefied

R: cyclic shear strength at effective overburden pressure

$R = C_w \times R_L$

C_w: correlation coefficient for earthquake type

Type 1 earthquake (plate boundary type, large scale)

$C_w = 1.0$

Type 2 earthquake (inland type)

$C_w = 1.0$ $(R_L \leq 1.0)$

$= 3.3R_L+0.67$ $(0.1<R_L \leq 0.4)$

$= 2.0$ $(0.4 < R_L)$

R_L: cyclic resistance ratio obtained by laboratory test

$R_L = 0.0882 \quad (Na/1.7)^{0.5}$ $(Na<14)$

$= 0.0882 \quad (Na/1.7)^{0.5} + 1.6\times10^{-6} (Na-14)^{4.5}$ $(14 \leq Na)$

Sandy Soil

$Na = c_1 N + c_2$

$c_1 = 1$ $(0\% \leq Fc < 10\%)$,

$= (Fc + 40) /50$ $(10\% \leq Fc < 60\%)$

$= Fc/20 - 1$ $(60\% \leq Fc)$

$c_2 = 0$ $(0\% \leq Fc < 10\%)$

$= (F-10)/18$ $(10\% \leq Fc)$

Fc : fine contents

Gravelly Soil

$Na = \{1-0.36\log_{10}(D_{50}/2.0)\}N_1$

N: SPT blow count

Na: N value correlated for grain size

N_1: $1.7N/(\sigma_v'+0.7)$

D_{50}: grain diameter of 50% passing (mm)

L: shear stress to the effective overburden pressure

$L = \alpha / g \times \sigma_v/\sigma_v' \times r_d$

r_d : stress reduction factor

$r_d = 1.0 - 0.015x$

x : depth in meters below the ground surface

α: peak ground acceleration (gal)

g: acceleration of gravity (= 980 gal)

σ_v: total overburden pressure

σ_v': effective overburden pressure

<u>P_L Method (Iwasaki et al. 1982)</u>

$$P_L = \int_0^{20} F \cdot w(z)dz$$

$15 < P_L$	Very high potential
$5 < P_L \leq 15$	Relatively high potential
$0 < P_L \leq 5$	Relatively low potential
$P_L = 0$	Very low potential

$F = 1-F_L \quad (F_L<1.0)$

$\quad = 0 \quad (F_L \geq 1.0)$

$w(z) = 10 - 0.5z$

P_L: liquefaction potential index

F_L: liquefaction resistance factor

w(z): weight function for depth

z: depth in meters below the ground surface

7.3.3. Precondition for the Analysis

(1) Analyzed Area

In general, liquefaction takes place in loose Alluvial saturated sandy deposits. The Japanese Design Specifications for Highway Bridges describes the following conditions for soil stratum, which requires liquefaction potential evaluation:

In principle, Alluvial saturated sandy deposits, which satisfy the following three (3) conditions at the same time, require liquefaction potential analysis:

1. Saturated sandy layer above the depth of 20 m from the present ground surface with ground water level within 10 m from the present ground surface.
2. Soil layer with fine contents (FC) less than 35%, or with plastic index less than 15% even with the FC more than 35%.
3. Soil layer with mean grain size (D50) less than 10 mm, and with grain size of 10 % passing less than 1 mm.

Liquefaction potential evaluation is recommended for Diluvial deposits with a low N value or without diagenesis.

Areas of the evaluation are selected by the following steps:

1) Select area where sandy soil is mainly distributed or where sandy soil shows horizontal continuity.

From the particle size distribution shown in Figure 7.3.2, Yd, Qal, Ksf, Cf and Sbf are sandy soil or have sandy soil layer.

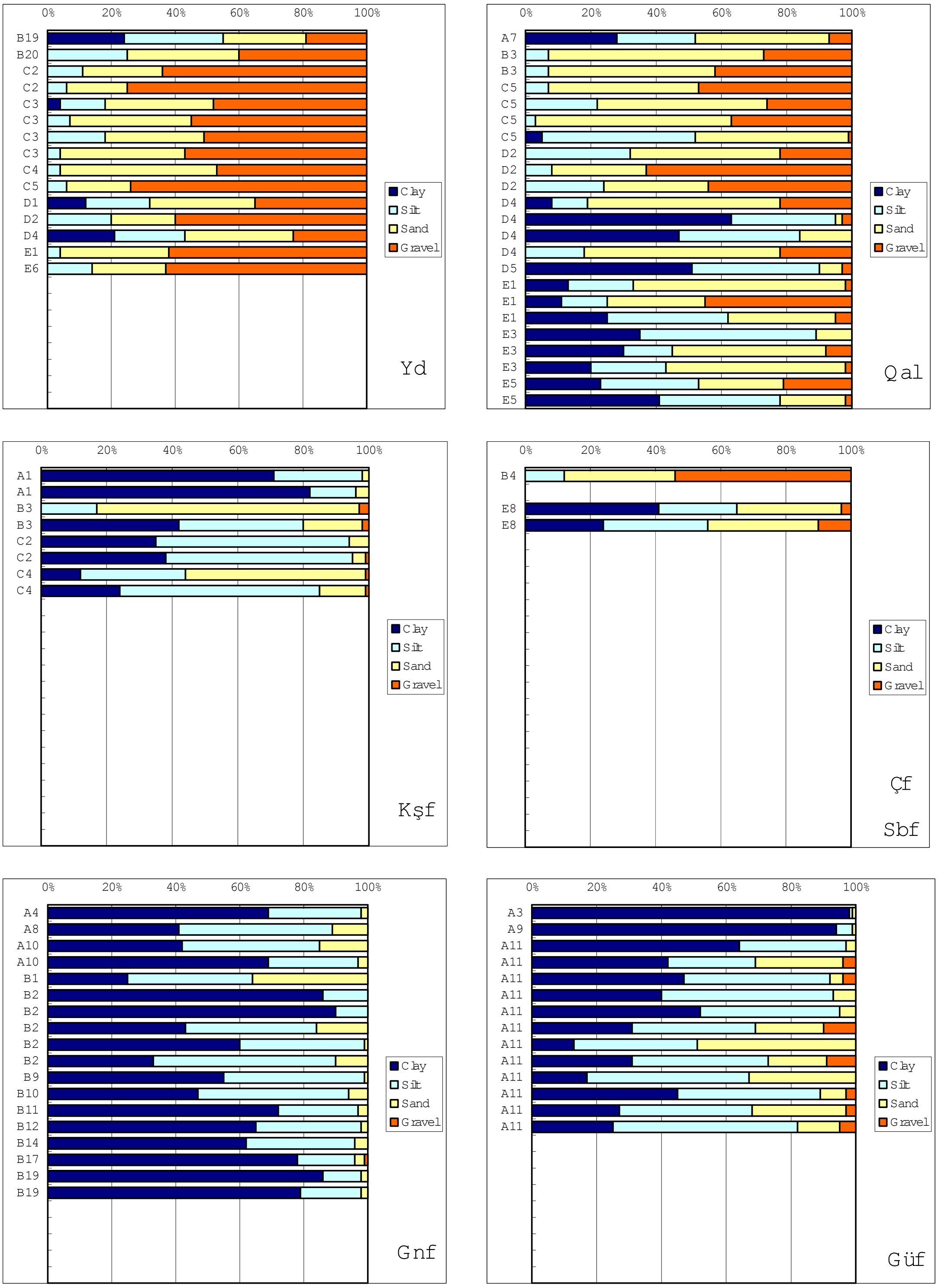


Figure 7.3.2 Particle Size Distribution

2) Select area where soft soil is prevailing

Çf and Sbf are not considered to have liquefaction potential because these layers are Tertiary deposits and their degree of cementation is relatively high due to diagenesis. Figure 7.3.3 shows the range of N-value of each soil stratum. Tertiary deposit (Çf, Sbf) obviously have a higher N-value than man made ground (Yd) and Quaternary deposit (Qal, Kşf).

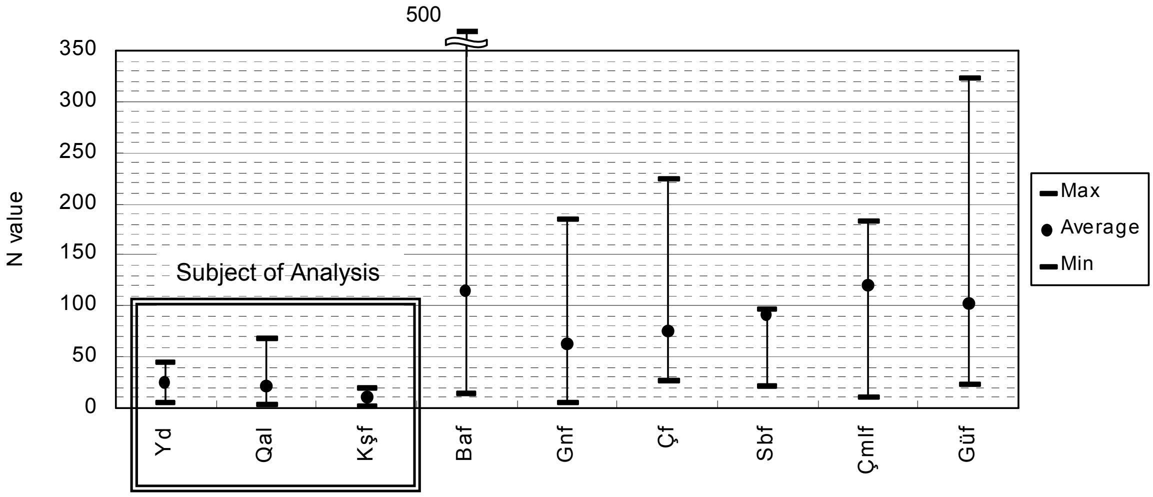
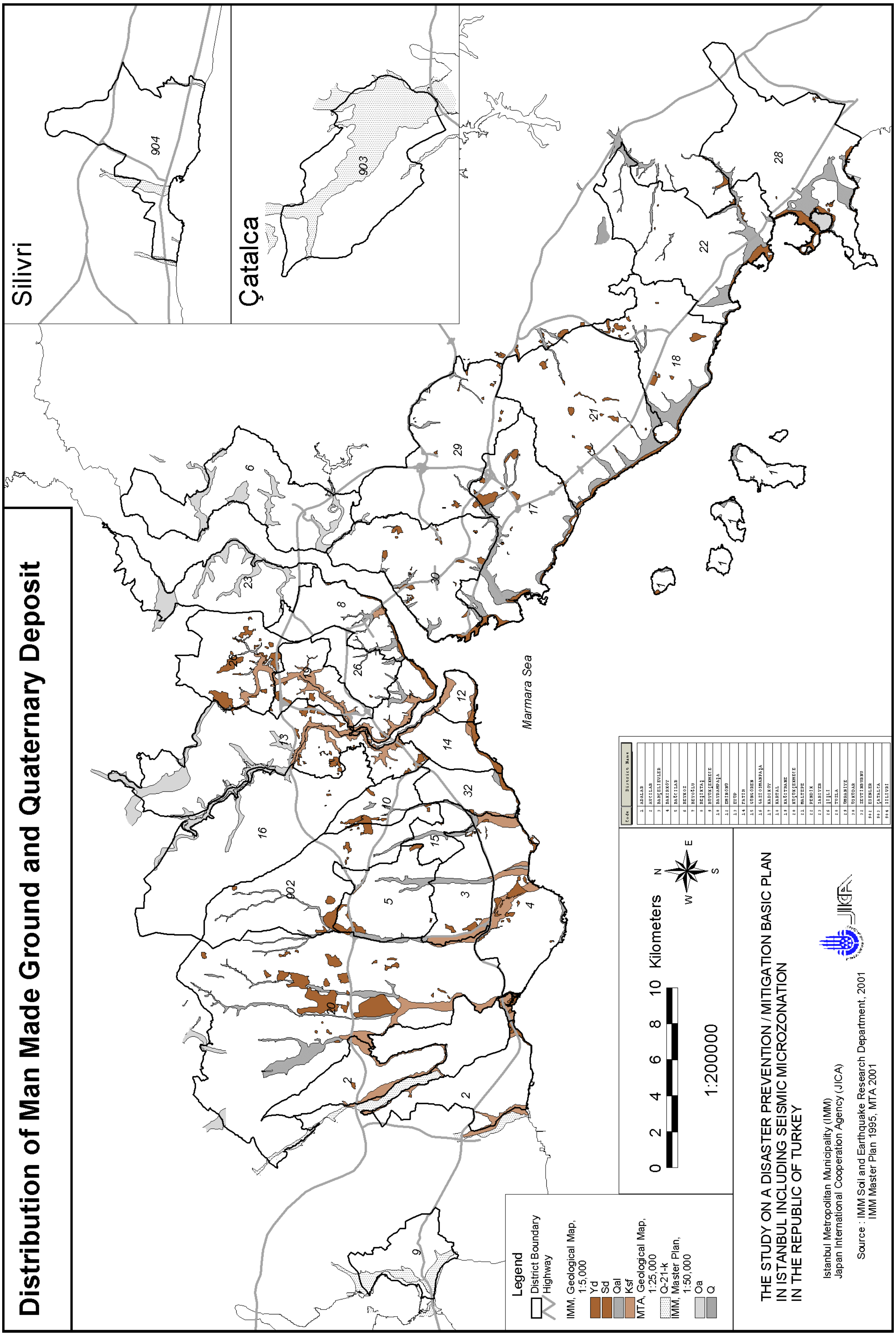


Figure 7.3.3 Range of N-value of Uncemented Soil Layers

Liquefaction is a phenomenon in which soil particles are re-arranged and soil ground is compressed by the cyclic vibration caused by an earthquake. By this reason, liquefaction potential is higher in looser soil, and softer in soil that has a smaller N-value. Therefore, the liquefaction potential study is conducted only in the area where man made ground (Yd) and Quaternary deposits (Qal, Kşf) are present.

Figure 7.3.4 shows the area of man made ground and Quaternary deposits.


Distribution of Man Made Ground and Quaternary Deposit
Silivri
Çatalca
Marmara Sea
Legend
District Boundary
Highway
IMM, Geological Map, 1:5,000
Yd
Sd
Qal
Ksf
MTA, Geological Map, 1:25,000
Q-21-k
IMM, Master Plan, 1:50,000
Oa
Q
0 2 4 6 8 10 Kilometers
1:200000
N
E
S
W
THE STUDY ON A DISASTER PREVENTION / MITIGATION BASIC PLAN IN ISTANBUL INCLUDING SEISMIC MICROZONATION IN THE REPUBLIC OF TURKEY
Istanbul Metropolitan Municipality (IMM)
Japan International Cooperation Agency (JICA)
Source : IMM Soil and Earthquake Research Department, 2001
IMM Master Plan 1995, MTA 2001

Characteristics of each district from a viewpoint of distribution of man made ground and Quaternary deposits are as shown below:

Average ratios of the man made ground and Quaternary Deposits in each district are approximately 3% and 11%, respectively. In other words, the strata to be studied, regarding liquefaction, occupy approximately 14% in the Study Area (See Table 7.3.1 and Figure 7.3.5).

The district having the highest ratio is Çatalca (approx. 40%). On the other hand, the district having the lowest ratio is Gaziosmanpaşa (approx. 3%).

Table 7.3.1 Summary of Liquefaction Potential Soils Distribution by District

Code	District	Area (ha)								Ratio (%)		
		IMM				Master Plan	MTA	Others	Total	Man Made Ground	Quaternary Deposit	Others
		Man Made Ground		Quaternary Deposit								
		Yd	Sd	Qal	Kşf	Oa	Q-21-k					
1	ADALAR	10	0	73	0	0	0	1,016	1,100	0.9	6.7	92.4
2	AVCILAR	40	0	0	350	0	0	3,471	3,861	1.0	9.1	89.9
3	BAHÇELİEVLER	42	0	125	154	0	0	1,340	1,661	2.5	16.8	80.7
4	BAKIRKÖY	131	0	80	350	0	0	2,390	2,951	4.4	14.6	81.0
5	BAĞCILAR	117	0	163	0	0	0	1,914	2,194	5.3	7.4	87.2
6	BEYKOZ	0	0	0	0	503	0	3,653	4,156	0.0	12.1	87.9
7	BEYOĞLU	74	0	59	143	0	0	614	889	8.3	22.7	69.0
8	BEŞİKTAŞ	51	0	101	27	0	0	1,632	1,811	2.8	7.0	90.1
9	BÜYÜKÇEKMECE	0	0	0	0	0	321	1,153	1,474	0.0	21.8	78.2
10	BAYRAMPAŞA	67	0	27	0	0	0	865	958	7.0	2.8	90.3
12	EMİNÖNÜ	32	0	0	102	0	0	374	508	6.4	20.0	73.6
13	EYÜP	156	0	9	297	529	0	4,059	5,050	3.1	16.5	80.4
14	FATİH	81	0	1	55	0	0	909	1,045	7.8	5.3	86.9
15	GÜNGÖREN	1	0	68	0	0	0	649	718	0.2	9.5	90.3
16	GAZİOSMANPAŞA	4	0	0	4	153	0	5,515	5,676	0.1	2.8	97.2
17	KADIKÖY	110	114	407	0	0	0	3,496	4,128	5.4	9.9	84.7
18	KARTAL	87	56	260	0	0	0	2,733	3,135	4.5	8.3	87.2
19	KAĞITHANE	35	0	2	247	0	0	1,158	1,443	2.5	17.3	80.2
20	KÜÇÜKÇKMECE	657	0	641	434	309	0	10,133	12,173	5.4	11.4	83.2
21	MALTEPE	76	78	309	0	0	0	5,066	5,530	2.8	5.6	91.6
22	PENDİK	13	97	424	0	0	0	4,197	4,731	2.3	9.0	88.7
23	SARIYER	0	0	0	0	465	0	2,309	2,774	0.0	16.8	83.2
26	ŞİŞLİ	244	0	79	128	0	0	3,092	3,543	6.9	5.9	87.3
28	TUZLA	12	164	384	0	0	0	4,437	4,998	3.5	7.7	88.8
29	ÜMRANİYE	47	0	100	0	13	0	4,401	4,561	1.0	2.5	96.5
30	ÜSKÜDAR	98	42	150	0	29	0	3,463	3,783	3.7	4.7	91.5
32	ZEYTİNBURUNU	39	0	29	29	0	0	1,052	1,149	3.4	5.0	91.6
902	ESENLER	154	0	121	0	0	0	3,616	3,890	4.0	3.1	92.9
903	ÇATALCA	0	0	0	0	0	2,127	3,137	5,263	0.0	40.4	59.6
904	SİLİVRİ	0	0	0	0	0	125	3,703	3,828	0.0	3.3	96.7
Total		13,435						85,546	98,981	13.6		86.4
Average		-						-	-	3.2	10.9	86.0

Source: The JICA Study Team
Note: A geological unit is counted using 50 m square grids. A count unit is the number of the 50 m grids in each geological unit.

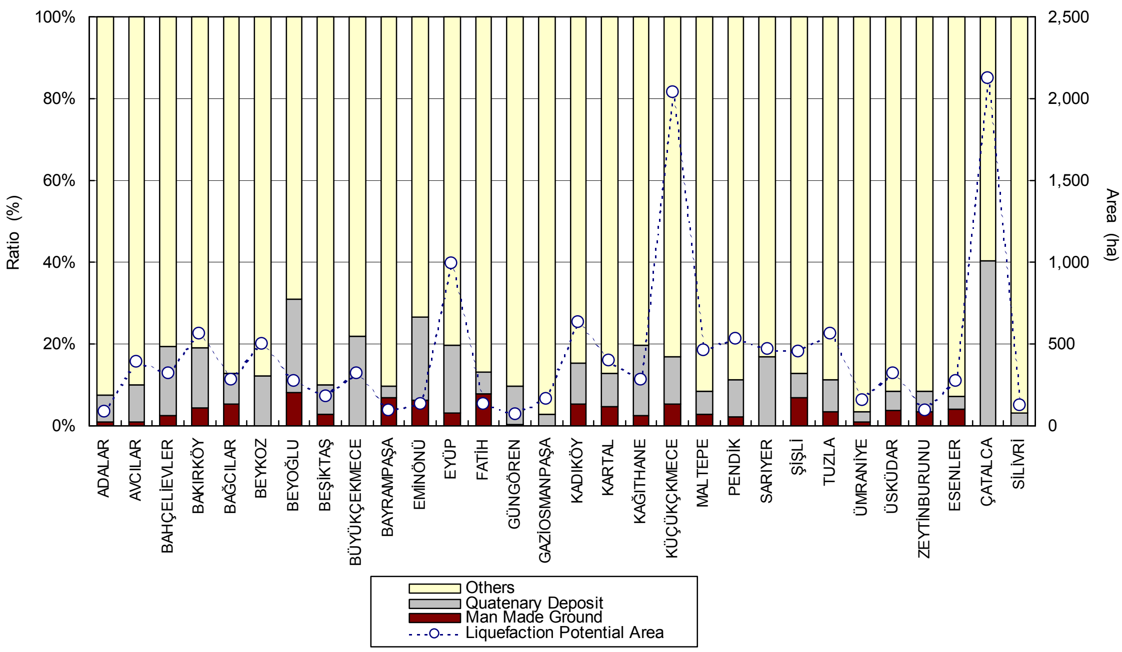


Figure 7.3.5 Liquefaction Potential Soils Distribution by District

(2) Setting up of the soil parameters

1) Gathering of soil condition information

The following data were used as information sources regarding soil conditions in the analyzed area:

- The boring logs based on boring conducted by the Study Team in the analyzed area (No. C1-C5, D1-D5 and E1-E5) and the results of laboratory tests (46 samples).
- The existing boring logs (for 480 holes) of the same area and the results of past laboratory tests (for 93 holes, 214 samples).

The number of the existing results of the past soil laboratory tests is much less than that of the existing boring logs,. Most of the soil classification of the past boring logs were made depending on the engineers' empirical and qualitative judgment. Therefore, only the matrix information described in the section "Soil Description" has been used from the existing boring logs.

2) Classification of soil properties

In many cases, soil property distribution provides very complicated aspects. It is not difficult to imagine that the layer phases of the Quaternary Deposit, particularly distributed in the valleys of the Study Area, are complicated in both vertical and horizontal directions.

However, it is difficult to carry out the detailed study reflecting the complicated layer phases, since ground information is limited. Such being the situation, it was decided to study the land liquefaction covering as wide an area as possible, utilizing the limited information most effectively by simplifying the classification of the soil properties as shown below:

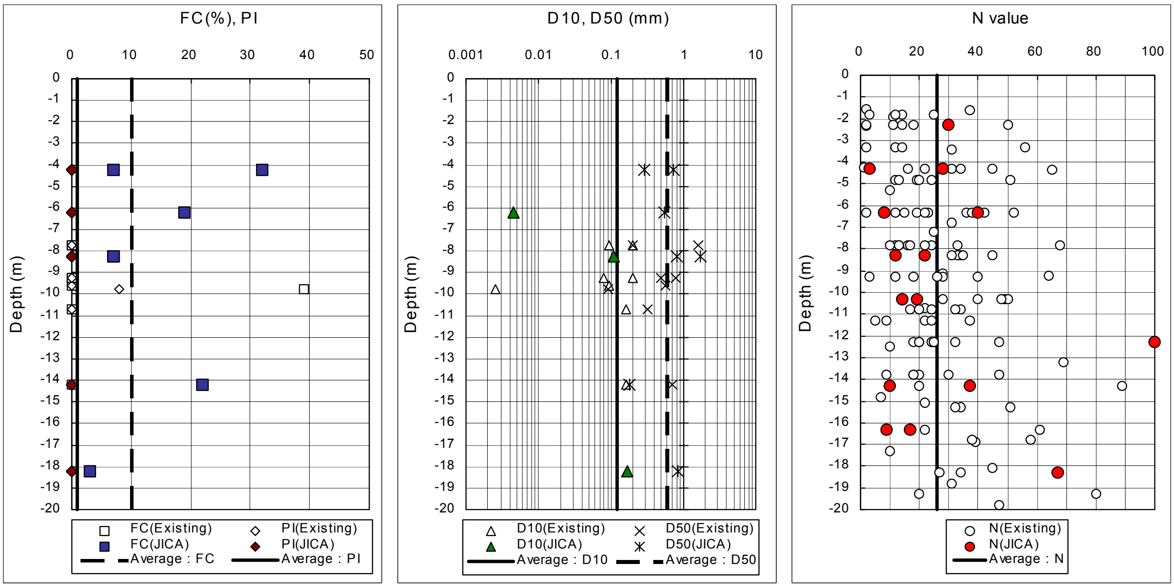
Man-made ground: It is estimated that various materials are used in artificially made grounds and it is too difficult to set up the constant for each ground. Therefore, it was decided to regard the man-made grounds as a single soil property section, considering all the man-made grounds have average soil properties.

Quaternary Deposit: In studying liquefaction, the soil properties are basically and necessarily classified as clayey soil, sandy soil, and gravely soil. Taking into consideration that effective data obtained from the existing boring logs are matrixes, it is reasonable to divide Qal and Kşf into 3 individual classes. Consequently, the quaternary deposit has been classified as Qal-Clay, Qal-Sand, Qal-Gravel, Kşf-Clay, Kşf-Sand, and Kşf-Gravel.

3) Setting up of the soil parameters

The soil parameters necessary for the study are *N value, Unit weight, Fine contents, Grain size of 10% passing, Grain size of 50% passing,* and *Plasticity index*. The individual parameters have been statistically processed and set up for the individual soil classifications. The data distribution used for setting up the constants for Qal-Sand and the constants consequently set up are shown in Figure 7.3.6 as an example.

Regarding the raw data and graphs of individual soil properties, please refer to Supporting Report.



(a) Fine Contents : FC
Plasticity Index : PI

(b) Grain Size of 50% and 10% passing

(c) N value

Figure 7.3.6 Qal-Sand (Example)

Because the unit weight data for each of the 7 types of soils were not available, that data has been set up according to Table 7.3.2, which contains the approximate unit weight values for various types of soils (Japanese Design Specifications for Highway Bridges, 1990).

Table 7.3.2 Approximate Values of Unit weight, Average Grain Size and Fine Particle Contents of Various Types of Soils

Soil Type	Unit Weight below Ground Water γ_{t2} (tf/m^3)	Unit Weight above Ground Water γ_{t1} (tf/m^3)	Grain Size of 50% passing D_{50} (mm)	Fine Contents FC (%)	Geology Classification
Top Soil	1.7	1.5	0.02	80	-
Silt	1.75	1.55	0.025	75	-
Sandy Silt	1.8	1.6	0.04	65	Qal-Clay, Kşf-Clay
Silty Fine Sand	1.8	1.6	0.07	50	-
Very Fine Sand	1.85	1.65	0.1	40	-
Fine Sand	1.95	1.75	0.15	30	-
Medium Sand	2.0	1.8	0.35	10	-
Coarse Sand	2.0	1.8	0.6	0	Qal-Sand, Qal-Gravel Kşf-Sand
Gravelly Sand	2.1	1.9	2.0	0	Man Made Ground, Kşf-Gravel

Source: Japanese Design Specifications for Highway Bridges (partially modified)

Listed in Table 4.5.3 are the soil property constants used in the calculations.

Table 7.3.3 Summary of Soil Properties for Liquefaction Analysis

Geology Classification	FC (%)	PI	D_{10} (mm)	D_{50} (mm)	N	γ_{t2} (tf/m^3)	γ_{t1} (tf/m^3)
Man Made Ground	22	4	0.15	2.7	17	2.1	1.9
Qal-Clay	59	23	no data	0.036	21	1.8	1.6
Qal-Sand	10	1	0.12	0.58	26	2.0	1.8
Qal-Gravel	11	3	0.11	1.3	26	2.0	1.8
Kşf-Clay	67	43	0.006	0.037	12	1.8	1.6
Kşf-Sand	6	0	0.12	0.50	17	2.0	1.8
Kşf-Gravel	9	0	0.69	4.2	27	2.1	1.9

FC : Fine Contents
PI : Plasticity Index
D_{10} : Grain Size of 10% passing
D_{50} : Grain Size of 50% passing
N : N value
γ_{t1} : Unit Weight above Ground Water
γ_{t2} : Unit Weight below Ground Water

(3) Underground water level

Change of underground water level by seasons and tide levels is not known. The underground water level used in the calculation has been set as GL-1m. Taking in consideration the shallowest underground water level observed during boring work, by the Study Team and in the observation holes, this is a fairly safe estimate.

(4) Modeling of the ground

Though the study on liquefaction was planned to cover a comparatively wide area, the available ground information of the Study Area is limited and the classification of the soil properties has been simplified to 7 classes. Because the study aims to obtain a general view of the distribution of soils with liquefaction potential in order to identify the districts with high risk, it is necessary to make a judgment on liquefaction covering as wide an area as possible.

From this viewpoint, the ground models have been set up by the following procedures, taking the purpose of the study and the available ground information into consideration:

- Cross-sections of soil layers are prepared based on the 7 geological classes (Qal-Clay, Qal-Sand, Qal-Gravel, Ksf-Clay, Ksf-Sand and Ksf-Gravel) covering the man-made ground and Quaternary Deposits.
- Three dimensional soil layer constitutions are estimated based on the cross sections and configuration of the grounds.

- Model columns of the soil layers are prepared, using the 500 m grids, which are units for seismic motion calculation, and employing an average soil constitution in each grid (Ref. Figure 7.3.7).
- Models covering soil layers from ground surface to 20 m depth or less are set up.

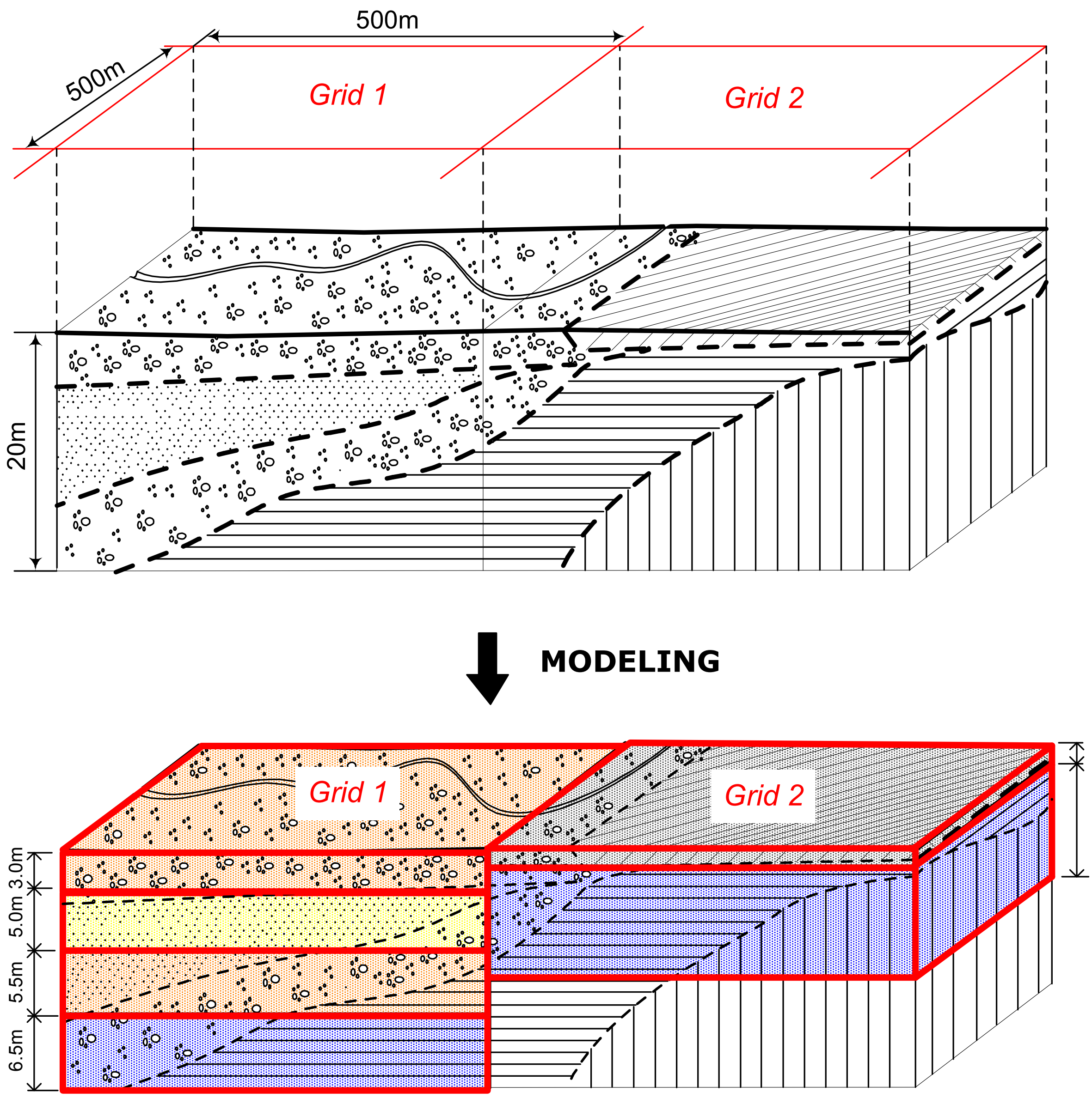
  <example>

  - When either of the man-mad ground or the Quaternary deposits are continuously distributed forming a 20 m or thicker layer, a soil layer from the surface down to 20 m in depth is modeled.
  - When either of the man-made ground or the Quaternary Deposit are distributed in layers less than 20 m, the soil layer less than 20 m is modeled.

Figure 7.3.8 shows the 500 m grids in the area where the man-made ground and Quaternary Deposits prevail (1492 grids). Particularly, the specific places where the soil data are available and liquefaction study is carried out are framed with red lines (179 grids).

(5) Peak ground acceleration

The peak ground acceleration obtained from the result of the earthquake analysis is put into the calculation. The liquefaction studies are carried out for the two earthquake scenario cases, Model C and Model A.



Geology Model

Grid 1		Grid 2	
Soil	Thickness (m)	Soil	Thickness (m)
Qal Gravel	3.0	Man Made Ground	1.5
Qal Sand	5.0	Qal Clay	9.5
Qal Gravel	5.5	-	-
Qal Clay	6.5	-	-

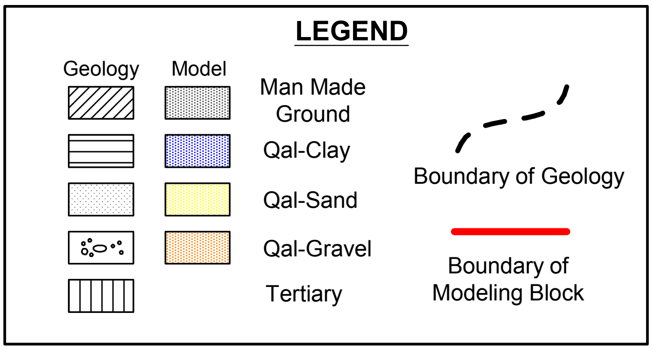


Figure 7.3.7 Schematic Chart of the Ground Model

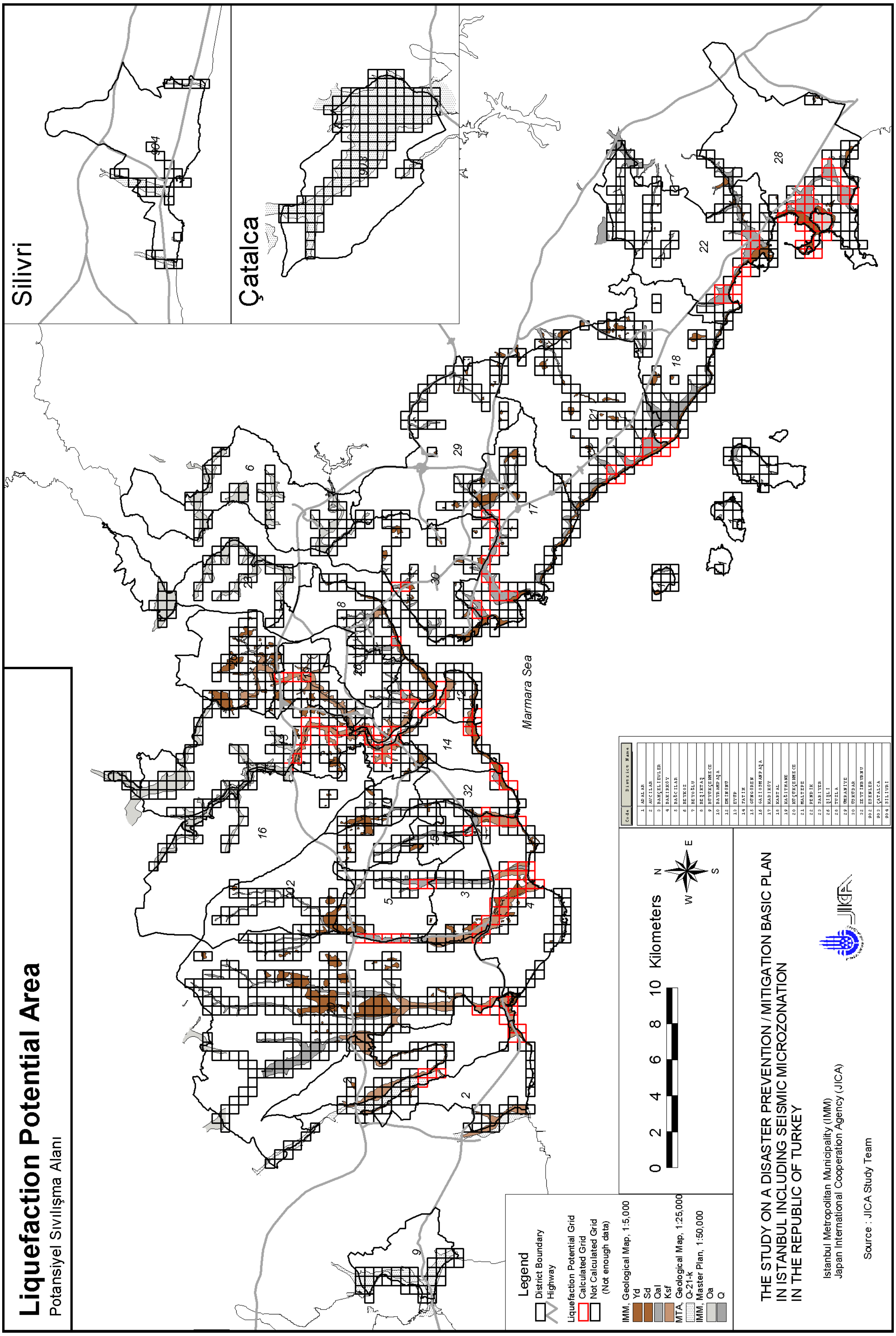


Figure 7.3.8 Liquefaction Potential Area

7.3.4. Liquefaction Potential

The results of the analysis for each grid are shown in the Supporting Report. These results are summarised in Table 7.3.4 and

Figure 7.3.9 to

Figure 7.3.10.

Table 7.3.4 Summary of the Liquefaction Analysis

Liquefaction Potential	Criterion	Explanation	No. of Grids	
			Model A	Model C
Very high	$15<P_L$	Ground improvement is indispensable	38	40
Relatively high	$5<P_L\leq 15$	- Ground improvement is required - Investigation of important structures is indispensable	35	42
Relatively low	$0<P_L\leq 5$	Investigation of important structures is required	36	28
Very low	$P_L=0$	No measure required	70	69
Unknown	-	No ground information exists	1,313	1,313

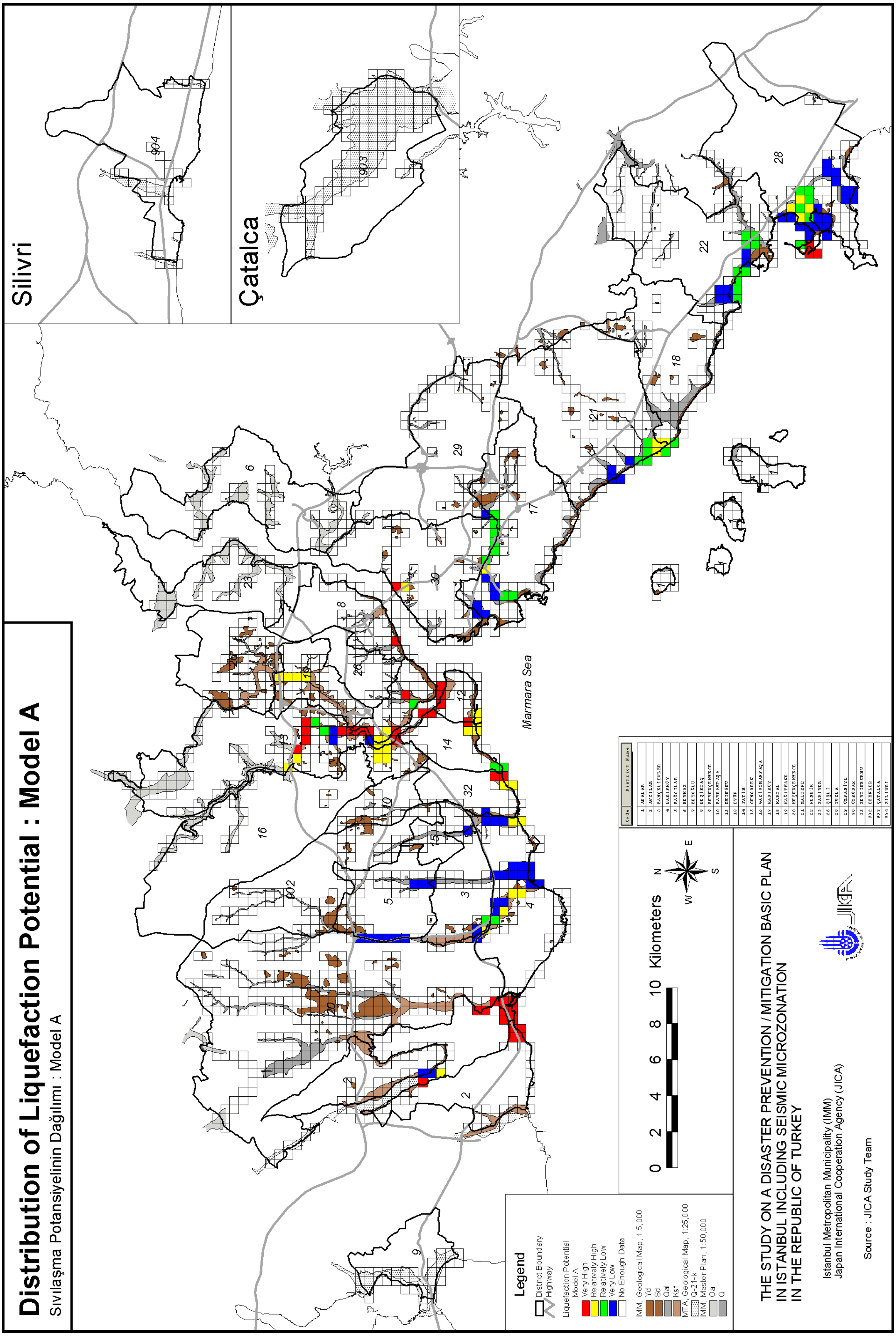


Figure 7.3.9 Distribution of Liquefaction Potential: Model A

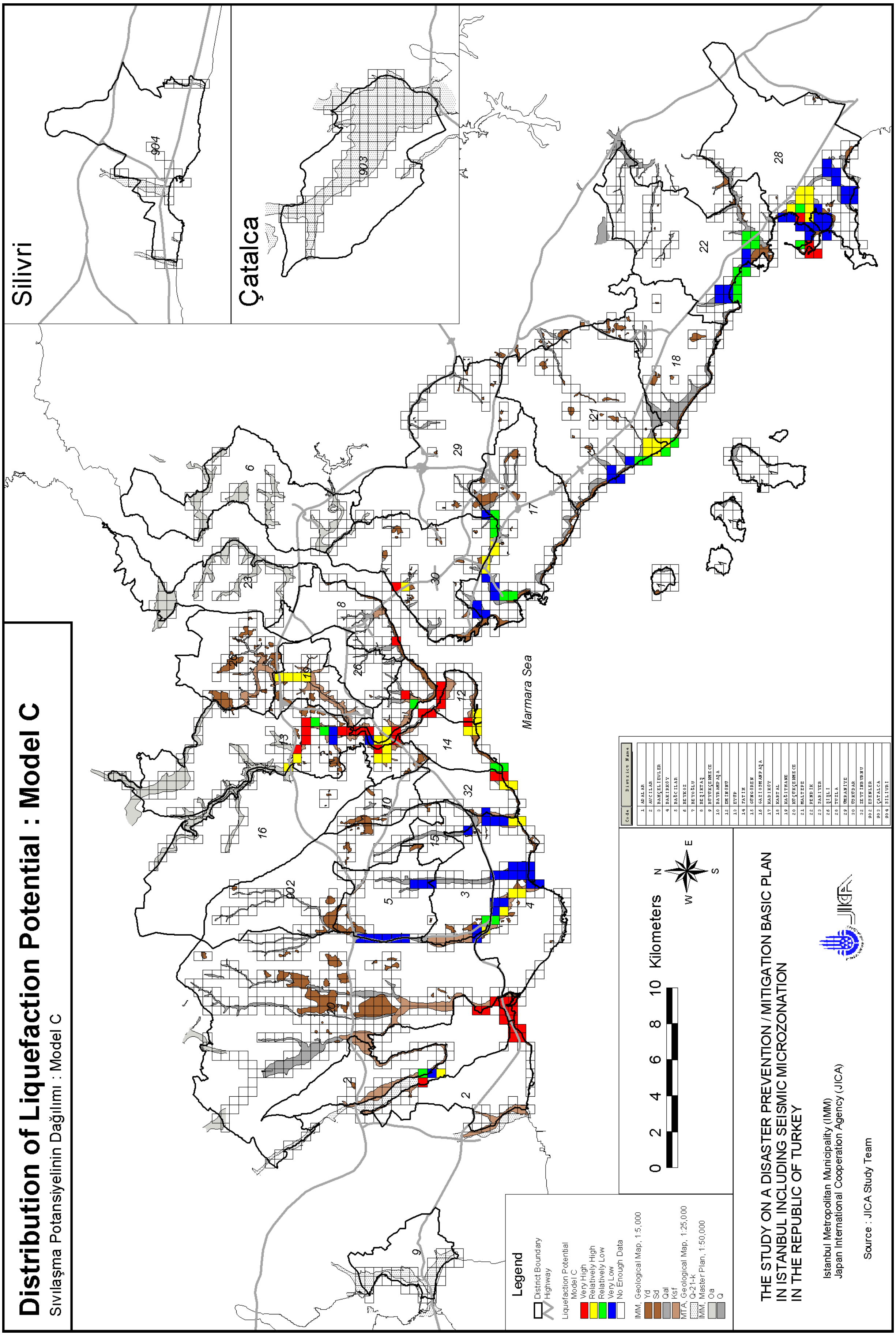


Figure 7.3.10 Distribution of Liquefaction Potential: Model C

The result for earthquake model C gives a little higher liquefaction potential than that of model A.

Liquefaction potential varies in different localities. Some areas have low liquefaction potential, while other areas have high liquefaction potential. These areas with high liquefaction potential are as follows:

(1) Area along swamp extending in NNE to SSW direction, in the west of Küçükçekmece Gölü
(2) Sandbar in the south of Küçükçekmece Gölü
(3) Coastal area close to the border between Zeytinburnu
(4) Coastal area close to the border between Fatih and Eminönü
(5) Coastal area of Haliç
(6) Swamp area in upstream of Haliç
(7) Area in the middle of swamp running down to Gazi Hasan Paşa Park in Beyoğlu
(8) Area around the Beşiktaş Harbor
(9) Area around coast in the north of Boğaziçi Bridge in Asian side
(10) Area close to the peninsula of Sakız Adası, Tuzla

Table 7.3.5 shows the general land-use in areas mentioned above.

Table 7.3.5 Land-use in Areas for High Liquefaction Potential

Area	General Characteristics of Land-Use
a	Swamp. No buildings exist.
b	Highway is running in the middle of sandbar. Low to middle storied commercial and residential buildings exist.
c	Mostly used as parks or open space. Few buildings. Located in urban planning zone.
d	Low to middle storied commercial and residential buildings exist densely.
e	Area along bay is used as harbor. Area between roads to harbor is used as park, and inland area is used mostly as commercial zone.
f	Lowland along river. Mostly used as park or green zone.
g	Mostly used as park or green zone. Many low storied residential buildings exist.
h	A harbor exists. Area between the roads to the sea is used as park, and inland area is used mostly as commercial zone.
i	Area is used as park and green zone.
j	Used as coastal industrial zone.

Source: The JICA Study Team

Table 7.3.6 and Figure 7.3.11 show liquefaction analysis results by districts. The area in the table was calculated reflecting the results by a 500 m grid in the shape of the geological ground.

- The ratio of the area examined in the liquefaction analysis for the liquefaction potential is 17%.
- The districts for which a liquefaction analysis was not conducted were Adaral, Büyükçekmece, Bayrampaşa, Saryer, Şişli, Esenler, Çatalca and Silivri.
- The districts whose area was evaluated "Very High" (Model C) and were greater than 40 ha were Küçükçekmece, Eyüp, Avcilar and Beyoğlu.

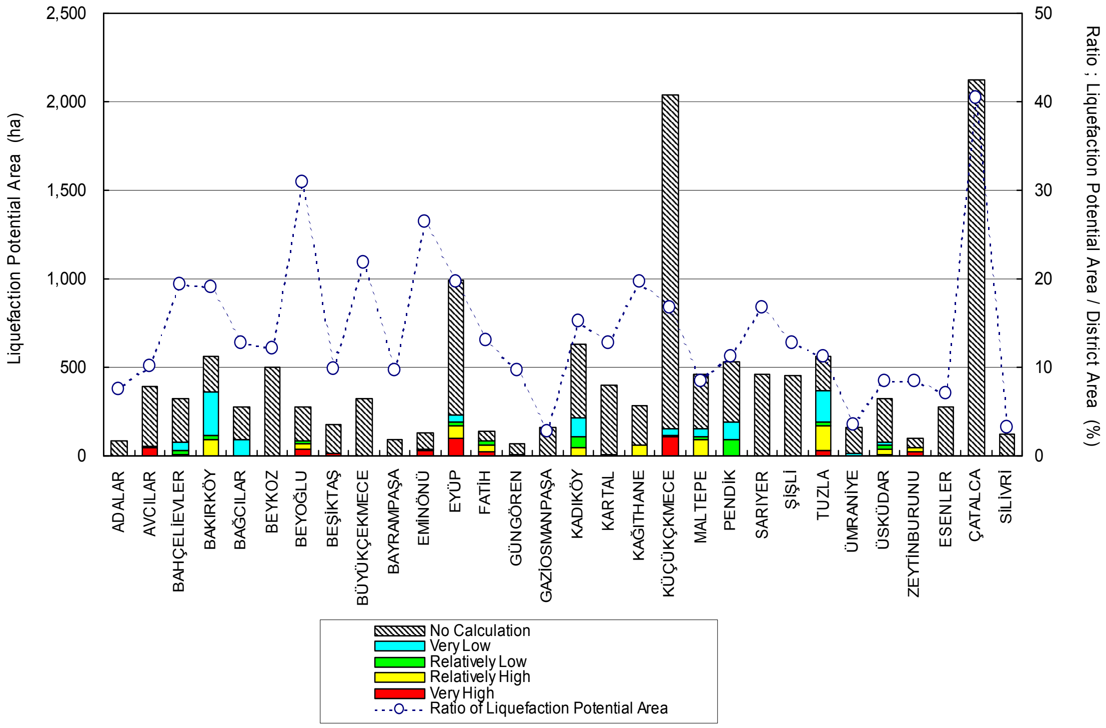


Figure 7.3.11 Liquefaction Analysis Results by Districts (Model C) and Ratio of Liquefaction Potential Area

The following are the necessary future efforts, derived from the results of the liquefaction evaluation:

- A detailed study should be carried out in order to perform a more precise evaluation for the areas with high liquefaction potential.
- Data collection and additional ground studies should be carried out to evaluate the area that is located on man-made land or on Alluvium ground, where an evaluation was not performed as part of this study.

- This study aims to identify areas with high liquefaction potential. Therefore, individual evaluations will be necessary for important facilities that are located on man-made land or on Alluvium ground.

Table 7.3.6 Liquefaction Analysis Results by Districts

Code	District	Man Made Ground and Quatenary Deposit (ha)	Liquefaction Potential Area (ha)										Calculation Area / Liquefaction Potential Area (%)
			Model A					Model C					
			Very High	Relatively High	Relatively Low	Very Low	No Calculation	Very High	Relatively High	Relatively Low	Very Low	No Calculation	
1	ADALAR	84	0	0	0	0	84	0	0	0	0	84	0
2	AVCILAR	390	45	0	0	11	334	45	0	7	4	334	14
3	BAHÇELİEVLER	321	0	11	17	51	242	0	11	17	51	242	25
4	BAKIRKÖY	561	0	96	23	246	196	0	96	23	246	196	65
5	BAĞCILAR	280	0	0	0	91	189	0	0	0	91	189	32
6	BEYKOZ	503	0	0	0	0	503	0	0	0	0	503	0
7	BEYOĞLU	275	41	29	15	2	188	41	29	15	2	188	32
8	BEŞİKTAŞ	179	18	0	0	0	160	18	0	0	0	160	10
9	BÜYÜKÇEKMECE	321	0	0	0	0	321	0	0	0	0	321	0
10	BAYRAMPAŞA	93	0	0	0	0	93	0	0	0	0	93	0
12	EMİNÖNÜ	134	31	10	0	0	93	31	10	0	0	93	31
13	EYÜP	991	95	73	27	38	757	103	65	27	38	757	24
14	FATİH	137	26	34	22	0	55	26	34	22	0	55	60
15	GÜNGÖREN	70	0	0	0	4	66	0	0	0	4	66	6
16	GAZİOSMANPAŞA	161	0	3	0	0	158	0	3	0	0	158	2
17	KADIKÖY	631	0	15	95	104	418	0	48	62	104	418	34
18	KARTAL	402	0	4	3	0	395	0	4	3	0	395	2
19	KAĞITHANE	285	0	60	0	0	225	0	60	0	0	225	21
20	KÜÇÜKÇKMECE	2,041	108	7	0	39	1,886	108	7	0	39	1,886	8
21	MALTEPE	464	0	42	65	45	312	0	90	17	45	312	33
22	PENDİK	534	0	0	94	98	341	0	0	94	98	341	36
23	SARIYER	465	0	0	0	0	465	0	0	0	0	465	0
26	ŞİŞLİ	451	0	0	0	0	451	0	0	0	0	451	0
28	TUZLA	561	13	79	100	178	190	32	133	26	178	190	66
29	ÜMRANİYE	160	0	0	1	11	148	0	0	1	11	148	7
30	ÜSKÜDAR	320	9	16	35	14	246	9	33	18	14	246	23
32	ZEYTİNBURNU	97	23	20	1	5	47	23	20	1	5	47	51
902	ESENLER	275	0	0	0	0	275	0	0	0	0	275	0
903	ÇATALCA	2,127	0	0	0	0	2,127	0	0	0	0	2,127	0
904	SİLİVRİ	125	0	0	0	0	125	0	0	0	0	125	0
Total		13,435	409	500	499	938	11,089	436	644	335	931	11,089	17

7.4. Evaluation of Slope Stability

7.4.1. Method of Slope Stability Evaluation

(1) Present Topographic Condition and Slope Stability Condition

Kutay Özaydın (2001) summarized the general conditions of slopes as follows:

> In areas where the surface geology is of Güngören or Gülpnar Formations, many landslides occur. This sliding phenomenon is characteristic of areas with the following: 1) ground surface gradient exceeds 30%, 2) cut and fill work are undertaken, and 3) a change of groundwater level occurs.

Erdoğan Yüzer (2001) summarized the general condition of slopes as follows:

> On the Asian side, surface geology is mainly rock, and landslides are not common. On the European side, landslides are observed alongside coast lines and their adjacent areas. This phenomena is observed far beyond the Silivri District. The scale of the slide can be from 50 m to several hundred meters of sliding blocks of soil. The eastside slope of Büyükçekmece Lake, the south coast of the Avcılar District, and southwest coast of Küçükçekmece lake are especially typical landslide areas. In these areas, soil strength is considered as a residual condition.

The JICA Study team also observed some surface failures of slope in rock formations. In these areas the slope gradient was observed as over 100%, and there are residential buildings in below and atop failure surfaces.

Considering the above mentioned slope conditions, major types of slope failure are classified as follows:

<u>Area of Rock Formation</u>

Rock formation slope failure takes into account the surface failure of weathered zones or talus. Large rock failures, exceeding several hundreds meters, are not considered. Stability of these kinds of large failures must be examined through detailed and individual investigations.

<u>Area of Tertiary Formation</u>

Güngören Formation and Gülpnar Formation areas have often suffered from landslide activities. Ground strength is considered a residual condition. Surface failure of weathered zones or talus is considered in other areas characterized prevailingly by Tertiary deposits.

Area of Quaternary Formation and Fill Material

General circular slip is considered.

(2) Method of the Slope Stability Evaluation

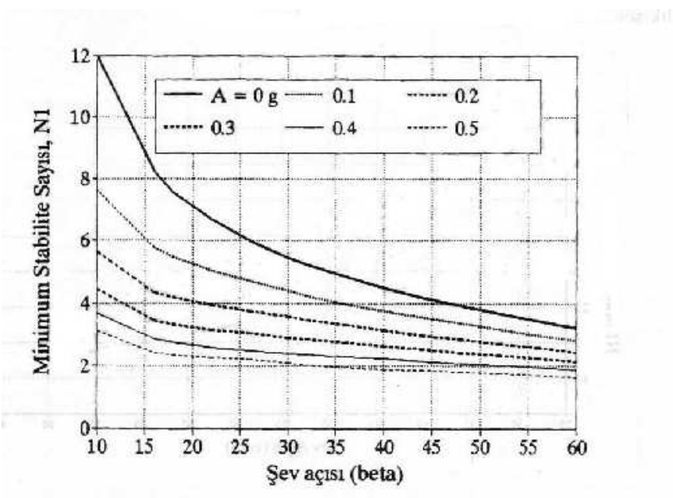
Siyahi and Ansal studied a procedure of slope stability for microzonation purposes. This procedure is introduced in the "Manual for Zonation on Seismic Geotechnical Hazards" by TC4, ISSMFE (1993). Applicability of the procedure was validated against an earthquake that occurred in 1967 affecting the Akyokus Village, in the Adapazarı region of Turkey. Bilge Siyahi (1998) revised this procedure. Variation in shear strength with depth is assumed, and potential failure surface is taken as a circular arc. Finally, a safety factor *Fs* for slope stability is induced as

$$Fs = N_1 \tan\phi \qquad \text{(eq.7.4.1)}$$

where N_1: stability number

ϕ: angle of internal friction

Thus, the safety factor depends on the angle of shear strength and stability number N_1 representing the configuration of the slope and failure surface. The minimum value of the stability number is determined by carrying out a parametric study on configuration of slope and N to find the most critical failure surface as given in Figure 7.4.1. The variation of minimum N_1 can be expressed as a function of β (slope angle) and A (earthquake acceleration). It becomes possible to calculate the minimum safety factor Fs, if ϕ value can be determined or estimated.



Horizontal axis:	Slope gradient (degree)
Vertical axis:	Minimum shear strength stability index
A:	Acceleration
g:	Gravitational acceleration

Figure 7.4.1 Relationship between Slope Gradient, Seismic Coefficient and Minimum Shear Strength Stability Number

Source: Siyahi (1998)

(3) Consideration of Analysis Procedure

There are varieties of slope characteristics in the Study Area, thus, it is difficult to identify slope failure parameters for every slope in detail. Therefore, it is required that slope stability be qualitatively evaluated, assuming slope failure categorization.

Siyahi's procedure introduced the idea for obtaining minimum safety factors for various shapes of failure surface and slope. It also assumes circular arc failure in normally consolidated soil. Slope gradient and shear strength are the only required data for calculation.

Furthermore, as results of the parametric approach, this procedure is considered to extend to not only circular surface failure, but, to some extent, another type of slope failure. Slopes and failure types in the Study Area are not always that assumed in Siyahi's procedure. However, the characteristics of the procedure act advantageously in considering the slope failure categorization.

In this Study, Siyahi's procedure is applied to evaluate slope stability for small analysis units. Each result of evaluations is aggregated into microzonation units.

(4) Procedure of Analysis and Evaluation of Stability

The outline of the evaluation method is described below and shown in Figure 7.4.2.

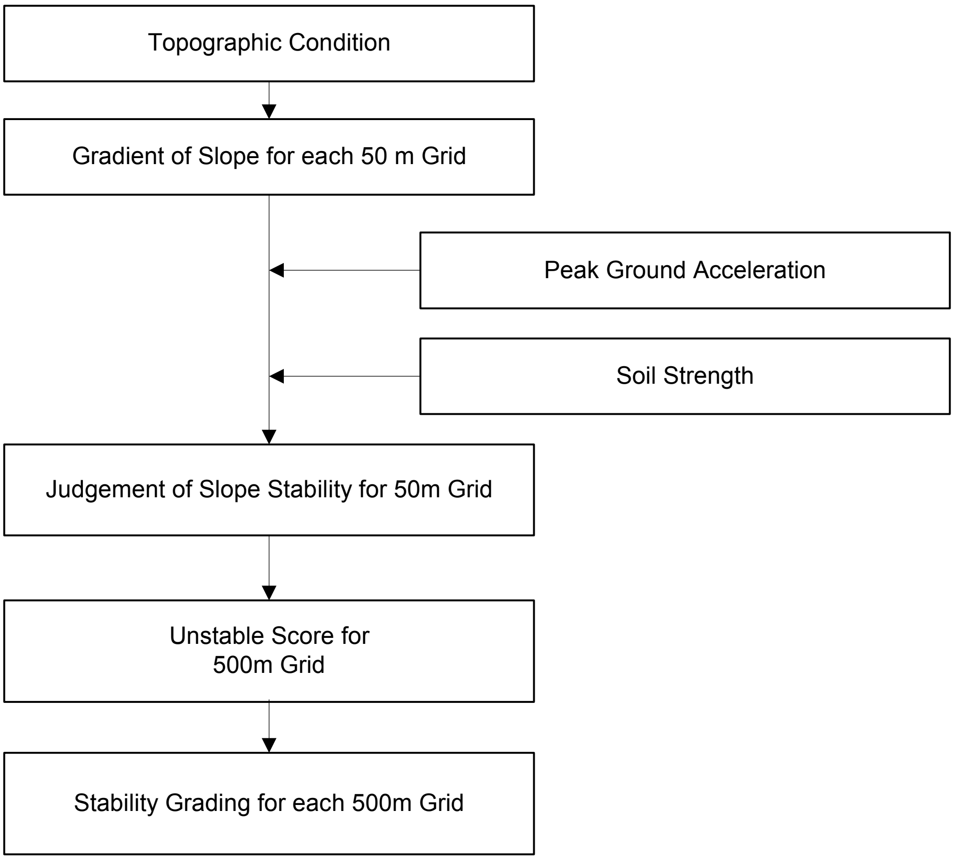


Figure 7.4.2 Flowchart of Slope Failure Evaluation
Source: The JICA Study Team

a. Slope Stability Evaluation for 50 m Grids

The slope gradient for each 50 m gri, that covers all of the Study Area is calculated first. Then, the slope stability of each point is judged using Siyahi's equation (Eqn. 7.4.1), taking the peak ground acceleration value and strength of soil into account. A score $F_i = 0$ for a stable point ($Fs > 1.0$) or $F_i = 1$ for an unstable point ($Fs < 1.0$) is then given.

b. Slope Stability Evaluation for 500 m Grids

There are a total 100 of 50 m-grids in every 500 m grid, and the stability score for each 500 m grid is determined as follows:

$$\text{Unstable Score}\left(500\text{m Grid}\right) = \sum_{i=1}^{100} \text{Score } F_i \left(50\text{m Grid}\right)$$

$$F_i\left(50\text{m Grid}\right) = 1\left(unstable\right) \quad or \quad 0\ (stable)$$

If all 50 m grids are evaluated as unstable, then *Score (500m grid)* is calculated as 100. If all 50 m grids are evaluated as stable, then *Score (500m grid)* is calculated as 0. This score directly represents what percent of the 50 m grids in each 500 m grid is judged as unstable. Finally, the results are represented by risk for each 500 m grid, as shown in Table 7.4.1.

Table 7.4.1 Evaluation of Risks on Slope Stability for 500m Grid

Unstable Score (500m Grid)	Risk Evaluation for 500m Grid
0	Very low
1-30	Low
31-60	High
61-100	Very high

(5) Parameters for Calculation

a. Slope Gradient

Slope gradient is determined as 50 m grid base.

b. Ground Motion

Scenario Earthquake Model A and model C are considered because these two scenarios represent the most general hazard conditions.

c. Shear Strength of Ground

Shear strength is the most important parameter for calculation. Available data on shear strength for soil is limited and does not cover all the geological formations. Therefore, values are estimated considering two existing references. One is *strength of sliding surface for weathered rocks*, quoted in "Design Guideline for Road Construction, Slope Treatments and Stabilization," Japan Road Association, 1999. Another reference is *strength of sliding surface for weathered rocks*, quoted in "Slope Stability and Stabilization Methods," L. Abramson et al., 1996. The determined strength of each formation and considered failure type are summarized in Table 7.4.2.

Table 7.4.2 Applied Angle of Shear Strength for Slope Stability Calculation

Ground Type	Geological Formation		Angle of Shear Strength (Degree)	Remarks
	Geological Map	Formation		
Rock	IBB 1:5,000	Kuf, Af, Gf, Df, Kf, Tf, Blf, Trf, Bg, V	25	Considering surface failure of weathered zone or talus.
	MP 1:50,000	Kuf, Af, Gf, Df, Kf, Tf, Blf, Trf, Kz, Saf		
	MTA 1:25,000	tsk, ts, tq, ptq		
Tertiary Sediments	IBB 1:5,000	Sf, Cf, Baf	25	Considering surface failure of weathered zone or talus.
	MP 1:50,000	Sf, Cf, Baf		
	IBB 1:5,000	Cmlf	15	Same as Güf, Gnf
	IBB 1:5,000	Sbf, Çf, Saf	30	Considering surface failure of weathered zones or talus. Gravel conditions are taken into account.
	MP 1:50,000	Çf,		
	MTA 1:25,000	m2m3-19-k		
	IBB 1:5,000	Güf , Gnf	15	Landslides occur in these formations. Residual strength is considered.
	MP 1:50,000	Güf , Gnf		
	MTA 1:25,000	e3-ol1-10-s, ebed-20-s, ebed-8-s, m3-pl-18k, ol2-18-k, ol2m1-19-k, ol-8-s,pgg		
Quaternary Sediments	IBB 1:5,000	Ksf, Qal, Ym	25	General slope failure. Same as weathered zone.
	MP 1:50,000	Oa, Q		
	MTA 1:25,000	Q-21-k		
Fill	IBB 1:5,000	Yd, Sd	25	

Source: The JICA Study Team

7.4.2. Slope Stability

(1) Slope Stability Risk

The results of the slope stability risk evaluation are shown in Figure 7.4.3, Figure 7.4.4.

In the case of Model A, "very high risk" grids exist in Adalar and Silivri. These correspond to steep cliffs and not residential areas. "low risk" grids exist in Avcılar and Küçükçekmece, Büyükçekmece. These correspond to residential areas.

In the case of Model C, "very high risk" grids extend to Avcılar. "high risk" grids prevail in Büyükçekmece. These correspond to residential areas. "low risk" grids extend through Bahçelievler, Bakirköy, and Güngören, and these correspond to residential areas.

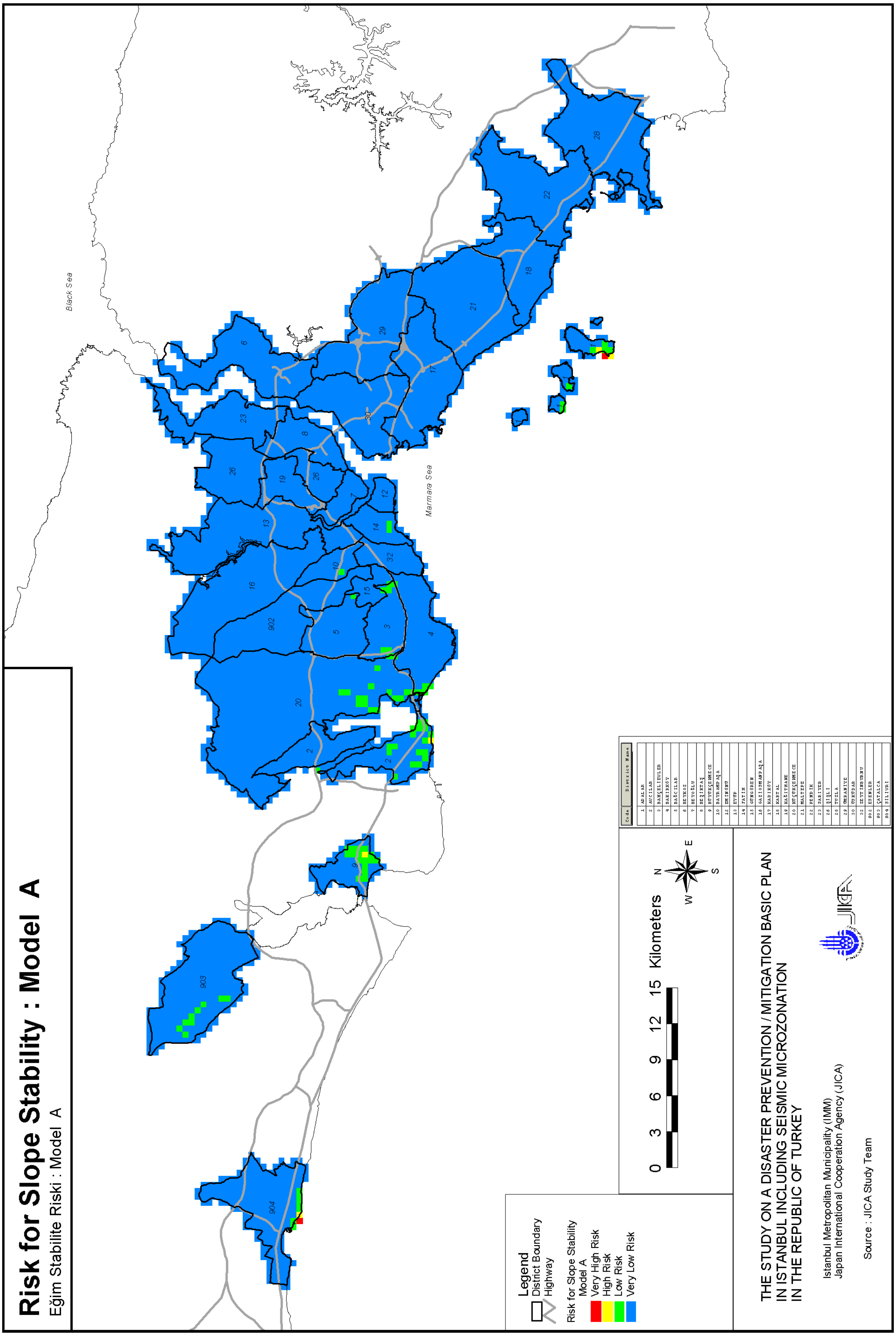


Figure 7.4.3 Slope Stability Risk: Model A

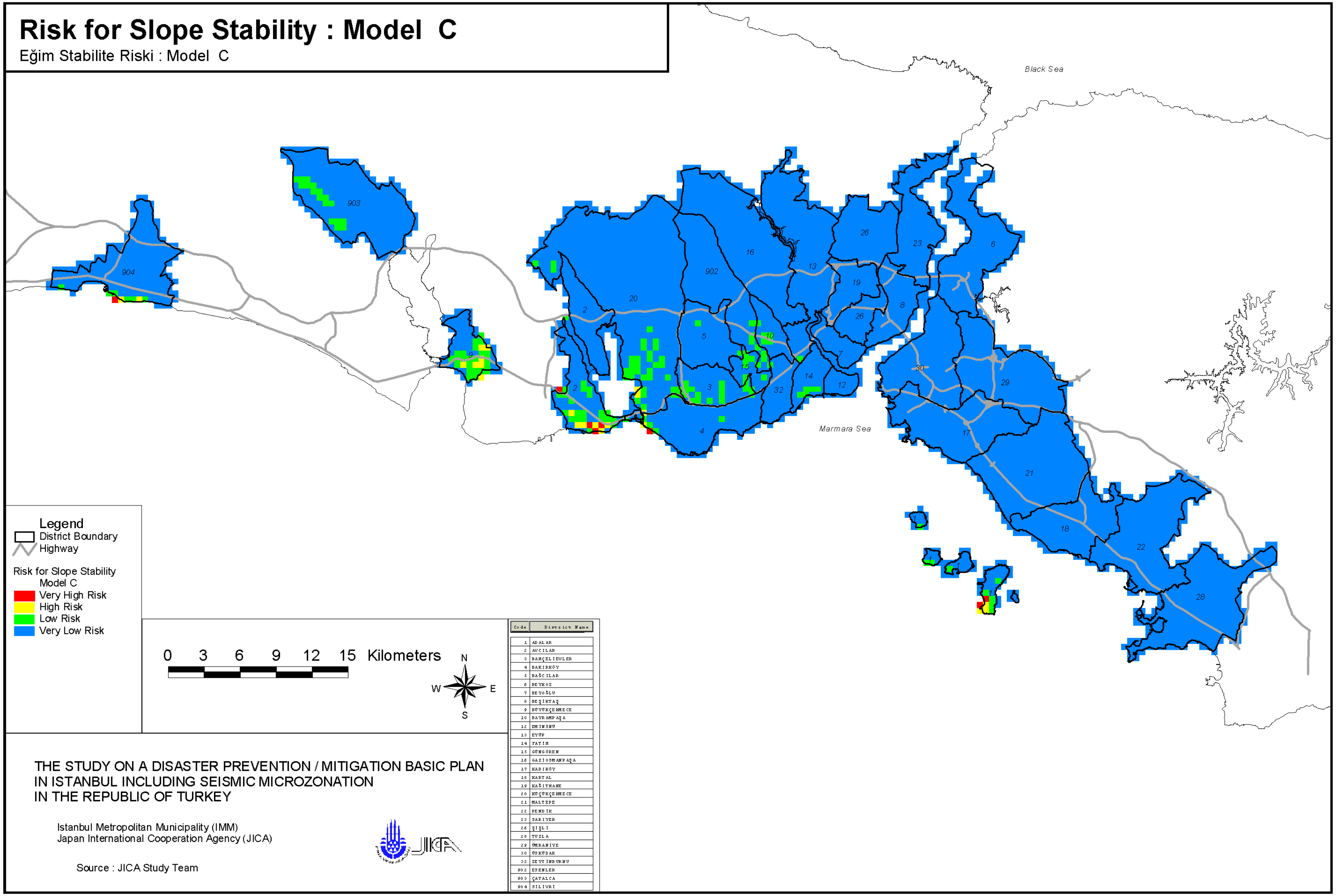


Figure 7.4.4 Slope Stability Risk: Model C

(2) Slope Stability Condition for each District and Geological Formation Unit

Slope risks are examined on a more detailed level. Unstable scores are summarized for each district and each geological formation.

The stability score for each district is determined as follows:

$$\text{Unstable Score}\left(\text{District}\right) = \frac{\text{Number of Unstable 50m grid}}{\text{Number of 50m grid in the District}} \times 100\ (\%)$$

First, slope stability for each 50 m grid is calculated. Next, the number of unstable grids in a district is calculated. Then, the area ratio for these grids is calculated. This score directly represents what percent of area for each district is unstable.

The stability score for each geological unit is determined as follows:

$$\text{Unstable Score}\left(\text{Geological Formation}\right) = \frac{\text{Number of Unstable 50m grid}}{\text{Number of 50m grid in the Formation}} \times 100\ (\%)$$

First, slope stability for each 50 m grid is calculated. Next, the number of unstable grids in each geological formation is calculated. Then, the area ratio for these grids is calculated. This score directly represents what percent of area for each geological formation is unstable.

Unstable scores are summarized for each district and for geological formation units. Results are shown in Table 7.4.3 and Table 7.4.4, respectively.

In the Büyükçekmece District, areas of “low risk” and “high risk” prevail. Unstable scores are about 3% for Model A and about 7% for Model C, respectively. This area is characterized by landslides. Unstable areas are concentrated to the eastside slope of Büyükçekmece Lake. The low strength of the Güf Formation contributes to the resulting high damage ratio, even though the slope gradient is not steep.

In the Adalar District, areas of “high risk” and “very high risk” exist in the southern part of Büyükada Island. The area is closest to the source fault. Unstable scores are about 2% for Model A and about 5% for Model C, respectively. Unstable areas are concentrated on Büyükada Island because this district is closest to earthquake source fault.

In the Avcılar Dıstrıct, areas of “high risk” and “very high risk” exist in the southern part of the district. Unstable scores are about 1% for Model A and about 4% for Model C, respectively. This area is also characterized by landslides. Unstable areas are concentrated in the southern coast area where Gnf formations prevail. Some unstable areas exist in the districts of Bahçelievler, Bakirköy, Güngören, Çatalca and Silivri.

Table 7.4.3 Results of Slope Stability Analysis by District

District Name	Calculation Points (50m grid)	Model A		Model C	
		Unstable Points (50m grid)	Unstable Score (Average Unstable Area Ratio %)	Unstable Points (50m grid)	Unstable Score (Average Unstable Area Ratio %)
Adalar	3786	75	1.98	185	4.89
Avcilar	15358	140	0.91	608	3.96
Bahçelievler	6638	26	0.39	111	1.67
Bakirköy	11678	49	0.42	95	0.81
Bağcilar	8768	0	0.00	8	0.09
Beykoz	15208	0	0.00	0	0.00
Beyoğlu	3487	0	0.00	0	0.00
Beşiktaş	7217	0	0.00	0	0.00
Büyükçekmece	5520	166	3.01	402	7.28
Bayrampaşa	3840	1	0.03	14	0.36
Eminönü	2001	0	0.00	0	0.00
Eyüp	20208	0	0.00	1	0.00
Fatih	4157	3	0.07	23	0.55
Güngören	2880	6	0.21	24	0.83
Gaziosmanpaşa	22680	0	0.00	0	0.00
Kadiköy	16304	0	0.00	0	0.00
Kartal	12462	0	0.00	0	0.00
Kağithane	5778	0	0.00	0	0.00
Küçükçekmece	47949	59	0.12	256	0.53
Maltepe	22038	0	0.00	0	0.00
Pendik	18822	0	0.00	0	0.00
Sariyer	11040	0	0.00	0	0.00
Şişli	14161	0	0.00	0	0.00
Tuzla	19641	0	0.00	0	0.00
Ümraniye	18252	0	0.00	0	0.00
Üsküdar	15059	0	0.00	0	0.00
Zeytinburnu	4583	0	0.00	2	0.04
Esenler	15552	0	0.00	16	0.10
Çatalca	21054	50	0.24	144	0.68
Silivri	15262	116	0.76	141	0.92
Total	391383	691	0.18	2030	0.52

Source: The JICA Study Team

Table 7.4.4 Results of Slope Stability Analysis by Geological Formation Unit

Covering Geological Map	Formation Name	Calculation Points (50m grid)	Model A		Model C	
			Unstable Points (50m grid)	Unstable Score (Average Unstable Ratio %)	Unstable Points (50m grid)	Unstable Score (Average Unstable Ratio %)
IBB 1:5,000 MP 1:50,000	Gnf	18562	259	1.59	1063	6.69
	Çmlf	3284	1	0.03	18	0.55
	Güf	1991	24	1.21	77	3.87
	Tf	2104	3	0.14	3	0.14
	Af	4497	52	1.16	144	3.20
	Kuf	24427	16	0.07	31	0.13
	V	436	4	0.92	7	1.61
MTA 1:25,000	ebed-8-s	908	25	2.75	73	8.04
	ol2-18-k	19289	282	1.46	544	2.82
	ol-8-s	488	24	4.92	60	12.30
	pgg	1026	1	0.10	10	0.97
Total		391383	691	0.18	2030	0.52

Source: The JICA Study Team

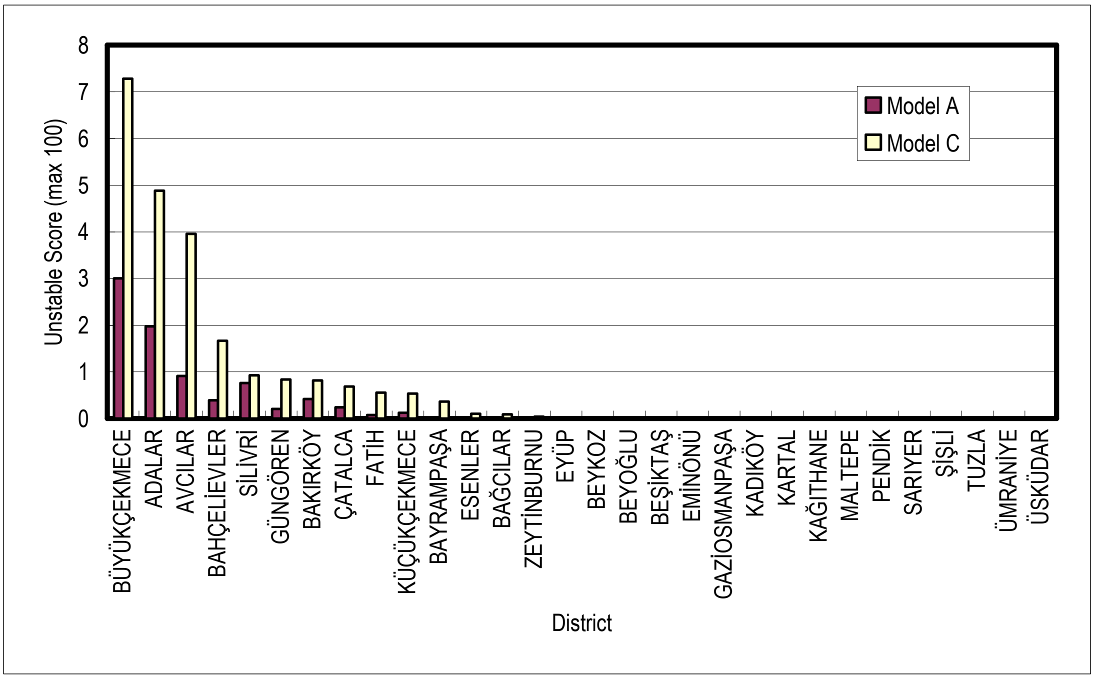


Figure 7.4.5 Unstable Score (Area Ratio) of Slope by District

Souce: The JICA Study Team

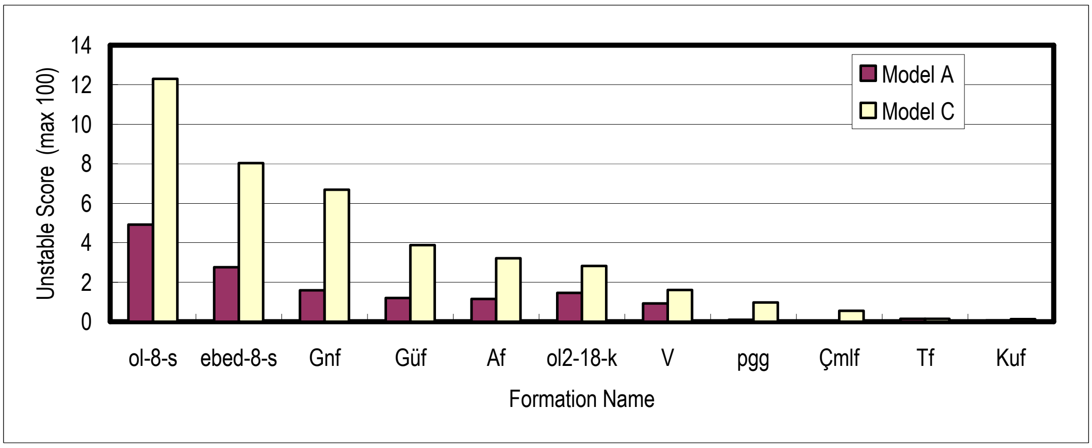


Figure 7.4.6 Unstable Score (Area Ratio) of Slope by Geological Formation

Souce: The JICA Study Team

Acknowledgement

The slope stability analysis in this chapter was conducted under close discussions with Dr. Prof. Kutay Özaydın, Yıldız Technical University, Faculty of Civil Engineering, Department of Engineering, Geotechnical Division, Dr. Prof. Erdoğan Yüzer, Istanbul Technical University, Faculty of Mining, Geological Engineering Department, Dr. Assoc. Prof. Bilge G. Siyahi, Boğaziçi University, Kandilli Observatory and Earthquake Research Institute, and Department of Earthquake Engineering. The Study Team expresses special thanks to their collaboration.

References for Section 7.4

Bilge G. Siyahi, 1998, Deprem Etkısindeki Normal Konsolide Zemin Şevlerinde Yari-Statik Stabilite Analizi, İMO Teknik Dergi, Yazı 112, 1525-1552.

Erdoğan Yüzer, 2001, Privarte Interview.

ISSMFE, 1993, Manual for Zonation on Seismic Geotechnical Hazards, Technical Committee for Earthquake Geotechnical Engineering, TC4, International Society of Soil Mechanics and Foundation Engineering.

Japan Road Association, 1996, Japanese Design Specification of Highway Bridge (in Japanese).

Japan Road Association, 1999, Design Guideline for Road Construction, Slope Treatments and Stabilization, pp. 352. (in Japanese)

Kutay Özaydın, 2001, Private Interview.

Lee Abramson, Tom Lee, Suil Sharma, Glenn Boyce, 1996, Slope Stability and Stabilization Methods, John Willy & Sons, pp94.

Chapter 8. Estimation of Damages and Casualties

Earthquake damage is calculated for Model A and Model C scenario earthquakes, respectively. Comparing the results of the seismic motion distribution of the four different scenario earthquakes shown in Chapter 7, the following observations can be made:

- Distribution of peak ground acceleration (PGA) of Model D resembles that of Model A
- Therefore, the damage distribution pattern for Model D is expected to resemble to that of Model A
- PGA value of Model D is less than that of Model ATherefore, damage for Model D will be less than that for Model A.On the European side, distribution of peak ground acceleration (PGA) of Model B is almost similar to that of Model C
- Therefore, the damage distribution pattern for Model B is expected to resemble to that of Model C
- PGA value of Model B is less than that of Model C
- Therefore, damage amount of Model B will be less than that of Model C

To conclude, the damage estimation for Model A is conducted as the most probable case, and for Model C as the worst case.

Caution

Seismic microzonation is not the prophecy of future earthquakes. Scenario earthquakes are never meant predict the next event. It cannot be said that one of these models will occur next.

Though the analysis is based on up-to-date scientific knowledge, results include inevitable errors. The estimated damage amount and distribution included in this report can be used only for the purpose of establishing a disaster prevention / mitigation plan in Istanbul.

8.1. Buildings

8.1.1. Methodology

(1) General

a. Schematic Flow of Damage Estimation

In this study damage is estimated comparing **"the response displacement of the building"** and **"the displacement in which the building come at the damage"**. Schematic flow chart is shown in Figure 8.1.1.

Regarding **"the response displacement of the building"**;

The earthquake excitation can be given as **"Acceleration Response Spectrum S_a"**.

Each building is classified to the building type that is shown in Table 8.1.1, and kinetic modeling is carried out. **"Capacity Spectrum"** is established as a result.

"Response Displacement of Building" can be obtained using **"Acceleration Response Spectrum S_a"** and **"Capacity Spectrum"**.

In above-mentioned procedure, **"Capacity Spectrum"** is set taking account into the non-linearity caused by yielding of particular member of the building. Therefore **"Response Displacement of Building"** can be more certain index than acceleration or force. This is an advantage that can be obtained by using this method.

Regarding **"the displacement in which the building come at the damage"**;

The damage state is classified into 3 categories "Heavily"□"Moderately" and "Partly" as shown in. Each damage state is defined by the value of story drift. Each value of story drift is converted into spectral displacement. However if the technological uncertainty of the earthquake motion and the building model is taken into account, a kind of probabilistic method is needed here because the damage state evaluation may have some dispersion. The lognormal distribution is applied in order to reflect this dispersion, and **"Fragility Function"** is obtained as a result. **"Fragility Function"** gives **"Damage Ratio"** that the building come at.

"Number of Damaged Buildings" can be obtained when **"Damage Ratio"** is multiplied by the number of buildings that is counted in **"Building Inventory"**.

Building damages are calculated based on scenario earthquakes Model A and Model C. In these estimations, every type of building included in the building census for the year 2000 is included. Important public facilities such as schools, hospitals, and fire stations will be studied separately in another chapter.

Buildings are calculated as "heavily," "moderately," or "partly" damaged. "Heavily" damaged buildings are buildings that are severely damaged or have collapsed, and these buildings are unfit to occupy until they are repaired or rebuilt. "Moderately" damaged buildings are buildings that are able to used for evacuation purposes just after the hazard, but they need to be repaired before occupied permanently. "Partly" damaged buildings can be used for living, but it is desirable they be repaired because the structure is partly damaged and its earthquake-resistance has been compromised.

The cause of damage is limited to the seismic vibration itself. Damage due to other causes such as liquefaction, landslide, and fire is not included. This assumption will not affect the result because these phenomena are not main causes of earthquake disasters in Istanbul.

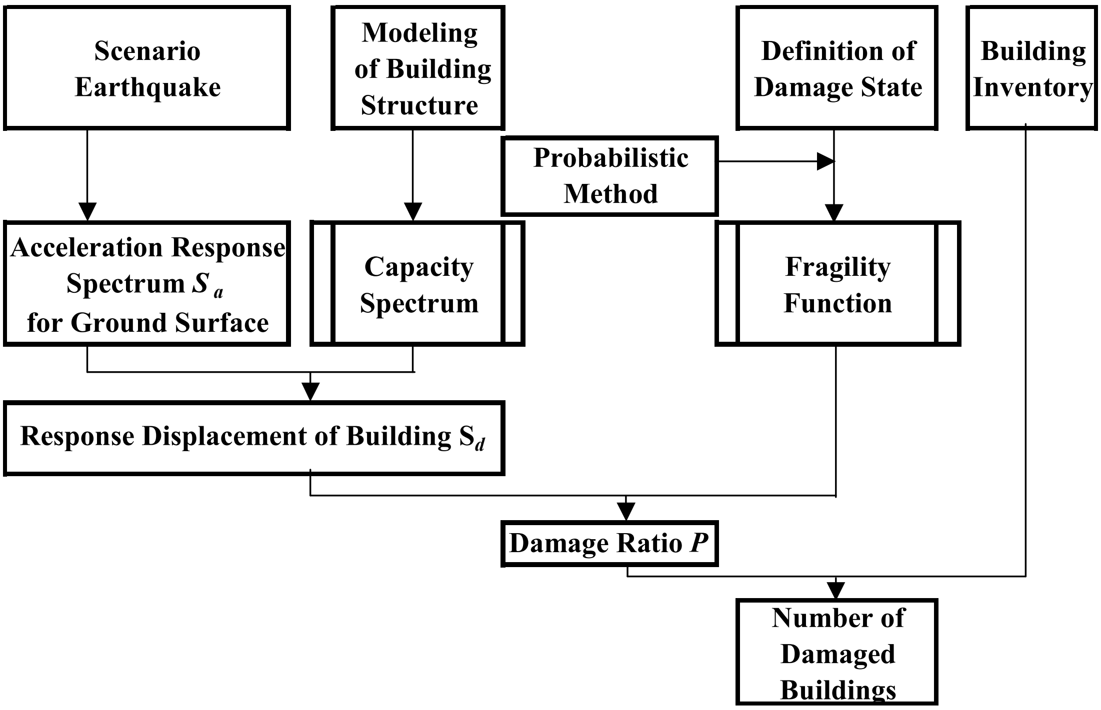


Figure 8.1.1 Schematic Flowchart of Building Damage Estimation

b. Building inventory for damage estimation

In this study, building types are classified as shown in Table 8.1.1. Each group of building type is defined as a combination of “Structure”, “Floor Number” and “Construction Year”. The damage vulnerability function will be given for each of building type.

Table 8.1.1 Building Number by Classification for Damage Estimation

Classification	Structure	Floor Number	Construction Year			Total
			-1959	1960 - 1969	1970 -	
1	RC Frame with Brick Wall	1 - 3F	7,120 (1.0%)	13,757 (1.9%)	200,950 (27.7%)	221,827 (30.6%)
2		4 - 7F	6,280 (0.9%)	15,449 (2.1%)	280,231 (38.7%)	301,961 (41.7%)
3		8F -	481 (0.1%)	886 (0.1%)	18,468 (2.5%)	19,835 (2.7%)
4	Wood Frame	1 - 2F	4,755 (0.7%)	697 (0.1%)	1,583 (0.2%)	7,035 (1.0%)
5		3F -	3,611 (0.5%)	222 (0.0%)	358 (0.0%)	4,191 (0.6%)
6	RC Shear Wall	1 - 3F	1 (0.0%)	0 (0.0%)	13 (0.0%)	13 (0.0%)
7		4 - 7F	0 (0.0%)	0 (0.0%)	200 (0.0%)	200 (0.0%)
8		8F -	0 (0.0%)	0 (0.0%)	564 (0.1%)	564 (0.1%)
9	Masonry	1 - 2F	25,967 (3.6%)	24,881 (3.4%)	83,215 (11.5%)	134,063 (18.5%)
10		3F -	16,952 (2.3%)	8,208 (1.1%)	8,877 (1.2%)	34,037 (4.7%)
11	Prefabricated		20 (0.0%)	12 (0.0%)	864 (0.1%)	896 (0.1%)
Total			65,188 (9.0%)	64,113 (8.8%)	595,322 (82.2%)	724,623 (100.0%)

(2) Modeling and Capacity Spectrum

a. Modeling

Multi degree of freedom model (hereinafter reffered to as "MDOFM"), that is shown schematically in Figure 8.1.2 is generated for each building type. Then a set of eigenvalue (natural period and eigen vector) is obtained applying eigenvalue analysis.

Single degree of freedom model (hereinafter reffered to as "SDOFM") can be substituted for MDOFM applying a set of eigenvalue. Response Displacement of Building S_d can be calculated using SDOFM.

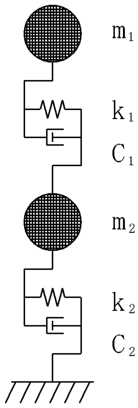


Figure 8.1.2 Schematic drawing of multi degree of freedom model (Example for 2 stories building)

b. Capacity Spectrum

The capacity Spectrum is configured using fundamental eigenvalue that is obtained by the procedure explained above. The concept of capacity Spectrum is shown in Figure 8.1.3.

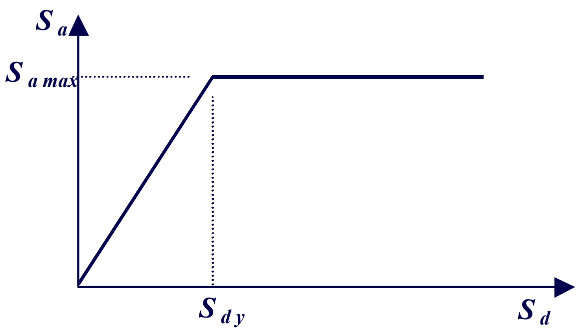


Figure 8.1.3 Schematic Drawing of Capacity Spectrum

Capacity spectrum defines a specific SDOFM that represents the component of fundamental eigenvalue of MDOFM explained in Figure 8.1.2.

Vertical axis of Fig. 8.1.3 shows the response acceleration that represents the component of fundamental eigenvalue of MDOFM S_a. The horizontal axis shows the response displacement that represents the component of fundamental eigenvalue of MDOFM S_d.

Gradient of the second solid line in Figure 8.1.3 is assumed as horizontal. The off-set value of $(S_a)_{\max}$ is given by Eq. (8.1.1).

$$(S_a)_{\max} = \left(\frac{V}{W}\right) \cdot \frac{G}{\alpha_1} \qquad (8.1.1)$$

where,

$(S_a)_{max}$: Capacity acceleration

$\left(\frac{V}{W}\right)$: Ratio of horizontal seismic load to weight

G : Acceleration of gravity

α_1 : Effective mass ratio of fundamental mode

$$\alpha_1 = \frac{M_{x1}}{\sum m_n} \quad (8.1.2)$$

where,

M_{x1} : Effective mass of fundamental mode

$\sum m_n$: Total mass

Gradient of first solid line in Fig.8.1.3 represents the fundamental period, and is given by Eq. (8.1.3).

$$\frac{S_{a\max}}{S_{dy}} = \left(\frac{2\pi}{T}\right)^2 \quad (8.1.3)$$

(3) Probabilistic Method and Fragility Function

a. Probabilistic Method

In this study, damage evaluation will be carried out using a fragility function that is given as a lognormal distribution in which a spectral displacement is applied as a stochastic variable. A basic equation is shown in Eq. (8.1.4).

$$P[D \geq d_s S_d] = \Phi\left[\frac{\ln\left(\frac{S_d}{S_{d,d_s}}\right)}{\beta_{ds}}\right] \quad (8.1.4)$$

where

$P[D \geq d_s S_d]$: Damage Ratio It means probability of that damage state of the building D become under d_s.

S_d : Spectral displacement

S_{d,d_s} : Median values of spectral displacement when the building shows the damage state d_s

β_{ds}：Standard deviation of logarithm of the displacement when the building shows the damage state d_s

Φ：Operational calculus for obtaining the cumulative standard normal distribution functions

b. Fragility Function

The fragility function is to derive the relation between the damage ratio and response of building model. That is specified by the median values of spectral displacement when the building shows the each damage state S_{d,d_s} and Standard deviation of logarithm of the displacement when the building shows the each damage state β_{ds}. (See Eq. (8.1.4))

The value S_{d,d_s} is given by Eq. (8.1.5) on the basis of a story drift ratio D_s.

$$S_{d,d_s} = \frac{D_s}{F_p \cdot \left[\frac{\phi_j - \phi_{j+1}}{H_j}\right]_{\max}} \qquad (8.1.5)$$

where,

D_s：Story drift ratio when the damage state reaches d_s

F_p：Participation Factor

ϕ_j：Eigen vector of story j

H_j：Height of story j

The remaining coefficient β_{ds} represents the dispersion of the value S_d. The coefficient of variation C_V that is defined in Eq. (8.1.6) and (8.1.7) is effective in determining the value β_{ds}.

$$\beta_{ds} = \sqrt{\ln \frac{1 + \sqrt{1 + 4\left(\frac{\sigma}{\exp\left(\ln S_{d,d_s}\right)}\right)^2}}{2}} \qquad (8.1.6)$$

$$\sigma = C_V \cdot S_{d,d_s} \qquad (8.1.7)$$

where

σ：variance

C_V：coefficient of variation

(4) Parameter setting

Several coefficients shall be determined to specify the capacity spectrum and the fragility function. These coefficients are determined originally from building structure and individual from the seismic ground motion. It is an advantage of the damage estimation method employed in the Study that we can study the characteristics of the building and seismic ground motion separately.

At the initial stage of determination of the coefficients, the following items are taken into consideration.

1) Existing study on capacity of structure

2) Trend of earthquake resistant standard in the Study area

3) General common sense of construction engineer in the Study area

4) Impression from site survey in the Study area (especially, quality of finishing)

Actual dameges by past earthquakes also give convincing information. In other word, these can be regarded as actual size experiment. Therefore, those coefficients which are primarly determined are cariblated and reconsidered with reference to the existing past earthquake damage ratio. The coefficients are finally determined by following procedure.

1) Determine the coefficients temporarily based on descriptions in the earthquake resistant standard adopted in Istanbul, taking the result of site survey into consideration

2) Set the capacity spectrum and the fragility function and apply them to the area where the damages of past earthquake are reported

3) Applied seismic motion is the response spectrum accerelation calculated based on observed accerelation wave form which is considered to represent the actual seismic motion well.

4) Relations between Damage ratio and Seismic intensity are generally reported in those past earthquake damage investigations. In this case, adjusted response spectrum accrelation at each building points are calculated from reported seismic intensities.

a. Capacity spectrum

Examples of capacity spectrum is shown in Figure 8.1.4.

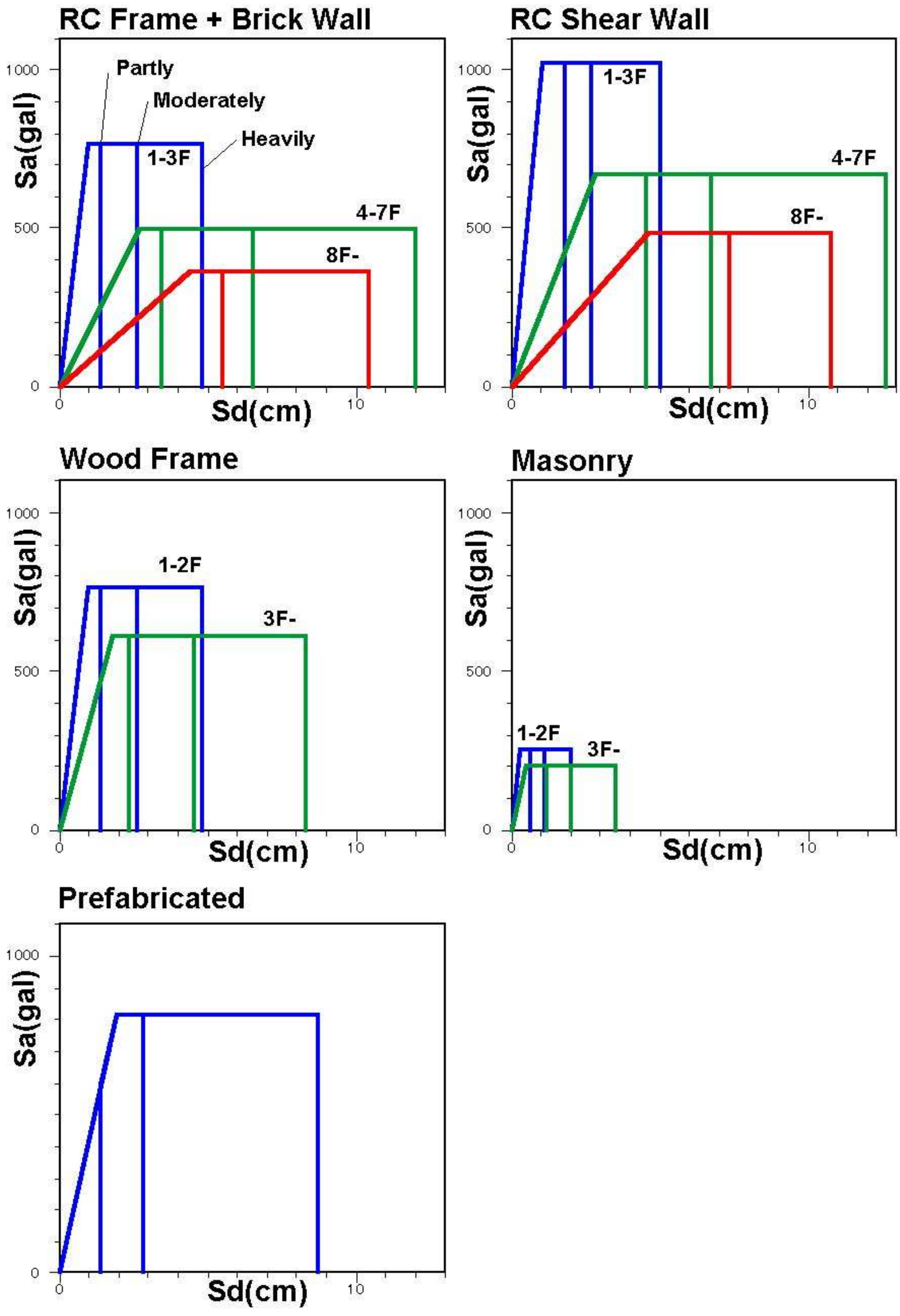


Figure 8.1.4 Capacity Spectrum of the Buildings Constructed after 1970

b. Fragility Function

Examples of fragility function are shown in Figure 8.1.5.

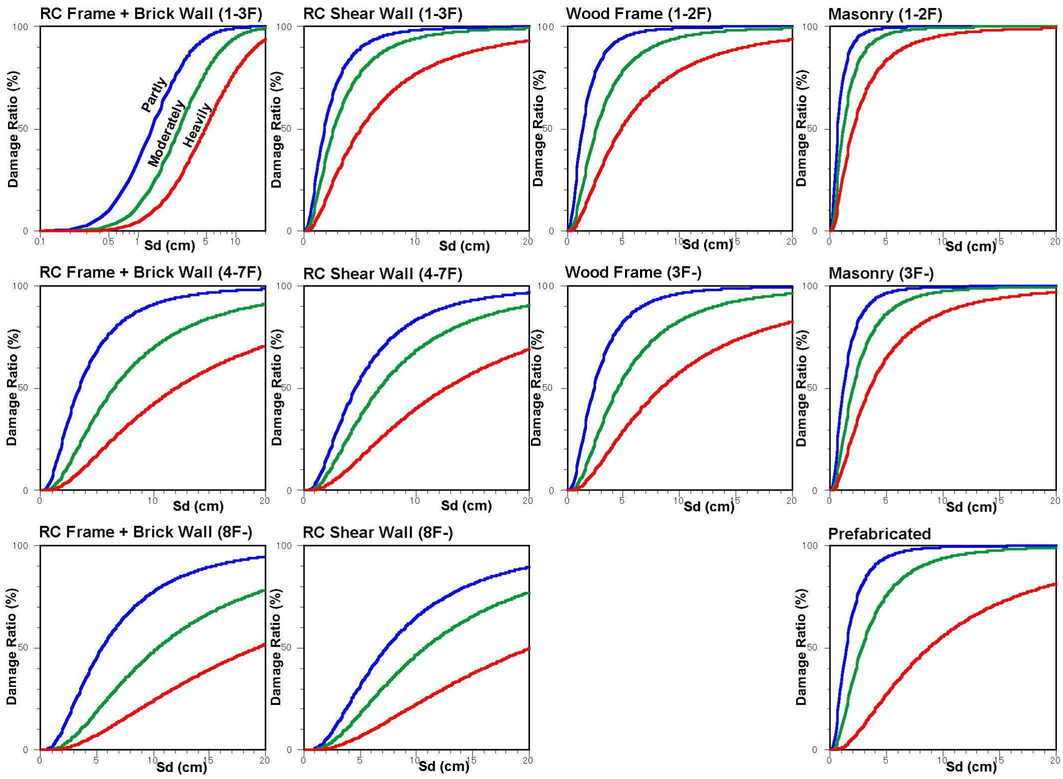


Figure 8.1.5 Fragility Function of the Buildings Constructed after 1970

8.1.2. Seismic Motion for Damage Estimation

The building inventory database was constructed from a compilation of building census 2000 data collected for each mahalle. The data include the total number of buildings in each mahalle by the eleven structural classes that are shown in Table 8.1.1. However, seismic motion, PGA, PGV and Sa values are calculated by 500m grid cells. To calculate building damage by mahalle, the seismic intensity for each mahalle is necessary. If the building distribution density throughout the mahalle is not very different, it is acceptable to use the simple mean building distribution value ofseveral 500m grid cells, which are contained either fully or partially within the mahalle boundary. However, the building distribution in Istanbul sometimes differs greatly, even within one mahalle. Therefore, the following procedure is adopted to evaluate the seismic motion by mahalle:

5) Determine the number of buildings in each 500m grid cell using a 1/1,000 map. Developed using GIS, the IMM has a 1/1,000 map and data file that includes the location of approximately 1,000,000 buildings. The location and the number of floors for each building are included as attributes in the data file, but neither the structural type nor the constructionyear are included in this database. Therefore, this database was used only to determine the number of buildings in each 500m grid cell.

6) Determine the number of buildings in each mahalle.

7) Calculate the seismic motion using the following formula:

$$Sm = \frac{\sum_i Sg_i \cdot Bgf_i + \sum_j Sg_j \cdot Bgp_j}{Bm}$$

Sm : seismic motion of mahalle

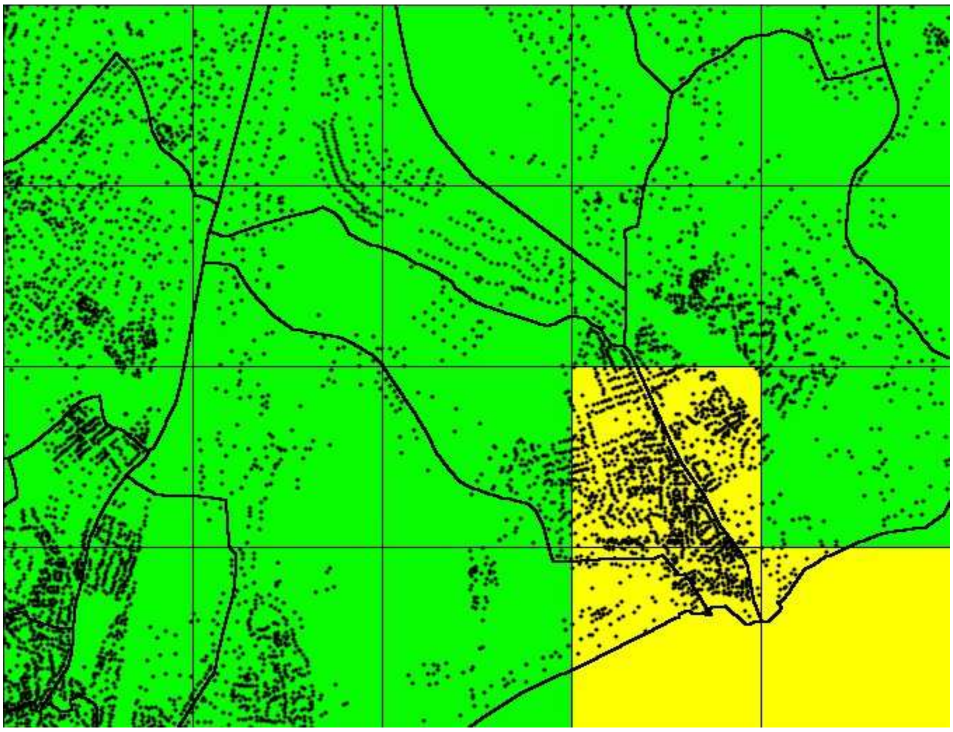
Sg_i : seismic motion of i - th grid

Bgf_i : number of builgings in i - th grid, which are fully included in mahalle

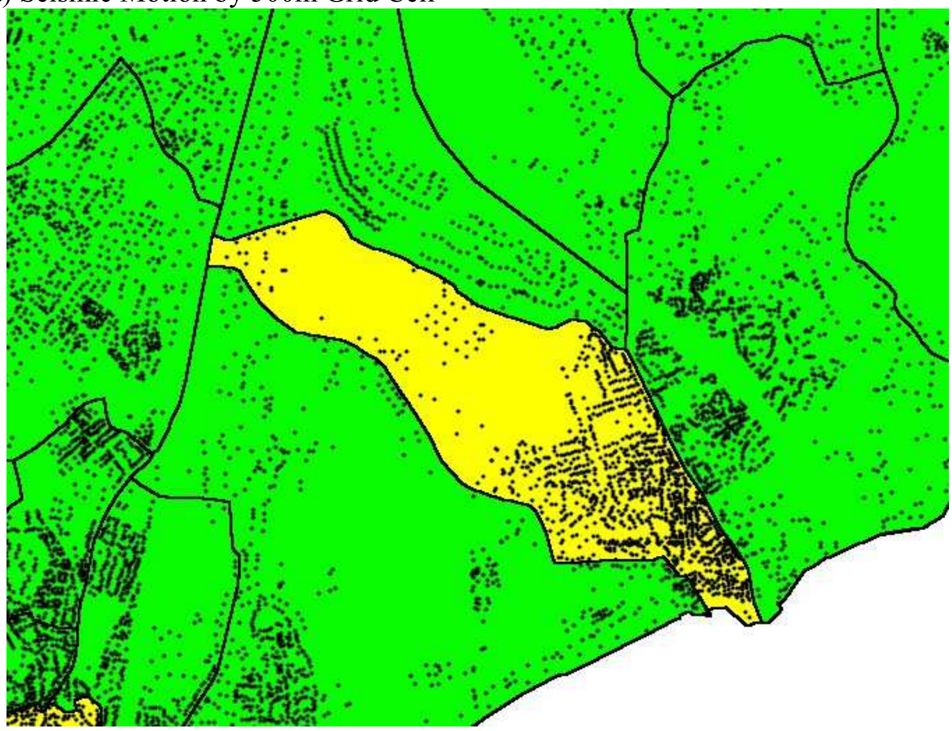
Bgp_j : number of buildings in the part of j - th grid that is included in mahalle, which are partially included in mahalle

$Bm = \sum_i Bgf_i + \sum_j Bgp_j$: building number in the mahalle

Figure 8.1.6 shows an example of seismic motion evaluation for mahalles. Figure 8.1.6a) shows the seismic motion for each 500m grid cell. The black lines denote the mahalle boundaries, and each black dot corresponds to an existing building. Only the southeast end of the mahalle, which is located at the center of the figure, is yellow in color, the rest is green. Therefore, the majority of buildings inthis mahalle exist in the yellow area. Figure 8.1.6b) is the seismic motion of a mahalle, which is calculated based on this procedure. The simple mean of this mahalle is green but because of the building density distribution, this mahalle is evaluated as yellow. Determination of the seismic motion of the mahalles using this procedure leads to a better estimation of damage analysis because it reflects the building density heterogeneously.



a) Seismic Motion by 500m Grid Cell



b) Seismic Motion by Mahalle for Damage Estimation

Figure 8.1.6 Example of Seismic Motion for Damage Estimation

8.1.3. Damage Estimation

Building damages are calculated based on scenario earthquakes Model A and Model C. In these estimations, every type of building included in the building census for the year 2000 is included. Important public facilities such as schools, hospitals, and fire stations will be studied separately in another chapter.

Buildings are calculated as "heavily," "moderately," or "partly" damaged. "Heavily" damaged buildings are buildings that are severely damaged or have collapsed, and these buildings are unfit to occupy until they are repaired or rebuilt. "Moderately" damaged buildings are buildings that are able to used for evacuation purposes just after the hazard, but they need to be repaired before occupied permanently. "Partly" damaged buildings can be used for living, but it is desirable they be repaired because the structure is partly damaged and its earthquake-resistance has been compromised.

The cause of damage is limited to the seismic vibration itself. Damage due to other causes such as liquefaction, landslide, and fire is not included. This assumption will not affect the result because these phenomena are not main causes of earthquake disasters in Istanbul.

Table 8.1.2 Definition of Building Damage

Object	All buildings in Building Census 2000	
Evaluation unit	Damage possibility of each building is evaluated and damage number in each mahalle is summed	
Cause of damage	Seismic vibration	
Definition of damage grade	Heavily	Collapse or heavy structure damage For evacuation: Unusable, Danger For living: Unusable without repair or rebuild (Damage Grade 4 & 5 in EMS-98; see Figure 8.1.7, Figure 8.1.8)
	Moderately	Moderate structure damage For evacuation: Usable For living: Necessary for repair (Damage Grade 3 in EMS-98; see Figure 8.1.7, Figure 8.1.8)
	Partly	Partly structure damage For evacuation: Usable For living: Usable, repair is desirable (Damage Grade 2 in EMS-98; see Figure 8.1.7, Figure 8.1.8)

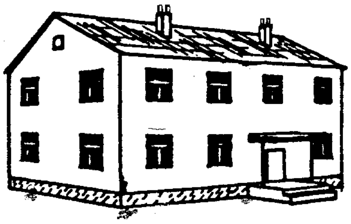
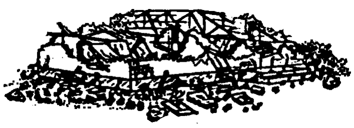
Classification of damage to masonry buildings	
	**Grade 1: Negligible to slight damage** **(no structural damage,** **slight non-structural damage)** Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
	**Grade 2: Moderate damage** **(slight structural damage, moderate** **non-structural damage)** Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage,** **heavy non-structural damage)** Large and extensive cracks in most walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
	**Grade 4: Very heavy damage** **(heavy structural damage,** **very heavy non-structural damage**) Serious failure of walls; partial structural failure of roofs and floors.
	**Grade 5: Destruction** **(very heavy structural damage)** Total or near total collapse.

Figure 8.1.7 Classification of Damage to Masonry Building

Source: EMS-98

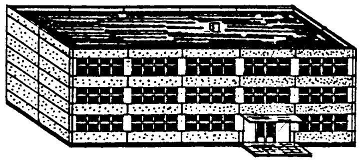
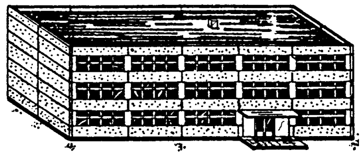
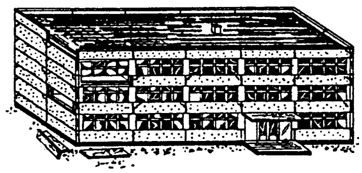
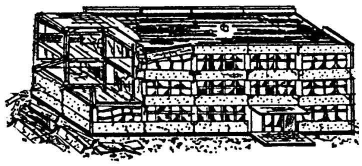
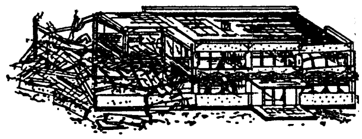
Classification of damage to buildings of reinforced concrete	
	**Grade 1: Negligible to slight damage** **(no structural damage,** **slight non-structural damage)** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
	**Grade 2: Moderate damage** **(slight structural damage,** **moderate non-structural damage**) Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage,** **heavy non-structural damage)** Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods. Large cracks in partition and infill walls, failure of individual infill panels.
	**Grade 4: Very heavy damage** **(heavy structural damage,** **very heavy non-structural damage)** Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
	**Grade 5: Destruction** **(very heavy structural damage)** Collapse of ground floor or parts (e. g. wings) of buildings.

Figure 8.1.8 Classification of Damage to Reinforced Concrete Buildings

Source: EMS-98

Damage is calculated for each mahalle and building classification. A summary of results are shown in Table 8.1.3. In this table, the results of a simulation of the Izmit earthquake are also included. As building damage in some mahalle was not available, only the damage ratio is shown. The building damage analysis method is calibrated by the damage observed during the Izmit and Erzincan earthquakes as shown in the previous section. The simulated results compare well to the observed damage.

Table 8.1.3 Summary of Building Damage

		Heavily	Heavily + Moderately	Heavily + Moderately + Partly
Model A	Building	51,000 (7.1%)	114,000 (16%)	252,000 (35%)
	Household	216,000	503,000	1,116,000
Model C	Building	59,000 (8.2%)	128,000 (18%)	300,000 (38%)
	Household	268,000	601,000	1,300,000
Izmit Eq.	Simulation	(0.15%)	(0.50%)	
	Observed	(0.06%)	(0.33%)	

The damages for each district are summarized in Table 8.1.4 and Table 8.1.5. The damage for each mahalle is shown in Figure 8.1.9 and Figure 8.1.12.

Characteristics of damage for two scenario earthquakes are as follows:

(1) Model A

The total number of heavily damaged buildings is estimated as 51,000. This is 7.1% of total buildings in the Study Area. The number of moderately and heavily damaged buildings, namely the buildings that need repair in order to occupy, is 114,000. Results indicate the southern area of Istanbul is more heavily damaged than the northern area because of the earthquake motion distribution. The southern coast of the European side is the most severely affected area. More than 30% of buildings in several mahalle along the coast are heavily damaged. More than 200 buildings in several mahalle on the European side and some mahalle on the Asian side will suffer heavy damage. It should be noted that more than 300 buildings in Şilivri and Büyükçekmece are also heavily damaged.

(2) Model C

The total number of heavily damaged buildings is estimated as 59,000. This is 8.2% of the total buildings in Study Area. The number of moderately or heavily damaged buildings, namely the buildings that need to berepaired before they can be occupied, is 128,000. The damage distribution is almost the same as that of Model A. More than 40% of buildings in one mahalle along the coast of the European side are heavily damaged. More than 200 buildings in several mahalle on the European side and some mahalle on the Asian side will suffer heavy damage. It should be noted that more than 400 buildings in Şilivri and Büyükçekmece are also heavily damaged.

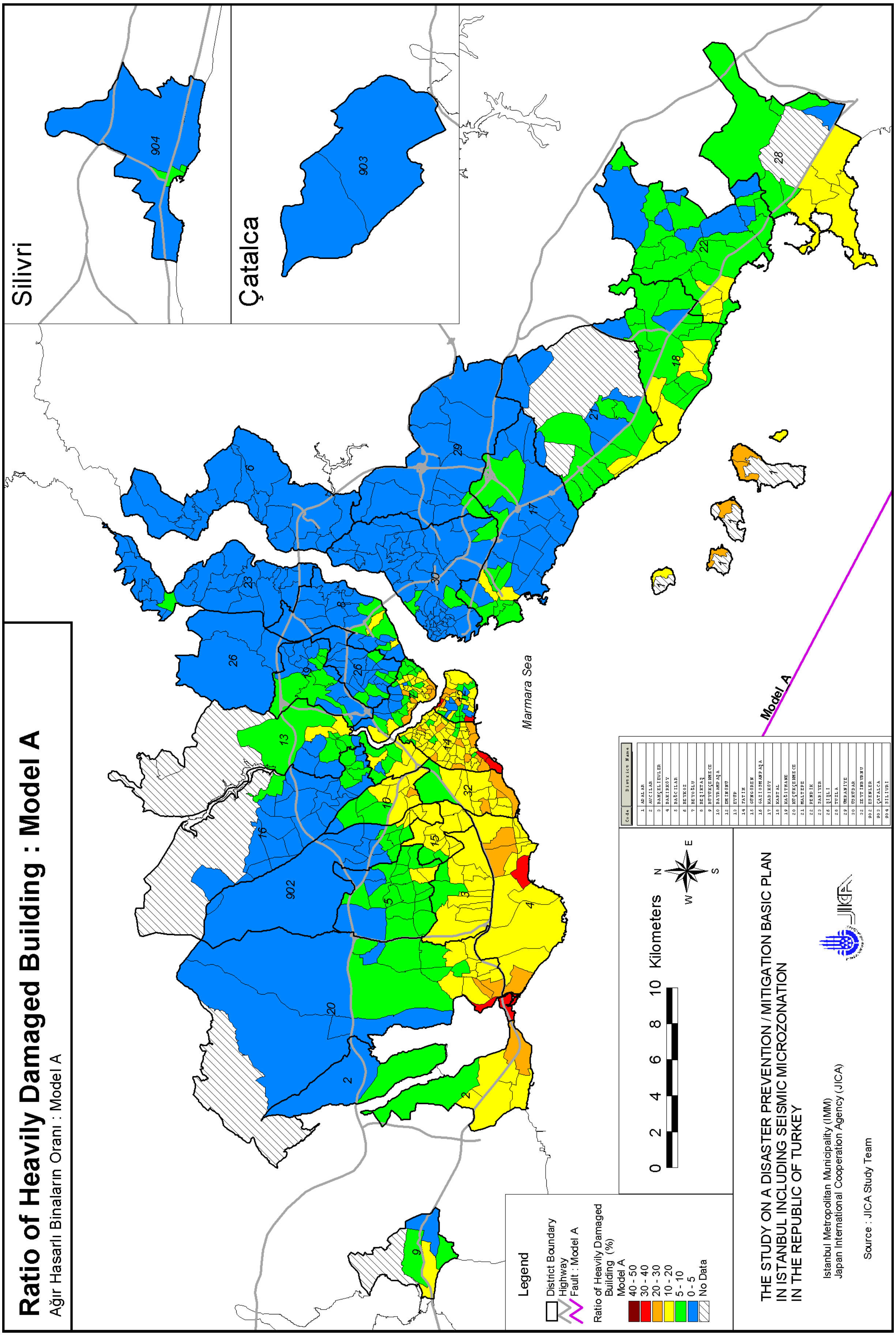


Figure 8.1.9 Ratio of Heavily Damaged Building : Model A

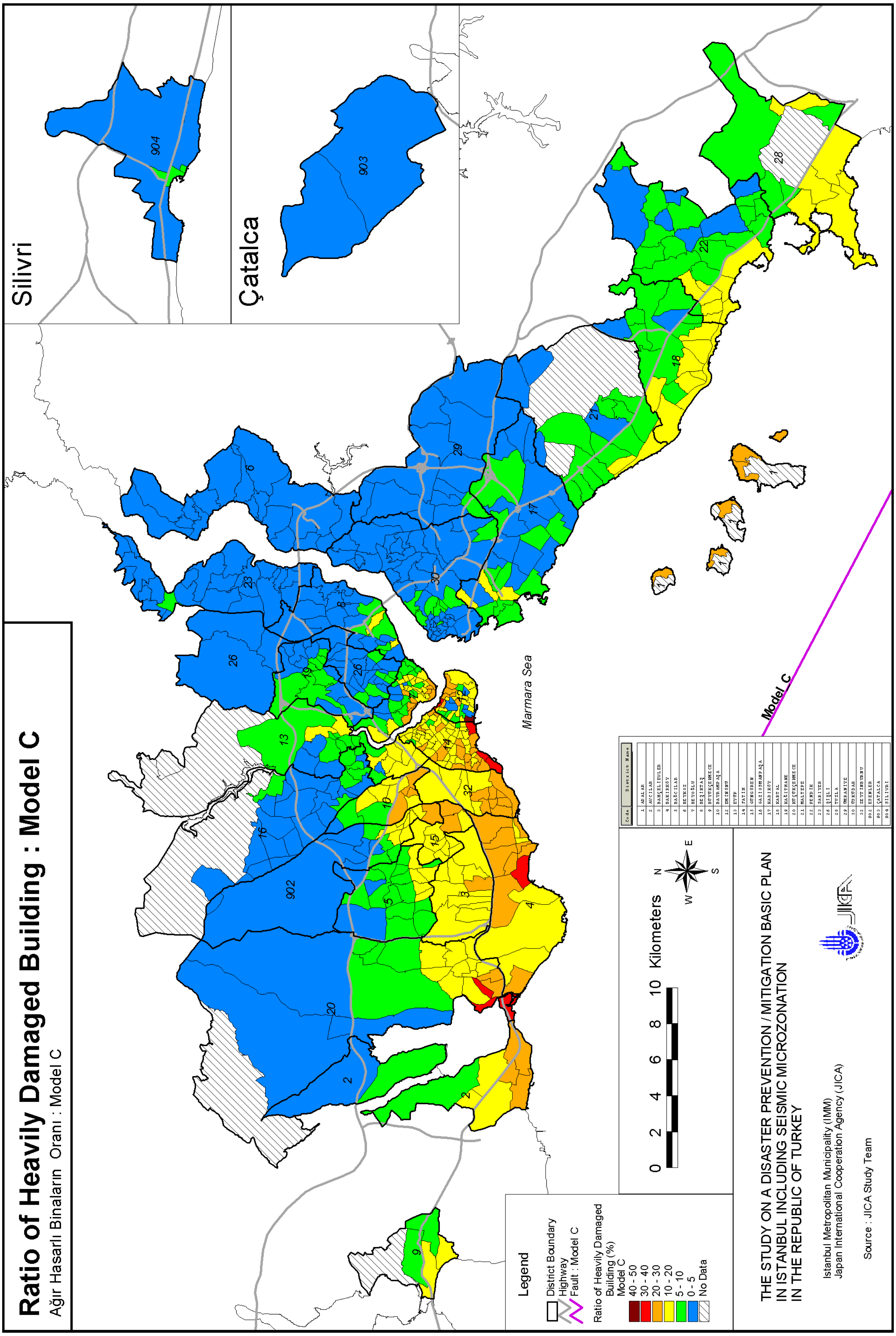


Figure 8.1.10 Ratio of Heavily Damaged Building : Model C

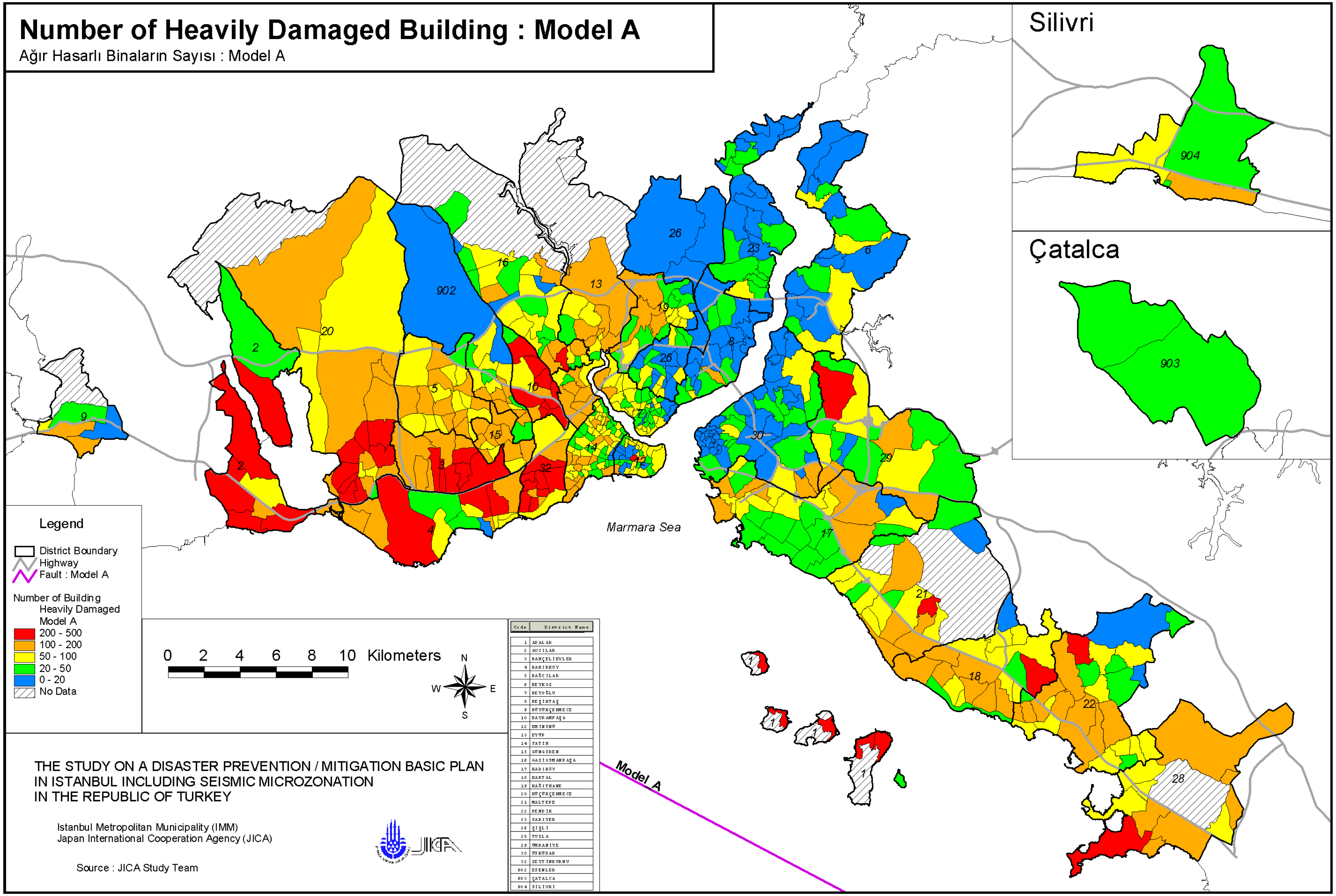


Figure 8.1.11 Number of Heavily Damaged Building : Model A

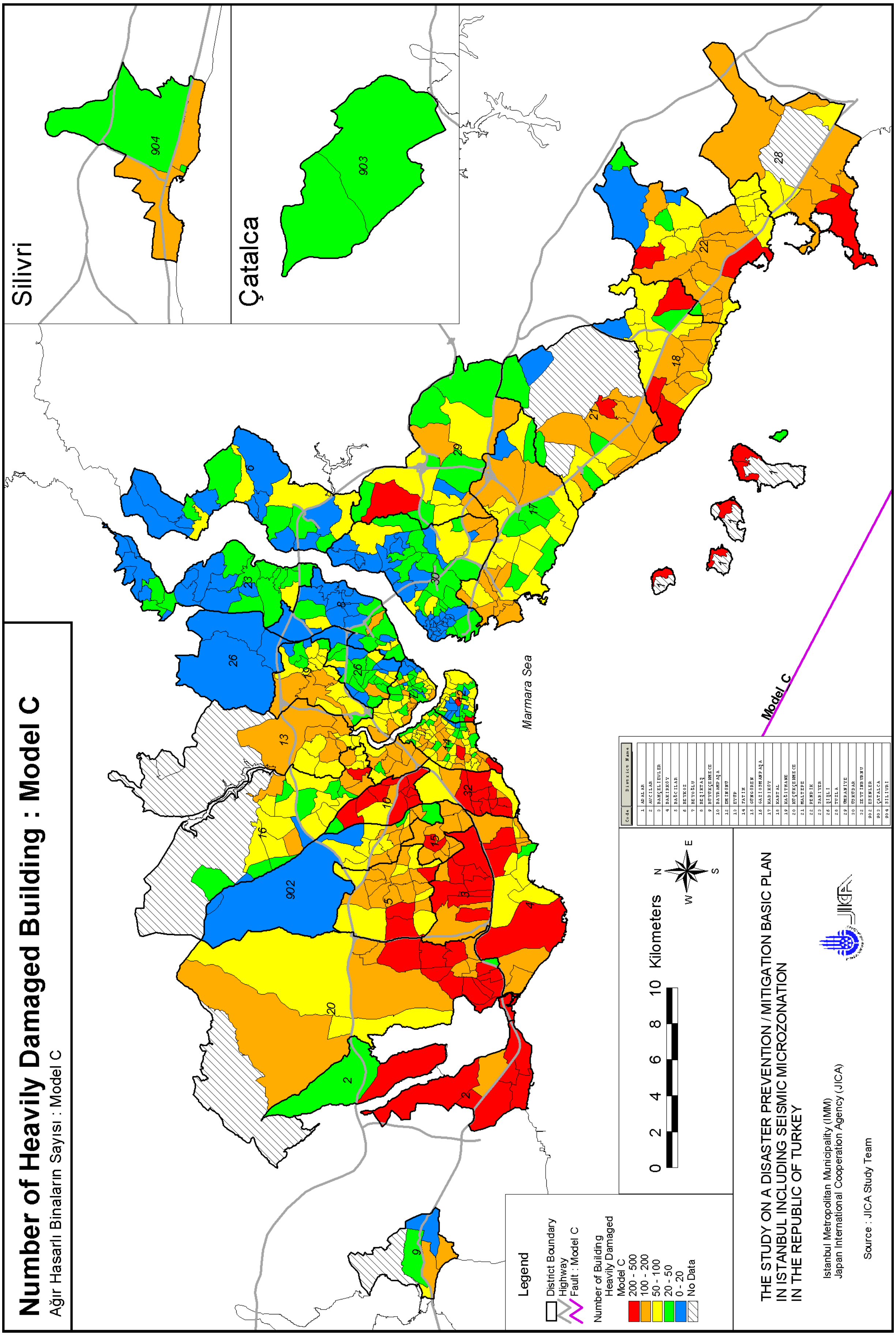


Figure 8.1.12 Number of Heavily Damaged Building : Model C

Table 8.1.4 Building Damage by District : Model A

District Code	District Name	Total Building Number	Heavily		Heavily + Moderately		Heavily + Moderately + Partly	
			number	%	number	%	number	%
1	Adalar	6,522	1,614	24.8	2,703	41.4	4,131	63.3
2	Avcılar	14,030	1,975	14.1	4,172	29.7	7,781	55.5
3	Bahçelievler	19,690	2,577	13.1	5,748	29.2	11,287	57.3
4	Bakırköy	10,067	1,839	18.3	3,686	36.6	6,434	63.9
5	Bağcılar	36,059	2,384	6.6	5,915	16.4	14,353	39.8
6	Beykoz	28,280	476	1.7	1,268	4.5	4,225	14.9
7	Beyoğlu	26,468	2,335	8.8	4,940	18.7	10,197	38.5
8	Beşiktaş	14,399	584	4.1	1,410	9.8	3,744	26.0
9	Büyükçekmece	3,348	351	10.5	800	23.9	1,680	50.2
10	Bayrampaşa	20,195	2,493	12.3	4,929	24.4	9,488	47.0
12	Eminönü	14,149	1,967	13.9	3,798	26.8	6,902	48.8
13	Eyüp	25,718	1,890	7.3	4,122	16.0	8,979	34.9
14	Fatih	31,947	5,111	16.0	9,908	31.0	17,689	55.4
15	Güngören	10,655	1,253	11.8	2,846	26.7	5,813	54.6
16	Gaziosmanpaşa	56,484	1,888	3.3	4,932	8.7	14,113	25.0
17	Kadıköy	38,615	1,944	5.0	4,755	12.3	12,206	31.6
18	Kartal	24,295	1,986	8.2	4,351	17.9	9,465	39.0
19	Kağıthane	28,737	1,107	3.9	2,747	9.6	7,367	25.6
20	Küçükçekmece	45,817	4,299	9.4	9,219	20.1	19,293	42.1
21	Maltepe	25,313	1,600	6.3	3,709	14.7	8,779	34.7
22	Pendik	39,877	2,835	7.1	6,365	16.0	14,343	36.0
23	Sarıyer	30,781	410	1.3	1,117	3.6	4,082	13.3
26	Şişli	22,576	727	3.2	1,874	8.3	5,386	23.9
28	Tuzla	14,727	1,331	9.0	2,844	19.3	6,024	40.9
29	Ümraniye	43,473	1,005	2.3	2,730	6.3	8,662	19.9
30	Üsküdar	43,021	1,093	2.5	2,978	6.9	9,335	21.7
32	Zeytinburnu	15,573	2,592	16.6	5,296	34.0	9,525	61.2
902	Esenler	22,700	1,355	6.0	3,312	14.6	8,216	36.2
903	Çatalca	2,573	67	2.6	176	6.8	529	20.6
904	Silivri	8,534	359	4.2	885	10.4	2,342	27.4
	Total	724,623	51,447	7.1	113,535	15.7	252,370	34.8

Table 8.1.5 Building Damage by District : Model C

District Code	District Name	Total Building Number	Heavily		Heavily + Moderately		Heavily + Moderately + Partly	
			number	%	number	%	number	%
1	Adalar	6,522	1,710	26.2	2,830	43.4	4,254	65.2
2	Avcılar	14,030	2,311	16.5	4,696	33.5	8,270	58.9
3	Bahçelievler	19,690	3,184	16.2	6,764	34.4	12,305	62.5
4	Bakırköy	10,067	2,119	21.0	4,103	40.8	6,792	67.5
5	Bağcılar	36,059	2,899	8.0	6,949	19.3	15,771	43.7
6	Beykoz	28,280	521	1.8	1,376	4.9	4,481	15.8
7	Beyoğlu	26,468	2,644	10.0	5,495	20.8	10,989	41.5
8	Beşiktaş	14,399	692	4.8	1,644	11.4	4,175	29.0
9	Büyükçekmece	3,348	415	12.4	914	27.3	1,806	53.9
10	Bayrampaşa	20,195	2,846	14.1	5,532	27.4	10,261	50.8
12	Eminönü	14,149	2,156	15.2	4,106	29.0	7,279	51.4
13	Eyüp	25,718	2,044	7.9	4,414	17.2	9,426	36.7
14	Fatih	31,947	5,776	18.1	10,996	34.4	18,900	59.2
15	Güngören	10,655	1,550	14.6	3,376	31.7	6,402	60.1
16	Gaziosmanpaşa	56,484	2,183	3.9	5,628	10.0	15,511	27.5
17	Kadıköy	38,615	2,312	6.0	5,554	14.4	13,569	35.1
18	Kartal	24,295	2,236	9.2	4,841	19.9	10,198	42.0
19	Kağıthane	28,737	1,286	4.5	3,148	11.0	8,134	28.3
20	Küçükçekmece	45,817	4,915	10.7	10,325	22.5	20,641	45.1
21	Maltepe	25,313	1,824	7.2	4,167	16.5	9,503	37.5
22	Pendik	39,877	3,128	7.8	6,956	17.4	15,263	38.3
23	Sarıyer	30,781	462	1.5	1,255	4.1	4,437	14.4
26	Şişli	22,576	884	3.9	2,232	9.9	6,093	27.0
28	Tuzla	14,727	1,456	9.9	3,079	20.9	6,344	43.1
29	Ümraniye	43,473	1,152	2.6	3,095	7.1	9,434	21.7
30	Üsküdar	43,021	1,301	3.0	3,477	8.1	10,361	24.1
32	Zeytinburnu	15,573	3,036	19.5	5,999	38.5	10,184	65.4
902	Esenler	22,700	1,655	7.3	3,922	17.3	9,111	40.1
903	Çatalca	2,573	74	2.9	194	7.5	564	21.9
904	Silivri	8,534	407	4.8	981	11.5	2,498	29.3
	Total	724,623	59,176	8.2	128,047	17.7	272,953	37.7

8.1.4. Seismic Intensity based on the Building Damage

Seismic intensity is evaluated based on building damage described in the description of the seismic intensity scale. In many microzonation studies, seismic intensity is evaluated based on the empirical relation between PGA and seismic intensity, but the definition of the seismic intensity itself is mainly associated with the degree of observed building damage. Building damage will be different depending on the building structures in an area if the PGA is the same. Therefore, it is better to estimate the seismic intensity based on building damage rather than an empirical relation between PGA and seismic intensity.

In this study, seismic intensity is not used as the index of seismic motion for the damage estimation. This is evaluated only to help enhance the understanding of engineers, who are familiar with seismic intensity.

Seismic intensity was evaluated using the European Macroseismic Scale 1998, EMS-98. In EMS-98, buildings are classified from most weak class A to class F, depending on their vulnerability. According to Erdik (2001), most buildings in Istanbul are classified as class C. Table 8.1.6shows the definition of EMS-98 for intensities VII to XI concerning building class C.

Table 8.1.6 Definition of Seismic Intensity in EMS-98

EMS-98 Intensity	Definition
XI	Most buildings of vulnerability class C suffer damage of grade 4; many of grade 5.
X	Many buildings of vulnerability class C suffer damage of grade 4; a few of grade 5
IX	Many buildings of vulnerability class C suffer damage of grade 3; a few of grade 4.
VIII	Many buildings of vulnerability class C suffer damage of grade 2; a few of grade 3.
VII	A few buildings of vulnerability class C sustain damage of grade 2.

"Few," "many," and "most" are based on a scale bar in EMS-98. In this study, ranges 0 to 15%, 15 to 55%, and 55% to 100% are used respectively"Heavily," "moderately," and "partly" damaged buildings in this study correspond to damage grade 4 and 5, 3, and 2 respectively. Based on these relations, the definition of seismic intensity is rewritten as shown in Table 8.1.7.

Table 8.1.7 Definition of Seismic Intensity in the Study

Intensity	Definition
XI:	Heavily Damage Ratio > 55%
X:	55% > Heavily Damage Ratio > 15%
IX:	15% > Heavily Damage Ratio .AND. Heavily + Moderately Ratio > 15%
VIII:	15% > Heavily + Moderately Ratio .AND. Heavily + Moderately + Partly Ratio >15%
- VII:	15% > Heavily + Moderately + Partly Ratio

The building structure composition is actually different in each mahalle, but the average composition of the Study Area is used for all mahalle as a simplification. The evaluated seismic intensity is shown in Figure 8.1.13 and Figure 8.1.14. In either Model, intensities VII to X are estimated in Istanbul. A large area of the European side is estimated to experience intensity X.

Acknowledgement

The building damage analysis in this Chapter was conducted under close discussions with Prof. Dr. Nuray Aydinoğlu of the Department of Earthquake Engineering, KOERI. Most notably, the principles of building classification and building damage estimation is based on his suggestions. The Study Team expresses special thanks for this collaboration on the Study.

References to Section 8.1

Erdik, M., E. Durukal, Y. Biro, B. Siyahi and H. Akman, 2001, Earthquake Risk to Buildings in Istanbul and a Proposal for its Mitigation, Bogaziçı University, Kandilli Observatory and Earthquake Research Institute, Department of Earthquake Engineering, Department Report No: 2001/16,

http://www.koeri.boun.edu.tr/earthqk/earthqk.html.

European Macroseismic Scale 1998, EMS-1998,
http://www.gfz-potsdam.de/pb5/pb53/projekt/ems.

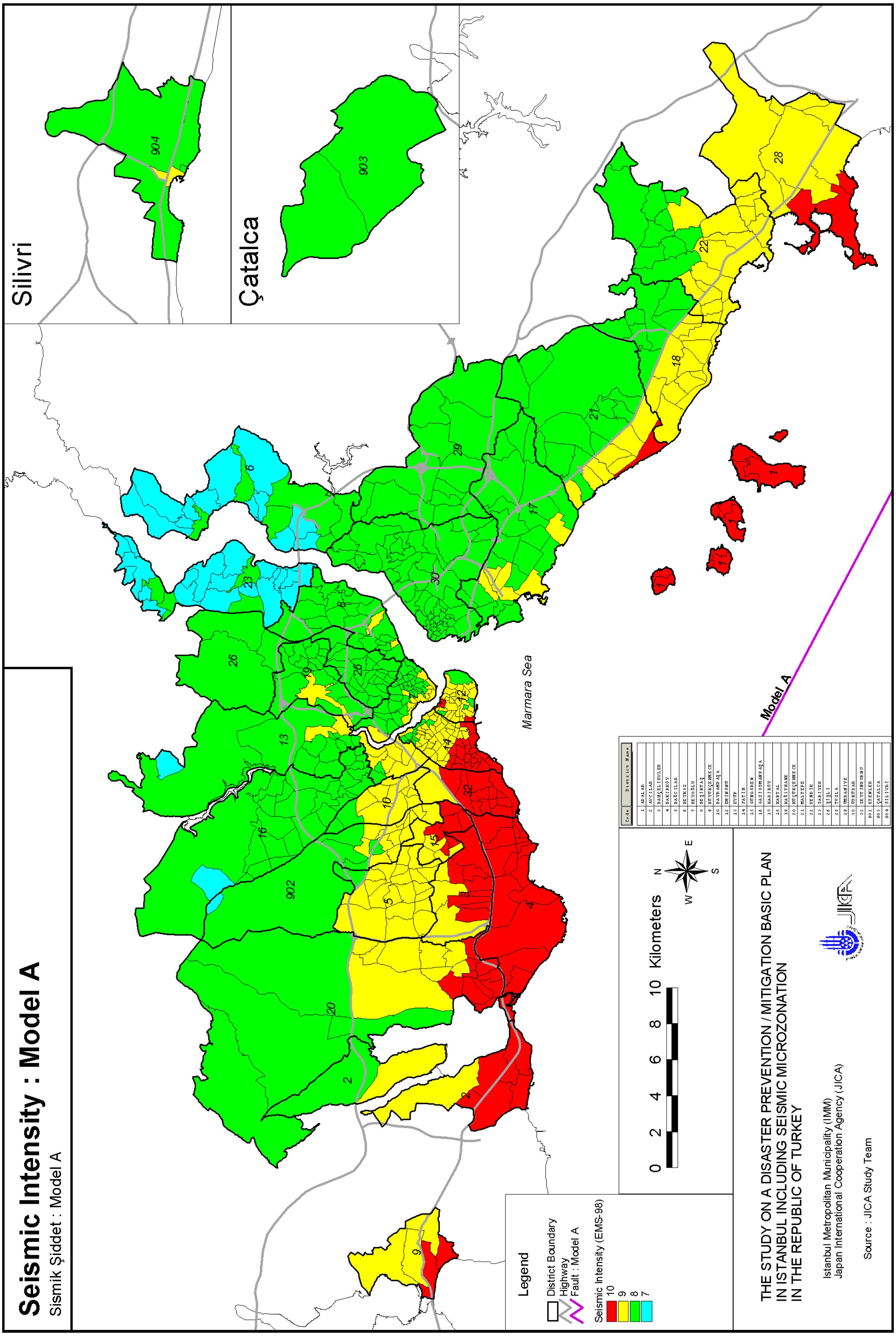


Figure 8.1.13 Seismic Intensity : Model A

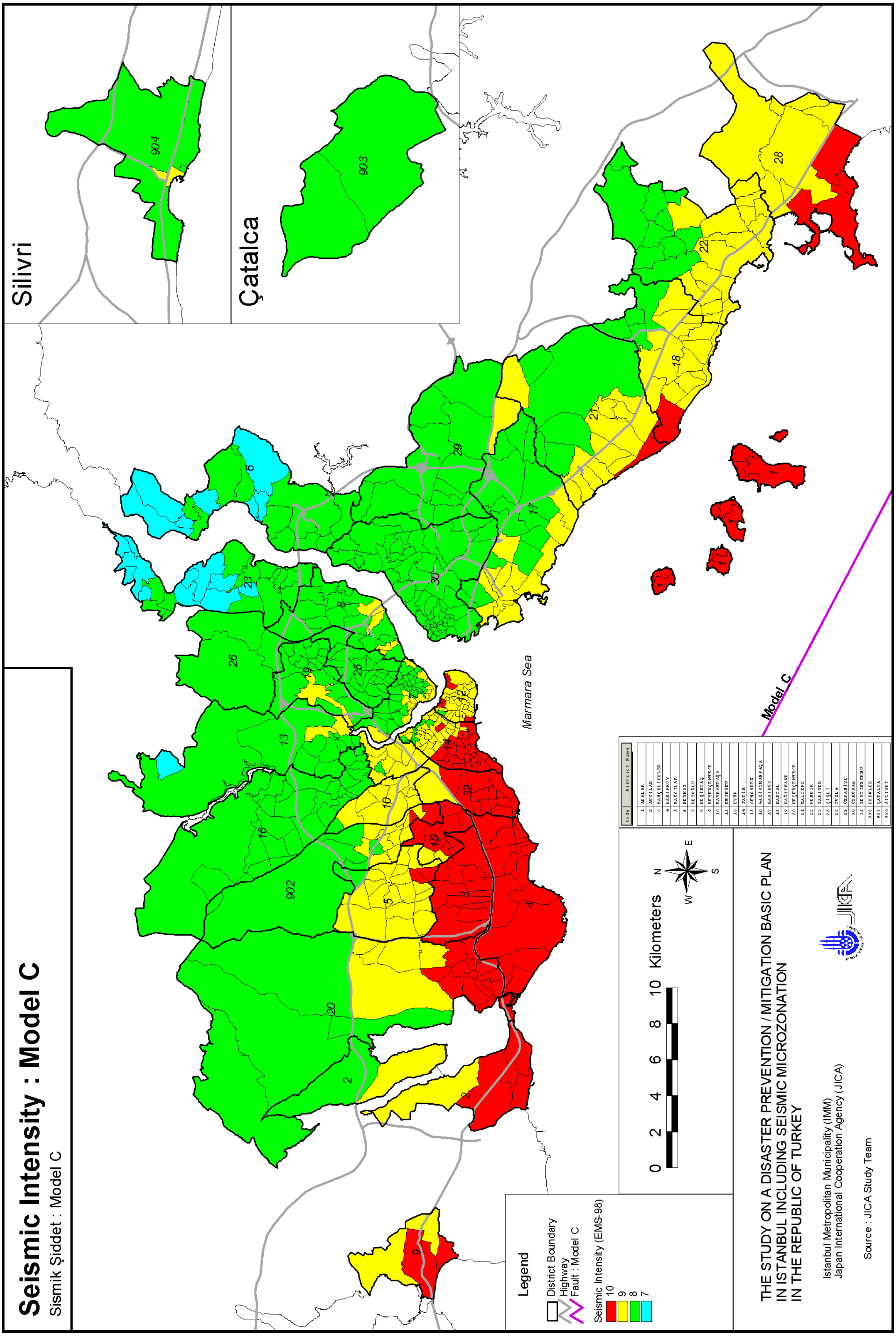


Figure 8.1.14 Seismic Intensity : Model C

8.2. Human Casualties

8.2.1. Methodology

Direct causes of earthquake casualties include collapse of buildings, fires, tsunamis, rockslides, landslides, etc. Among them, human casualties due to building collapse are a general phenomena observed in all areas subject to earthquake disasters. In Turkey, during the 1999 Izmit Earthquake, over 17,000 people were killed mainly by building collapse. Considering the weakness of buildings in Istanbul, building collapse will be the most notable cause of human casualties in future earthquakes.

Therefore, to estimate the expected number of deaths, the relation of building damage to death toll was studied based on the earthquake hazard in Turkey. Damage functions for death tolls and the number of people severely injured are derived from this analysis. Number of deaths and severe injuries is evaluated based on empirical relationships and building damage distribution. The flowchart of the human casualties estimation is shown in Figure 8.2.1.

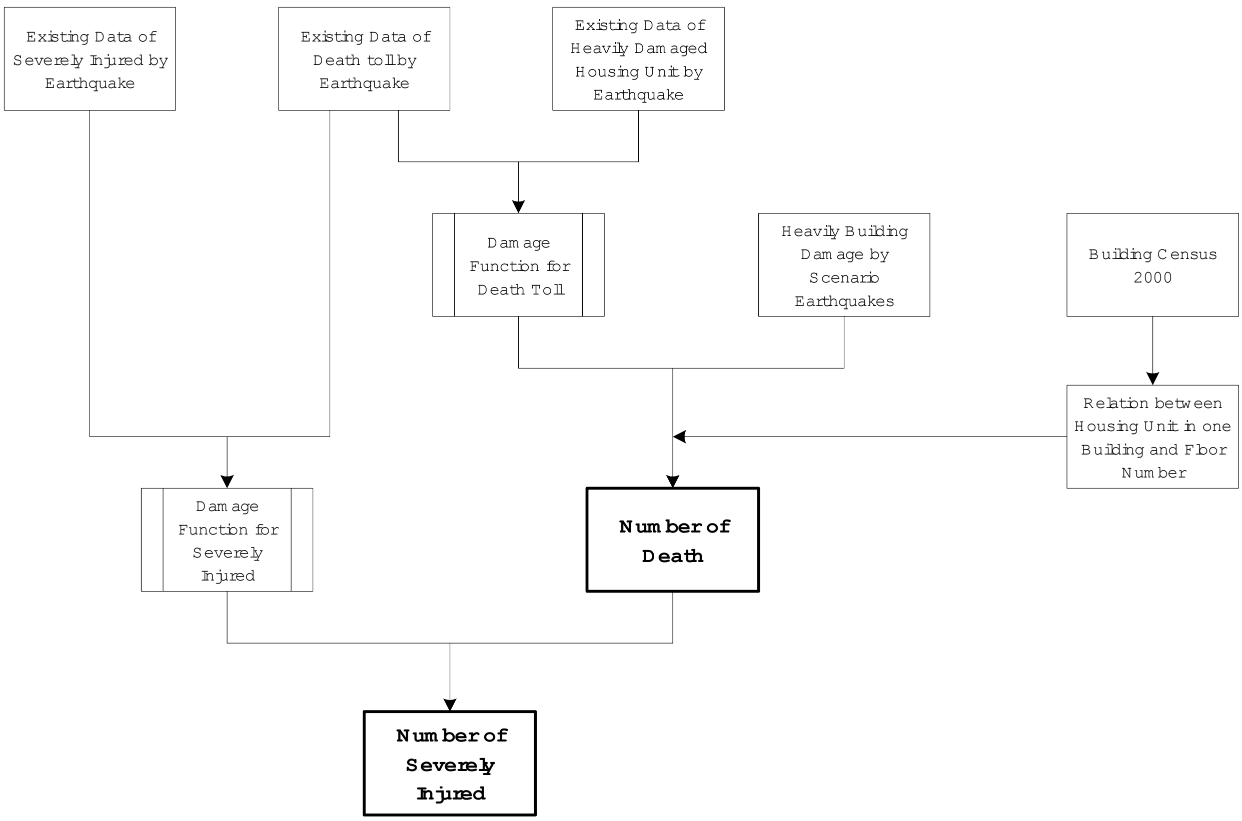


Figure 8.2.1 Flowchart of Human Casualties Estimation

Table 8.2.1 is the summary of building damage and casualties during the 1999 Izmit earthquake in Istanbul. The damages are compiled by district. It is notable that not only is the number of damaged buildings included in this table but also the number of damaged housing units. This data is important to evaluate the casualties in Istanbul because there are many apartment houses with many different storey heights.

To find the most appropriate indicators of death toll and building damage, several relations are examined and shown in Figure 8.2.2. For the death toll parameter, the number of deaths and death ratio are used. For the building damage parameter, the number of heavily damaged buildings, the heavily damaged building ratio, the number of heavily damaged housing units, the number of moderately to heavily damaged buildings, the ratio of moderately to heavily damaged buildings, and the number of moderately to heavily damaged housing units are used. This figure shows that the relation between the number of deaths and the number of heavily damaged housing units (upper right in Figure 8.2.2) is the most appropriate in relating the death toll to building damage.

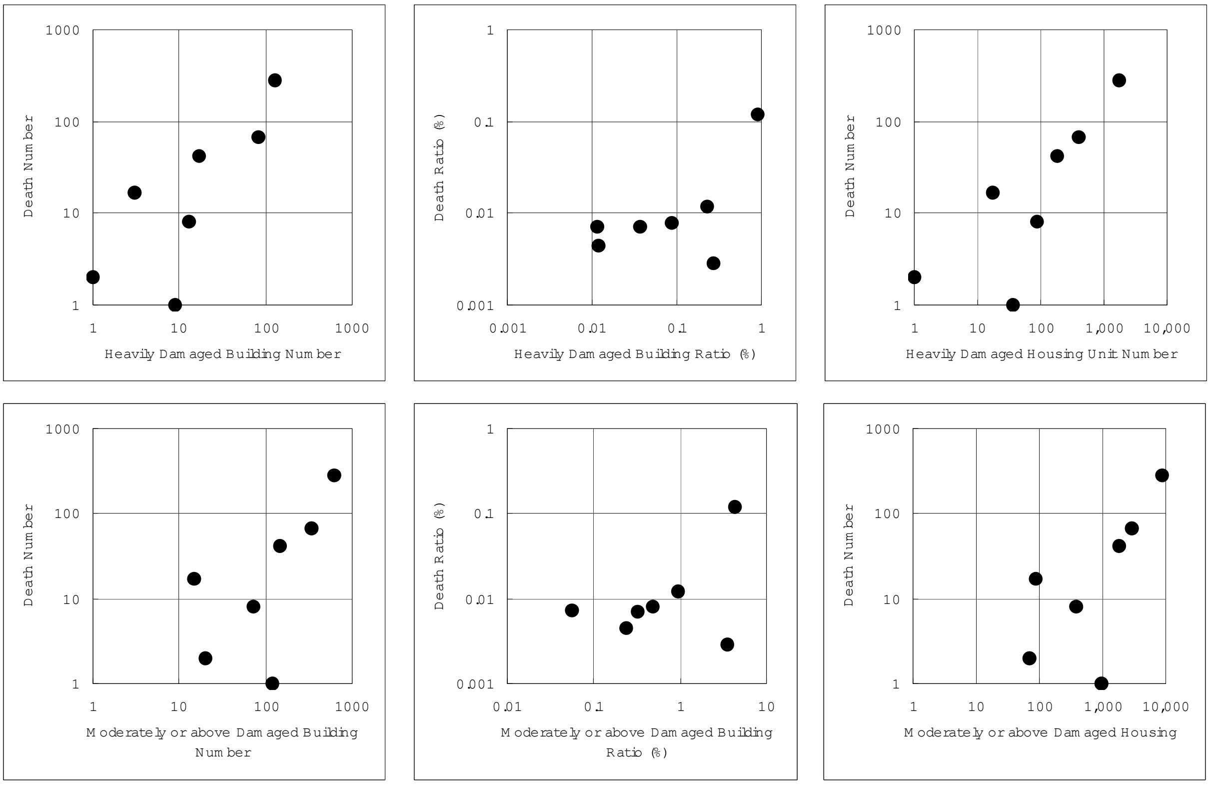


Figure 8.2.2 Several Relationships between Building Damage and Death

Table 8.2.1 Building Damage and Casualties during 1999 Izmit Earthquake in Istanbul by District

District Code	Building number	Heavily Damaged		Heavily + Moderately Damaged		Heavily Damaged Housing Unit number	Heavily + Moderately Damaged Housing Unit number	Population	Death		Severely Injured		Slightly Injured
		number	%	number	%				number	%	number	%	
1	6,522	0	0.000	0	0.000	0	0	17,738			0	0.000	0
2	14,030	126	0.898	614	4.376	1,706	8,679	231,799	281	0.121	630	0.272	0
3	19,690	5	0.025	62	0.315	48	1,131	469,844			0	0.000	40
4	10,067	15	0.149	49	0.487	92	396	206,459			14	0.007	450
5	36,059	83	0.230	339	0.940	404	2,890	557,588	67	0.012	85	0.015	
6	28,280	0	0.000	0	0.000	0	0	182,864			0	0.000	32
7	26,468	3	0.011	15	0.057	17	88	234,964	17	0.007	4	0.002	125
8	14,399	3	0.021	9	0.063	4	55	182,658			0	0.000	
9	3,348	9	0.269	118	3.524	37	971	34,737	1	0.003	163	0.469	
10	20,195	8	0.040	19	0.094	73	142	237,874			44	0.018	3
12	14,149	4	0.028	12	0.085	7	29	54,518			4	0.007	0
13	25,718	7	0.027	19	0.074	19	159	232,104			0	0.000	0
14	31,947	9	0.028	40	0.125	54	303	394,042			753	0.191	64
15	10,655	1	0.009	25	0.235	19	368	271,874			87	0.032	0
16	56,484	0	0.000	32	0.057	0	237	667,809			0	0.000	151
17	38,615	0	0.000	4	0.010	0	24	660,619			6	0.001	0
18	24,295	2	0.008	7	0.029	18	65	332,090			6	0.002	714
19	28,737	1	0.003	10	0.035	3	84	342,477			0	0.000	29
20	45,817	17	0.037	146	0.319	186	1,785	589,139	42	0.007	8	0.001	302
21	25,313	0	0.000	15	0.059	0	88	345,662			0	0.000	0
22	39,877	0	0.000	39	0.098	0	216	372,553			0	0.000	210
23	30,781	2	0.006	7	0.023	2	12	212,996			0	0.000	5
26	22,576	0	0.000	4	0.018	0	120	271,003			0	0.000	602
28	14,727	13	0.088	71	0.482	86	387	100,609	8	0.008	11	0.011	
29	43,473	2	0.005	18	0.041	12	60	443,358			6	0.001	0
30	43,021	1	0.002	15	0.035	1	78	496,402			0	0.000	1,380
32	15,573	1	0.006	12	0.077	60	143	239,927			1	0.000	0
902	22,700	0	0.000	11	0.048	0	95	388,003			11	0.003	0
903	2,573	5	0.194	10	0.389	34	80	15,624			2	0.013	3
904	8,534	1	0.012	20	0.234	1	70	44,432	2	0.005	3	0.007	125
Total	724,623	318	0.044	1,742	0.240	2,883	18,755	8,831,766	418	0.005	1,838	0.021	4,235

Source: Disaster Management Center, Governership of Istanbul Province

Figure 8.2.3 shows the empirical relationship between the number of deaths and the number of heavily damaged housing units in Turkey. In this figure, damage due to the 1992 Erzincan Earthquake, the 1999 Düzce Earthquake, and the 1999 Izmit Earthquake (excluding and including Istanbul) are also plotted. All the data are shown in Table 8.2.2. The data of the Düzce Earthquake show significantly less damage than the other earthquakes. The reason is that this earthquake occurred only three months after the Izmit Earthquake and many people were still evacuated; therefore, many collapsed buildings were inhabited at the time of the event. The black line in Figure 8.2.3 is the damage function that was used to calculate the death toll in this study. This line was drawn greatly accounting for the damage due to the Izmit earthquake. Accordingly, the estimated damage is applicable for a nighttime event because the Izmit earthquake occurred at 3 AM.

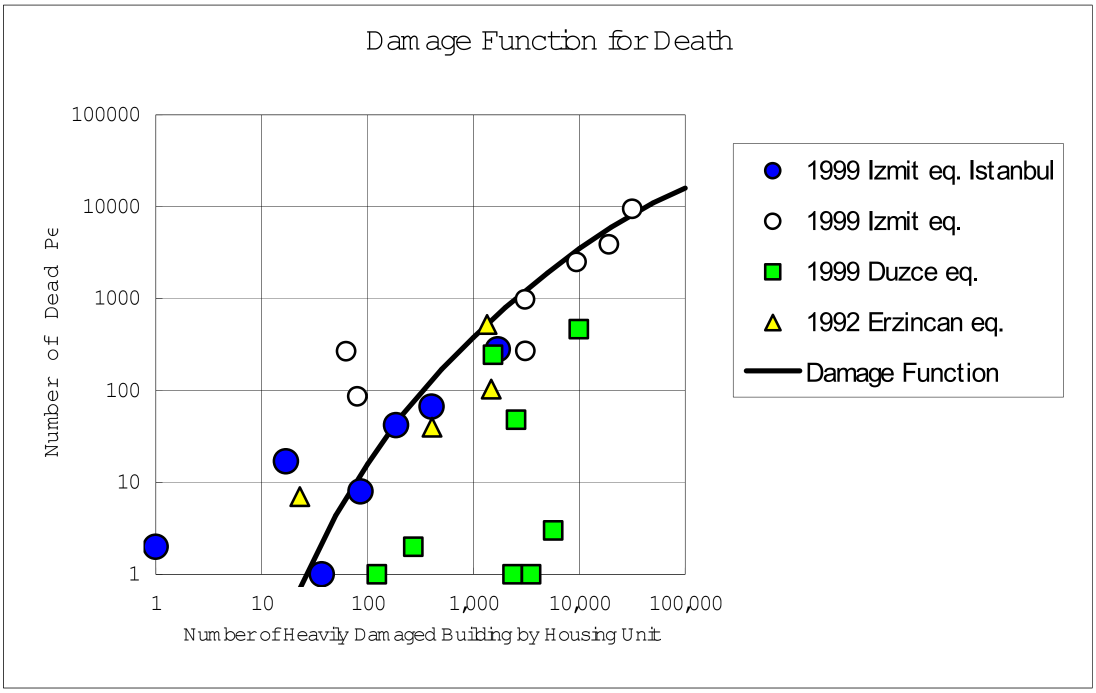


Figure 8.2.3 Empirical Relation of Building damage and Death Toll in Turkey and Damage Function

Table 8.2.2 Building Damage and Casualties of earthquakes in Turkey

a) 1999 Düzce earthquake

Area		Heavily Damaged Housing Unit Number	Number of Death	Number of Severely Injured
Bolu	Merkez	2,532	48	354
Düzce	Merkez	9,928	463	2,800
	Akçakoca	272	2	96
	Cumayerrı	122	0	39
	Çilimli	119	0	0
	Gölyaka	123	1	68
	Gümüşova	54	0	34
	Kaynaşlı	1,537	244	544
	Yığılca	358	0	42
Eskişehir		10	0	0
Kocaeli		2,355	1	61
Sakarya		5,675	3	168
Yalova		3,511	1	25
Zonguldak		108	0	189

Source: : İnşaat Mühendisleri Odası ve İnşaat Mühendisliği Bölümü (2000)

b) 1999 Izmit earthquake

Area		Heavily Damaged Housing Unit Number	Number of Death
Bolu	Bolu	7	270
	Düzce	3,088	
Bursa	Bursa	63	268
Sakarya	Sakarya	19,043	3,891
Yalova	Yalova	9,462	2,504
Kocaeli	Kocaeli	19,315	9,477
	Gölcük	12,310	
Istanbul	Istanbul	3,073	981
Eskişehir	Eskişehir	80	86

Source: Başbakanlık Kriz Yönetim Merkezi (2000)

c) 1992 Erzincan earthquake

Area		Heavily Damaged Housing Unit Number	Number of Death	Number of Severely Injured
Erzincan	city	1,344	526	3,400
	village	1,469	104	
Uzumlu	city	23	7	
	village	406	40	

Source: Joint Reconnaissance Team of Architectural Institute of Japan, Japan Society of Civil Engineers, and Bogazici University, Istnabul, Turkey (1993)

d) 1966 Varto earthquake

Village	Heavily Damaged Building Number	Number of Death	Number of Severely Injured
Erzurum	161	0	181
Hınıs	7,008	123	181
Tekman	591	10	38
Çat	453	2	2
Bulanık	2,626	97	38
Varto	6,366	2,266	1,192
Karlıova	1,808	31	49

Source: Wallace(1966)

To estimate the death toll using the damage function in Figure 8.2.3, the number of heavily damaged housing units is necessary. Building damage is evaluated according to number of buildings; therefore, the number of housing units in one building is necessary to make the calculation.

The 2000 Building Census conatins information on the number of housing units per building. The number of housing units per in Istanbul is analyzed based on the number of storeys per building and shown in Figure 8.2.4. This relationship is used in the casualty analysis.

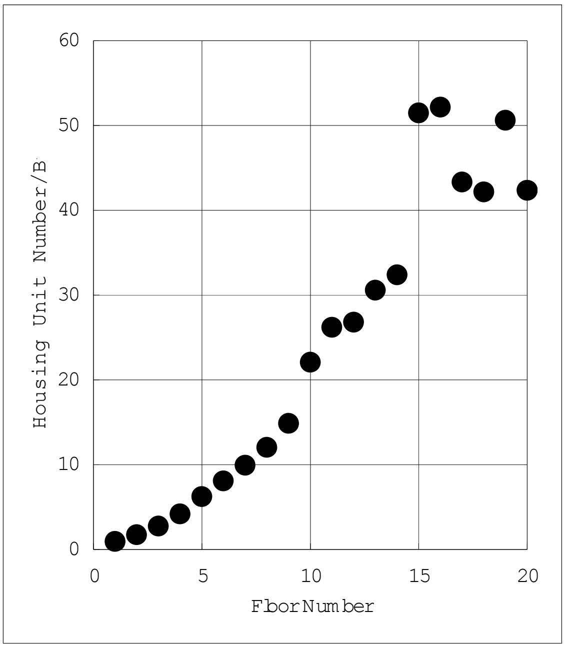


Figure 8.2.4 Housing Unit Number in One Building Depending on the Floor Number

To estimate the number of severely injured people, the empirical relation between the number of deaths and severe injuries is adopted (see Figure 8.2.5).. This figure is made from the data in Table 8.2.1 and Table 8.2.2. The black line in Figure 8.2.5 is the damage function that was used to calculate the number of severely injured in this study. This line was drawn taking the damage in Istanbul due to the Izmit earthquake into great account.

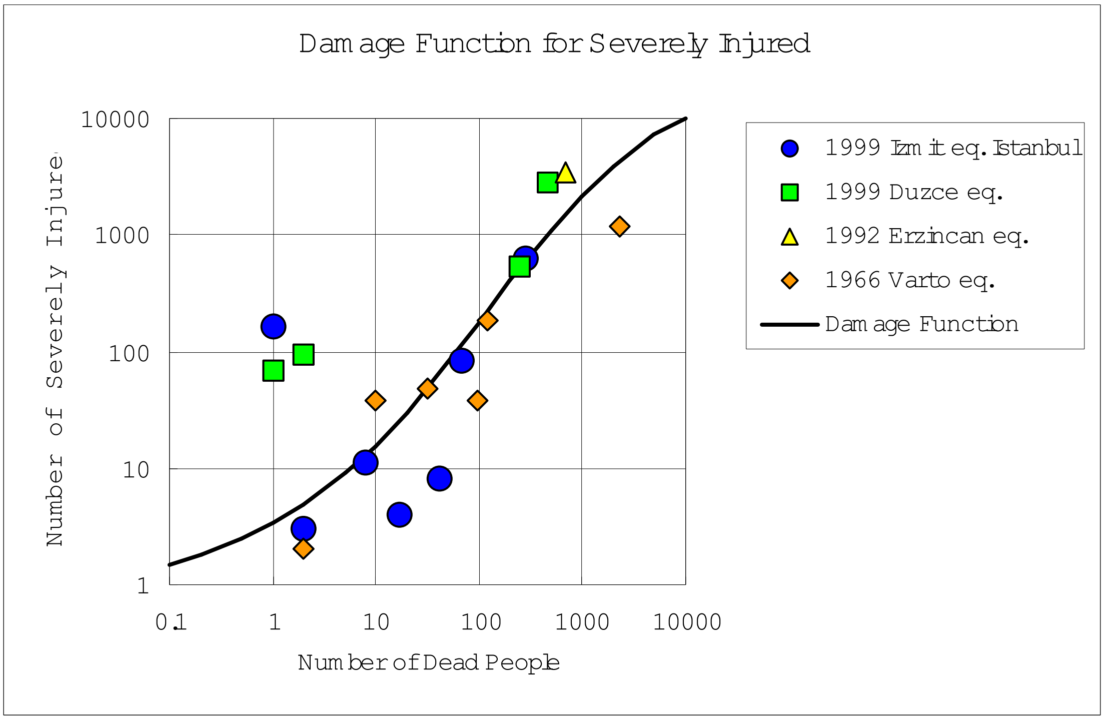


Figure 8.2.5 Empirical Relation of Severely Injured and Death Toll in Turkey and Damage Function

8.2.2. Damage Estimation

Casualties were calculated for scenario earthquakes Model A and Model C. In this estimation, the event is assumed to occur at nighttime. The major cause of damage is building collapse. In large-scale earthquakes, people may die from diseases in refugee camps, but these deaths are not included in the assumption. The dead are assumed to die either instantaneously or within a few days of the initial building collapse.

Table 8.2.3 Definition of Casualty Damage

Time of event	Nighttime	
Evaluation unit	Person	
Cause of damage	Mainly building collapse	
Definition of damage grade	Death	- Instant death under collapsed building structure - Suffocation under collapsed roofs or walls - Trapped in collapsed building and not rescued promptly
	Severely Injured	- Bone fracture, rupture of internal organs, crush syndrome, etc.; needs hospitalization

Human casualties and injuries are calculated for each district, and the summary of the results are shown in Table 8.2.4. In this table, the result of the simulation based on the Izmit earthquake is also included. The casualty analysis method is based on existing earthquake damages, including the Izmit and Erzincan earthquakes, as shown in the previous section. The simulated results compare well to the observed damage.

Table 8.2.4 Summary of Human Casualties and Injuries

		Deaths	Severely Injured
Model A		73,000 (0.8%)	120,000 (1.4%)
Model C		87,000 (1.0%)	135,000 (1.5%)
Izmit Eq.	Simulation	700	1,200
	Observed	418	1,838

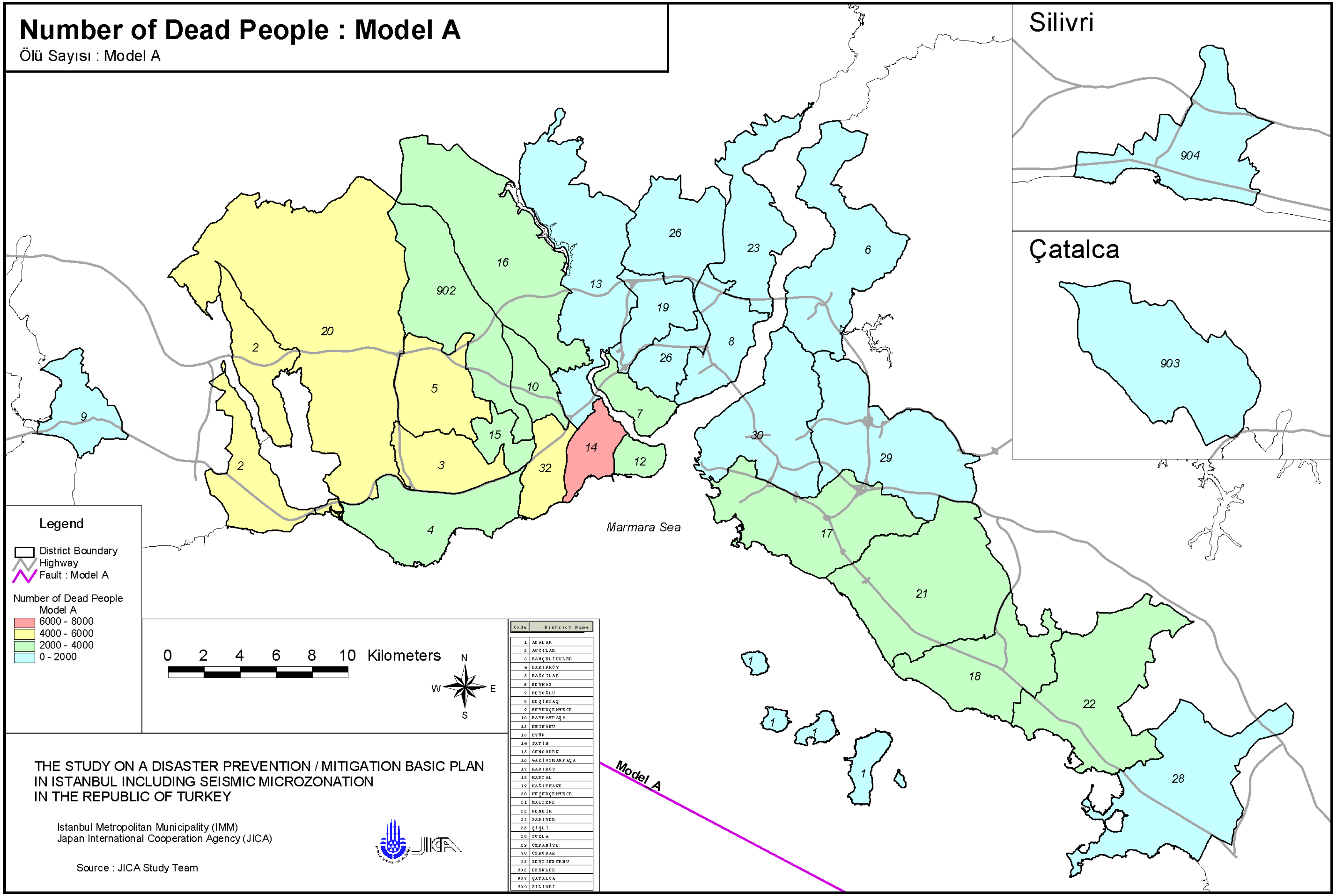
Human damages for each district are shown in Figure 8.2.6 to Figure 8.2.9 and Table 8.2.5 to Table 8.2.6. Characteristics of damage of the two scenario earthquakes are as follows:

(1) Model A

The death toll is estimated as 73,000, namely 1.0% of the total number of people in the Study Area. The severely injured people number 135,000. In Fatih, more than 6,000 people will die. Adalar shows the highest death ratio of 8.4%.

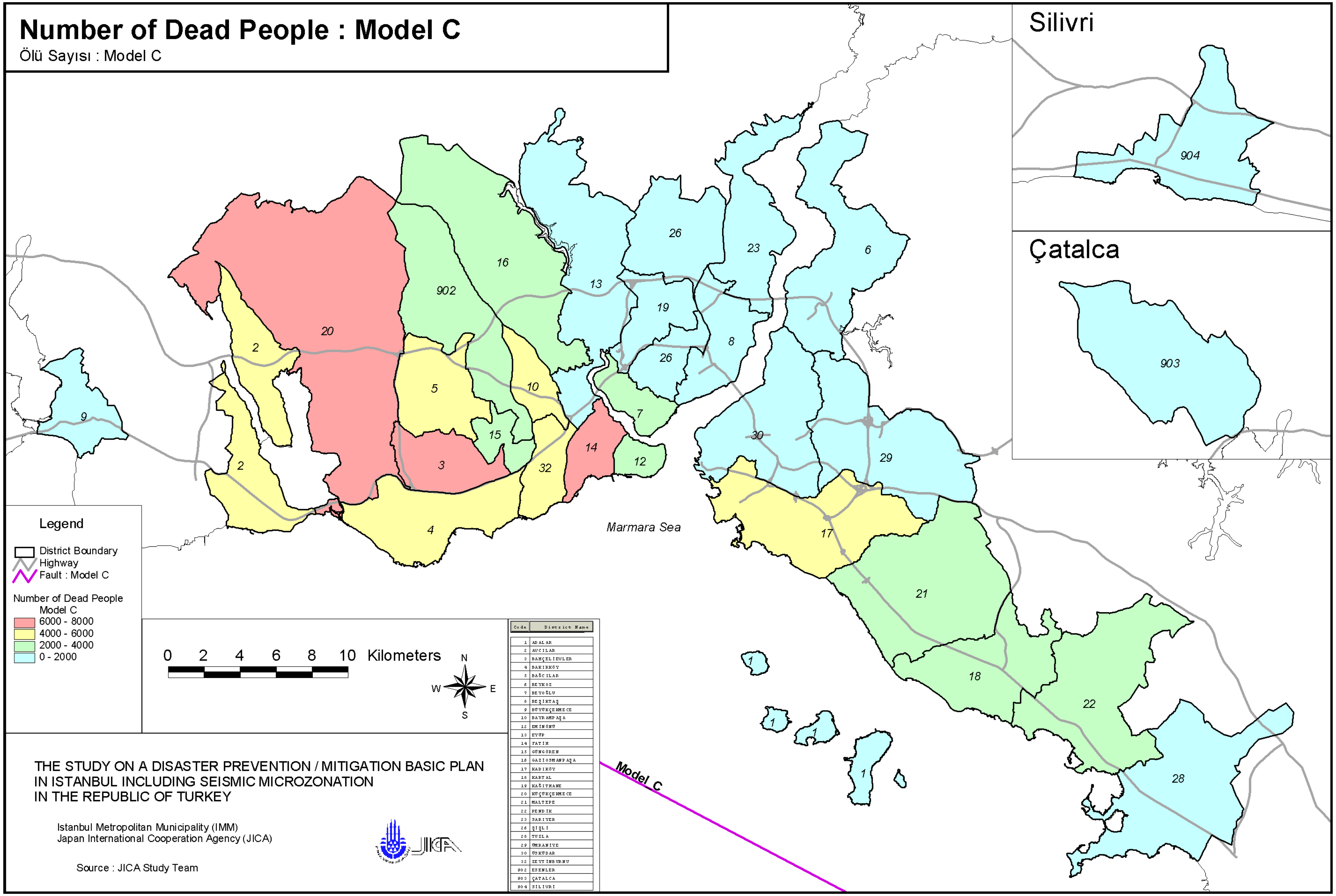
(2) Model C

The death toll is estimated as 87,000, namely 0.8% of the total number of people in the Study Area. The severely injured people number 120,000. In Bahçelievler, Fatih and Küçükçekmece, more than 6,000 people will die. Adalar shows the highest death ratio of 9.3%.



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 8.2.6 Number of Dead People : Model A



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 8.2.7 Number of Dead People : Model C

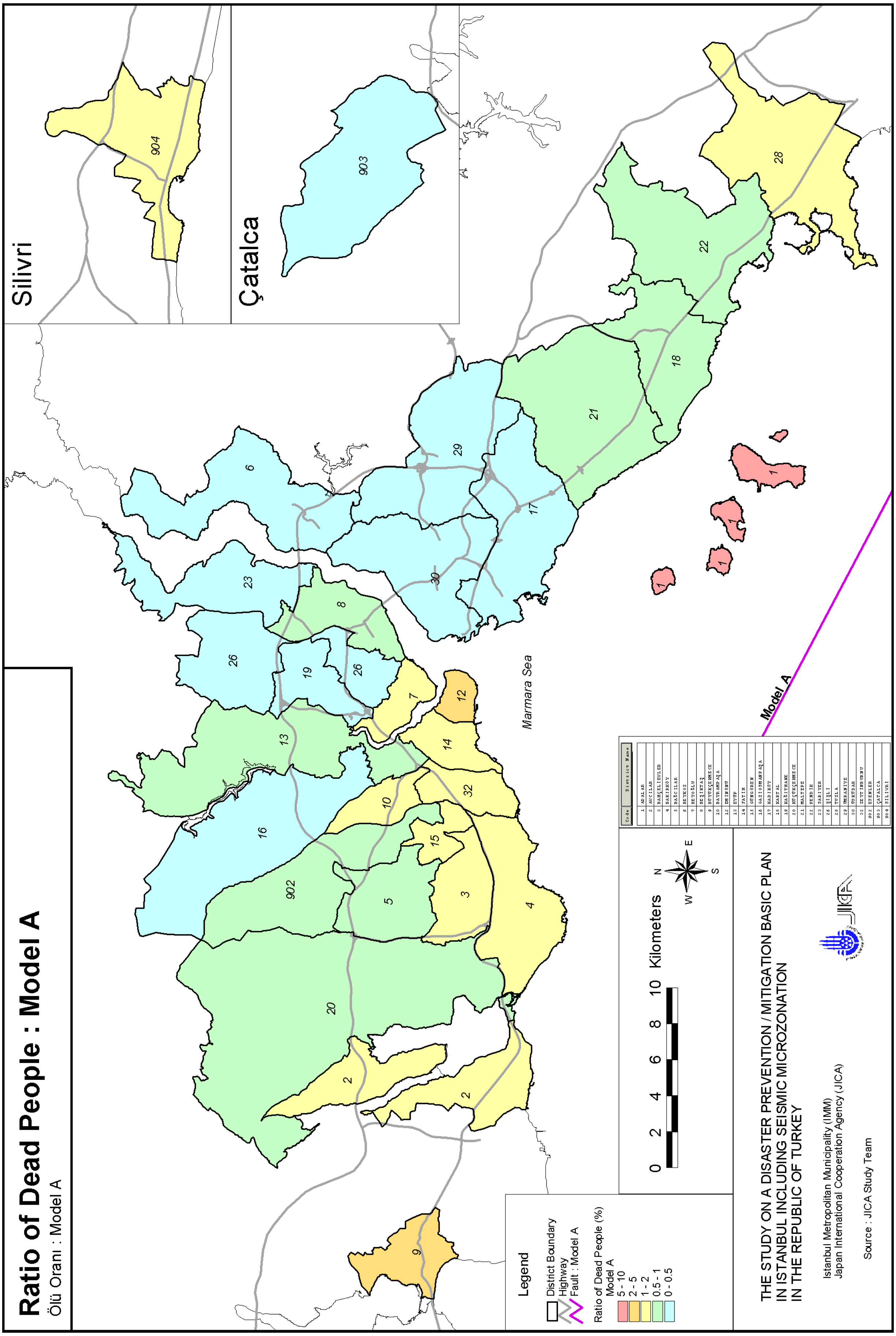


Figure 8.2.8 Death Ratio : Model A

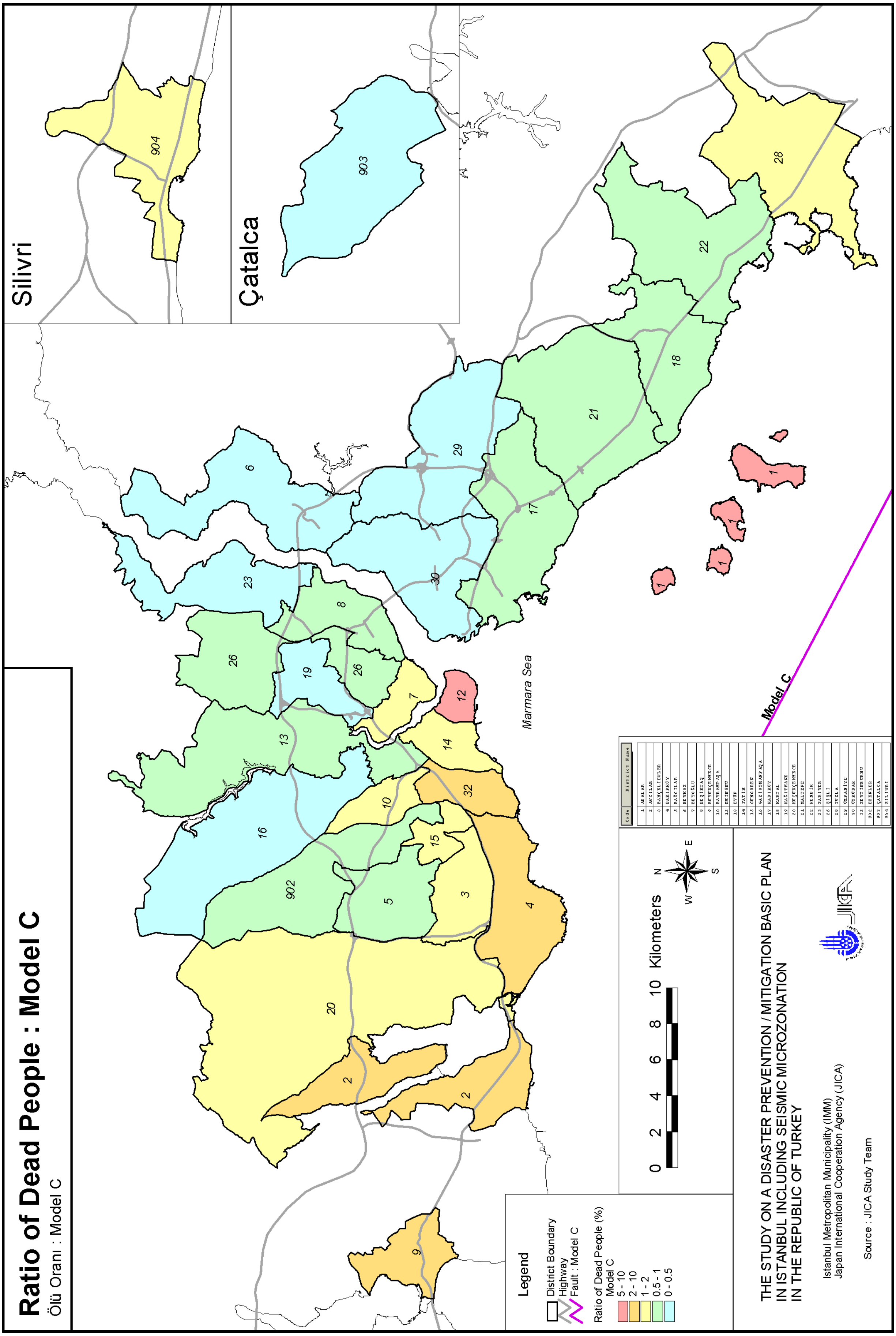


Figure 8.2.9 Death Ratio : Model C

Table 8.2.5 Casualties by District : Model A

District Code	District Name	Population	Death		Severely Injured	
			number	%	number	%
1	Adalar	17,738	1,496	8.4	3,001	16.9
2	Avcılar	231,799	4,064	1.8	6,154	2.7
3	Bahçelievler	469,844	5,768	1.2	7,630	1.6
4	Bakırköy	206,459	3,689	1.8	5,735	2.8
5	Bağcılar	557,588	4,263	0.8	6,376	1.1
6	Beykoz	182,864	304	0.2	646	0.4
7	Beyoğlu	234,964	2,956	1.3	4,914	2.1
8	Beşiktaş	182,658	972	0.5	2,108	1.2
9	Büyükçekmece	34,737	763	2.2	1,661	4.8
10	Bayrampaşa	237,874	3,670	1.5	5,713	2.4
12	Eminönü	54,518	2,512	4.6	4,418	8.1
13	Eyüp	232,104	1,684	0.7	3,316	1.4
14	Fatih	394,042	6,202	1.6	7,873	2.0
15	Güngören	271,874	2,995	1.1	4,959	1.8
16	Gaziosmanpaşa	667,809	2,000	0.3	3,846	0.6
17	Kadıköy	660,619	3,207	0.5	5,196	0.8
18	Kartal	332,090	2,375	0.7	4,265	1.3
19	Kağıthane	342,477	1,290	0.4	2,654	0.8
20	Küçükçekmece	589,139	5,685	1.0	7,583	1.3
21	Maltepe	345,662	2,071	0.6	3,925	1.1
22	Pendik	372,553	2,610	0.7	4,528	1.2
23	Sarıyer	212,996	277	0.1	585	0.3
26	Şişli	271,003	1,120	0.4	2,369	0.9
28	Tuzla	100,609	1,354	1.3	2,762	2.7
29	Ümraniye	443,358	972	0.2	2,108	0.5
30	Üsküdar	496,402	1,355	0.3	2,764	0.6
32	Zeytinburnu	239,927	4,629	1.9	6,785	2.8
902	Esenler	388,003	2,683	0.7	4,610	1.2
903	Çatalca	15,624	30	0.2	47	0.3
904	Silivri	44,432	492	1.1	1,080	2.4
	Total	8,831,766	73,487	0.8	119,609	1.4

Table 8.2.6 Casualties by District : Model C

District Code	District Name	Population	Death		Severely Injured	
			number	%	number	%
1	Adalar	17,738	1,648	9.3	3,255	18.4
2	Avcılar	231,799	4,678	2.0	6,841	3.0
3	Bahçelievler	469,844	6,724	1.4	8,165	1.7
4	Bakırköy	206,459	4,204	2.0	6,310	3.1
5	Bağcılar	557,588	5,167	0.9	7,294	1.3
6	Beykoz	182,864	374	0.2	807	0.4
7	Beyoğlu	234,964	3,464	1.5	5,482	2.3
8	Beşiktaş	182,658	1,226	0.7	2,547	1.4
9	Büyükçekmece	34,737	926	2.7	2,010	5.8
10	Bayrampaşa	237,874	4,180	1.8	6,283	2.6
12	Eminönü	54,518	2,871	5.3	4,820	8.8
13	Eyüp	232,104	1,938	0.8	3,742	1.6
14	Fatih	394,042	6,866	1.7	8,245	2.1
15	Güngören	271,874	3,703	1.4	5,750	2.1
16	Gaziosmanpaşa	667,809	2,526	0.4	4,435	0.7
17	Kadıköy	660,619	4,040	0.6	6,127	0.9
18	Kartal	332,090	2,905	0.9	4,858	1.5
19	Kağıthane	342,477	1,662	0.5	3,278	1.0
20	Küçükçekmece	589,139	6,515	1.1	8,049	1.4
21	Maltepe	345,662	2,532	0.7	4,441	1.3
22	Pendik	372,553	3,114	0.8	5,091	1.4
23	Sarıyer	212,996	372	0.2	802	0.4
26	Şişli	271,003	1,520	0.6	3,040	1.1
28	Tuzla	100,609	1,597	1.6	3,169	3.2
29	Ümraniye	443,358	1,262	0.3	2,607	0.6
30	Üsküdar	496,402	1,803	0.4	3,516	0.7
32	Zeytinburnu	239,927	5,455	2.3	7,455	3.1
902	Esenler	388,003	3,358	0.9	5,365	1.4
903	Çatalca	15,624	41	0.3	65	0.4
904	Silivri	44,432	604	1.4	1,322	3.0
	Total	8,831,766	87,273	1.0	135,169	1.5

8.2.3. Validation

Coburn and Spence (1992) surveyed worldwide earthquake damage to identify the relationship between building damage and human casualties. The relationship is shown in Figure 8.2.10. The general trend of the relationships and the results of the Study are added onto this Figure. "Building damages" consist of only heavily damaged and collapsed buildings, to the exclusion of buildings destroyed by fire or tsunami.

In cases where the number of damaged buildings is 1,000, the distribution of fatalities will range from zero to 1,000. This range of distribution decreases as the number of heavily damaged buildings increases.

The most serious earthquake resulting in the largest number of casualties of the 20th century is the Tangshan Earthquake in China in 1976; killing 240 thousand people and heavily damaging one million buildings. The number of deaths compared to building damage is high if the deaths were mainly caused by the collapse of RC high-rise buildings, as seen in the 1999 Izmit earthquake, 1986 Armenia earthquake and 1985 Mexico City earthquake. The ratio of fatalities to building damage is low in the case of Japanese timber frame buildings because spaces remain if the buildings collapse. The relation of fatalities to weak masonry buildings is located between the upper and lower trend lines. The 1975 Haicheng earthquake is the exception because this earthquake was predicted.

In two scenario earthquakes, the relationship between the number of heavily damaged buildings and the number of deaths agrees with those of RC high-rise buildings.

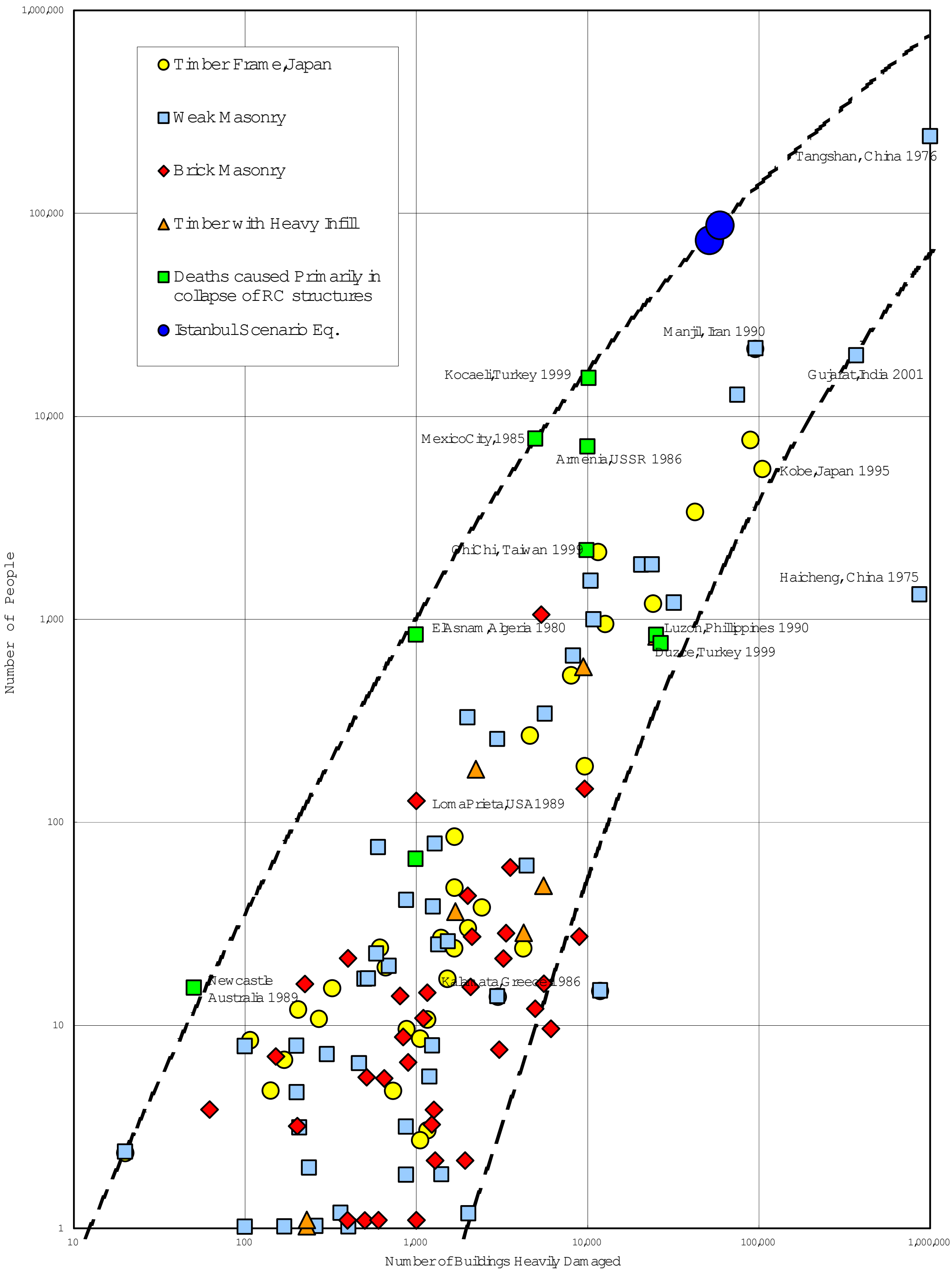


Figure 8.2.10 Relationship between Total Casualty Figures and Total Building Damage Statistics (retouched to Coburn · Spence 1992)

References to Section 8.2

Başbakanlık Kriz Yönetim Merkezi, 2000, DEPREMLER 1999.

Coburn, A.W. and R.J.S. Spence, 1992, Earthquake Protection, John Wiley.

İnşaat Mühendisleri Odası ve İnşaat Mühendisliği Bölümü, 2000, Marmara ve Düzce Depremleri Mühendislik Raporuç.

Joint Reconnaissance Team of Architectural Institute of Japan, Japan Society of Civil Engineers, and Bogazici University, Istnabul, Turkey, 1993, Damage Report on 1992 Erzincan Earthquake, Turkey.

Wallance, R. E., 1968, Eartquake of August 19, 1966, Varto Area, Eastern Turkey, Bull. Seism. Soc. Am., Vol. 58, No. 1.

Chapter 9. Evaluation of Urban Vulnerability

9.1. Buildings

9.1.1. Present aspect of building design and construction

(1) Construction Procedures and Quality Control

In Turkey, vulnerability of buildings are widely known, however, it is not clear that what makes the reason to build such a weak buildings, especially for residential buildings. It is important to know what kind of regulations and quality controls are accepted under construction. This section describes to clear the problem of construction procedure in Istanbul to find out the way to strength the buildings and minimize the human loss against strong Earthquake.

a. Building Permission

For the process of constructing new buildings, building permission has to be accepted by the District Municipalities, where under jurisdiction of construction sites. Directorate of Constriction, Department of Planning and Construction, IMM, also check the registration form and attached documents to inspect the reliability randomly from District Municipalities. According to the meeting with Department of Planning and Construction, they mentioned about the restriction of building permission after Kocaerii Earthquake, 1999. As a result, more illegal buildings are increased and number of submissions to get building permission is decreased drastically. In fact, restriction of building permission makes to increase the number of poor construction ironically.

b. Construction

Before the Kocaerii Earthquake, there was no construction supervision enforcement at the construction site and responsibilities are not clearly defined. Therefore, only major buildings, such as office buildings, shopping centers, which are constructed by major rich companies, are kept high in quality. However, residential buildings, which are constructed mostly not seriously considered about Earthquake or lack of budget to build strong buildings against Earthquake are widely accepted without any doubt. In order to minimize such trend, *"CONSTRUCTION SUPERVISION LAW #4708"* was enacted in 2000 controlled by Ministry of Public Work and Settlements and modified in August 2001. Its aims are as follows;,

1) To secure the safety of human life and physical by structures,

2) To avoid no plan/inspection and low quality construction which causes waste of resources,

3) To construct structures which reach recent standards,

4) To secure structure inspection to fulfill item 3),

5) To secure individual rights from loss by damage of structure, and

6) To insure from losses that may be occur in the future.

By this law, each construction site has to employ supervisor(s) from Construction Supervision Company. The company cannot have any function other than supervision to keep clearness of the inspection work.

This law is effective for all construction of buildings except which is single story building without basement floor and less than 180 m^2 of floor area. Supervision duration is from the starting date of submission of building permit and up to end of approval of usage permit.

By enacting of this law, it is true that strong building are built stronger, however, unless there are many ways to evade this law, low quality building may not be decreased in the future. It is strongly necessary to find a way to obey the law strictly.

(2) Earthquake resistant code

A latest earthquake resistant design code is "Specification for Structures to be Built in Disaster Areas (PART III - EARTHQUAKE DISASTER PREVENTION)" that is established by Ministry of Public Works and Settlement, Government of Republic of Turkey in 1997.

This code prescribes through the latest knowledge concerning the basic principles of building structure system, seismic load and details of structure. However, this does not include the provision for earthquake induced earth pressure.

Chambered Office of Civil Engineers published a reference book "*DEPREM MUHENDISLIGINE GIRIS ve DEPREME DYANIKLI YAPI TASARIMI*" that can offer the ways to confirm a safety by calculation.

However, since it is clear from not strict process of building permit, it cannot be said that newly constructed buildings were confirmed a safety by calculation.

(3) Earthquake resistance of existing buildings

A first step of the building survey was carried out to gain a numerical understanding of the earthquake resistance of the buildings in the study area.

The investigated buildings are following 2 schools.

- ÜSKÜDAR TİCARET MESLEK LİSESİ (S-1)
- HAZERFEN AHMET ÇELEBİ İLKÖĞRETIM OKULU (S-2)

Photo 9.1.1 ÜSKÜDAR TİCARET MESLEK LİSESİ

Photo 9.1.2 HAZERFEN AHMET ÇELEBİ İLKÖĞRETIM OKULU

The former school is comparatively old building, completion of design was in 1977, completion of construction was in 1985. The latter school is comparatively new building, completion of design was in 1987. Both of them are designed based on a building standard design named 10403.

The method applied in this survey is based on *first step diagnosis* that is proved in "Specification of diagnosis on RC Composed Existing buildings (version 2001) (Public Works of Construction Japan)". This method gives Seismic Index of Structure *IS* as a capacity of the buildings, by referring "cross section area of columns and walls", "total weight of structure above the corresponding story", and "Uniaxial compressive strength of concrete".

This index can give effective information to quantitative understanding, not a subjective assessment data, nevertheless, there can be some difference between the concept of Turkish RC building structure and the Japanese one.

The process of calculation is shown in Figure 9.1.1. An example of calculation data of ÜSKÜDAR TİCARET MESLEK LİSESİ is shown in Figure 9.1.2.

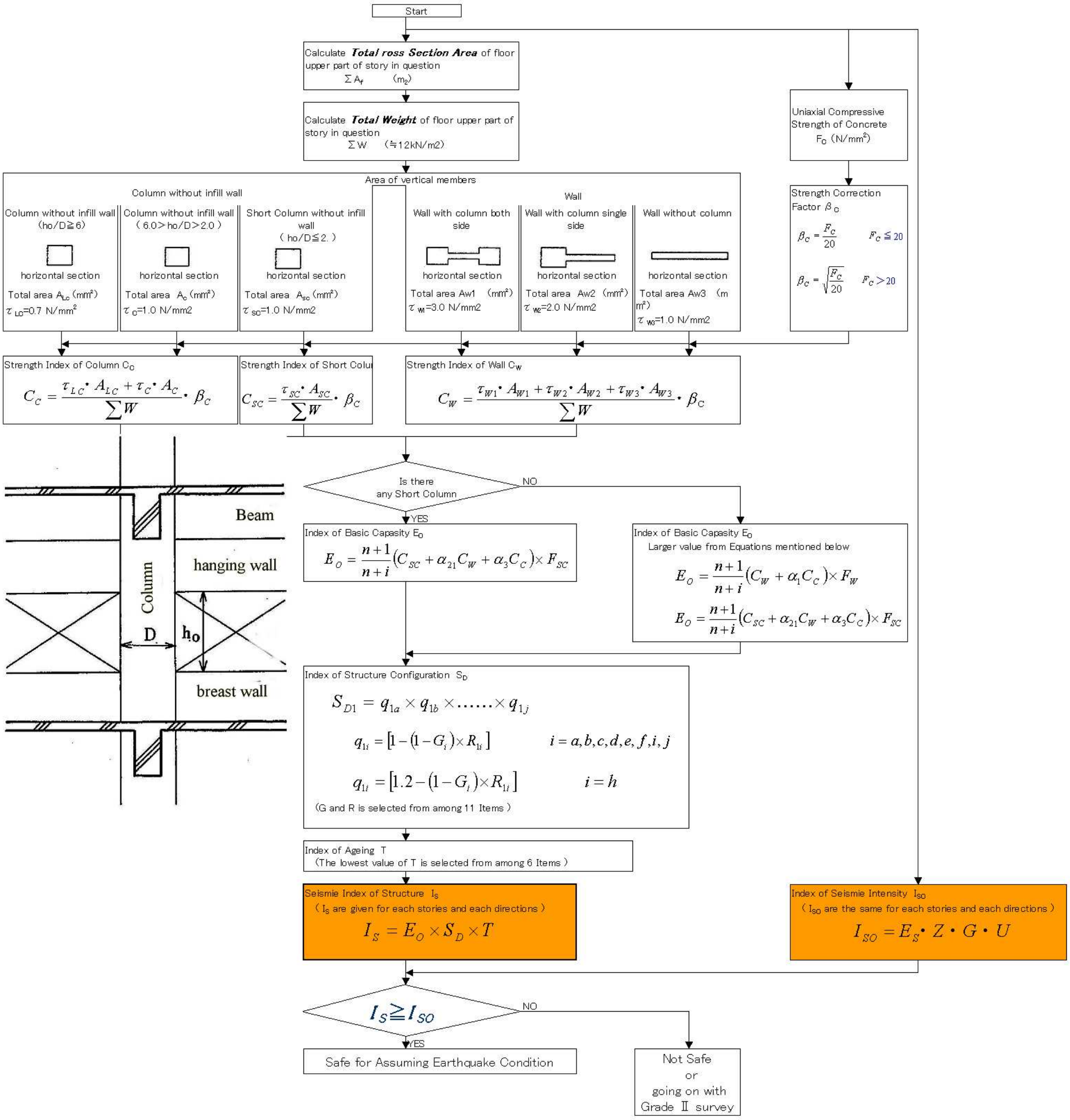


Figure 9.1.1 Process of calculation (I_S)

Seismie Index of Structure I_S

Number of stories n	5
Corresponding story 1 for ground floor n for top floor	1
Total weight of structure above the corresponding story ΣW (N)	23,211,058.500

Strength Index C

Column (ho/D≧6) Total cross ection area A_{Lc} (mm²)	22,332,000
τ_{LC} (N/mm²)	0.7
$\tau_{LC}\times A_{Lc}$ (N)	15,632,400
Column (6.0＞ho/D＞2.0) Total cross ection area Ac (mm²)	
τ_C (N/mm²)	1.0
$\tau_C\times A_c$ (N)	0
Column (ho/D＜2.0) Total cross ection area Asc (mm²)	
τ_{SC} (N/mm²)	1.5
$\tau_{SC}\times A_{Sc}$ (N)	0

Wall (with column both side) Total cross ection area A_{w1} (mm²)	
τ_{W1} (N/mm2)	3.0
$\tau_{W1}\times A_{w1}$ (N)	0
Wall (with column single side) Total cross ection area A_{w2} (mm²)	
τ_{W2} (N/mm²)	2.0
$\tau_{W2}\times A_{w2}$ (N)	0
Wall (without column) Total cross ection area A_{w3} (mm²)	0
τ_{W3} (N/mm²)	1.0
$\tau_{W3}\times A_{w3}$ (N)	0

Uniaxial compressive strength of concrete F_C (N/mm²)	18.0
β_C	0.9

Strength index of column C_C (h_o/D＞2.0)	0.606
Strength index of short column C_{SC} (h_o/D≦2.0)	0.000
Strength index of wall C_W	0.000

Proportionate contribution factor α	
α_1	1.0
α_2	0.7
α_3	0.5

Ductility index F	
F_C Column (h_o/D＞2.0)	1.0
F_{SC} Short column (h_o/D≦2.0)	0.8
F_W Wall	1.0

Index of Basic Capasity E_O

E_0 (by Equation (2))	0.606
E_0 (by Equation (3))	0.242
applied Equation	No short column, by Equation (2)
Index of basic capacity E_0	0.606

Index of Irregularity in Plan S_D	0.54
Aged Deterioration Index T	0.8
Seismie Index of Structure I_S	*0.262*

Seismie Index requirement I_{SO}

Basic index of earthquake resistance E_s	0.8
Seismic zone factor Z	1.0
Geographical configuration Index G General configuration : 1.0 On the cliff : 1.1 Irregular geological layer: 1.1 Located on a hill : 1.1	1.1
Importance factor U Building Usage Class Ⅰ : 1.5 Building Usage Class Ⅱ : 1.25 Building Usage Class Ⅲ : 1.0	1.50
Required Seismie Index I_{SO}	*1.320*

Earthquake Resistance	Arguable against the corresponding earthquake

: Required value

: Obtained value or paragraph

: Fixed value

ÜSKÜDAR TİCARET MESLEK LİSESİ

1st Story, Direction : X

Figure 9.1.2 An example of calculation data of ÜSKÜDAR TİCARET MESLEK LİSESİ (Span direction)

The assessed result for each direction of each building *Is* is shown in Table 9.1.1 and Table 9.1.2.

Table 9.1.1 The assessed result for each direction of each buildings I_S (ÜSKÜDAR TİCARET MESLEK LİSESİ)

		Index of basic capacity E_O	Index of Irregularity in Plan S_D	Aged Deterioration T	Seismic Index of Structure I_S
Ridge direction	5th story	2.068	0.540	0.800	0.893
	4th story	1.004	0.540	0.800	0.434
	3rd story	0.734	0.540	0.800	0.317
	2nd story	0.645	0.540	0.800	0.279
	1st story	0.606	0.540	0.800	0.262
Span Direction	5th story	2.569	0.540	0.800	1.110
	4th story	1.235	0.540	0.800	0.534
	3rd story	0.895	0.540	0.800	0.387
	2nd story	0.771	0.540	0.800	0.333
	1st story	0.718	0.540	0.800	0.310

Table 9.1.2 The assessed result for each direction of each buildings I_S (HAZERFEN AHMET ÇELEBİ İLKÖĞRETIM OKULU)

		Index of basic capacity E_O	Index of Irregularity in Plan S_D	Aged Deterioration T	Seismic Index of Structure I_S
Ridge direction	4th story	1.683	0.600	0.800	0.808
	3rd story	0.822	0.600	0.800	0.395
	2nd story	0.632	0.600	0.800	0.303
	1st story	0.556	0.600	0.800	0.267
Span Direction	4th story	1.861	0.600	0.800	0.893
	3rd story	0.909	0.600	0.800	0.436
	2nd story	0.697	0.600	0.800	0.334
	1st story	0.613	0.600	0.800	0.294

Seismic Index of Structure IS value shown in Table 9.1.1 and Table 9.1.2 represent resistivity of building and this index shall be compared with Required *Seismic Index Iso*, then safety against assumed earthquake could be assessed. As it was shown in Table 9.1.1 and Table 9.1.2, *Required Seismic Index Iso* is on the basis of *Basic index of earthquake resistance Es* and its value is 0.8.

The specific value of Basic index of earthquake resistance *Es* was fixed referring the damage distribution of 1968 Tokachi Earthquake and 1978 Miyagi Earthquake. There was only one damaged building in the case of $E_S \geq 0.7$ and no damage was found in the case of $E_S \geq 0.8$.

"Specification of diagnosis on RC Composed Existing buildings (version 2001)" proves an equation in which Basic index of earthquake resistance ES was multiplied by Seismic zone factor Z, Geographical configuration Index G and Importance factor U. As it was shown in Figure 9.1.2, the value of *Iso* shall be 1.32 when following set of value is applied. (Seismic zone factor Z=1.0, Geographical configuration Index G=1.1, Importance factor U=1.5 considering the priority of this building)

Similar method was applied for the damage investigation on 1992 Erzincan Earthquake and relation between the result value of IS and actual damage ratio was compared as shown in Figure 9.1.3.

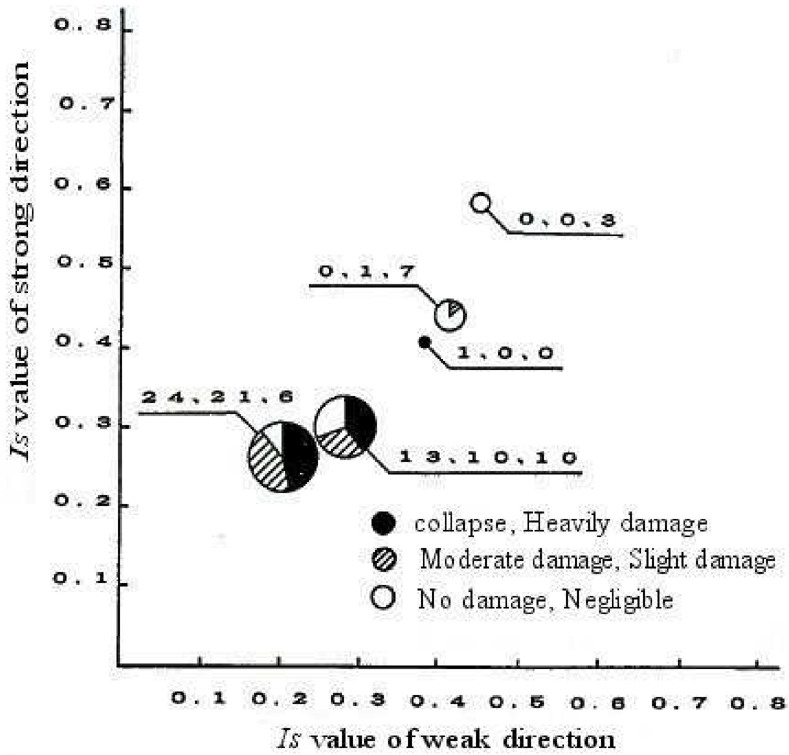


Figure 9.1.3 relation between the result value of I_S and actual damage ratio (1992 Erzincan Earthquake)

- The buildings which have the value of I_S=0.4□0.5 may stay in slight damage under the condition of 1992 Erzincan Earthquake.
- Half of the buildings which have the value of I_S□0.2 may reach collapse or heavily damage under the condition of 1992 Erzincan Earthquake.

The lowest *Is* value of each investigated buildings at 1st story are 0.108 for Üsküdar Ticaret Meslek Lisesi and 0.189 for Hazerfen Ahmet Çelebi İlköğretim Okulu. Therefore, it is possible that these buildings may collapse or heavily damage under the condition of 1992 Erzincan Earthquake. It is easily presumed that almost all the school buildings may have similar earthquake resistance, because these investigated buildings are designed based on the school building design standard.

In addition, there are following remarkable points, which show the reasons why these buildings do not have sufficient earthquake resistance in investigated buildings.

- The story that was designed as a basement was made as 1st story by unknown reason. It means that it is similar to the building with added stories after completion of construction illegally. Nevertheless, cross section of the columns and walls were not increased appropriately. Therefore, the IS value of the buildings is lower than the value that is required to endure the earthquake motion similar to 1992 Erzincan Earthquake. If the 1st story of Hazerfen Ahmet Çelebi İlköğretim Okulu was constructed as the basement as of original drawing and water leakage is not observed, *Is* value increase from 0.189 to 0.429. This assumption means that Hazerfen Ahmet Çelebi İlköğretim Okulu could endure the earthquake similar to 1992 Erzincan Earthquake, if the building constructed following original design and maintained carefully.
- The shear wall layout was changed from the original design standard in order to prioritize convenience of usage. Therefore, the capacity, for the direction of which the shear wall was omitted, becomes lower than the one that originally designed. For instance, in the case of Üsküdar Ticaret Meslek Lisesi, there is no shear wall that is effective for ridge direction, as a result, the *Is* value for this direction give the lowest figure 0.108.
- The torsion mode behavior can occur, if the wall is arranged unevenly.
- Some critical stress concentration will occur, when the walls are arranged carelessly. i.e. the column was reformed to the wall.

Similar observation is also shown in the report on the school buildings in Avcilar district prepared by Prof. Zekeriya POLAT (Y.T.U).

9.1.2. Indication of a controversial point on Structure

Most of Turkish buildings generally have following defect.

(1) The cross section area of the columns is frequently insufficient

The result of school building survey represents the ordinary earthquake resistant level of Turkish buildings. The fact that *Seismic index of structure Is* of investigated buildings is very low means that cross section area of vertical member (column and wall) is insufficient. The value of *Is* does not only reach the required level of Japanese ordinary building, but also not improved from the level given to damaged buildings of 1992 Erzincan Earthquake.

In addition, many buildings that have more insufficient number of columns compared to surveyed school buildings were found during the field investigation in Istanbul.

(2) The reinforcement of the columns is frequently insufficient

In addition to insufficiency of the cross section area of the column and wall, the number and diameter of re-bar in cross section area is also insufficient.

The re-bar is not connected appropriately through the story. This point has been designated as a reason why the collapse caused by failure of column-beam connection is predominant in Turkey. However, the evident collapse of this kind was observed even at 2002 AFYON Earthquake. This point out that problem in column-beam connection was not improved: nevertheless, brittleness of that part have been cautioned since 1992 Erzincan Earthquake.

The cross section area of the hoops are insufficient, the interval of the hoops are insufficient. In addition, the end of the hoops are usually fixed by 90 degree hooks even though some design code in Turkey prove appropriate detail, (i.e. hoops shall always have 135 degree hooks at both ends hooks shall be bent around a circle).

If fixing of the stirrup end is insufficient, then bar may slip off, and column itself does not exert vertical load-carrying capacity.

The shear failor of the column and the buckling of concrete may occur after the problem of column-beam connection is solved.

Photo 9.1.3 An example of the failure between the column and the beam

(3) Difference between the mechanism of column and wall is not identified

In general, column is expected to have load-carrying capacity even if it is under large story-drift caused by earthquake excitation, therefore, column must have considerable ductility as well.

However, some amount of stiffness is needed, because load-carrying capacity of the column is lost when it suffer excessive story-drift. Reasonable amount of shear-wall is effective for controlling story-drift. Shear-wall should be arranged for ridge direction and span direction, and should be distributed evenly.

Concerning the buildings in Turkey, there are many examples that is composed of only column. Especially flat section column is used to control the stiffness of horizontal direction. It is doubtable that this kind of column has sufficient ductility, because hoops in this kind of section do not come into effect even if considerable amount of hoops exist. Many examples of failure were found at the columns of subway structures in 1995 Kobe Earthquake.

(4) Framework is confused in many building structure

Beam is not identified clearly in many cases of residence buildings. This kind of framework is not effective for horizontal force.

(5) There are big difference between the indicated strength of concrete and real strength

The concrete that is mixed in situ is still used frequently. The quality of that kind of concrete is doubtable, because quality inspection and control are not sufficient as many Turkish engineers insist.

(6) Capacity and stiffness for ridge direction is not taken into consideration in many buildings at urbanized area

For instance, when a building that forms a part of one block is demolished, some strut usually placed between neighboring buildings. This treatment shows that neighboring building may be deformed to void space and collapse at last, even though there is no earthquake.

(7) Wrong usage of hollow brick

Hollow bricks are widely used as partition walls, but load-carrying capacity and shear capacity cannot be expected in these walls. However, some buildings that are composed of only by hollow brick are observed. Law prohibits this kind of structure, but frequently exists.

(8) Earthquake resistant design code is not strictly obeyed

Earthquake resistant design code has been improved reasonably up to the present, however, buildings which applies this code seem very limited especially for residential buildings.

9.1.3. Recommendation on earthquake resistant strengthening

There are several levels for the concrete measures of earthquake resistant strengthening.

Regarding the intensity of earthquake to be targeted;

- □ The intensity of earthquake caused by 1999 Izmit Earthquake; it may be easily understood by many citizen in Istanbul. That intensity was not so large in Istanbul, however, some building damages were observed in Istanbul.
- □ The intensity of earthquake that is proved in the earthquake resistant design code; probability of exceedance of that earthquake within a period of 50 years may be about 10%.
- □ The intensity of earthquake caused by scenario earthquake; this is the largest earthquake that can be expected for Istanbul area.

How much damage can we control against above mentioned intensity of earthquake are as follows;

a) Keep the structure as fully operational,

b) Keep the structure as operational but some repair is needed, and

c) Prevent only complete collapse (i.e. Pancake crush) ; huge numbers of human life can be saved

Therefore, it is very important that which type of measure can be corresponded to which intensity of earthquake. Needless to say that it is not realistic to correspond □ and a). The main countermeasures for the scenario earthquake is not to prevent structural damage of each building, but to improve the earthquake mitigation system.

Some reasonable correspondence is selected in Table 9.1.3. The most important countermeasure is to correspond □ and c).

Table 9.1.3 Counter measure correspond to earthquake intensity

	Earthquake Performance Level		
	a) Fully Operational	b) Operational but Repair is needed	c) Prevent Complete Collapse
① Frequent Earthquake	✓		
② Eartquake that is provided in Present Earthquake Resistant Code		✓	
③ Scenario Earthquake			✓

Some earthquake resistant strengthening was already carried out in Istanbul. The construction methods are;

- Column jacketting with RC
- Beam jacketting with RC
- Adding RC wall
- Changing porous bricks to RC wall

Chambered Office of Civil Engineers regularly hold seminar on the earthquake resistant strengthening design. Certification system for the earthquake resistant strengthening designer named Proje Muhendıisliği (Project Engineering License) exists in Turkey.

There is a following fundamental difference between Turkish understanding of column jacketting and the one in Japan.

Typical distruction mode of Turkish buildings is pulling out of re-bar in the column-beam connection because fixing of re-bar is not sufficient. So the textbook of seminar emphasize that the re-bar must be connected appropriately through the story. Steel plate jacketting of column was not observed in Istanbul area, but this method is introduced in textbook. Connecting by bolt through the story is recommended even the steel plate jacketting.

On the other hand, connecting jacket through the story is rather prevented in Japan. The slit is usually made as shown in Figure 9.1.4 in order to make jacket not to load the axial force. The main purpose of jacketting in Japan is to resist against the shear failure and the concrete buckling of column, because typical distruction mode of Japanese buildings is the shear failure at middle part of the column.

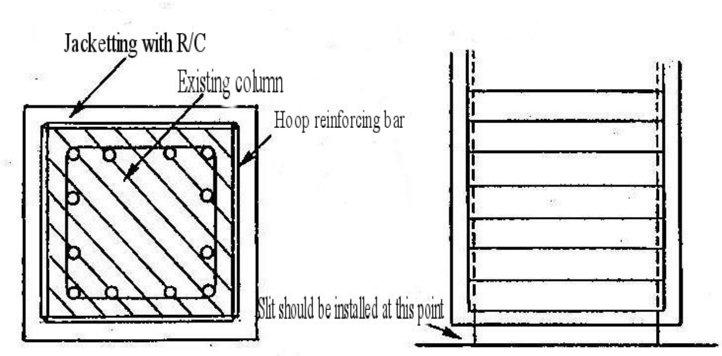


Figure 9.1.4 Schematic drawing of slit that is made at the column end

The concept of earthquake resistant strengthening in Japan is shown in Figure 9.1.5.

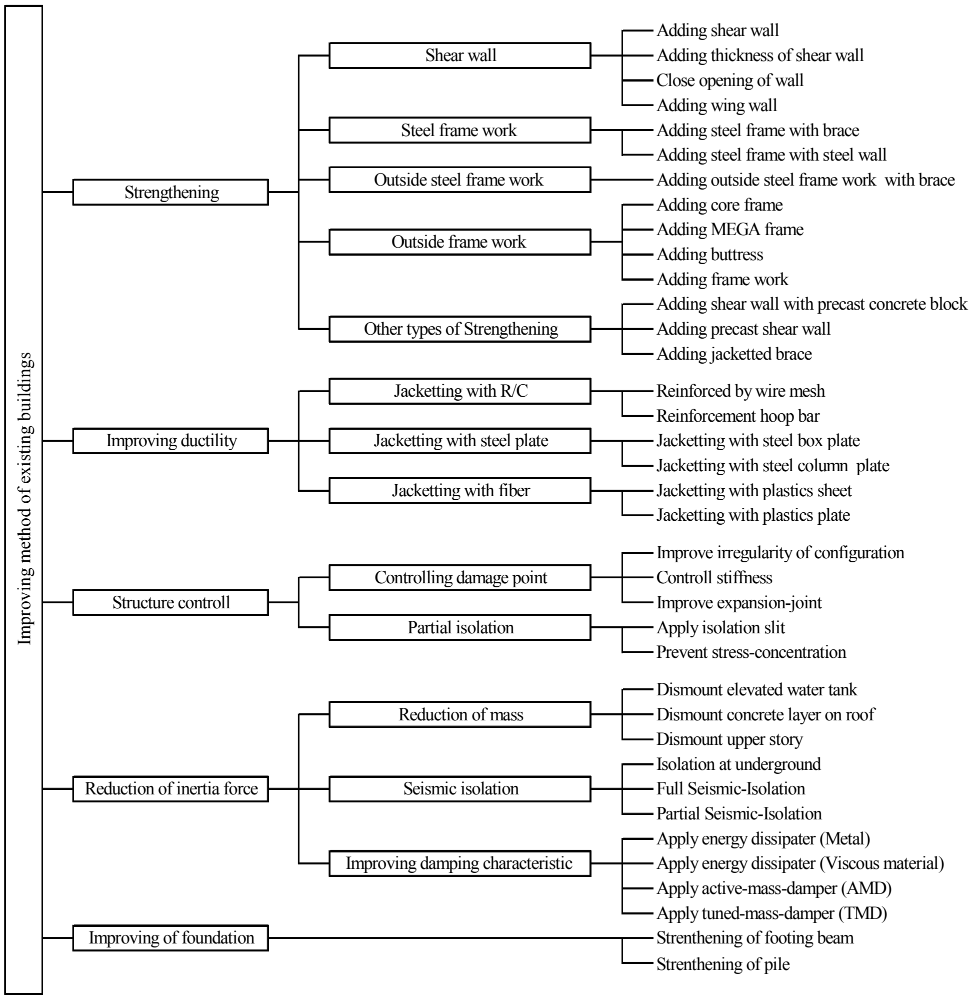


Figure 9.1.5 Concept of earthquake resistant strengthening in Japan

In any case, the main principle of the earthquake resistant strengthening is to redress an imbalance of capacity and to make every members of the building to be able to exert it's own capacity. It must avoid to jackett all menbers. If this kind of measure is needed, the demolishing and reconstruction are more cost effective.

The strengthening method that is considered effective are as follows;

(1) Jacketting column and beam, Adding RC wall

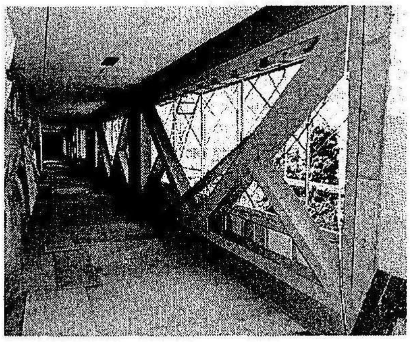
This type of methods is already known and applied by Turkish engineers.

(2) Adding steel frame work

Steel frame work is effective to control the story drift. This method also can correct the uneven distribution of stiffeness.

The vertical members of the steel frame work also can be expected to carry a part of vertical load when the building suffers excessive story-drift.

However, there are some different characteristics between the Turkish buildings and Japanese ones, therefore, some effort of experimental design and loading test using speciemen is necessary.



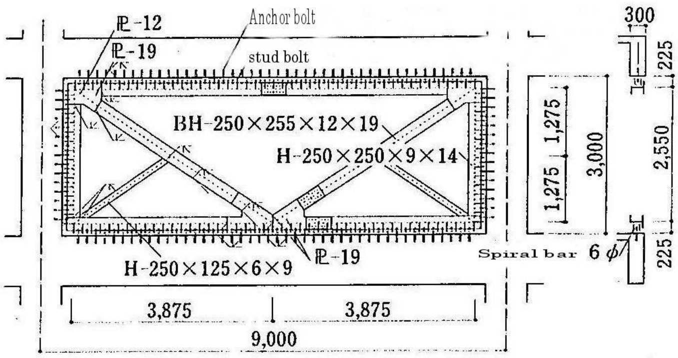


Figure 9.1.6 An example of steel frame work

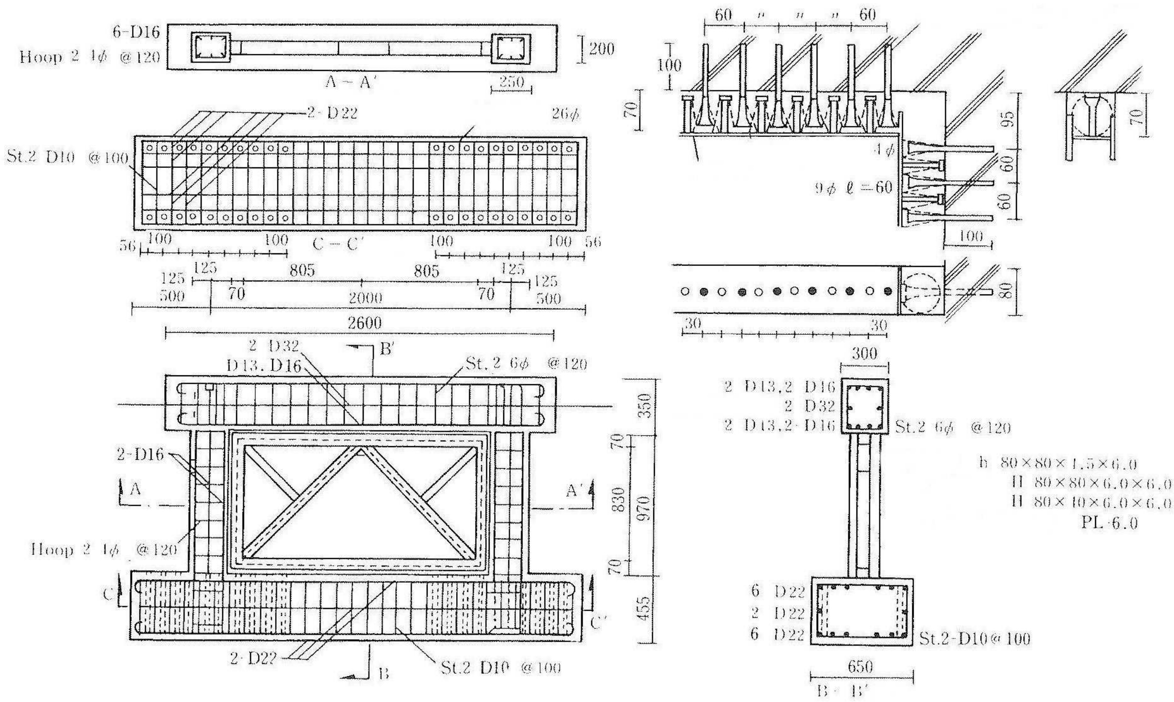
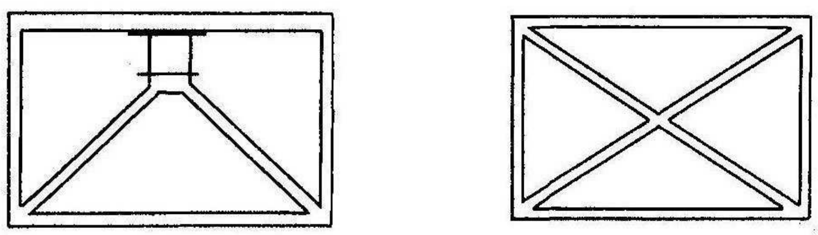


Figure 9.1.7 Test specimen for experiment

(3) Applying dynamic structure control

When the Y-configurated steel frame work is applied, energy absorption device can be set at the linking point of Y shape. Usually, energy absorption device is composed of high ductility steel plate. This concept is called “dynamic structure control”.



a) Y-shape brace b) X-shape brace

Figure 9.1.8 Y and X configurated steel frame work

When the X-configurated steel frame work is applied, the high ductility steel brace can be set. In this case, the high ductility steel brace is covered by steel jacket, in order to prevent buckling of the brace. The relation between the brace and jackett is made as allow slip, in order not to carry by jacket the axial force and only resist against bending. This type of method is developed by Japanese company and called “combined material brace” or “un-bonded brace”.

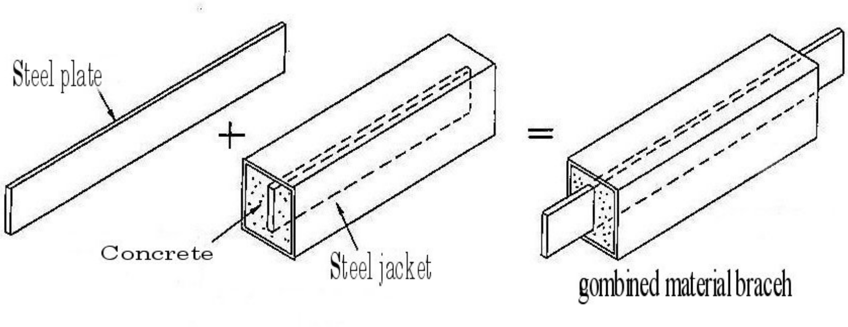


Figure 9.1.9 Schematic drawing of "combined material brace" or "un-bonded brace"

(4) Applying concept of seismic isolation

When the principle of the enlonging natural period is added to the concept of dynamic structure control, it becomes the concept of seismic isolation. The buildings that are designed by this concept are increasing drastically in Japan. This concept is very effective for reducing the inertia force caused by earthquake, but careful examination is needed, if considered about the capacity of Turkish existing buildings.

(5) Objective buildings

If some materials are added to existing buildings, mass of the structure increase necessarily and inertia force caused by earthquake increase. Some kind of *trade offer* relation that is to say more effective increase of capacity than the increase of inertia force must be obtained. If the original structure is excessively poor, that *trade offer* may not be concluded. When highly developed technic is applied, construction cost may also increase. Cost-performance consideration must be taken into account.

When the objective buildings is selected, pilot study has to be carried out at first, taking into account the following stronghold facility for Earthquake Disaster Mitigation. It is realistic to extend by priority.

- School buildings
- Hospital
- Public hall
- Governmental facility
- Fire fighting facility
- Police facility

- General financial institution
- Hazardarous facility

9.2. Major Public Facilities

Many major public facilities have critical roles in the event of an earthquake: For example, office of disaster management, evacuation shelters and medical facilities such as hospitals. Damages on the public facilities by an earthquake would impact on physical, social and economical aspects of human lives. Therefore it is important to have earthquake resistant public facilities. In this section damage estimations on the following public facilities are conducted.

1) Educational Facilities: Primary and High Schools

- Educational facilities can be landmarks of local communities.
- Open spaces in the schools might be used as refuge after evacuation.
- School buildings might serve as temporary houses and shelters if they are not damaged seriously.
- Schools are important for future generation.

2) Medical Facilities: Hospitals and Policlinics

- Medical Facilities are very important places to get medical attention.
- Inpatients need continuous medical care even during and after earthquake and extremely vulnerable; they might get cut on-going medical treatments or/and injured by the earthquake incidence.

3) Fire Fighting Facilities: Fire Fighting Station

- Fire fighting facilities are equipped with all the necessary functions and gears to respond to fire hazardous and to rescue people.
- Fire fighters who are well trained and stationed at the facility can act swiftly for emergency needs.
- Fire fighting station would be a center of the rescue mission.

4) Security Facilities: District Police (İlçe emniyet), Police and Gendarme (Jandarma)

- Security facilities are essential agencies regarding rescues, maintenances of public order and traffic controls, and other domestic security measures.

5) Governmental Facilities: Ministry, Provincial and Municipality

- Governmental facilities are the pivotal points for carrying out counter measures with earthquake damages, disaster mitigation and management, and recovery in/after the event of earthquake.
- Disfunctioning governmental facilities due to the earthquake would impact negatively local lives and activities.

Such major public facilities discussed above should be built strong so that they withstand strong earthquake impact. In general the structures of the public facilities are different form regular buildings. Photo 9.2.1 and Photo 9.2.2 below represent typical school and fire fighting station structures.

Photo 9.2.1 Primary School: Large Floor Area (A) to Height (H) Ratio

Photo 9.2.2 Fire Fighting Station: Garage and Office within the Same Building

Hence, the fragility function for the damage estimation must be set specifically for the public facilities. However, currently sufficient data were not available to determine the fragility function for the public facilities. Therefore damage estimation on the public facilities is conducted using the measure of damage estimation on all buildings as discussed in section 8.1.

Consequently for further analysis it is necessary to keep it in one's mind that the damage estimation on the major public facilities was determined with all buildings-function. Drawbacks of such approximation are stated below.

1) Fragility function on all buildings includes not only buildings whose structures are close to the public facilities but also other buildings. Thus the resultant damage estimation does not entirely represent the public facilities which have unique structures.

2) The public facilities are made stronger than regular buildings in general. Therefore the predicted damages might have been over estimated.

Also some public buildings, in which seismic retrofitting has been under construction, were not considered in this damage estimation.

Under the above circumstances, the damage estimation on the major public facilities in the entire Study Area represents the whole and each individual district was not estimated. Significances of the damages on the major public buildings were identified by comparing with the damages on all the buildings stated in Section 8.1.

9.2.1. Facilities Data

The parameters of the data used for the scenario earthquake study are shown in Table 9.2.1 below.

Table 9.2.1 Data and Parameters

Data		Unit	Structure	Story	Construction Year	Numbers of Data	Data used for Damage Estimation
Type	Source						
Educational	Census 2000	Building	O	O	O	2,253	O
	Provincial Disaster Management (May, 2002)	Facility	X	X	X	1,933	X
Medical	Census 2000	Building	O	O	O	635	O
	Provincial Disaster Management (May, 2002)	Facility	X	X	X	468	X
Fire Fighting	The Fire Department of IMM (May, 2002)	Facility	O	O	X	40	O
Security	Provincial Disaster Management (February, 2002)	Building	O	O	X	166	O
Governmental	Provincial Disaster Management (February, 2002)	Building	O	O	X	491	O

Note: The date in ( ) is when the data was given to the Study Team.

(1) Educational Facilities

The data obtained from the province in May 2002 was summarized in a tabulate form for each district according to education level i.e. kindergarten, primary school, and high school. However, the table can only provide the data of the number of schools but not the information of structure, numbers of stories, and construction year for each school. Hence the data of buildings that could be applied for schools were selected from the census and used for the damage estimation.

According to the given data sets, total numbers of the buildings in the schools and of the schools as institution are 2,252 buildings and 1,933 schools (1,385 primary schools and 548 high schools) respectively. The average is 1.2 buildings per school. Our visual site investigation also confirmed that many schools consisted of 1 or 2 buildings. Therefore the building data from the census most likely represent the numbers of buildings at schools.

(2) Medical Facilities

The data obtained from the province in May 2002 were tabulated and summarized form for each district for hospital, policlinic, health center, and dispensary. However, the table can only provide the data for numbers of facilities but not the information for structure, numbers of story, and construction year of each facility. Hence the data of buildings, which could be mostly applied for medical facilities, were selected from the census and used for the damage estimation.

According to the data sets, the total numbers of the buildings in the medical facilities and of the medical facilities themselves are 635 buildings and 468 facilities (hospitals and policlinics) respectively. The average is 1.4 buildings per facility. Our visual site investigation also confirmed that many schools consisted of 1 or 3 buildings. Therefore, the data from the census regarding the buildings most likely represent that of the hospitals and policlinics.

The data must be up dated and added so that more accurate damage prediction could be done. The current problems are:

- Numbers of beds in the table did not include SSK' s.
- Statistics do not match: The number of hospitals according to the data obtained from the province in May 2002 is 201 while the number reported by the Ministry of Health is 185.

(3) Fire Fighting Facilities

The data obtained from IMM Fire Department in May 2002 include information with regard to numbers of facilities, structure, and numbers of stories. Therefore, the data were used for the damage estimation.

(4) Security Facilities

The data obtained from the province in May 2002 include information with regard to numbers of buildings, structure, and numbers of stories. Therefore, the data were used for the damage estimation.

(5) Governmental Facilities

The data obtained from the province in May 2002 included information with regard to numbers of buildings, structure, and numbers of stories. Therefore, the data were used for the damage estimation.

9.2.2. Characteristics of the Facilities

The data of the public facilities, such as structure of building, numbers of stories, construction year, and earthquake intensity are summarized in

Figure 9.2.1. The results of the damage estimation are also stated in the figure and will be discussed in Section 9.2.3.

(1) Structure

Table 9.2.2 summarized the percentages of the RC framed buildings and of the masonry buildings.

Table 9.2.2 Building Structure: RC Frame and Masonry (%)

Facility	RC Frame	Masonry
Educational Primary and High School	84.4% (+10.0%)	12.4% (-10.4%)
Medical Hospital and Policlinic	80.5% (+ 6.1%)	16.5% (- 6.3%)
Fire Fighting	95.0% (+20.6%)	5.0% (-17.8%)
Security Police and Gendarme	83.7% (+ 9.3%)	15.1% (- 7.7%)
Governmental Ministry, Province and Municipality	72.1% (- 2.3%)	19.6% (- 3.2%)
All Buildings	74.4%	22.8%

Note: ( ): Facilities(%) - All Buildings(%)

The table shows that more than 70% of the public facilities are made with RC-frame followed by Masonry type building: The ratio of RC framed buildings is higher in the public facilities (except the governmental facilities) than in all the buildings. Hence, it indicates that the public facilities are made more earthquake-resistant than regular buildings.

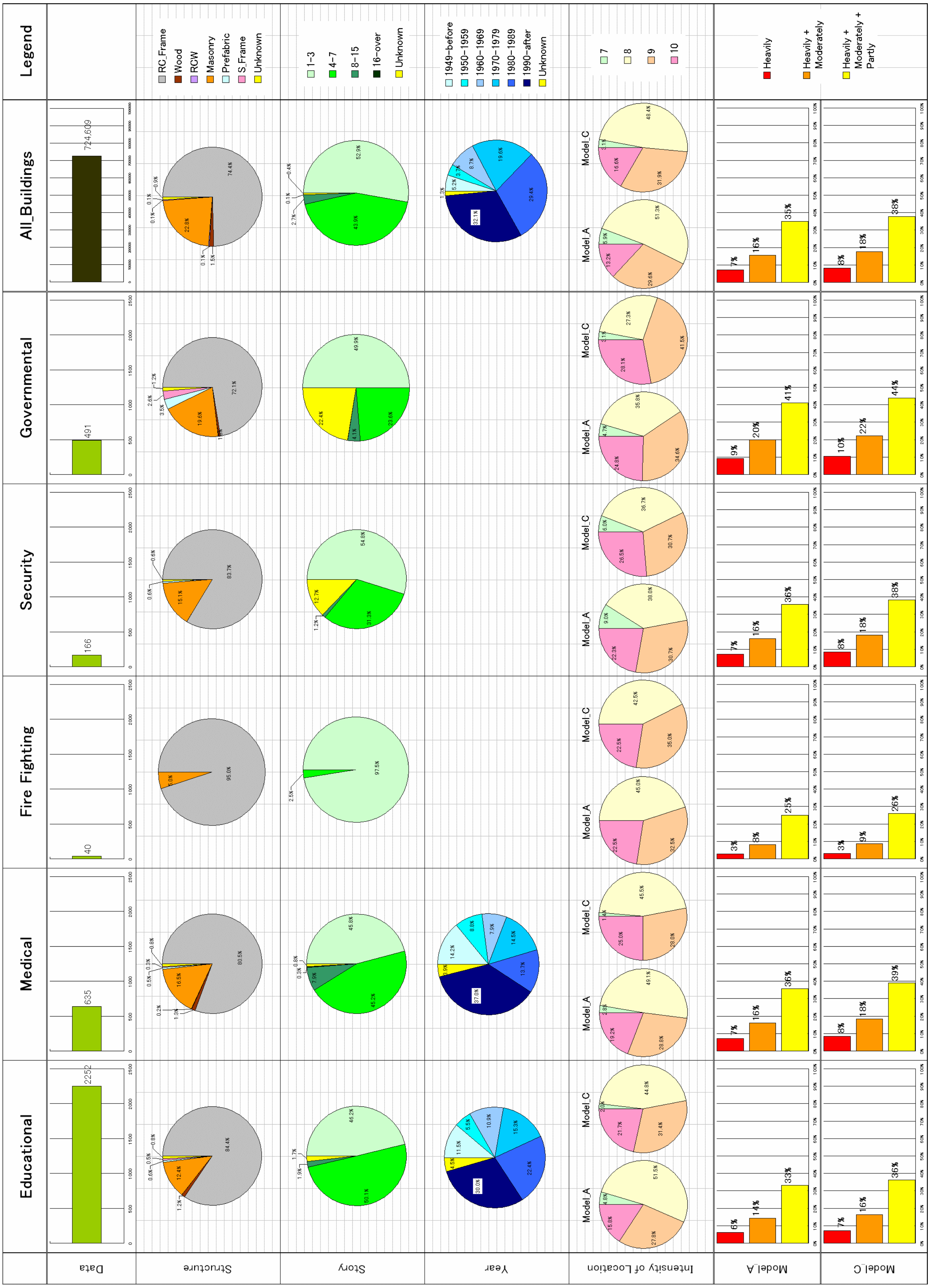


Figure 9.2.1 Characteristics of the Facilities and Results of the Damage Estimation

(2) Story

Table 9.2.3 shows the ratios of 1 to 3 story-buildings and of 4 to 7 story-buildings for the public facilities and all the buildings.

Table 9.2.3 Numbers of floors and facility type

Facility	1 – 3 Story building	4 – 7 Story building
Educational Primary and High School	46.2% (- 6.7%)	50.1% (+ 6.2%)
Medical Hospital and Policlinic	45.8% (- 7.1%)	45.2% (+ 1.3%)
Fire Fighting	97.5% (+44.6%)	2.5% (-41.4%)
Security Police and Gendarme	54.8% (+ 1.9%)	31.3% (-12.6%)
Governmental Ministry, Province and Municipality	49.9% (- 3.0%)	23.6% (-20.3%)
All Buildings	52.9%	43.9%

Note: ( ): Facilities(%) - All Buildings(%)

More than 70% of the public facilities are lower than 7 stories building. Among those the ratios of 1-3 story educational facilities and of 1-3 story medical facilities to the total number of buildings are slightly lower than that of all the 1-3 story buildings. The ratios of the same facilities built with 4-7 story are slightly higher than that of the all buildings. Most of the fire fighting station/department facilities are 1-3 story building. Numbers of stories were not reported for more than 10% of the security and the governmental buildings. However, our visual investigation confirmed that most of these buildings are lower than 7 stories. Therefore, it can be said that the ratios of the security building to and the governmental building to total number of buildings are similar to the case of all the buildings.

(3) Construction Year

Table 9.2.4 Educational and Medical facilities: before, in, and after 1980

Facility	1979 and Before	1980 and After
Educational Primary and High School	43.2% (+ 6.0%)	52.4% (- 9.1%)
Medical Hospital and Policlinic	45.4% (+ 8.2%)	50.7% (-10.8%)
All Buildings	37.2%	61.5%

Note: ( ): Each facilities(%) - All Buildings(%)

More educational and medical facilities have been built by 1979 than all other buildings (also refer to

Figure 9.2.1). This indicates that the educational and medical facilities are relatively older than all the buildings.

(4) Seismic Intensity at the Location of the Facilities

In Section 8.1.4, seismic intensity is estimated in each Mahalle based on the estimated damage of the buildings. The seismic intensity by the scenario earthquake at the location of each public facility is found and summarized in Table 9.2.5.

Table 9.2.5 Ratios of facilities whose intensity is greater than or equal to 9

Facility	Model A	Model C
	Intensity □ 9	Intensity □ 9
Educational Primary and High School	43.6% (+ 0.8%)	53.1% (+ 4.6%)
Medical Hospital and Policlinic	48.0% (+ 5.2%)	53.0% (+ 4.5%)
Fire Fighting	55.0% (+12.2%)	57.5% (+ 9.0%)
Security Police and Gendarme	53.0% (+10.2%)	57.2% (+ 8.7%)
Governmental Ministry, Province and Municipality	59.4% (+16.6%)	69.6% (+21.1%)
All Buildings	42.8%	48.5%

Note: ( ): each Facilities(%) - All Buildings(%)

More than 50% of all the facilities in the table resulted in the intensity greater than 9 by the Model C. Almost 70% of the governmental facility is distributed within the range. Also, the percentage on the public facilities whose intensities were greater than 9 is relatively higher than the case of all the buildings. The above results indicate that the public facilities could be located close to the earthquake center or/and on soft ground such as Quaternary Deposit.

9.2.3. Results of the Damage Estimation

(1) Educational Facilities

The degree of actual damages could be lower than the estimated one because:

Some schools were built with earthquake resistant technologies according to the new construction standard of 1998.

The fragility function was determined based on all the buildings and did not consider floor area-height ratio.

We tried to find an effect of school structure. In this particular case, the earthquake resistant structured schools were 287 which is merely less than 10% of the total numbers of schools: “Heavily + Moderately + Partly” damaged, “Heavily + Moderately” damaged, “Heavily” damaged schools were 32%, 14%, and 6% respectively. The damage ratios of the educational facilities are not so different in comparison with that of all the buildings. Therefore, prior to considering schools for emergency shelters reliability / strength / earthquake resistibility of the buildings must be thoroughly examined and evaluated. Moreover, new earthquake resistant structured schools shall be built taking into account of a practical emergency response management plan, proximity of shelters, and foundation/ground type.

(2) Medical Facilities

The damage estimation resulted in that the medical facilities would get damaged as much as all the buildings would. The results indicate that the medical facilities are not strong anymore than any other ordinary buildings. Hence, in order to keep the medical facilities functioning in the event of earthquake, they should be strengthened /retrofitted according to a plan taking into account precise numbers and locations of earthquake resistant medical facilities already exist.

(3) Fire Fighting Facilities

The damage rate of the fire fighting facilities is 4% to 12% lower than that of all the buildings. It could be because the buildings are RC structured and lower than or equal to 3 stories. However, a fire fighter station inherits weak structure against earthquake: the first floor of the building as garage has only 3 walls and the rest is open to the street and the walls are made of bricks. The stations need to be evaluated for earthquake resistibility and strengthen.

(4) Security Facilities

The damage estimation resulted in that the security facilities would get damaged as much as all the buildings would. It sounds reasonable because the structures of the facilities are similar to residential buildings. Since the security facilities have to function as the center of the emergency response measures, they must be evaluated for earthquake resistibility and strengthen the structure.

(5) Governmental Facilities

The damage estimation resulted in that the governmental facilities would get damaged more than the case of all the buildings. It sounds reasonable because the structures of the facilities are similar to residential buildings and such facilities tend to be located on the sites where seismic intensity is relatively high. Although some of the facilities are already earthquake resistant, since the governmental facilities would be the center of the emergency response measures, they must be evaluated for earthquake resistibility and strengthen the structure.

9.3. Fire

Istanbul has suffered from great fires repeatedly since its ancient days. The fire of 1782 reduced almost half of the city to ashes. The last great fires of Istanbul were the Hocapasa fire of 1865, the Beyoğlu fire of 1870, and the Laleli fire of 1912. After these fires, a fire-fighting organization was established and further construction of wooden buildings in the city was prevented. This enforcement seems successful, and no great fire has affected the Study Area after 1912. The wooden buildings in the Study Area are very few now, only 1.6% in total, and they exist in a limited area.

Figure 9.3.1 shows the number of fire outbreaks from 1996 to 2000 by 20 fire-fighting districts. Because data in some districts are missing, the total number of fire outbreaks in 12 districts is shown with a black line for comparison. The total number of fire outbreaks in one year is around 9000 in these 12 districts and is showing gradual decrease. This may be the result of switching from coal to natural gas for cooking and heating during the winter and progress made in transferring factories to suburban areas.

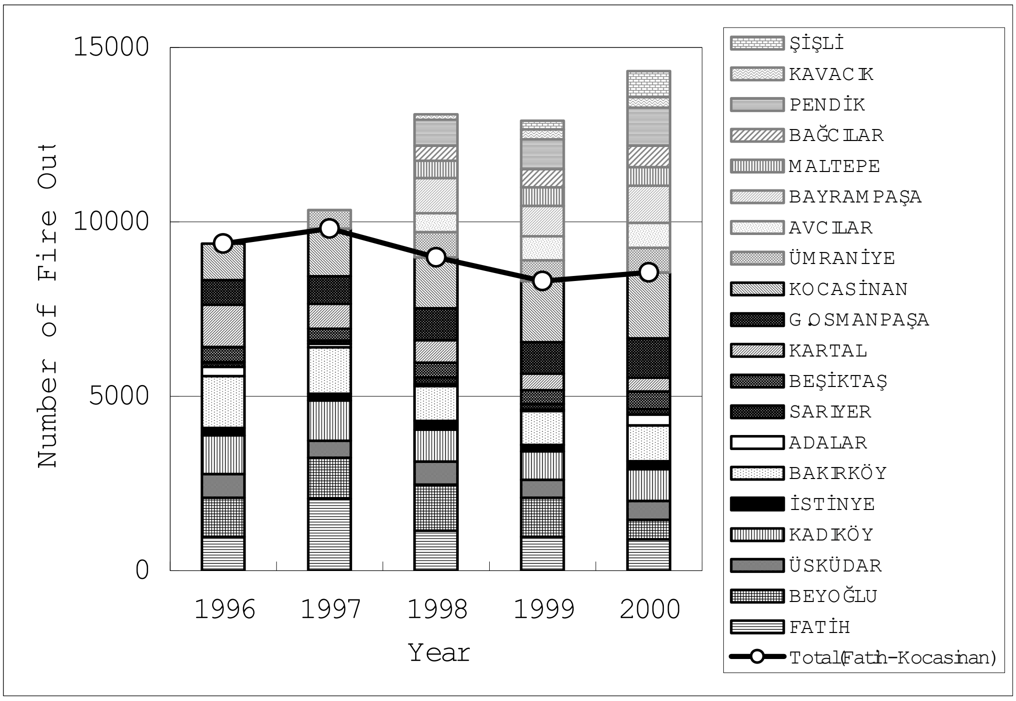


Figure 9.3.1 Number of Fire Outbreaks from 1996 to 2000

Source: Fire Brigade Department

Figure 9.3.2 shows the origin of fires in Istanbul. The most cases were due to the careless handling of the cigarettes, about 40% of all cases, and the second highest number of incidents were due to electric leakage or short circuits. It is notable that fires due to chimneys or sparks is diminishing. This may be also be the resulted of the switch from coal to natural gas for heating during the winter.

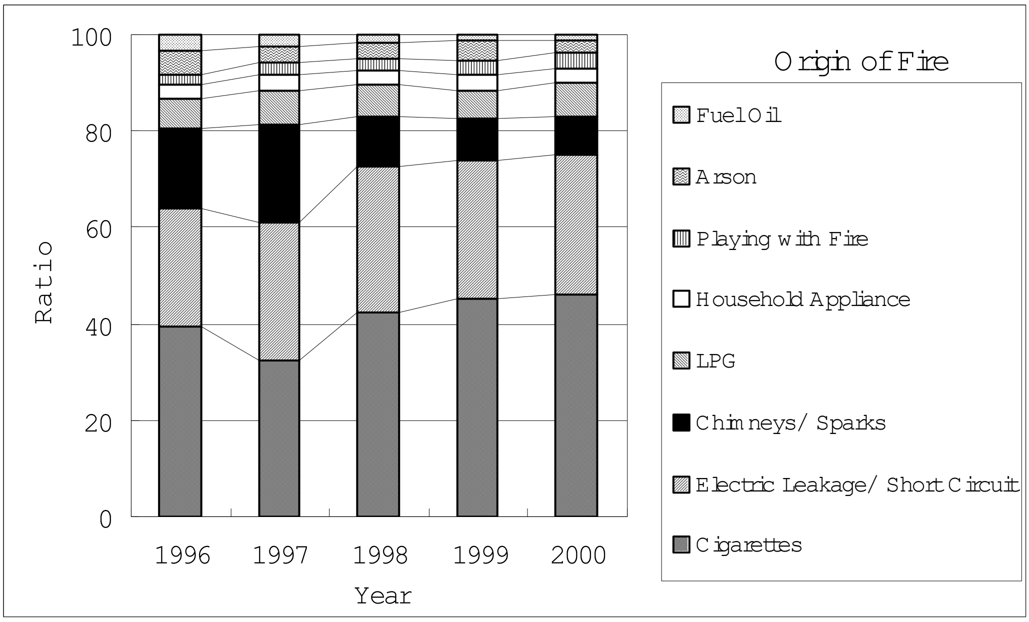


Figure 9.3.2 Origin of Fire from 1996 to 2000

Source: Fire Brigade Department

9.3.1. Fire Outbreak after Earthquake

After an earthquake, fire outbreaks from many facilities and buildings may occur. If the earthquake occurs during mealtimes, cooking stoves may become the main sources of fire outbreaks. Electric leakage or short circuits will also be significant sources of outbreaks. Over 100 fire outbreaks were reported in the Avcılar area due to the 1999 Izmit Earthquake, and it is estimated that most of them occurred due to electric leakage. It is also reported that no fires spread to other buildings.

The fire potential of building dwellings is strongly affected by the local situation, namely, the fuel used for the cooking stove, the structure of the kitchen, the heating system, etc. Therefore, it is necessary to statistically analyse fire outbreaks during past earthquakes and develop a vulnerability function for the local area, but this type of data is not available in Istanbul.

Therefore, the potential of fire outbreaks from facilities where flammable liquids or gas materials are handled is estimated in this study. These facilities are classified as follows:

1) Big LPG Storage

2) Factory of Paint/ Polish Products

3) Warehouse of Chemical Products

4) LPG Filling Station

5) Fuel Filling Station

The concepts of the estimation are as follows:

6) The offices of the facilities suffer damages caused by earthquake motion and the damage is estimated by the same procedure to the buildings as shown in the paragraph 8.1.

7) The damage grade of facilities is supposed to be same to that of the offices of facilities.

8) Inflammable liquids or gases will leak from the pipes and storage tanks of facilities that are heavily damaged.

9) The leaking liquids or gases will ignite to fire according to the following probability:

-	Big LPG Storage, LPG Filling Station	57.9%
-	Factory of Paint/ Polish Products, Warehouse of Chemical Products	3.66%
-	Fuel Filling Station	2.55%

(after Kanagawa Prefecture 1986)

10) The above values are estimated based on Japanese experience. No information on fire occurrences in Turkey is available. Consequently, the results show only a relative possibility of fire occurrence.

11) The number of fire outbreaks is summed for each mahalle and then expressed as a rating of fire from hazardous facilities.

Distribution of the vulnerability rating for mahalle is shown in

Figure 9.3.3 and

Figure 9.3.4.

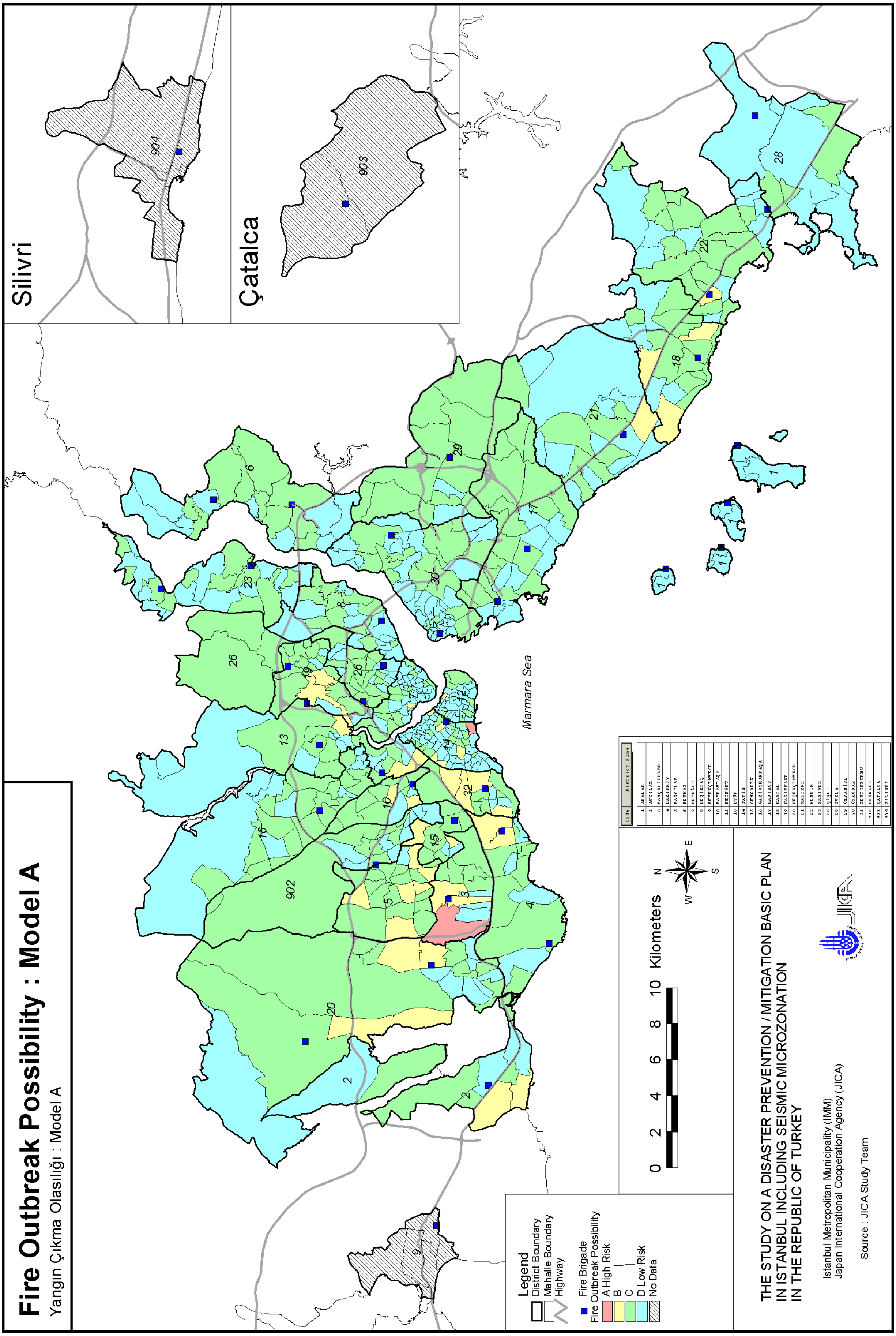


Figure 9.3.3 Fire Outbreak Possibility : Model A

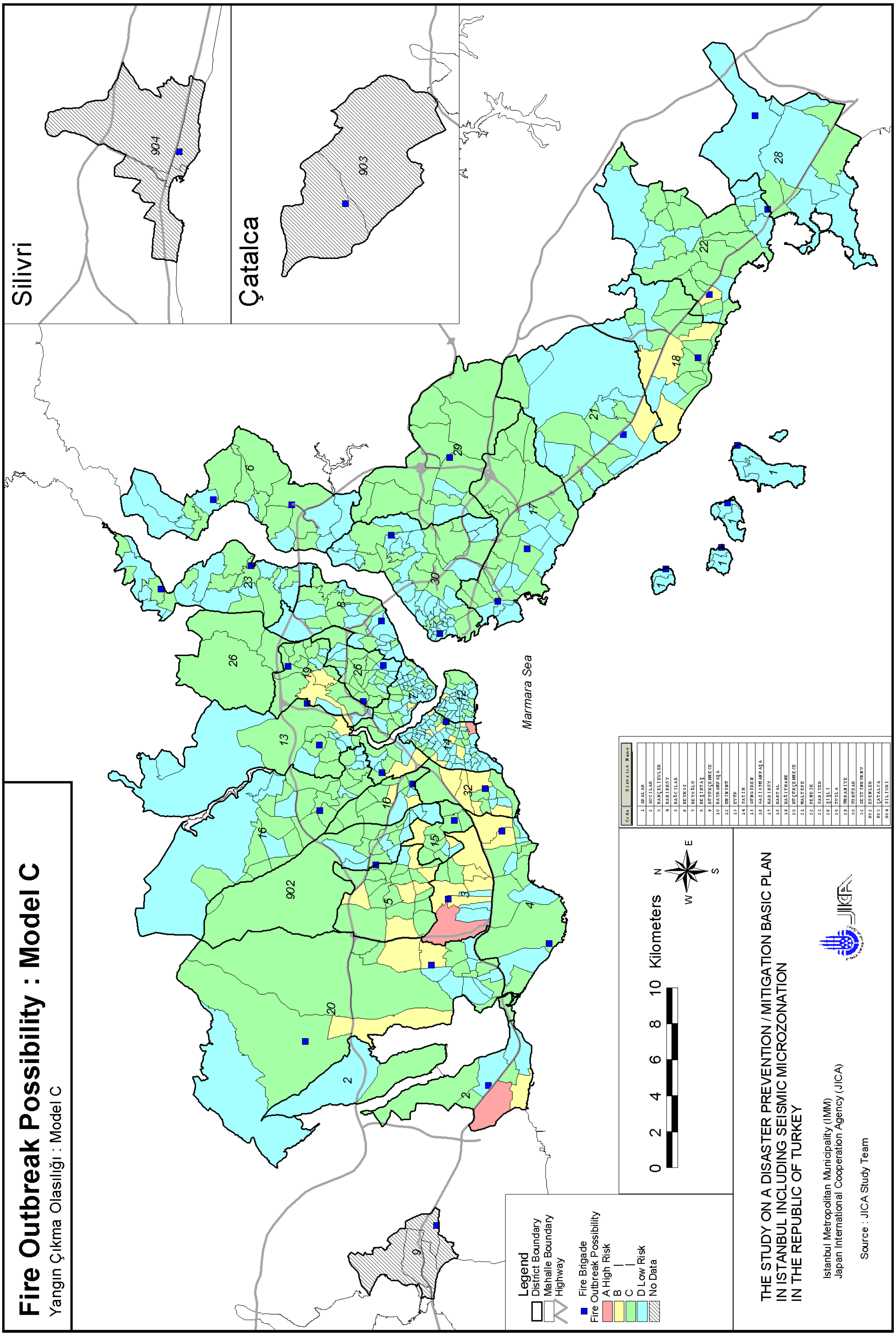


Figure 9.3.4 Fire Outbreak Possiblitiy : Model C

9.3.2. Fire Spread Possibility

If there are many wooden buildings in the area and if the space between buildings is limited, fire can more easily spread from one building to another. There are many wooden buildings in the city of Japan; therefore, the spread of fire in the city is well studied by Japanese researchers.

Figure 9.3.5 shows the result of the numerical simulation on the relation between "burnt area ratio" and the "wooden building coverage area ratio" by the Japanese Ministry of Construction (1982). The definition is as follows:

$$\text{Burnt Area Ratio} = \frac{\text{Burnt Floor Area}}{\text{Total Area}}$$

$$\text{Wooden Building Coverage Area Ratio} = \frac{\text{Wooden Building Coverage Area}}{\text{Total Area}}$$

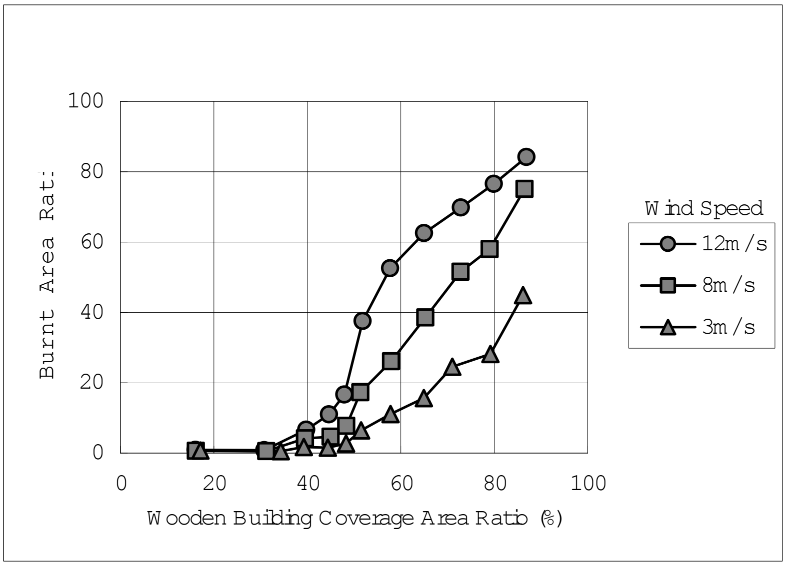


Figure 9.3.5 The Relation between Burnt Area Ratio and Wooden Building Coverage Area Ratio

From this figure, it is concluded that fire will never spread if the wooden building coverage area ratio is under 30%. The wooden building coverage area ratio of each mahalle is shown in

Figure 9.3.6and all the mahalle show a ratio of under 10%. This means no fire spreading is estimated in the study area.

In conclusion, there exists a small possibility of a great fire occuring because most buildings are constructed with concrete and bricks. However, it should be kept in mind that many fires occur immediately after an earthquake and, due to blockage of the roads by debris, much time can pass until a fire-fighting team reaches and can attend to the fire.

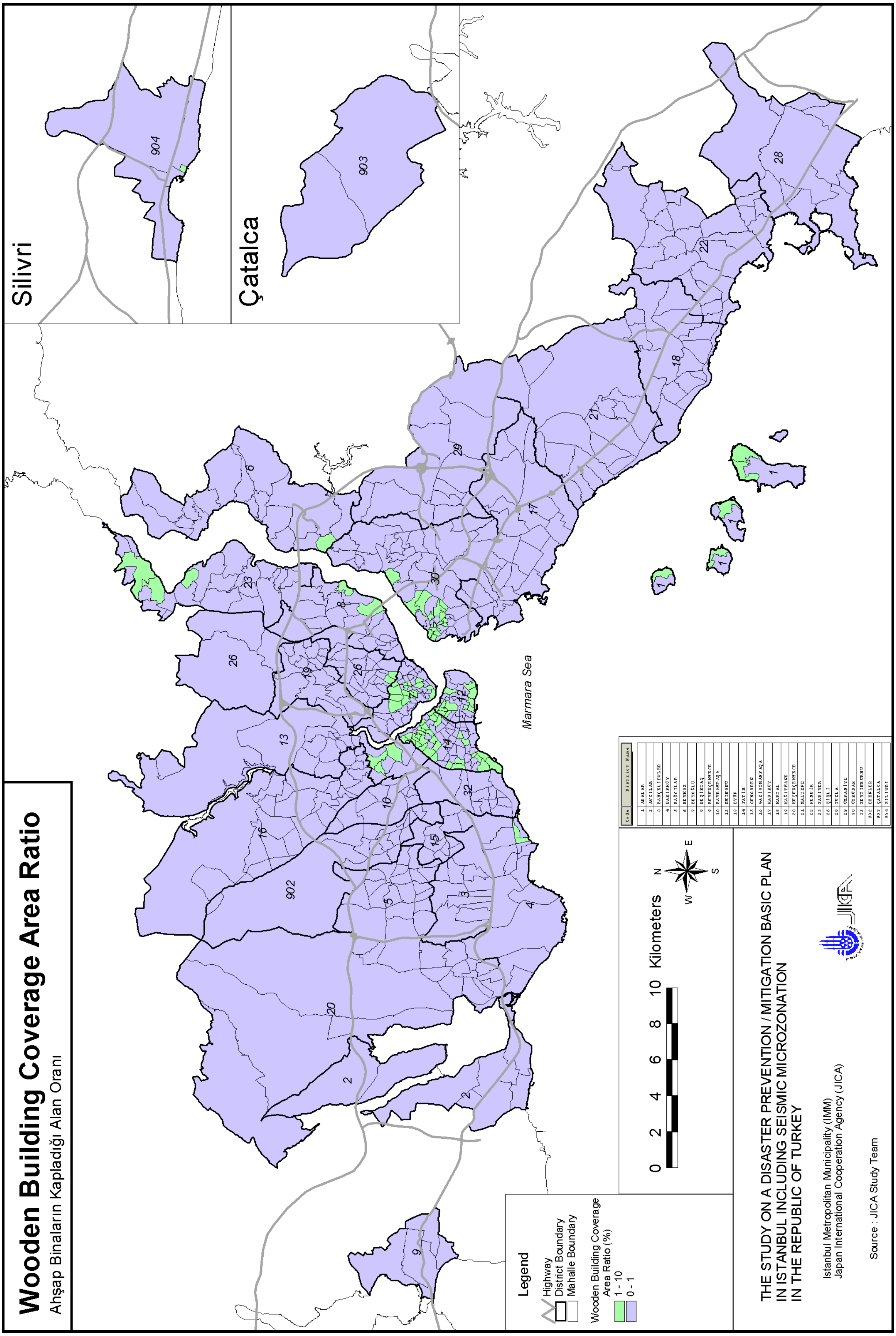


Figure 9.3.6 Wood Building Coverage Area Ratio

References to Section 9.3

Kanagawa Prefecture, 1986, Investigation Study Report on Earthquake Damage Estimation, Fire Outbreak and Hazardous Materials. (in Japanese)

Ministry of Construction, 1982, Report on the Development of Fire Prevention Measures in the City. (in Japanese)

9.4. Lifelines

In a broad sense of the word "lifeline" includes not only the water or electricity supply facilities but also road and transportation systems. In this report, the damage of bridges is described in section 9.5 and transportation facilities are described in section 9.6.

Citizens living in the city who enjoy their modernized and comfortable urban life strongly rely on lifeline facilities. Even if their homes are not severely damaged during an earthquake, it is impossible to live in the house if water and electricity service is cut off. Therefore, the information on seismic damage to lifelines is very important for the preparation of a seismic disaster management plan.

The following 5 types of lifelines are considered in this section:

1) Water Supply Pipeline

2) Sewage Pipeline

3) Gas Pipeline and Service Box

4) Electric Power Supply Cable

5) Telecommunication Cable

Lifeline facilities are to be classified into two major categories, nodes and links. Nodes include facilities such as substations and purification plants. Links include facilities such as pipes or cables for supply and distribution purposes. A statistical approach for damage estimation of links, i.e., distribution pipes and lines, is applied in this study

Damages to node facilities are not estimated in this 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 node facilities.

The 3 districts of Silivri, Çatalca, and Büyükçekmece are not included in the lifeline damage estimation because enough information was not available or not contributed.

9.4.1. Water Supply Pipeline

(1) Damage Estimation Method

Several researchers have proposed a correlation between pipeline damage and seismic parameters such as peak ground acceleration (PGA) or peak ground velocity (PGV). Kubo and Katayama (1975) reported one of the first studies that correlated water supply pipeline damage ratio with PGA from experiences in Japan, USA, and Nicaragua. The damage of water pipes in Kobe city in the 1995 Kobe Earthquake is one of the most well known examples, and the damage distribution and seismic motion in Kobe and the surrounding area are well studied. Isoyama *et al*. (1998) studied the correlation between the damage of pipes and several parameters, such as seismic motion, ground condition, pipe material, etc. They used PGA and PGV as seismic parameters and PGV showed a slightly better correlation based on their analysis. The Japan Waterworks Association (1998) published a report entitled, "Seismic Damage Estimation Procedure for Water Pipes" based on their study.

Toprak (1998) studied the 1994 Northridge Earthquake very precisely. He used PGA, PGV, and several other seismic parameters to evaluate their correlation with the damage ratio. He concluded that PGV showed the best correlation and PGA showed the next best.

Based on these studies, PGV was selected as the seismic parameter used to evaluate the damage of pipes in this study.

Figure 9.4.1 shows the damage function developed by the Japan Waterworks Association (1998) and Toprak (1998) for buried cast iron (CI) water pipes. This figure also shows the damage function that is used in HAZUS99 (FEMA, 1999).

The quantitative studies on seismic damage for pipelines in Turkey are very few. Sarıkaya and Koyuncu (1999) reported the damage of water pipelines in the town of Sapanca due to the Izmit earthquake. According to Sarıkaya and Koyuncu (1999), there were about 90km of water pipelines in Sapanca Town before the earthquake and 400 damage points were reported -- namely, 4.4 damages/km. They also pointed out that the material of almost all of the pipes is asbestos cement. It is well known that asbestos cement piping is fragile compared to CI or PVC piping. It is estimated that the damage ratio of asbestos cement pipes is 1 to 4 times larger than CI pipes in Japan. The earthquake motion in Sapanca Town is not observed unfortunately. Kudo (2001) estimated the seismic motion during the Izmit Earthquake in the city centre of Adapazari to have measured 108 to 127 kine (cm/sec). The seismic motion in Sapanca Town is estimated not to have been very different. The damage ratio in Sapanca Town due to the Izmit earthquake, which is estimated from above mentioned analysis, is shown in Figure 9.4.1. The damage ratio in Sapanca Town is shown to fall between the damage functions by HAZUS99 and Japan Waterworks Association.

The damage function of HAZUS99 estimates a much higher damage ratio than the other damage functions, including that of the Japan Waterworks Association. The damage function of HAZUS99 is based on work by O'Rourke and Ayala (1993). Toprak (1998) pointed out that their work is based on the damages due to the 1985 Michoacan, Mexico Earthquake, which has an extremely long duration; therefore, the damage ratio is high.

The damage function by Toprak (1998) shows a lower value than that of HAZUS99. Toprak broke up Los Angeles City into many isoseismal areas, which were interpolated from strong motion records without considering ground conditions, and only the areas that contained over 150km of pipelines were used in the analysis to reduce the bias of corroded or defected pipes. This may be a reason for the low value. Toprak says in his paper that this approach represents the large system-wide response.

The magnitude of the Kobe Earthquake (M=7.4) is comparable to the magnitudes of the scenario earthquake (M=7.5, 7.7). Isoyama *et al*. (1998) used the damage of pipes within 2km from strong motion stations for analysis. This approach can reflect the contributions of ground conditions to damage more precisely.

From the above considerations, the damage function developed by the Japan Waterworks Association (1998) is selected for use in the damage estimation in this analysis.

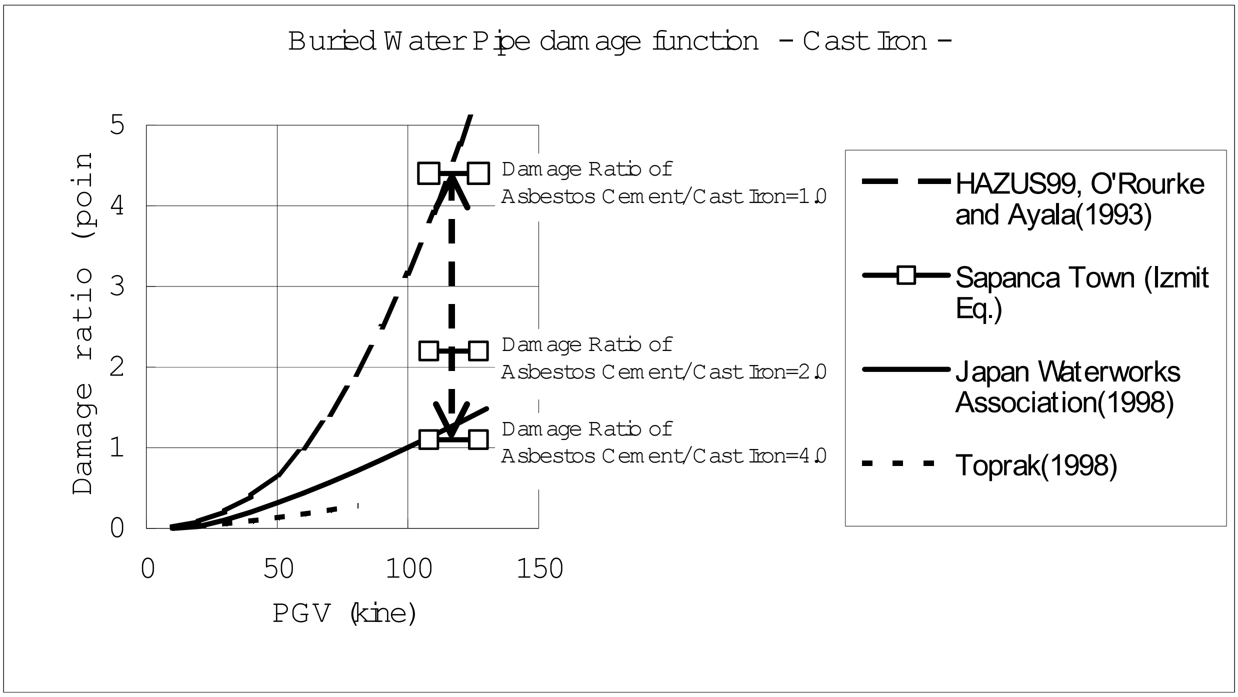


Figure 9.4.1 Relation between Cast Iron Water Pipe Damage Ratio and PGV

The damage function for Istanbul, based on damage functions of the Japan Waterworks Association (1998), is formulated as follows:

Rm(PGV) = R(PGV) x Cp x Cd x Cg x Cl

where

Rm(PGV): damage ratio (points/km)

PGV: Peak Ground Velocity (kine = cm/sec)

$R(PGV) = 3.11 \times 10^{-3} \times (PGV-15)^{1.3}$

Cp: pipeline material coefficient

1.0 for Concrete
0.3 for Steel
0.3 for Ductile Iron
1.0 for Galvanized Iron
0.1 for Polyethylene
0.0 for High Density Polyethylene

Cd: pipeline diameter coefficient

1.6 for less than 90mm
1.0 for 100 to 175mm
0.8 for 200 to 450mm
0.5 for over 500mm

Cg: ground condition coefficient

1.5 for Yd, Sd, Ym
1.0 for Qal, Ksf, Oa, Q
0.4 for others

Cl: liquefaction coefficient

2.0 for Ym, Yd, Sd, Qal, Ksf, Oa, Q
1.0 for others

(2) Estimated Damage

The damage estimation definition is shown in Table 9.4.1.

Table 9.4.1 Definition of Water Pipeline Damage Estimation

Object	Distribution, Service Pipes
Content of Damage	Break of pipes or joints Pull out of joints
Amount of Damage	Number of damage points

The damage in each 500m grid is calculated and shown in

Figure 9.4.2 to

Figure 9.4.3. The damage is added up by district and shown in Table 9.4.2.

About 1,400 and 1,600 points of damage are estimated for Model A and Model C respectively. The damage is concentrated in the pipeline network on the European side. The highest damage ratio was found in Fatih and Güngören.

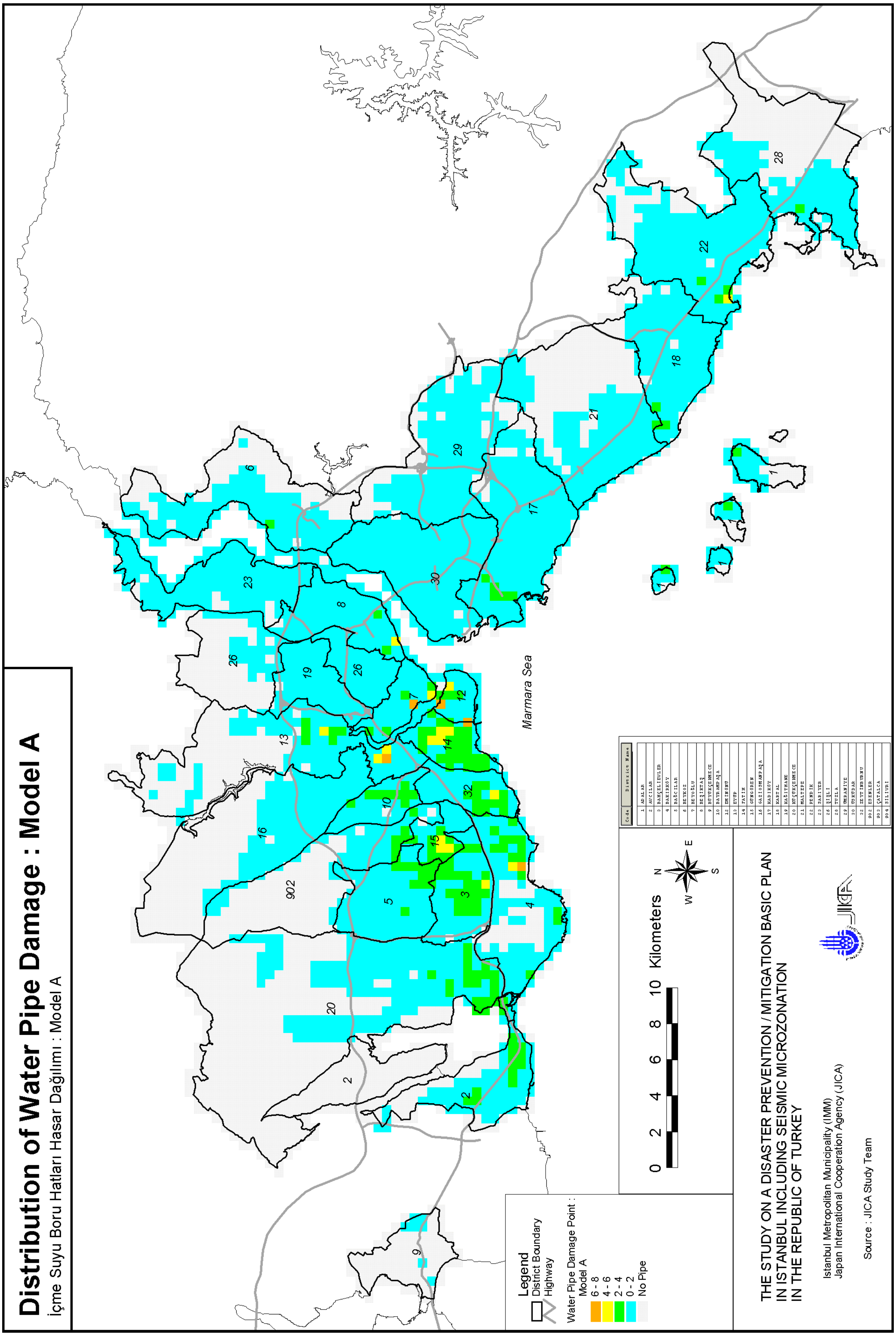


Figure 9.4.2 Distribution of Water Pipe Damage : Model A

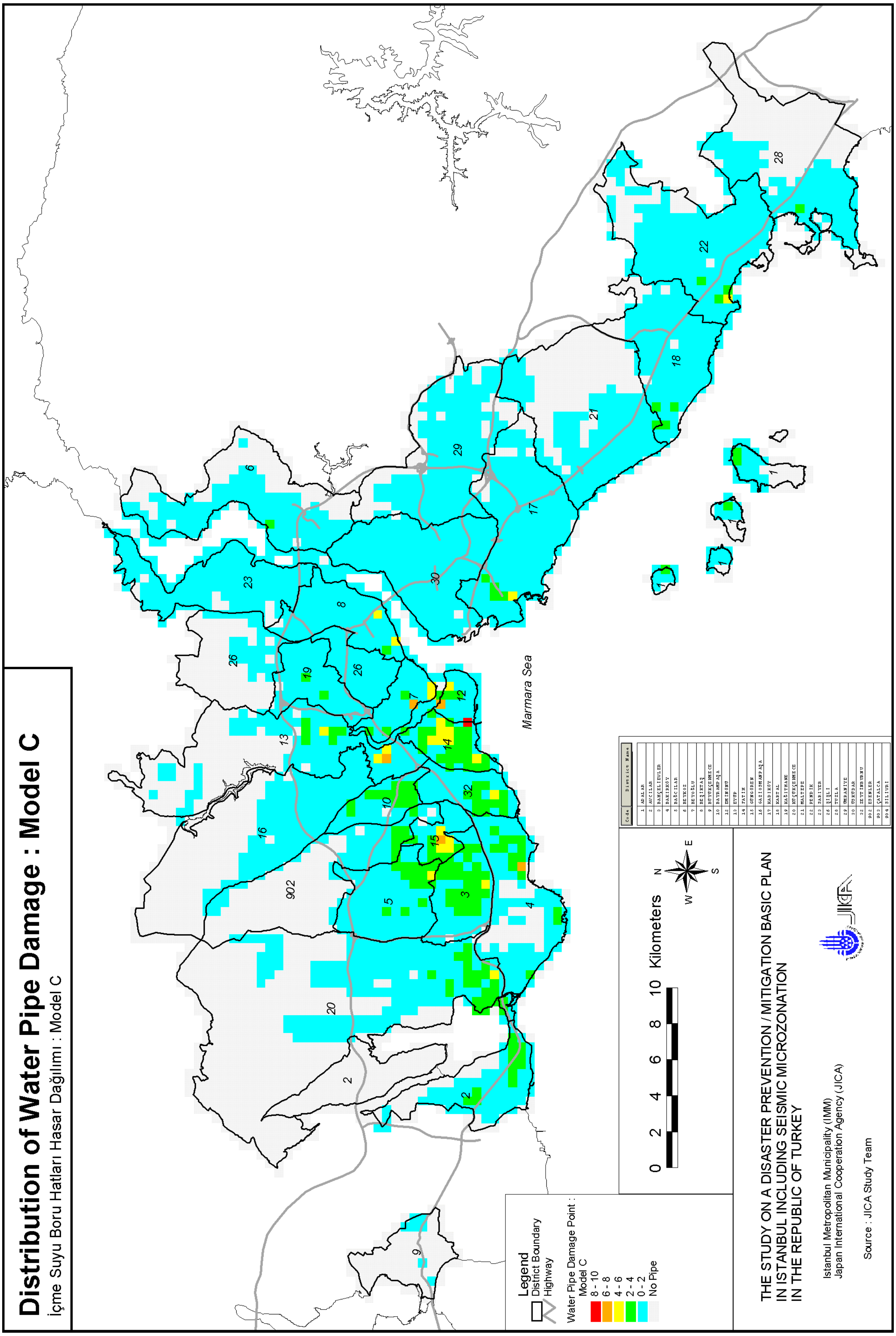


Figure 9.4.3 Distribution of Water Pipe Damage : Model C

Table 9.4.2 Damage to Water Pipeline

ID	District Name	Pipe Length (km)	Damage Points	
			Model A	Model C
1	Adalar	59	20	21
2	Avcı lar	187	65	66
3	Bahçelievler	321	107	115
4	Bakı rköy	207	98	97
5	Bağ cı lar	391	87	98
6	Beykoz	189	16	21
7	Beyoğ lu	220	46	54
8	Beş iktaş	234	24	31
10	Bayrampaş a	207	48	55
12	Eminönü	126	37	41
13	Eyüp	262	60	69
14	Fatih	321	110	122
15	Güngören	169	64	70
16	Gaziosmanpaş a	372	23	30
17	Kadı köy	527	71	85
18	Kartal	394	62	71
19	Kağ ı thane	264	21	27
20	Küçükçekmece	523	130	142
21	Maltepe	352	48	56
22	Pendik	432	59	69
23	Sarı yer	276	13	19
26	Ş iş li	247	15	21
28	Tuzla	138	29	32
29	Ümraniye	293	14	19
30	Üsküdar	471	32	42
32	Zeytinburnu	180	66	70
902	Esenler	205	31	36
Total		7,568	1,395	1,577

9.4.2. Sewage Pipeline

(1) Damage Estimation Method

The evaluation formula for sewage pipelines is the same as that of the water supply pipelines. The following values were used for each factor based on figures that are currently used in Japan.

Cp: pipeline material coefficient

- 0.5 no information is available for the material
  estimated to be Hume Pipe (Concrete)

Cd: pipeline diameter coefficient

- 0.6 no information is available for the diameter
  estimated to be 150 to 500mm

Cg: ground condition coefficient

- 1.5 for Yd, Sd, Ym
- 1.0 for Qal, Ksf, Oa, Q
- 0.4 for others

Cl: liquefaction coefficient

- 2.0 for Ym, Yd, Sd, Qal, Ksf, Oa, Q
- 1.0 for others

(2) Estimated Damage

The damage estimation definition is shown in Table 9.4.3.

Table 9.4.3 Definition of Sewage Pipeline Damage Estimation

Object	All Pipes
Content of Damage	Break of pipes or joints Pull out of joints
Amount of Damage	Number of damage points

The damage in each 500m grid is calculated and shown in

Figure 9.4.4 to

Figure 9.4.5. The damage is added up by district and shown in Table 9.4.4. Several districts are not included in this table because enough information was unavailable.

About 1,200 and 1,300 points of damage are estimated for Model A and Model C respectively. These numbers do not include the damage in several districts, where enough information was unavailable.

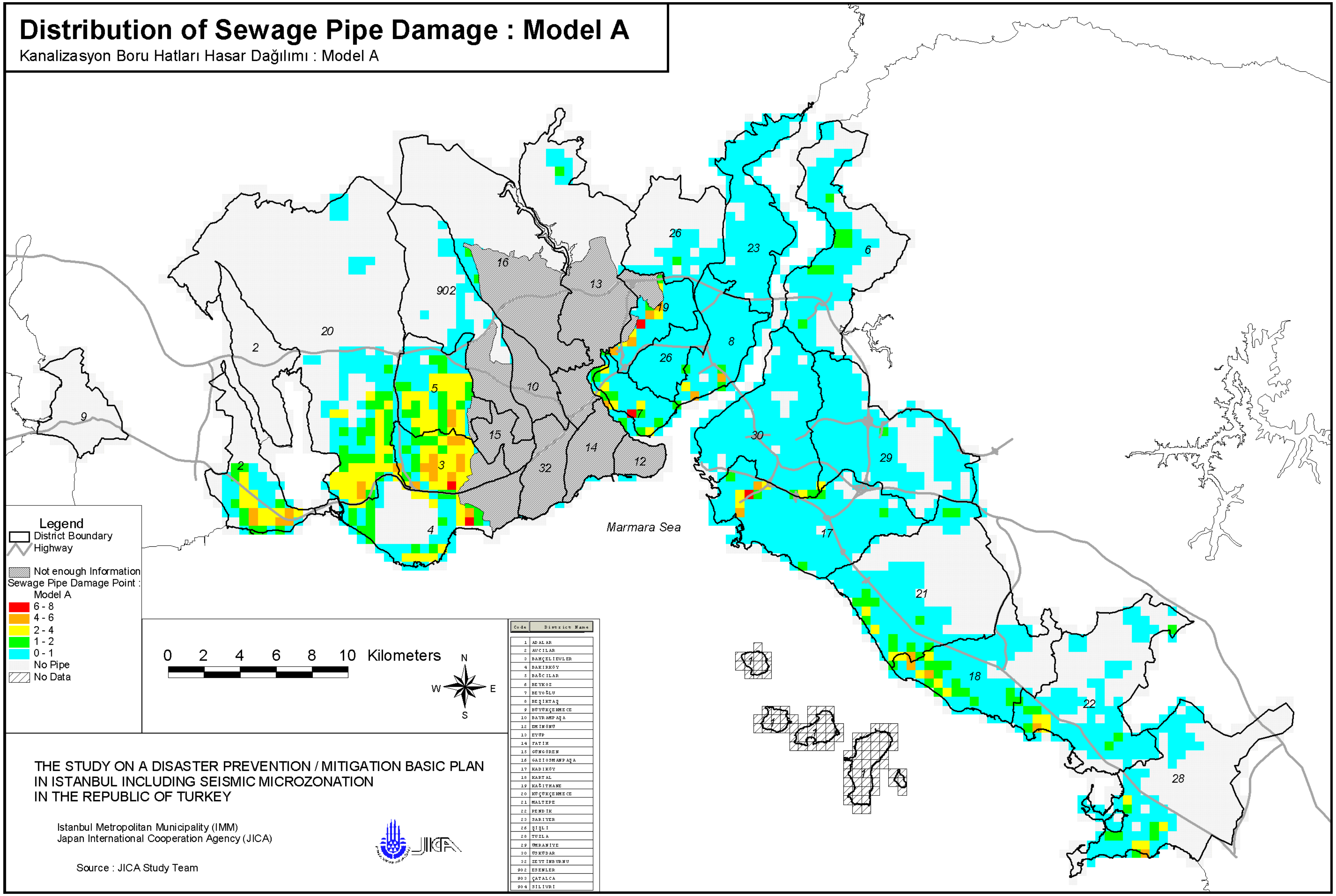


Figure 9.4.4 Distribution of Sewage Pipe Damage : Model A

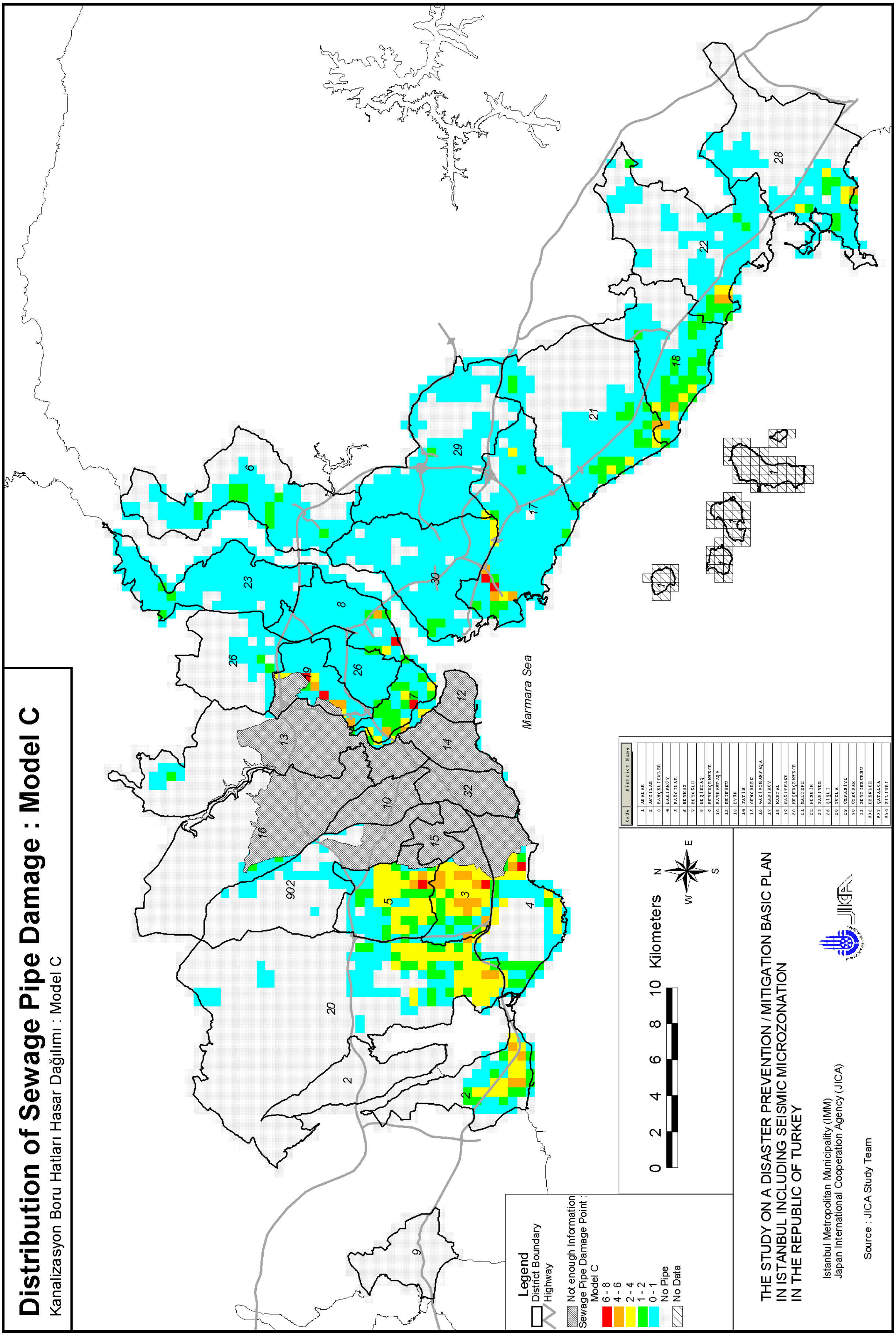


Figure 9.4.5 Distribution of Sewage Pipe Damage : Model C

Table 9.4.4 Damage to Sewage Pipeline

ID	District Name	Pipe Length (km)	Damage Points	
			Model A	Model C
2	Avcı lar	229	85	85
3	Bahçelievler	422	152	162
4	Bakı rköy	183	93	91
5	Bağ cı lar	474	121	136
6	Beykoz	318	20	28
7	Beyoğ lu	271	48	57
8	Beş iktaş	286	28	36
10	Bayrampaş a	Enough information is not available		
12	Eminönü			
13	Eyüp			
14	Fatih			
15	Güngören			
16	Gaziosmanpaş a			
17	Kadı köy	613	87	103
18	Kartal	398	71	81
19	Kağ ı thane	289	57	70
20	Küçükçekmece	525	152	165
21	Maltepe	402	63	73
22	Pendik	245	44	51
23	Sarı yer	307	12	18
26	Ş iş li	261	17	23
28	Tuzla	145	44	47
29	Ümraniye	343	21	28
30	Üsküdar	463	36	46
32	Zeytinburnu	Enough information is not available		
902	Esenler			
Total		6,174	1,152	1,299

9.4.3. Gas Pipeline and Service Box

(1) Damage Estimation Method

a. Pipeline

Figure 9.4.6 shows the damage function - used in the earthquake damage estimation study by the Disaster Prevention Council of the Tokyo Metropolitan Area (1997) for welded steel gas pipes. This damage function was derived from the damage in Kobe City due to the 1995 Kobe Earthquake. Polyethylene pipes are treated as suffering no damage.

The damage of gas pipes due to the Izmit earthquake is reported in some papers. *Tohma et al.* (2001) reported that there was no damage to gas distribution pipelines in the Avcılar area, which has polyethylene pipes, in spite of the heavy building damage. Kudo *et al.* (2002) estimated the PGV in the Avcılar area during the Izmit Earthquake to be about 35 kine.

O'Rourke *et al.* (2000) reported the damage in Izmit city. There were 367km middle density polyethylene (MDPE) pipes and 38km steel pipes in Izmit City and no damage was found. There is a strong motion seismometer in Izmit and the record shows 40 kine in PGV, but the station is located at a stiff rock site, so the PGV in the city area might have been higher.

Based on the damage function by Disaster Prevention Council of the Tokyo Metropolitan Area (1997), the damage to the pipeline in Izmit is estimated to be 0.14 points for steel pipes. This corresponds to the result of "no damage" in Izmit. If steel pipes experience one break in Izmit, the damage ratio becomes 0.026 point/km. Therefore "no damage" should be interpreted between 0.0 and 0.026 points/km from a statistical point of view.

From the above consideration, the damage function by the Disaster Prevention Council of the Tokyo Metropolitan Area (1997) is selected for use in the damage estimation in this analysis.

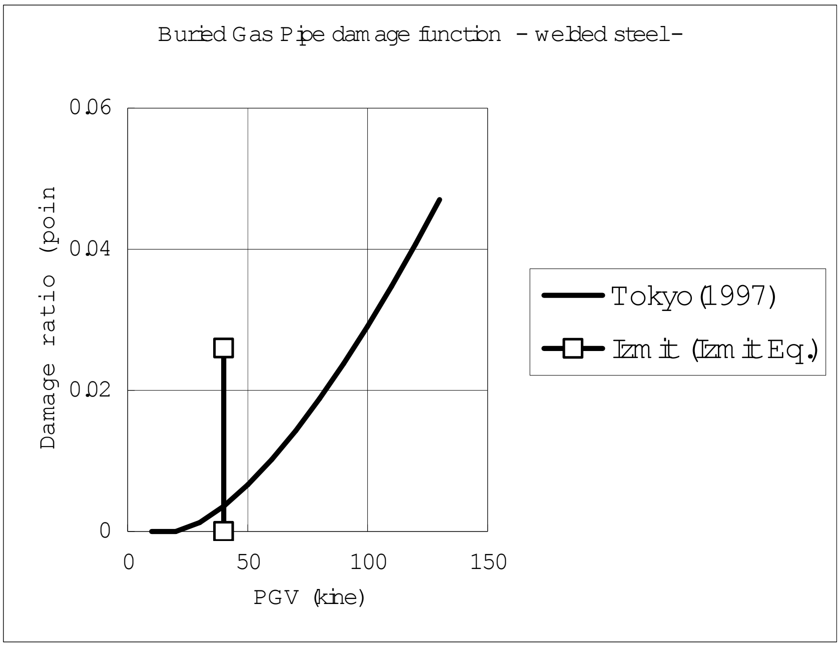


Figure 9.4.6 Relation between Damage Ratio of Welded Steel Gas Pipe and PGV

The damage function for Istanbul, based on Disaster Prevention Council of the Tokyo Metropolitan Area (1997), is formulated as follows:

Rm(PGV) = R(PGV) x Cp x Cg x Cl

where

Rm(PGV): damage ratio (points/km)

PGV: Peak Ground Velocity (kine = cm/sec)

R(PGV) = $3.11 \times 10^{-3} \times (PGV-15)^{1.3}$

Cp: pipeline material coefficient

0.01 for Steel

0.00 for Polyethylene

Cg: ground condition coefficient

1.5 for Yd, Sd, Ym

1.0 for Qal, Ksf, Oa, Q

0.4 for others

Cl: liquefaction coefficient

2.0 for Ym, Yd, Sd, Qal, Ksf, Oa, Q

1.0 for others

b. Service Box

The SIS census data has information on natural gas installations. In total, about 186,000 buildings (= 25.6%) have natural gas systems installed.

The gas service box is installed on the ground floor of the buildings or on the outer wall. If the building will collapse, the gas box will be damaged. Even if the gas pipeline is not damaged, gas leakage can occur from the service box, which may cause an explosion. In this study, it is assumed that all of the service boxes in heavily damaged buildings and half of those in moderately damaged buildings will be damaged. The following considerations support this assumption:

According to O'Rourke *et al.* (2000), there were 26,000 gas users in the city of Izmit before the Izmit Earthquake, and 860 service boxes were damaged. The mean number of housing units in one building in Izmit is assumed to be the same as in Istanbul-- namely, 4.2 housing units/building. Therefore, it is assumed that about 6,190 buildings have service boxes in them. Building damage estimates for Izmit are not available; therefore, the damage ratio in Izmit is assumed to be half of that of Gölcük and Değırmendere. Kabeyasawa *et al*. (2001) reported 16% of buildings heavily damaged and 18% of buildings moderately damaged in these areas. According to these assumptions, it is estimated that 774 gas boxes were damaged in Izmit.

(2) Estimated Damage

The damage estimation definition is shown in Table 9.4.5.

Table 9.4.5 Definition of Gas Pipeline Damage Estimation

Object	Distribution, Service Pipes	Service Box
Content of Damage	Break of pipes or joints Pull out of joints	Break of Box
Amount of Damage	Number of damage points	Number of damage points

The damage in each 500m grid is calculated and shown in

Figure 9.4.7 to

Figure 9.4.10. The damage is added up by district and shown in Table 9.4.6.

The damage of the gas pipeline system is slight. The main reason is that the gas pipeline in Istanbul wasrecently installed and IGDAŞ used polyethylene pipes, which have high flexibility and earthquake-resisting capacity, in accordance with the experience in past earthquake damage. However, the damage to service boxes amounts to over 25,000 because of the poor building structures.

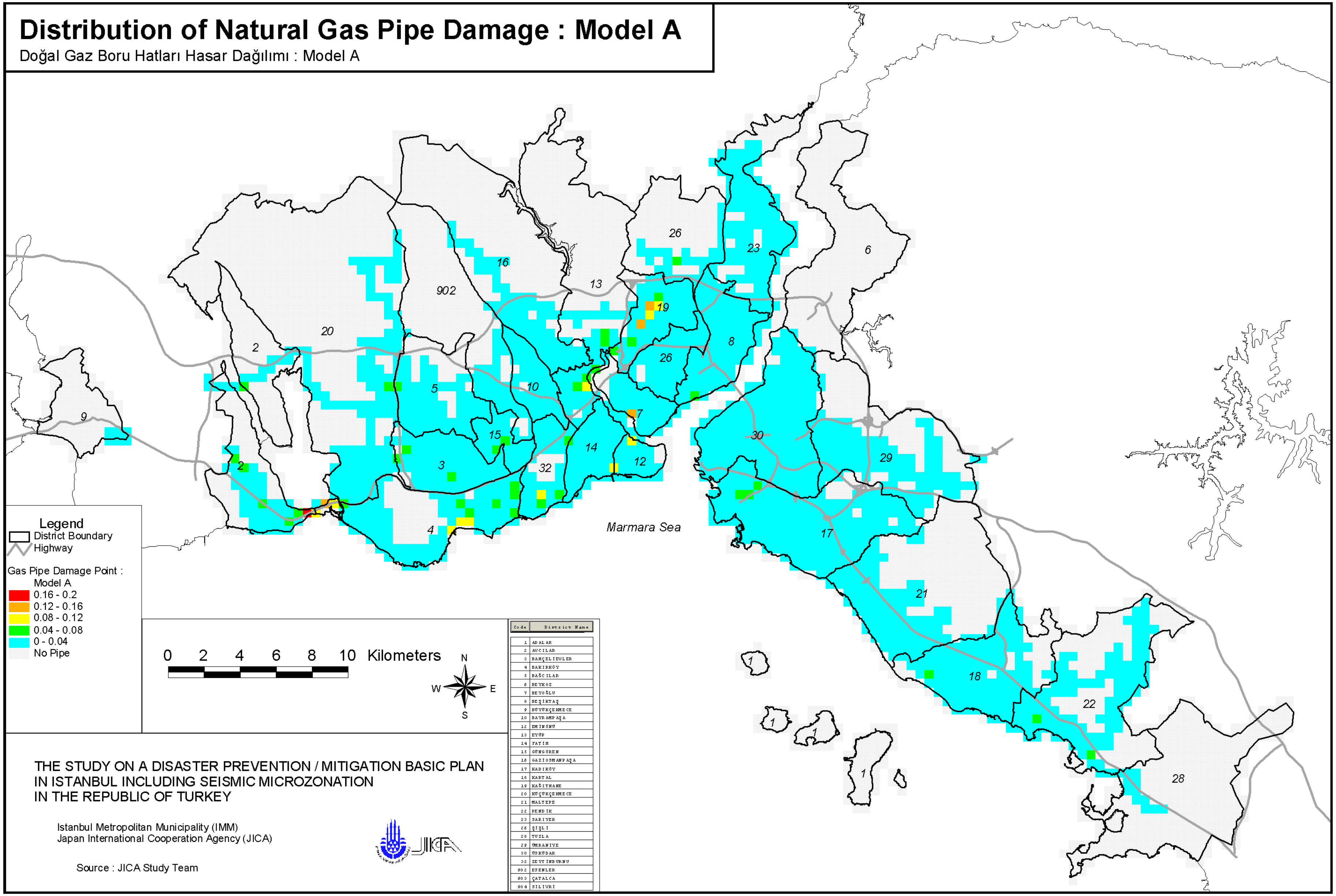


Figure 9.4.7 Distribution of Natural Gas Pipe Damage : Model A

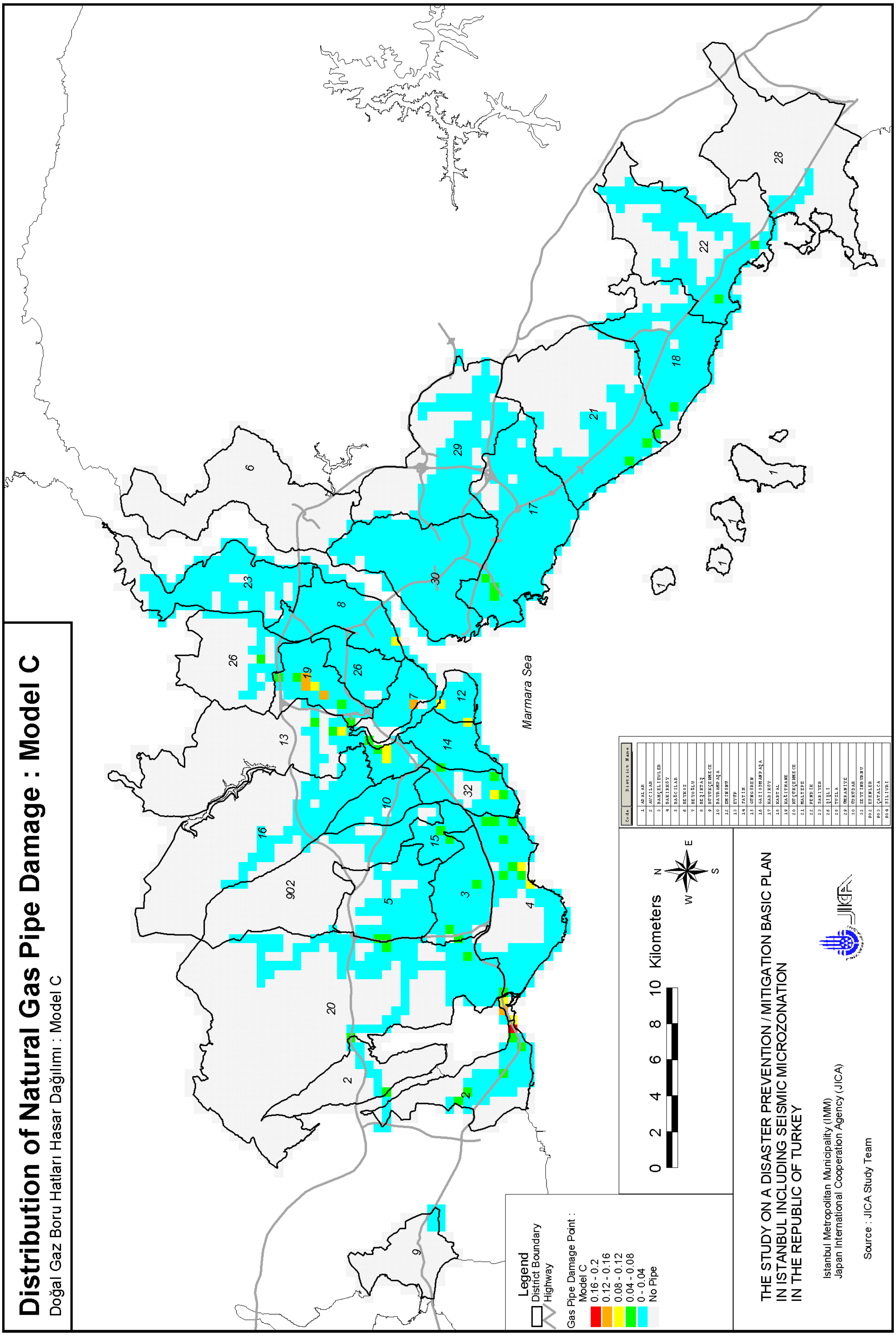


Figure 9.4.8 Distribution of Natural Gas Pipe Damage : Model C

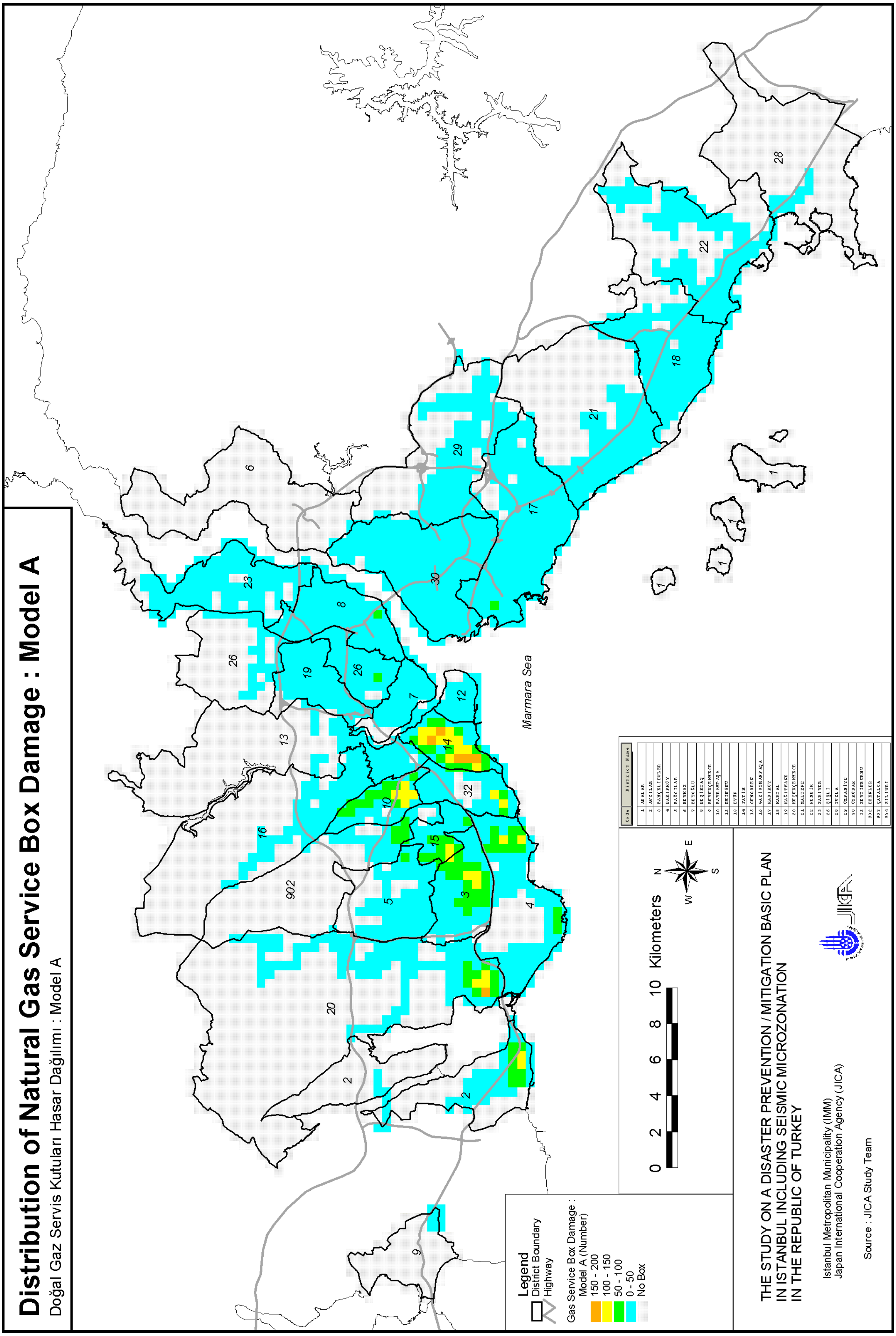


Figure 9.4.9 Distribution of Gas Service Box Damage : Model A

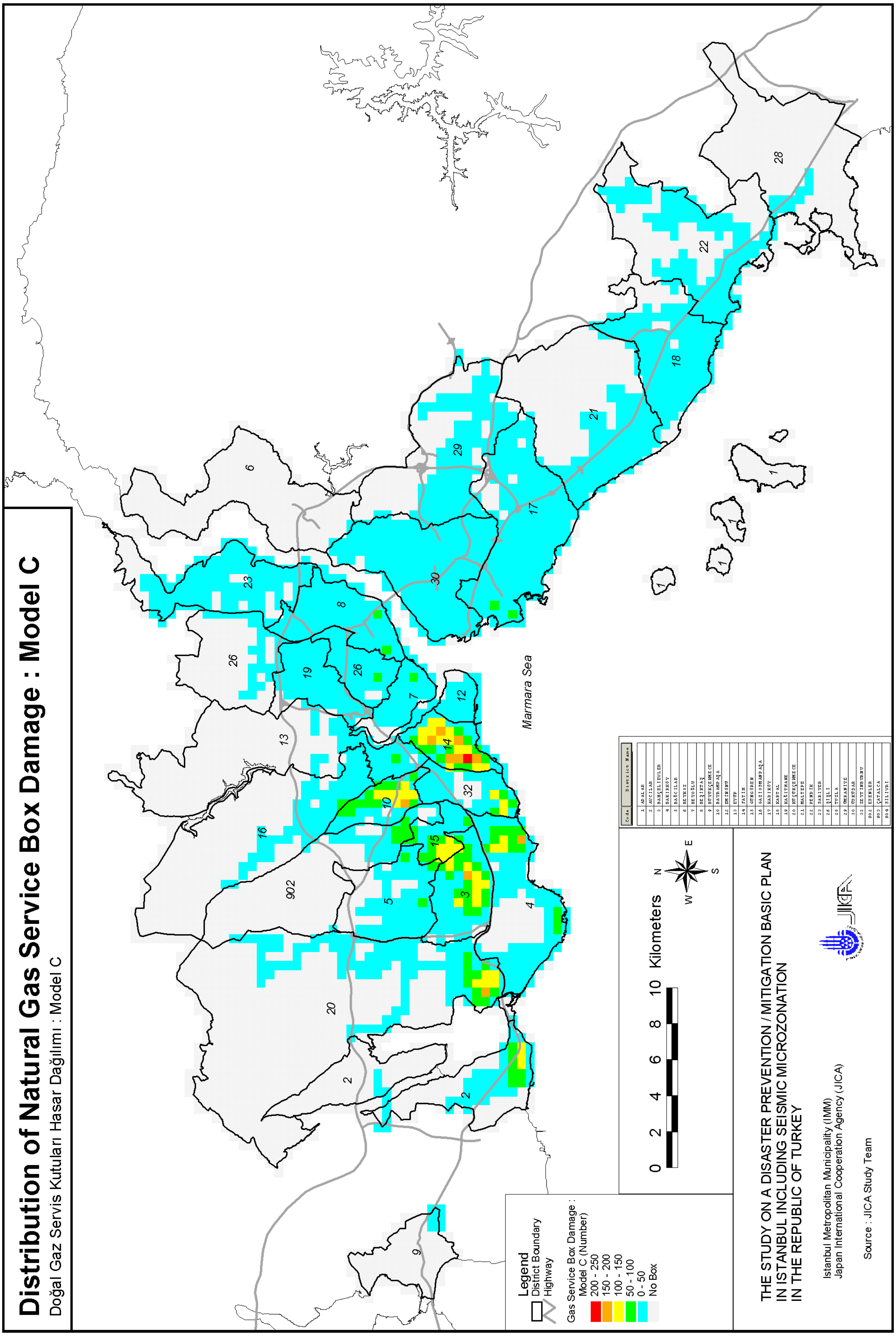


Figure 9.4.10 Distribution of Gas Service Box Damage : Model C

Table 9.4.6 Damage to Gas Pipeline and Service Box

ID	District Name	Pipe Length (km)	Damage Points		Service Box number	Damaged Box			
			Model A	Model C		Model A		Model C	
2	Avcı lar	119	1	1	4,263	1,254	29%	1,426	33%
3	Bahçelievler	240	1	1	11,305	2,457	22%	2,866	25%
4	Bakı rköy	194	1	1	7,978	2,208	28%	2,490	31%
5	Bağ cı lar	171	1	1	4,841	679	14%	807	17%
7	Beyoğ lu	101	0	0	3,776	449	12%	510	14%
8	Beş iktaş	217	0	0	9,290	551	6%	656	7%
10	Bayrampaş a	163	0	0	11,866	1,981	17%	2,246	19%
12	Eminönü	39	0	0	511	90	18%	100	20%
13	Eyüp	86	1	1	3,167	456	14%	498	16%
14	Fatih	214	1	1	15,243	3,620	24%	4,033	26%
15	Güngören	150	0	0	7,211	1,374	19%	1,653	23%
16	Gaziosmanpaş a	182	0	0	7,886	544	7%	631	8%
17	Kadı köy	462	1	1	17,963	1,532	9%	1,868	10%
18	Kartal	295	0	1	7,959	1,145	14%	1,272	16%
19	Kağ ı thane	111	1	1	1,924	114	6%	133	7%
20	Küçükçekmece	252	1	1	8,260	1,811	22%	2,023	24%
21	Maltepe	251	0	1	8,038	944	12%	1,096	14%
22	Pendik	186	1	1	3,940	649	16%	725	18%
23	Sarı yer	171	0	0	6,281	130	2%	151	2%
26	Ş iş li	173	0	0	8,088	466	6%	574	7%
28	Tuzla	5	0	0	146	26	18%	28	19%
29	Ümraniye	207	0	0	6,576	275	4%	330	5%
30	Üsküdar	520	0	0	22,726	1,121	5%	1,325	6%
32	Zeytinburnu	88	1	1	2,146	620	29%	700	33%
902	Esenler	75	0	0	3,572	491	14%	589	16%
Total		4,670	11	13	184,956	24,985	14%	28,729	16%

9.4.4. Electric Power Supply Cables

For high voltage electricity supply lines, hard copy maps of the network have been converted to GIS data, However, for the middle and low voltage line networks, only a statistical table, which was prepared by their distribution company, is available. The length of cable in each 500m grid cell is estimated based on the building distribution map on a 1/1,000 scale.

(1) Damage Estimation Method

O'Rourke *et al*. (2000) reported on the damage to electricity distribution systems due to the Izmit Earthquake. They pointed out that the physical damage to generation, transmission, and distribution equipment was consistent with the experiences in past earthquakes in California, Japan, and elsewhere. Some observations include the following:

- Generation plants are usually resistant to significant damage in earthquakes, provided their foundations do not undergo large deformations.
- Transmission towers and cables are highly resistant to earthquake damage, even when displaced by surface fault rupture.
- Underground cables are prone to damage where they connect to surface electrical supplies or buildings and due to subsequent degradation in cable insulation due to physical or electrical effects.

They provide statistics of damage length and pre-earthquake total length of cables and other facilities for the five primary provinces. The damage ratio of overhead and underground cables are shown in Figure 9.4.11 and Figure 9.4.12. The seismic intensity of each province is read from the isoseismal map by ERD and converted to PGA using Trifunac and Brady (1975).

The damage of overhead cables in Erzincan due to 1992 Erzincan Earthquake is also plotted in Figure 9.4.11 and Figure 9.4.12. Kawakami *et al.* (1993) reported that 4.0 km of 50 km overhead cable and 1.8 km of 32 km underground cable needed repair. One strong motion seismometer was installed in Erzincan and recorded a PGA equal to 480gal.

In the 1995 Kobe Earthquake, no electricity poles were damaged in areas of seismic intensity (MMI) less than 8, while 0.55% of poles and 0.3% of underground cables were damaged in areas of seismic intensity (MMI) 9 and over. This damage and the damage function in ATC-13 and HAZUS99 are also shown in Figure 9.4.11 and Figure 9.4.12.

For overhead cables, the damage in Turkey does not show differ greatly from that in the USA except for the damage in Yalova. On the contrary, the damage to underground cables due to the Izmit Earthquake shows a much higher damage ratio than HAZUS99. If the underground cable is properly laid, namely in pipes or conduits, the damage ratio is usually less than that of overhead cable, as seen in the case of Kobe. O'Rourke *et al.* (2000) said that direct-buried cables are used primarily in urban areas in Turkey, and they were damaged by ground failure, foundation failure of buildings, and from being pulled during post-earthquake building rescue and demolition activities. Therefore, the underground cable damage due to the Izmit Earthquake in Figure 9.4.12 includes post-earthquake damage.

Based on the damage observed in Turkey and existing damage functions, a new damage function for overhead cables is proposed, shown in Figure 9.4.11, and is used for the damage analysis. For underground cable damage, the damage function of HAZUS99 is used based on the damage in Erzincan. High voltage transmission lines are assumed to suffer no damage based on the past earthquake experiences.

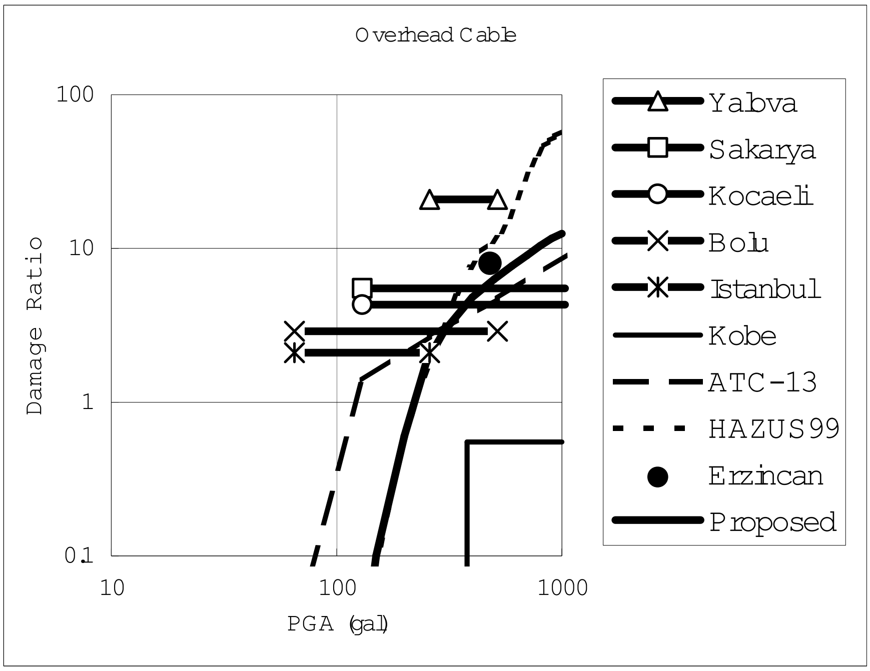


Figure 9.4.11 Relation between Damage Ratio of Overhead Electricity Cable and PGA

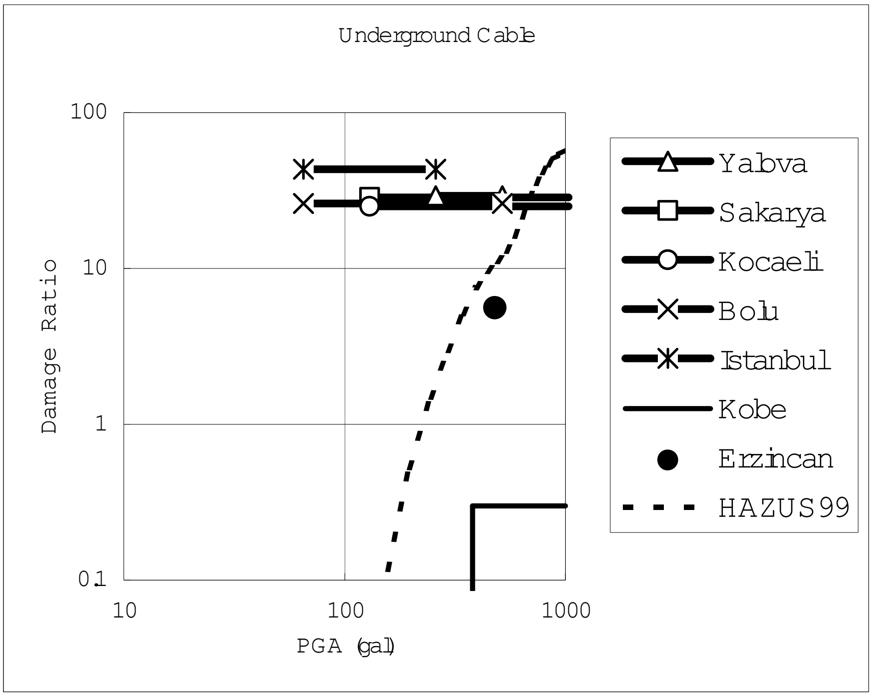


Figure 9.4.12 Relation between Damage Ratio of Underground Electricity Cable and PGA

(2) Estimated Damage

The damage estimation definition is shown in Table 9.4.7.

Table 9.4.7 Definition of Electricity Cable Damage Estimation

Object	Distribution line (Low and Middle Voltage)
Content of Damage	Cut of cables
Amount of Damage	Length of cables to be replaced

The damage in each 500m grid cell is calculated and shown in

Figure 9.4.13 to

Figure 9.4.14. The damage is added up by district and shown in

Table 9.4.8.

About 800 and 1,100 km of damage are estimated for Model A and Model C respectively. The damage is concentrated on the European side. The most severe damage is found in Zeitinburnu, Güngören, and Bahçelievler.

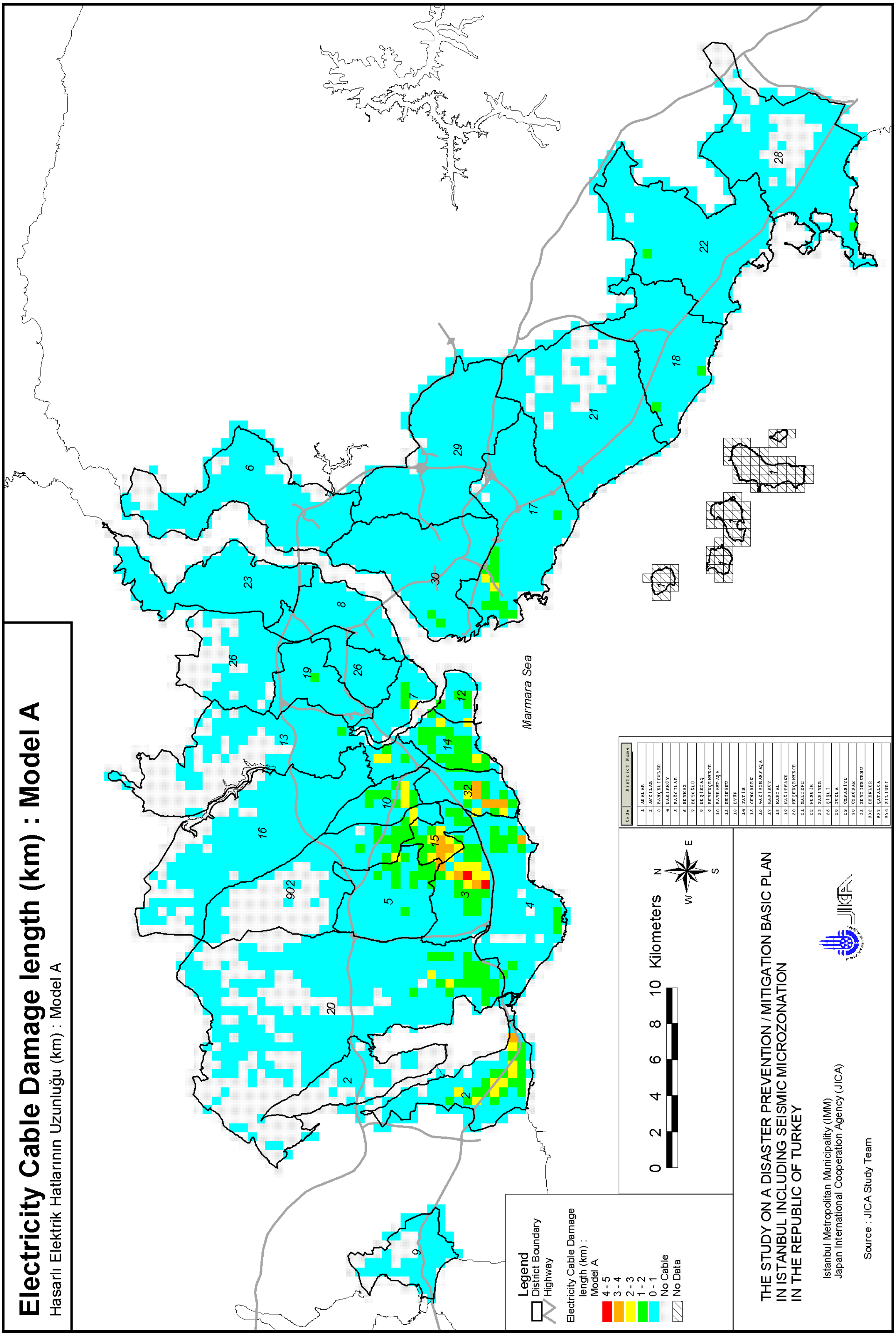


Figure 9.4.13 Electricity Cable Damage Length (km) : Model A

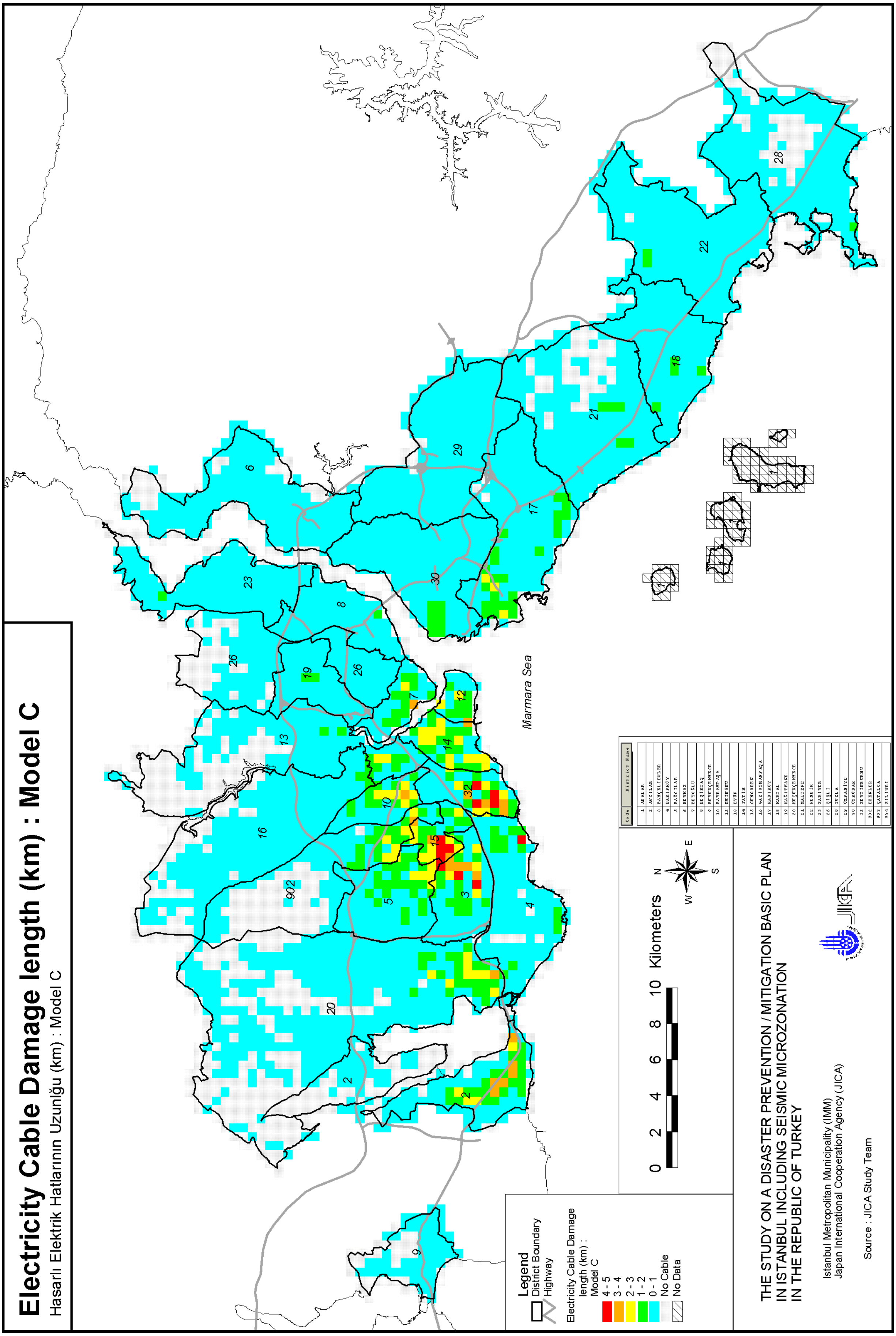


Figure 9.4.14 Electricity Cable Damage Length (km) : Model C

Table 9.4.8 Damage to Electricity Cable

ID	District Name	Cable Length: Over head (km)	Cable Length: Under ground (km)	Cable Length: Total (km)	Damaged Cable, Model A, Overhead: Length (km)	Model A, Overhead: (%)	Model A, Underground: Length (km)	Model A, Underground: (%)	Model A, Total: Length (km)	Model A, Total: (%)	Damaged Cable, Model C, Overhead: Length (km)	Model C, Overhead: (%)	Model C, Underground: Length (km)	Model C, Underground: (%)	Model C, Total: Length (km)	Model C, Total: (%)
[illegible]	Adalar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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9.4.5. Telecommunication Cables

With regards to telecommunication cables, only GIS data on the main fiber optic cable system is available. Other data on trunk and branch copper cable could not be collected, not even their total length in the Study Area.

Generally, the fragility of fiber optic cable in earthquakes is not well known. Quantitative damage statistics based on past earthquakes are indispensable in developing the fragility function for the damage estimation, but experience with damage to fiber optic cable is scarce not only in Turkey but also in other countries. The only available information in Turkey is the damage at the fault crossing to the east of Izmit during the Izmit Earthquake (Erdik, Online).

Therefore, it is impossible to estimate the damage of fiber optic cable quantitatively, but it can be pointed out that it is more vulnerable if the earthquake motion is larger or if liquefaction will occur.

Figure 9.4.15 shows the location of fiber optic cable with PGA distribution for Model C and the liquefaction potential area. The relatively vulnerable section can be seen in this map. In Figure 9.4.16 and Figure 9.4.17, the cable length distribution by PGA rank and liquefaction potential is shown.

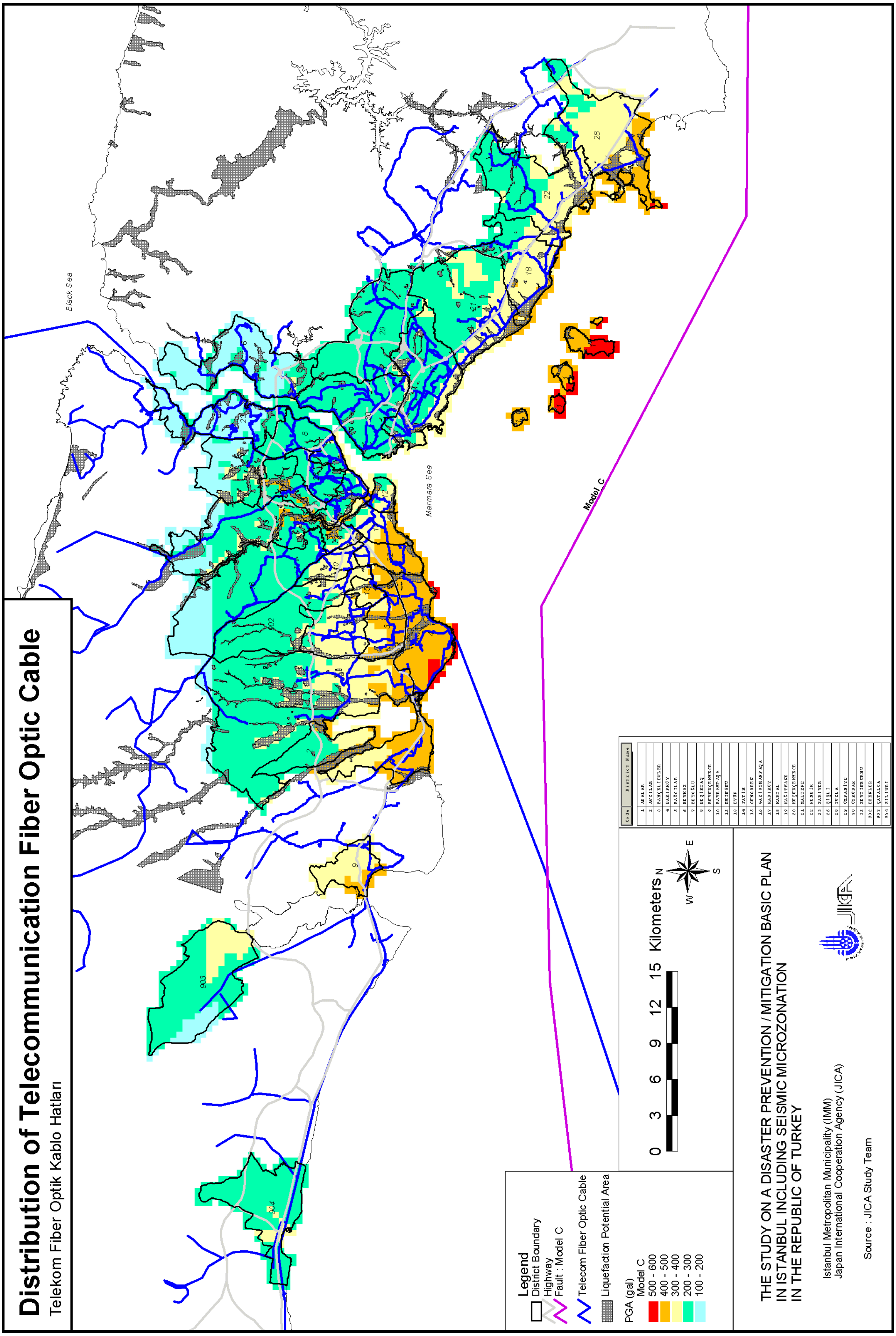


Figure 9.4.15 Distribution of Telecommunication Fiber Optic Cable

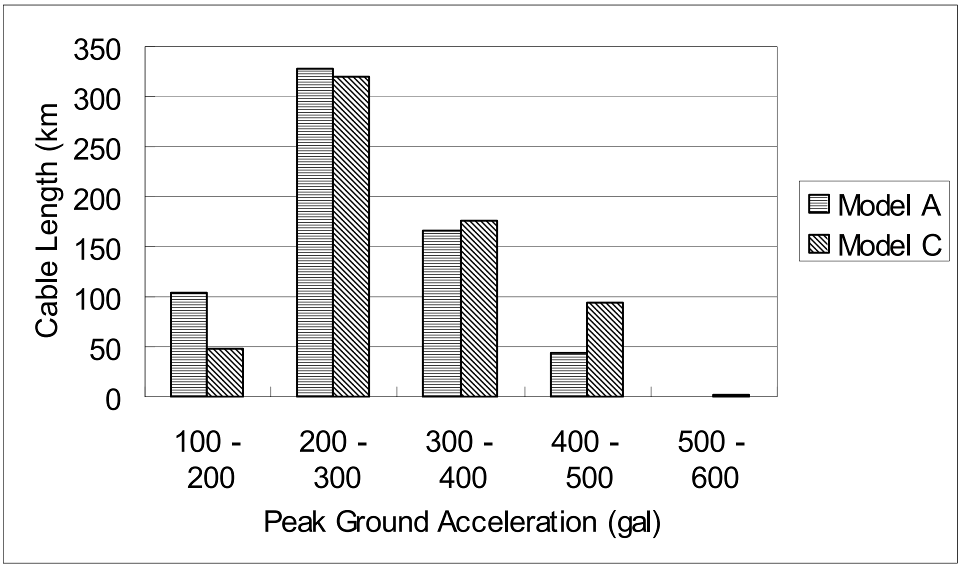


Figure 9.4.16 Summary of PGA along Fiber Optic Cable

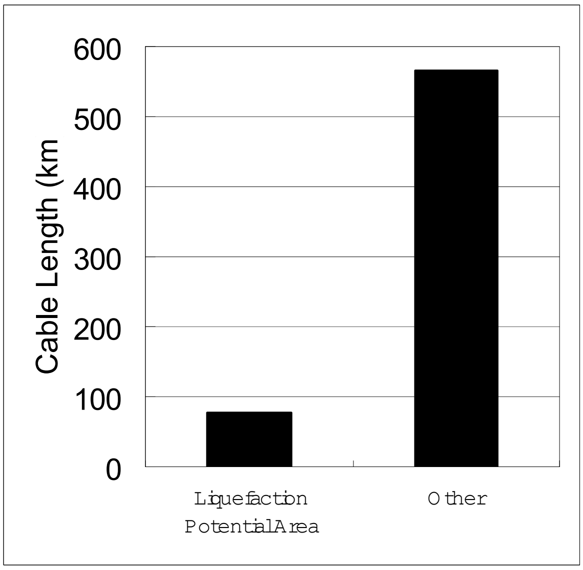


Figure 9.4.17 Summary of Liquefaction Potential area along Fiber Optic Cable

References to Section 9.4

Disaster Prevention Council of the Tokyo Metropolitan Area, 1997, Report on the Damage Estimation in Tokyo by the Earthquake Right Under the Area. (in Japanese)

Erdik, M., Online, Report on 1999 Kocaeli and Düzce (Turkey) Earthquake, http://www/koeri.boun.edu.tr/depremmuh/kocaeloreport.pdf.

FEMA, 1999, Earthquake Loss Estimation Methodology, HAZUS99 Technical Manual, National Institute of Building Science, Washington, D. C.

Isoyama, R. E. Ishida, K. Yune and T. Sirozu, 1998, Seismic Damage Estimation Procedure for Water Pipes, Proceedings of 10th Japan Earthquake Engineering Symposium. (in Japanese with English abstract)

Japan Waterworks Association, 1998, Seismic Damage Estimation Procedure for Water Pipes. (in Japanese)

Kabeyasawa, T., K. Kusu and S. Kono edited, 2001, Inventory Survey in Golcuk and Degirmendere, Report on the Damage Investigation of the 1999 Kocaeli Earthquake in Turkey, Architectural Institute of Japan, Japan Society of Civil Engineers and The Japan Geotechnical Society, pp. 200-251.

Kawakami, H., S. Morichi and M. Yoshimine, 1993, Damage to Civil Engineering Structures, Damage Report on 1992 Erzincan Earthquake, Turkey, Joinr Reconnaissance Team of Architectural Institute of Japan, Japan Society of Civil Engineers and Bogazici University, Istanbul, Turkey.

Kubo, K. and T. Katayama, 1975, Chap.7 Damage Estimation of Underground Water Supply Pipeline, Investigation Study Report on the Earthquake Disaster Prevention of Kawasaki City. (in Japanese)

Kudo, K., T. Kanno, H. Okada, O. Özel, M. Erdik, T. Sasatani, S. Higashi, M. Takahashi and K. Yoshida, 2002, Site Specific Issues for Strong Ground Motions during the Kocaeli, Turkey Earthquake of August 17, 1999, as Inferred from Array Observations of Microtremors and Aftershocks, Bull. Seism. Soc. Am., Vol. 92, No. 1.

O'Rourke, M. J. and G. Alaya, 1993, Pipeline Damage Due to Wave Propagation, Journal of Geotechnical Engineering, Vol. 119, No. 9, pp.1490-1498.

O'Rourke, T. D., F. H. Erdogan, W. U. Savage, L. V. Lund and A. T. Manager, 2000, Water, Gas, Electric Power, and Telecommunications Performance, Earthquake Spectra, Supplement A to Vol.16, 1999 Kocaeli, Turkey, Earthquake Reconnaissance Report, pp. 377-402.

Sarıkaya, H. Z., and I. Koyuncu, 1999, Evaluation of the Effects of Kocaeli Earthquake on Water and Wastewater Systems, Proceedings of ITU-IAHS International Conference on the Kocaeli Earthquake 17 August 1999, December 2-5, 1999, ITU.

Tohma, J., R. Isoyama, S. Tanaka and M. Miyajima, 2001, Damage to Lifelines, Report on the Damage Investigation of the 1999 Kocaeli Earthquake in Turkey, Architectural Institute of Japan, Japan Society of Civil Engineers and The Japan Geotechnical Society, pp. 194-199.

Toprak, S., 1998, Earthquake Effects on Buried Lifeline Systems, Doctoral Dissertation Presented to Cornel University.

Trifunac, M. D. and A. G. Brady, 1975, On the correlation of seismic intensity scales with the peaks of recorded strong ground motion, Bull. Seism. Soc. Am., Vol. 65, No. 1.

9.5. Bridge

9.5.1. Present aspect of bridge design and construction

(1) Earthquake resistant code

In Turkey, the latest earthquake resistant design code is "*Specification for Structures to be Built in Disaster Areas (PART III - EARTHQUAKE DISASTER PREVENTION)*" that is established by Ministry of Public Works and Settlement Government of Republic of Turkey in 1997.

However, this code defines only the inertia force for structures other than building type. There is no specific design code for bridge structure.

Foreign design code is made reference to, because there are many necessary rules for designing bridge in practice as shown in Table 9.5.1.

Table 9.5.1 Applied specification

Location of Bridges	Construction Year	Specifications used in Project
bridges on 1st highway (E5)	between 1973-1987	Technical Specifications for Bridges French Spec.
bridges on 2nd highway (TEM)	after 1987	AASHTO

(2) Earthquake resistance of existing briges

Failure of bridge structure can give an extensive malfunction even though each failure is limited to particular point in line of road system. Contribution of road system in reconstruction term of the city is very large, when the bridges are safe, but if some of the bridges of road are destructed, repairing of bridge need very long term. This is the reason why the destruction of the bridges should be prevented as much as possible.

Purpose of this section is to point out specific bridges that should be noticed in order to mitigate malfunction. This is so called "First screening".

Considering that, the falling-off of the girder can give the most serious effect to the road system. Therefore, a methodology that is proposed by Kubo/Katayama (hereafter reffered to as Katayama's method) is selected in this study because that methodology is very effective for evaluate the bridges on the view point of falling-off of the girder. Schema of this evaluation system is shown in Figure 9.5.1.

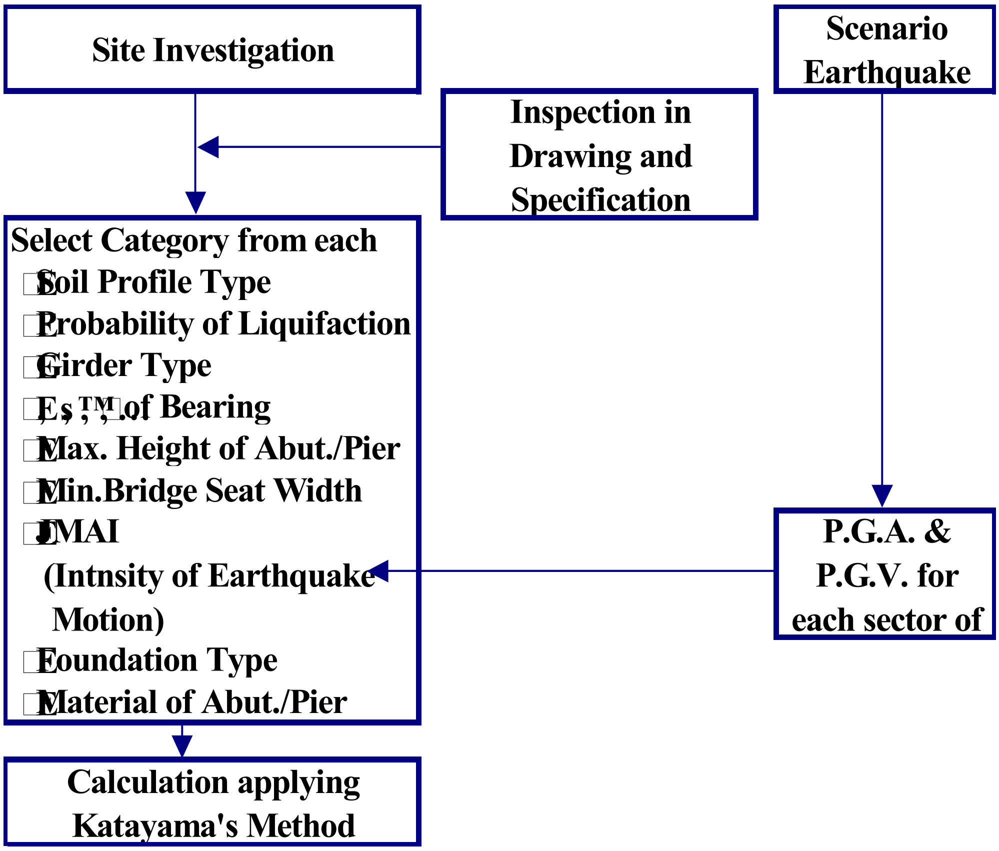


Figure 9.5.1 Schematic Drawing of Methodorogy

As shown in Figure 9.5.1, almost necessary data can be obtained by observing the bridges in site except a few exceptions. The foundation can be identified by the general drawing, the earthquake intensity and probability of liquefaction must be discussed by another way.

In Katayama's method, 10 items which are likely to affect the falling–off probability of the girder are studied. Each items consist of a few categories, they can be selected without complex calculations. The items, categories and category-score are shown in Table 9.5.2. The category-score is given to each category as a weighting factor. The category-score, which is modified by taking account of bridges in Istanbul is shown in this table.

Table 9.5.2 Items, Categories and Category-score

Item	Category		Category Score
Ground type	Stiff		0.5
	Medium		1.0
	Soft		1.5
	Very Soft		1.8
Probability of Liquifaction	Nothing		1.0
	Fear		1.5
	Having		2.0
Girder Type	1span	Arch or Rigid Frame	1.0
		Simple Beam	3.0
	2 or more span	Simple Beam	5.25
		Single Continues Girder	3.5
		more than one Continuous Girder	4.2
		Combination Of Continuous & Simple	6.3
Type of Bearing	with Specific Device (prevent falling-off of the girder)		0.6
	Bearing (with clear design concept)		1.0
	exist two bearing that can move axial deirection		1.15
Max. Height of Abut./Pier	less than 5 m		1.0
	5 to 10 m		1.35
	more than 10m		1.7
Min.Bridge Seat Width	Wide		0.8
	Narrow		1.2
JMA seismic intensity scale	5 (4.5 to less than 5.0)		1.0
	5.5 (5.0 to less than 5.5)		1.7
	6.0 (5.5 to less than 6.0)		2.4
	6.5 (6.0 to less than 6.5)		3.0
	７.O (6.5 and more than 6.5)		3.5
Foundation Type	Spread		1.0
	Pile		0.9
Material of Abut./Pier	Masonry		1.4
	Reinforced Concrete		1.0

the evaluated result can be given by substituting the data to Eq. (9.2.1)

$$y_i = \prod_{j=1}^{N} \prod_{k=1}^{M_j} X_{jk}^{\delta_j(jk)} \qquad (9.2.1)$$

where,

y_i Predictors of damage degrees of i-th bridges

N Number of all items

M_j Number of categories of j -th item

$\delta_i(jk)$ dummy variable

$\delta_i(jk)=1$ when the characteristics of the i -th bridge correspond to the category k in the item

$\delta_i(jk)=0$ otherwise

X_{jk} category-score for k -th category of the j -th item

$\prod_{j=1}^{N}$ multiplication sign from j -th value to N -th value

If practical expression is needed, above mentioned procedure means followings;

"Select the value of particular category for each item, and multiply the scores one another".

The seismic intensity scale in this context means the scale that is defined by JMA "the seismological observatory Japan", not correspond to MMI. The JMA intensity is selected because Katayama's method is based on this scale originally.

The analysis that is based on 30 sample of damaged bridges that are observed at 3 earthquake (1923 Kanto, 1948 Fukui, 1964 Niigata) results following critical value.

- The fall-off samples and the not falling-off samples were differentiated in the grade point value of 30 35.
- All samples of falling-off and samples on the edge of fall-off differentiated in the grade point value of 26.

Therefore, the boundary value of Predictors of damage degrees for this study was set as follows;

	Class of damage degree	boundary value of *Predictors of damage degrees*
(A)	Large probability of falling-off	30 and more than 30
(B)	Modelate probability	26 to less than 30
(C)	Less probability	less than 26

480 bridges were investigated in this sudy. The distribution of *Predictors of damage degrees* are shown in Figure 7.4.2. 21 samples of *Modelate proberbility* and 4 samples of *Large proberbility of falling-off* were identified. A lot of samples were centered on the degree of 10.

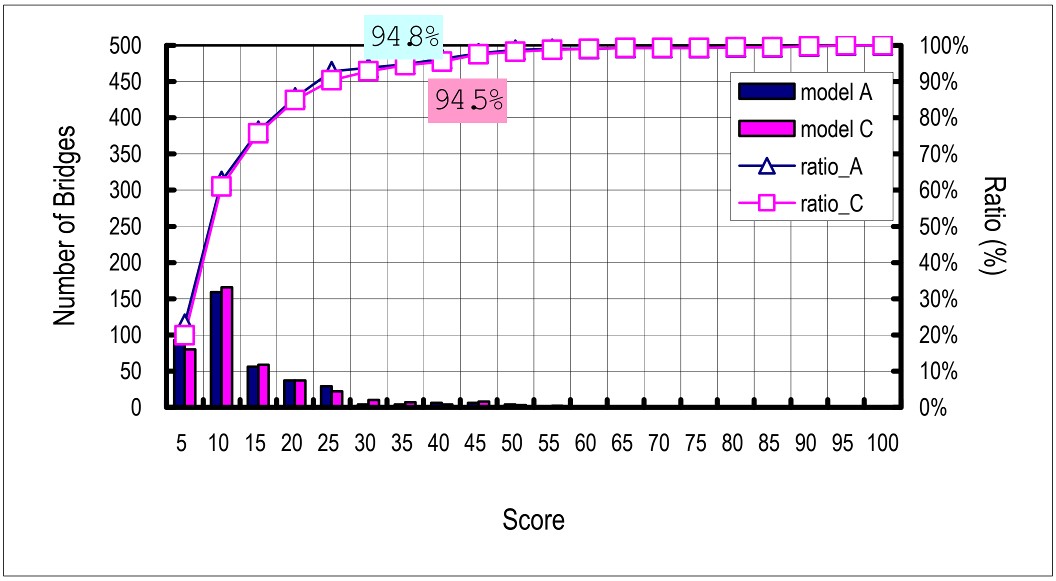


Figure 9.5.2 Distribution of *Predictors of damage degrees*

The list of the bridges that were evaluated as class (A) or (B) is shown in

Table 9.5.3.

The two samples that does not belong class (A) or (B) is shown in Table 9.5.4., these two bridges are under following condition;

- Peak Ground Acceleration of the site is more than 300gal
- Height of pier is more than 10 m

The bridges shown in

Table 9.5.3 and Table. Table 9.5.4 need to be done the next step detail investigation and reasonable earthquake resistant strengthening if necessary.

Table 9.5.3 Bridges that were evaluated as class (A) or (B)

BRIDGE No.	SOURCE	Ground type: Stiff	Ground type: Medium	Ground type: Soft	Ground type: Very Soft	Probability of Liquifaction: Nothing	Probability of Liquifaction: Fear	Probability of Liquifaction: Having	Girder Type, 1 Span: Arch or Rigid Frame	Girder Type, 1 Span: Simple Beam	Girder Type, 2 or more span: Simple Beam	Girder Type, 2 or more span: Single Continues Girder	Girder Type, 2 or more span: more than one Continuous Girder	Girder Type, 2 or more span: Combination Of Continuous & Simple	Type of Bearing: with Specific Device	Type of Bearing: Bearing (with clear design concept)	Type of Bearing: exist two bearing that can move axial deirection	Max. Height of Abut./Pier: less than 5 m	Max. Height of Abut./Pier: 5 to 10 m	Max. Height of Abut./Pier: more than 10m	Min.Bridge Seat Width: Wide	Min.Bridge Seat Width: Narrow	JMA seismic intensity scale: 5	5.5	6	6.5	7	5	5.5	6	6.5	7	Foundation Type: Spread	Foundation Type: Pile	Material of Abut./Pier: Masonry	Material of Abut./Pier: Reinforced Concrete	REMARKS	JMA seismic intensity scale: Model A	JMA seismic intensity scale: Model C	PGA (gal): Model A	PGA (gal): Model C	Predictors of damage degrees: Model A	Predictors of damage degrees: Model C	Class of damage degree: Model A	Class of damage degree: Model C
52	17_region	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	1		6.0	6.1	436	480	94	94	A	A
188	17_region	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	1		6.0	6.1	435	479	90	90	A	A
89	17_region	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	1		6.0	6.0	431	476	79	79	A	A
T5	TCDD	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	1		6.1	6.1	447	494	62	62	A	A
57	17_region	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1		5.9	6.0	413	456	48	60	A	A
AK5	IBB-Infra.coord Dpt	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	1		6.0	6.0	432	476	53	53	A	A
MT110	JICA	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	L	5.5	5.6	297	329	48	48	A	A
MT112	JICA	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	L	5.5	5.6	296	328	48	48	A	A
MT94	JICA	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	L	5.8	5.8	379	419	48	48	A	A
MT86	JICA	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	1	G,L	5.9	6.0	430	476	35	44	A	A
MT87	JICA	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	1	L	5.9	6.0	430	476	35	44	A	A
MT88	JICA	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	1	L	5.9	6.0	430	476	35	44	A	A
T4	TCDD	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	G,L	5.8	5.8	363	402	41	41	A	A
58	17_region	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	G,L	5.9	6.0	429	474	32	40	A	A
T28A	TCDD	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1	G,L	5.8	5.9	373	413	35	35	A	A
T28B	TCDD	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1	G,L	5.8	5.9	373	413	35	35	A	A
190	17_region	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	L	5.5	5.6	295	327	32	32	A	A
T33	TCDD	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	L	5.5	5.5	273	303	31	31	A	A
AK3	IBB-Infra.coord Dpt	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	1	G	5.9	6.0	429	473	24	30	C	A
AK4	IBB-Infra.coord Dpt	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	1	G,L	5.9	6.0	427	471	24	30	C	A
1	17_region	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	G	5.6	5.7	301	334	27	27	B	B
55	17_region	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	L	5.5	5.6	294	325	27	27	B	B
UAS17	IBB METRO	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	L	5.9	6.0	425	470	21	26	C	B
T30	TCDD	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	1		6.0	6.1	435	480	26	26	B	B

Table 9.5.4 Bridges (Peak Ground Acceleration of the site is more than 300gal, Height of pier is more than 10 m)

BRIDGE No.	SOURCE	JMA seismic intensity scale		PGA (gal)		Predictors of damage degrees		Class of damage degree	
		Model A	Model C	Model A	Model C	Model A	Model C	Model A	Model C
M1-3-A	IBB Mantanance	5.3	5.4	276.8	307.6	7.0	7.0	C	C
YIM5	IBB-construction	5.7	5.7	342.4	379.9	9.9	9.9	C	C

As mentioned above, Katayama’s method can evaluate vulnerability reflecting both qualitative characteristics and quantitative characteristics of the bridges. For instance “configuration of girder type”, “bearing”, “foundation”, and “material of pier abutment” represent qualitative characteristics.

It is reported that “configuration of girder type” can be effective factor to find the begining point of falling–off of the girder in the report of many earthquake disaster especialy “Kobe Earthquake”.

As mentioned above the main purpose of Katayama’s method is to differenciate the probability that the girder of the bridge fall-off. Another types of damage must be discussed using another method. i.e. damage of expansion joint failure of the girder and the crack of the pier

However it is effective to point out the bridges that have high risk, using this method as a first screening.

The statistical analysis of this method does not include the sample damaged by the ground surface displacement under the condition of faulting or land slide caused by faulting. Another discussion must be carried out if obvious evidence that indicate the possibility of faulting.

9.5.2. Indication of a controversial point

The number of the bridges that is evaluated as “Large proberbility of falling-off: more than 30 point” is 20. However detail explanation for each bridges is needed, and specific condition of Istanbul’s bridges must be explained. Therefore each of them will be descrived as follws even though it is for 5 examples.

(1) No.52 (Score; 93.7)





The evaluated result of this bridge shows the highest score 93.7, but some explanation is needed for this example. The reason why this bridge possesses the highest value is “there are a combination of single span of the girder and continuous girder” and “the pier is very high”. Some possibility of collision between continuous girder that has very large mass and single span of girder that has comparatively light mass. The girder that has lagrer mass compared with single span of the girder can give a large impact to the single span of the girder. Therefore careful discussion is needed considering collision. The falling-off prevention device can be effective for this situation as mentioned later.

(2) No.188 (Score; 89.8))

The evaluated result of this bridge is 89.8. The reason why this bridge possesses the high value is that this bridge is composed of simple beam of the girder and that pier is comparatively high. The collision between each girder can cause contingent boost of displacement and falling-off of the girder.

(3) No.89 (Score; 79.2)

The evaluated result of this bridge is 79.2. The reason why this bridge possesses the high value is that this bridge is composed of simple beam of the girder and that pier is comparatively high.

(4) T5 (Score; 62.0)


The evaluated result of this bridge is 62.0. The reason why this bridge possesses the high value is that this bridge is composed of simple beam of the girder. In addition two bearings on the pier allow relative displacement of the girder face to face. This kind of bearing condition can cause very large relative displacement, because neighboring pier may have two bearings, which do not allow relative displacement of the girder face to face. These two kinds of structure parts have very different natural period, so there can be large relative displacement of the girder.

However the neighboring under parts of structure are abutment which is bonded on the earth, so the natural period of the abutment can not be so long. This is a few exception which is assessed excessively severe in Ktayama's method, but this kind of bearing condition must be cautioned.

(5) No.57 (Score; 59.9)


However the void between the girder end and the face of abutment is comparatively large, so there may not be a collision in this part.

The void between each girder end on the pier could not be identified in this study. If that void is kept reasonably the problem of collision can be prevented. Regarding the Minimum Seat Width, if the width is kept reasonably the problem of falling-off of the girder can be prevented.

Enyhow some kind of falling-off prevention device that bind neighboring girder is needed to discussed on this bridge.

9.5.3. Recommendation on earthquake resistant strengthening

(1) Basic point

There can be some practical difference between the bridge design and building design even though basic principle of them are the same. The reason of difference are;

1) All of the bridges are public facilities in contrast that most of the building are owned by each person.

2) Very high level of function is required for the bridged at the rescue operations and reconstruction of the city.

3) The earthquake resistance of the bridges have to be guaranteed obviously by design.

Taking in account of above points counter□measure that is different from the one for building design is needed.

Regarding the intensity of earthquake to be targeted; it is same as the one for building design.

□ The intensity of earthquake in Istanbul caused by 1999 Izmit Earthquake.

□ The intensity of earthquake that is proved in the earthquake resistant design code; probability of exceedance of that earthquake within a period of 50 years may be about 10%.

□ The intensity of earthquake caused by scenario earthquake; this is the largest earthquake that can be expected for Istanbul area.

How much damage can we control against above mentioned intensity of earthquake are as follows;

a) Keep the structure as fully operational,

b) Basically keep the structure as operational.

If some incidental damage occur it has to be repaired rapidly (within 1 or 2 days).

Elastic design method may be applied.

c) Damage must be controlled for preventing excessive reduction of the bridge.

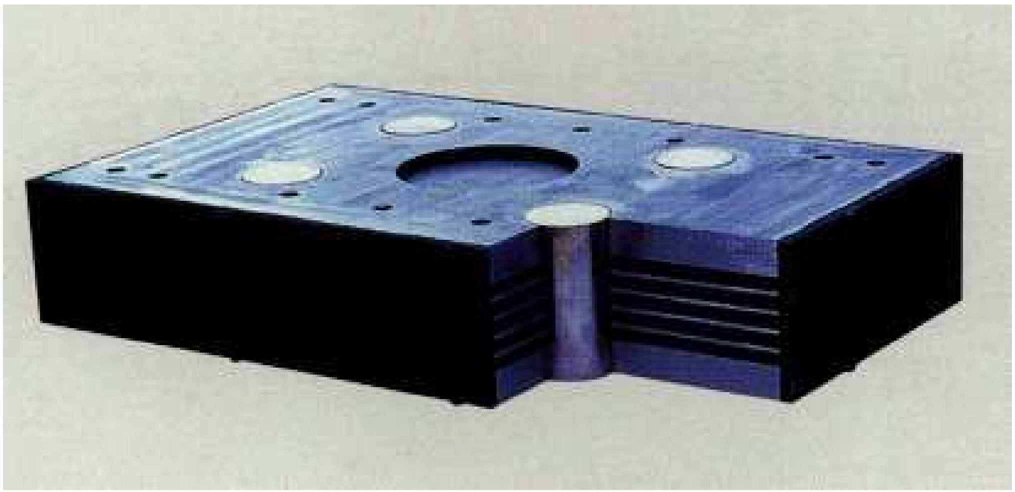
Sufficient ductility must be retained even though some yielding allowed at some part of the structure. This type of design method is called “Capacity Design”. In that method some plastic hinge is set in the structure model, then stability of whole structure and displacement is discussed.

Some reasonable correspondence between *intensity of earthquake* and *counter measure* is selected in Table 9.5.5.

Table 9.5.5 Counter measure correspond to earthquake intensity

	Earthquake Performance Level		
	a) Fully Operational	b) Operational but Repair is needed	c) Prevent Complete Collapse
① Frequent Earthquake	✓		
② Occasional Eartquake		**Linear Design**	
③ Very Rare Earthquake			**Capacity Design**

If bridge is designed taking into accout of the earthquake which is showed in Table 9.5.5 as “□Very Rare Earthquake” it is not so effective to get strength solely. There can be some case in which seismic isolation or dynamic structure control give effective solution. However some discussion regarding the cost performance must be needed because of their high-priced device. An example of seismic isolation device named “Lead rubber bearing” is shown in Figure 9.5.3.



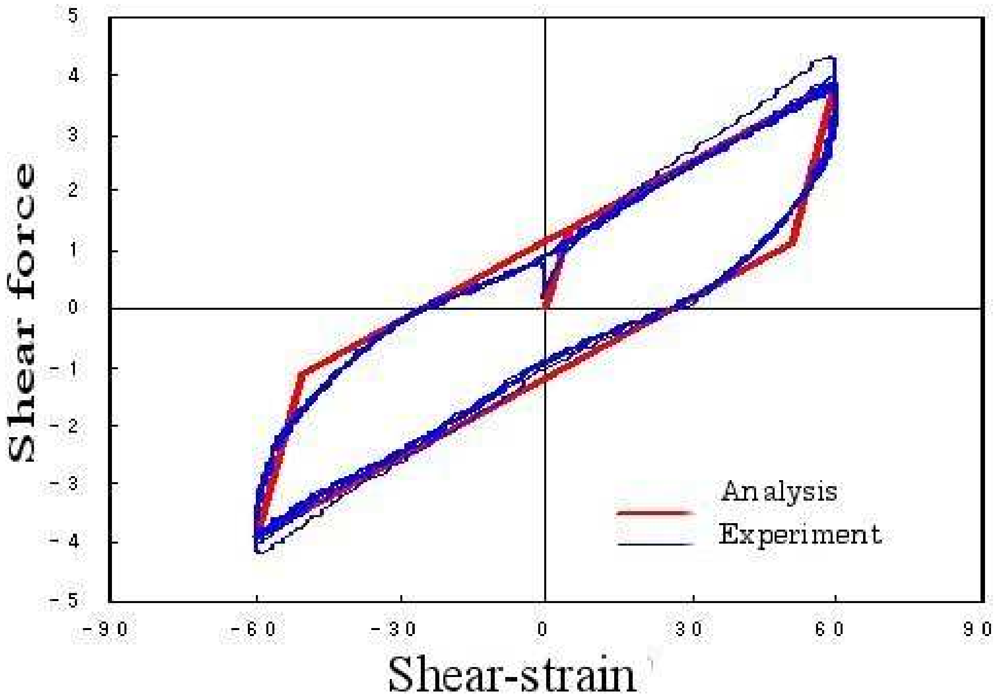


Figure 9.5.3 An example of seismic isolation device (Lead rubber bearing)

(2) Countermeasure on designing

Basically the drawings and specifications of every bridge must be kept by Competent Authority, and that must follow the present earthquake resistant design code of bridges. For this purpose appropriate design code for bridges must be discussed and established, because there is not the code, which contain practical design rule of bridge yet in Turkey. The failure at detail design can cause severe damage as shown in many previous disaster reports.

The design earthquake criterion that is defined in "Specification for Structures to be Built in Disaster Areas (PART III - EARTHQUAKE DISASTER PREVENTION)" give realistic suggestion, but further detail discussion is needed regarding *Structural Behavior Factors*, (**R**).

This factor is prepared in order that linear analysis can be applied as a simplified method even if the design earthquake criterion is so large that non-linear analysis is needed.

However this kind of simplified method cannot give sufficiently certain guaranty for severe earthquake, because the earthquake motion probable in Istanbul is larger than the design earthquake that is defined in present code.

Applying the capacity design method should be discussed in order to make safety of the bridges under ultimate limit state certain, taking into account the important role of the bridges under severe earthquake. When the design earthquake for this discussion is required the earthquake motion that is assumed in this study as a scenario earthquake can give effective suggestion.

(3) Urgent countermeasure

The important points for strengthening the bridges are certain design method and execution management. Considerably long term is needed to improve the design method and execution management, because sufficient discussion and corroboration of experiment is required. On the other hand, there can be some effective measure that can be done urgently as follows;

a. Bridge inventory

It is needed to make the bridge inventory written in certain form, and that must include entire information which is effective for discussion about earthquake resistant and daily maintenance.

When there are some old bridges that enough information can not be found necessary investigation has tobe carried out.

b. In case effective measure is possible without difficult discussion

In case effective measure is possible without difficult discussion quick construction of retrofit should be done. Case in point may be found in "Falling-off prevention system" defined by Specifications for highway bridges in Japan in Japan. "Falling-off prevention system" is composed of following three components

1) Extension of seat width on pier cap

2) Control of relative displacement between girder and pier/abutment

3) Control of relative displacement between girder and ajoining girder

The worst situation of bridge damage is the falling-off of the girder. The bridge can resume urgent service if the the falling-off of the girder is prevented.

Urgent service can be maintained by covering the void between the girder and ajoining girder with steel plate and asphalt even if the edge of the girder was destructed by excessive displacement under earthquake motion.

Even if the serious crack is generated on the pier and the load carrying capacity is reduced supporting the girder with sadndle can give the next best solution for urgent use.

Following is the schematic drawing of "Falling-off prevention system" in Japan. Figure 9.5.4 shows some typical sample of that device.

Figure 9.5.5 explains the effect at each stage of the earthquake intensity. Figure 9.5.6 shows an example in which relative displacement between the girder and ajoining girder is controlled by damper with specially equipped viscous material.

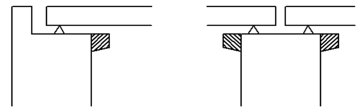
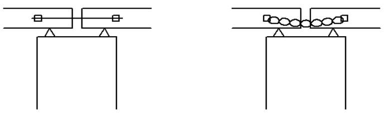
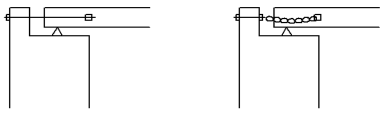
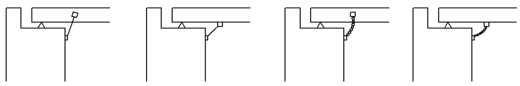
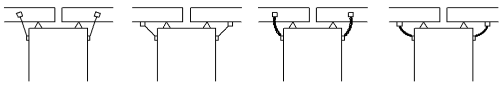
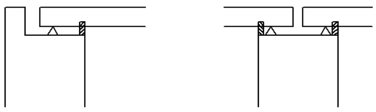
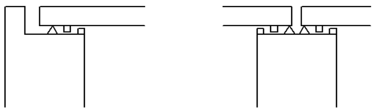
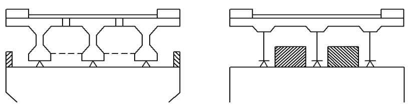
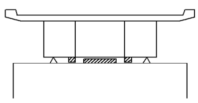
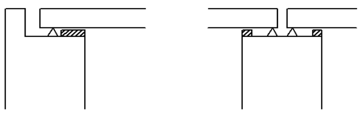
Direction	Category	Method	Location	Item	Material	Schematic Configration	Remark
Regarding longitadinal direction				Widening of Seat width	R/C or Steel plate		Adding Bracket
Regarding longitadinal direction	Fall-off prevention device			Connecting device between girder and adjoining girder	P/C Strand or Steel chain		
Regarding longitadinal direction	Fall□off prevention device and Relative displacement control	Connecting girder and substructure	Abutment	Connecting girder and parapet	P/C Strand or Steel chain		
Regarding longitadinal direction	Fall□off prevention device and Relative displacement control	Connecting girder and substructure	Abutment	Connecting girder and Substructure	P/C Strand or Steel chain		Attach to girder side or under surface
Regarding longitadinal direction	Fall□off prevention device and Relative displacement control	Connecting girder and substructure	Pier	Connecting girder and Substructure	P/C Strand or Steel chain		Attach to girder side or under surface
Regarding longitadinal direction	Fall□off prevention device and Relative displacement control	Bulge		Bulge on substructare	R/C or Steel plate		
Regarding longitadinal direction	Fall□off prevention device and Relative displacement control	Bulge		Conbination of bulge	R/C or Steel plate		
Transrerse direction	Fall□off prevention device and Relative displacement control	Bulge		Bulge on substructure	R/C or Steel plate		Outside or inside of girder
Transrerse direction	Fall□off prevention device and Relative displacement control	Bulge		Conbination of bulge	R/C or Steel plate		
Adding of landing space				Landing space on substructure	R/C or Steel plate		

Figure 9.5.4 Typical sample of "Falling-off prevention system"

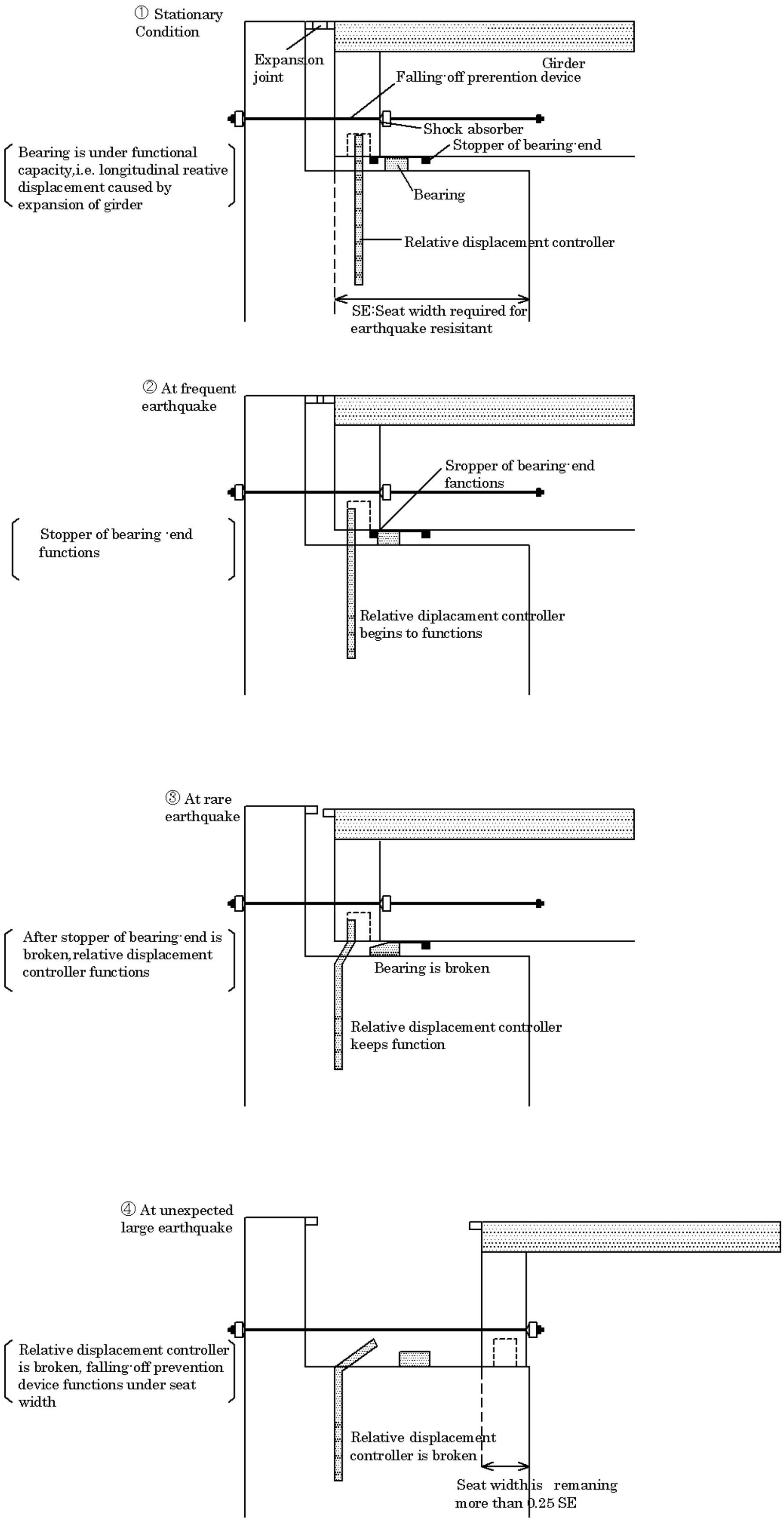


Figure 9.5.5 Explanation of the effect at each stage of the earthquake intensity

Figure 9.5.6 An example of displacement controlling by damper

9.6. Road and Traffics

9.6.1. Introduction

Roads are the most important means for traffic and transportation to support urban functions. Along roads, which extend linearly, various types of communication and supply and treatment facilities (such as those for tap and waste water, electricity, gas, etc.) are buried, providing roads with the functions of not only transporting people and goods but also transmitting information. Therefore, earthquake damages to roads pose not only the problem of resulting in physical damages to individual structures buried along roads, but also that of potential malfunction of the total systems resulting from the destruction of individual structures. Furthermore, roads play important roles in evacuation, information gathering, rescue, medical aid, etc., all of which are required immediately after earthquakes, and roads are also significantly important in the transportation of relief goods and restoration activities inevitably necessary after earthquakes. When considered from these points of views and in order to establish preventive measures against earthquake damages and establish plans for restoration, it is essential to first estimate the extent of the expected earthquake damages based on the result of the study and on an understanding of the current situation of roads and their functions. In addition, through evaluating theimportance of road networks, it becomes possible to clearly identify which routes and sections are important and to set up priorities among the preventive measures against earthquakes in advance, so that more reliable road systems can be constructed.

Based on the above viewpoints, the importance of road networks, the prioritisation evaluation of reinforcement of bridges against earthquakes, and the estimation of damage from road blockades caused by collapses of roadside buildings are described in this section.

9.6.2. Importance Evaluation on Road Network

On the roads in the Study Area surveyed, many bridges have been constructed because of road network characteristics and topographic reasons. Therefore, in evaluating the importance of the road network for the purpose of disaster prevention, it is necessary to study not only the relative importance of routes along sections of the entire network, but also the impact when bridges are damaged, as well as the potential impact to surrounding areas. Furthermore, it is effective to determine the importance of individual routes and prioritise these along with proposed measures to protect the bridges from earthquake disaster after comprehensively reviewing and evaluating the results from these studies. Figure 9.6.1 shows the flow of the evaluation study on the importance of road networks.

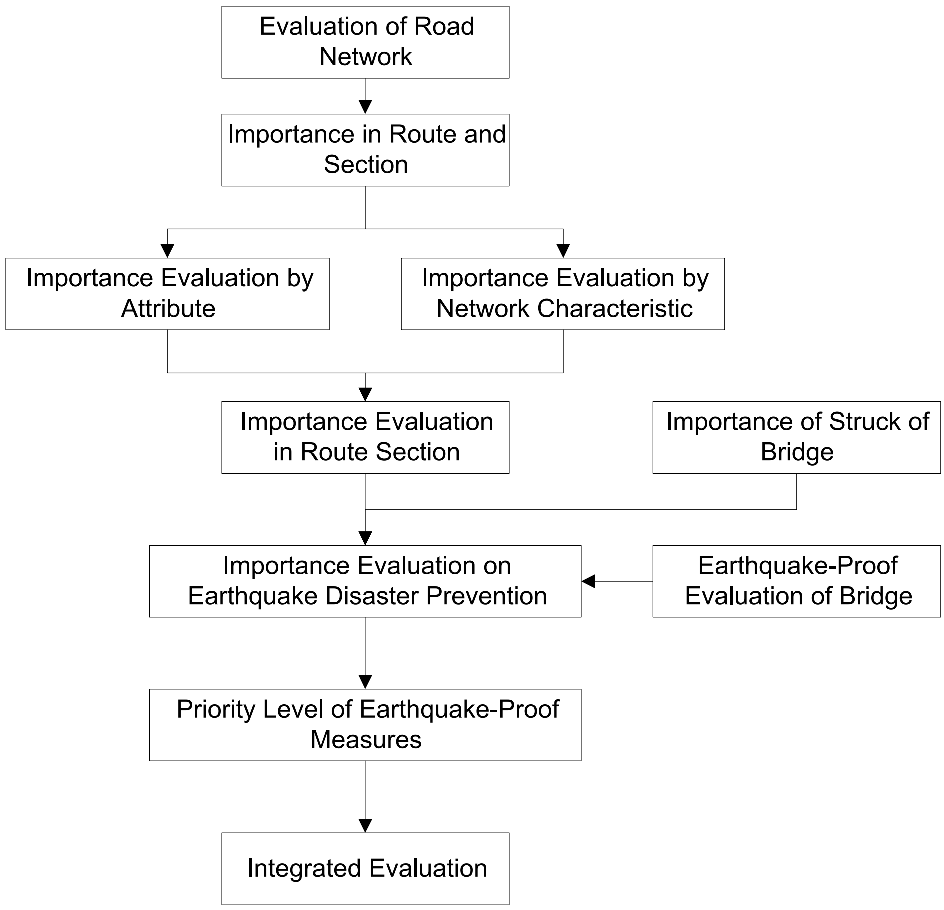
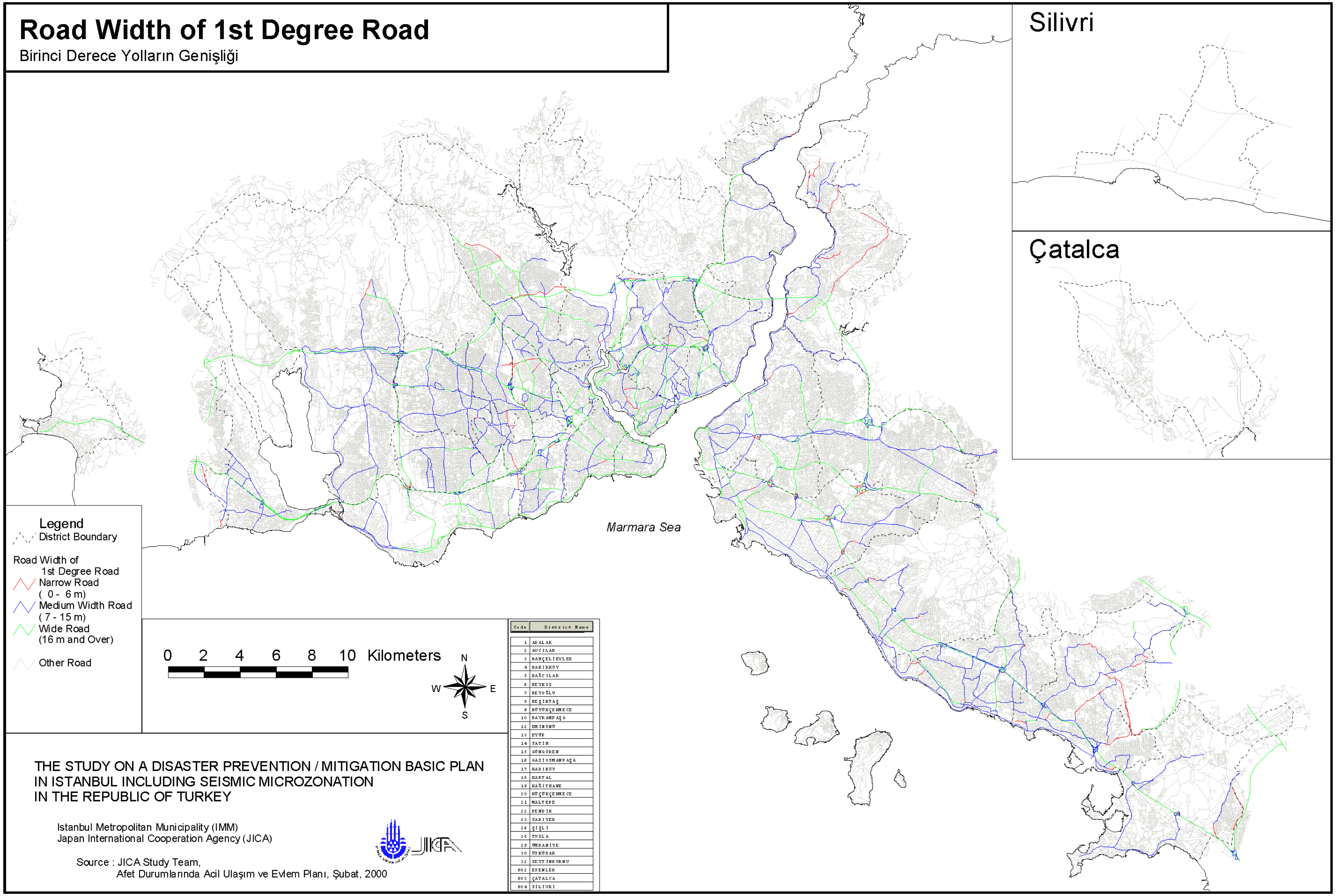


Figure 9.6.1 Examination Flow of Importance Evaluation

As shown in

Figure 9.6.2 to

Figure 9.6.4, IMM classifies roads based on their functions. In evaluating the importance of road networks, the IMM's classification has been referenced.



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 9.6.2 Road Width of 1st Degree Road

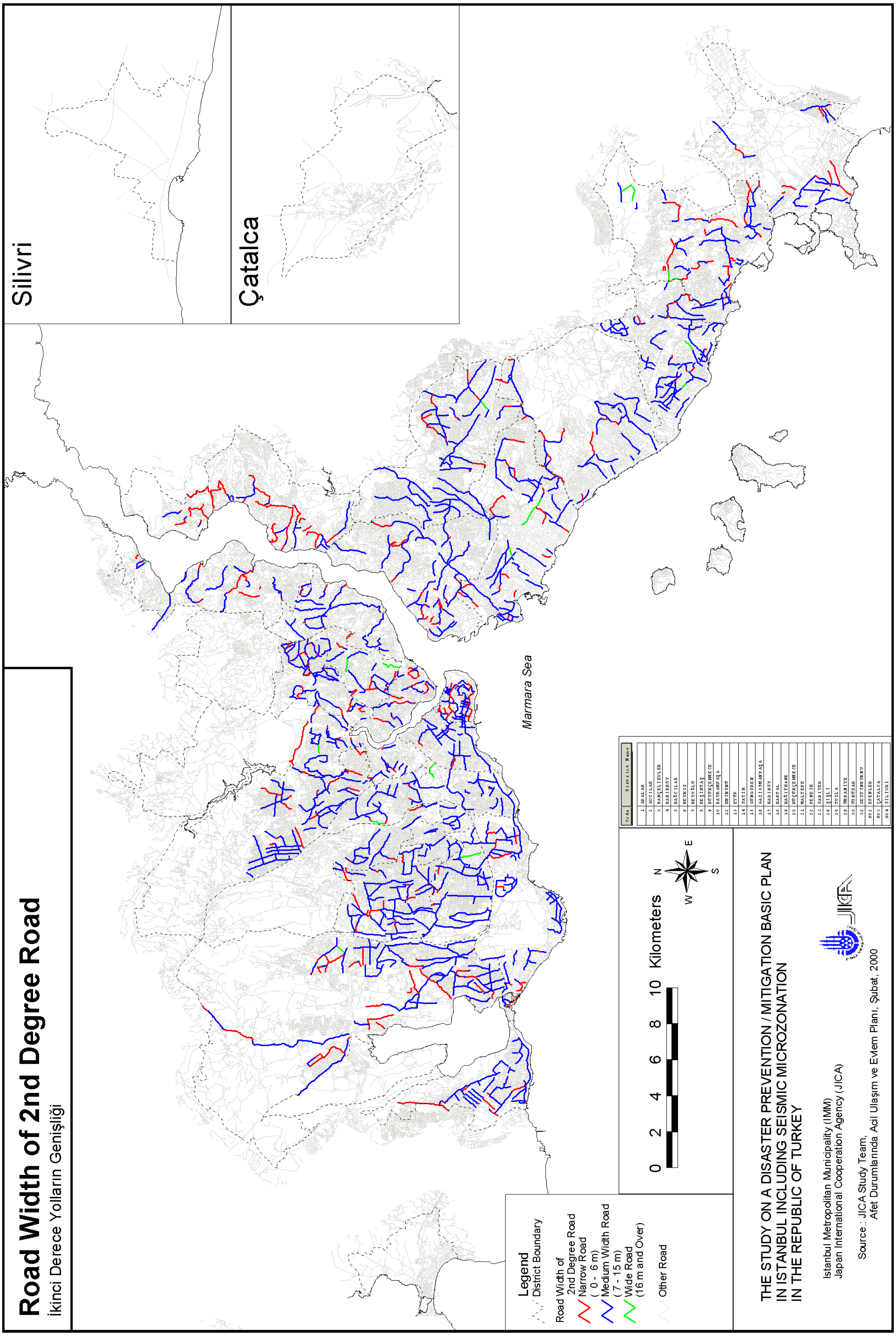


Figure 9.6.3 Road Width of 2nd Degree Road

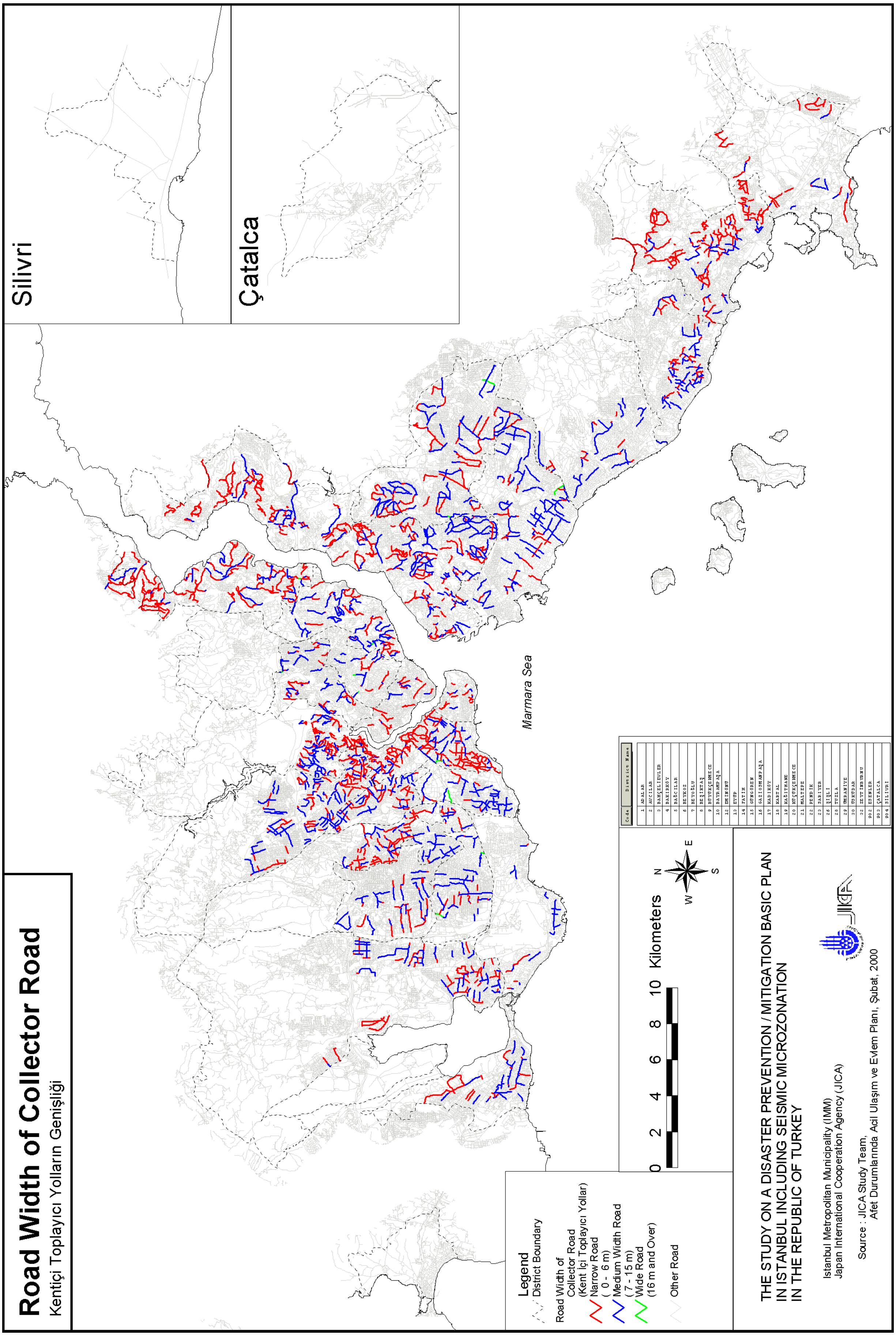


Figure 9.6.4 Road Width of Collector Road

(1) Importance Evaluation of Routes and Sections Along Network

a. Importance Evaluation of Route and Section Based on Attributes

Evaluation Method

As shown in Figure 9.6.5, the route to be studied is divided by 500 m grids to form sections, and factors capturing disaster prevention importance among routes and sections, traffic characteristics, route characteristic, and the status of each route's river crossing are assigned to each section as attributes. The "score" from the evaluation of an attribute j is expressed as Xj and is multiplied by Wj (weight coefficient of attribute j). The sum of the product "Xj x Wj" is calculated to determine the overall importance of a specific route and section. Namely, the evaluation score of a route and section, I_A, is expressed using the following formula:

$$I_A = \sum_{j=1}^{n} Wj \cdot Xj$$

I_A：Importance Score of Targeted Route and Section
Wj：Weight Coefficient of Attribute j
Xj：Points in Evaluation to Attribute j

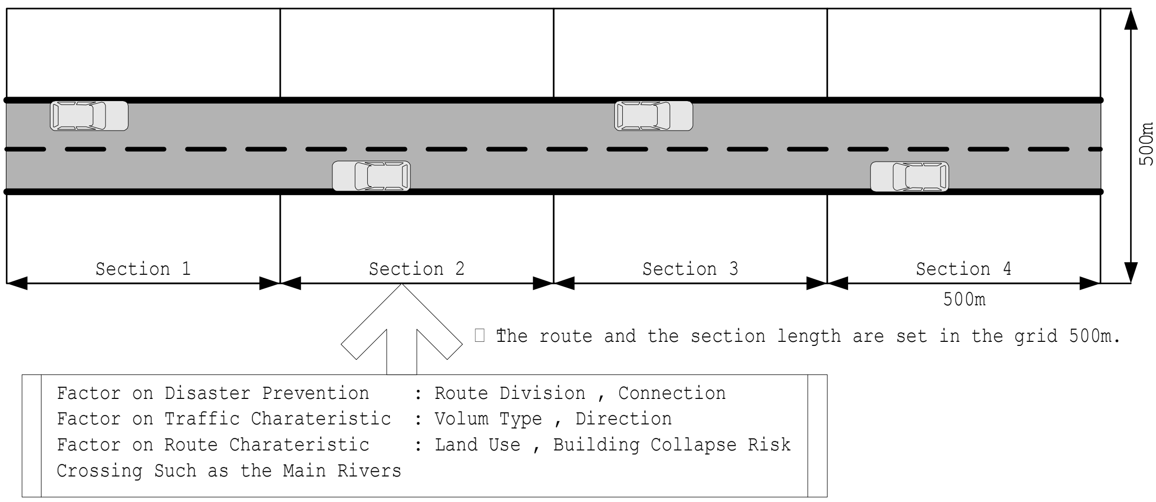


Figure 9.6.5 Evaluation and Attribute in Route

The larger the value of I_A, the higher the route's importance, and the relative importance of sections are classified as "primary," "secondary," or "other" as shown in the histogram of the score, or points, of evaluated sections. The following is an explanation of the 4 factors shown in Figure 9.6.5.

Factor on Disaster Prevention

Regarding the factor on disaster prevention, connecting status of the route division with other area, which is presumed by the road's function, etc., is considered.

Route Division (

Figure 9.6.6*)*

Routes have been classified into Type 1 to Type 4, supposing there are 4 types of roads: 1) evacuation or escape roads, 2) emergency transportation roads, 3) roads urgently developed for emergency use, and 4) other roads. Type 1 roads are for escape of refugees and other passersby as well as for rescue operations, and are assigned the highest number of points. Types 2 and 3 are considered to be the next important.

Connection (
Figure 9.6.7*)*

It is expected that wide routes and sections that serve as critical connections to other areas will perform important functions in rescue operations and the transportation of external relief supplies. Therefore, routes having such characteristics are assigned a high number of points.

Factor on Traffic Characteristic

As part of the traffic characteristic factor, traffic volume capacity and direction of roads are taken in consideration.

Volume Type (

Figure 9.6.8*)*

This factor is added to the traffic volume in evaluation. Higher points are given to roads with broad width and most capable of securing speed service.

Direction (

Figure 9.6.9)

In the area studied, there are two national traffic axes running east and west, other traffic axe(s) running north and south connecting the national axes, and routes which form an inner city traffic network. The two highways running east and west are the main "loop" roads in Istanbul, and the connecting roads running north and south as well asthe other roads directly connected to them can be regarded as "radial lines." In the road network, it is necessary to use the loop line to move between radial lines. Therefore, regarding road direction, loop lines are given higher points than radial lines. Main roads other than the radial lines are given lower points than the ones given to the radial lines, depending on their function.

Route Characteristic Factor

As part of the route characteristic factor, the status of land utilisation and degree of collapse risk of roadside buildings due to earthquakes are considered.

Land Use (

Figure 9.6.10*)*

For land use determination, IMM's data (2000) was utilised. In regard to the roadside land utilisation, areas are classified as "residential," "industry," "public facility," "transportation facility," "park," and "other Areas," and the routes and sections passing through these areas are assigned different points according to this classification. Once an earthquake has caused damages, public and transportation facilities are required to reserve and fulfill their functions as primary rescue centres to cope with the disaster. Therefore, with regards to the land use factor, routes passing through public or transportation facilities, which can cause great impacts when damaged, are assigned the highest number of points.

Building Collapse Risk (

Figure 9.6.11*)*

When roadside buildings collapse due to an earthquake, it is presumed that they lower the functionality of roads and greatly detering effective transportation and contributing to traffic congestion. Therefore, the number of collapsed houses due to the vibration in Model-C in each 500 m grid is counted to determine the house collapse risk of each section, and the sections with the highest collapse risk are given the highest points.

Crossing Large Bridges and Viaducts (

Figure 9.6.12*)*

Roads crossing over rivers and straits, as well as disaster prevention routes, are some of the most important factors in earthquake disaster. In Istanbul, it is likely that the damage of bridges spanning main rivers and straits would cause a break in the connection among areas and significantly inhibit escape, rescue, and restoration activities. From this point of view, routes and sections having bridges of 50 m or longer, and those crossing over rivers and straits, are considered to be very important and are assigned a high number of points accordingly.

Table 9.4.1 shows point and weight coefficients of individual attributes used in the evaluation of the importance of routes and sections.

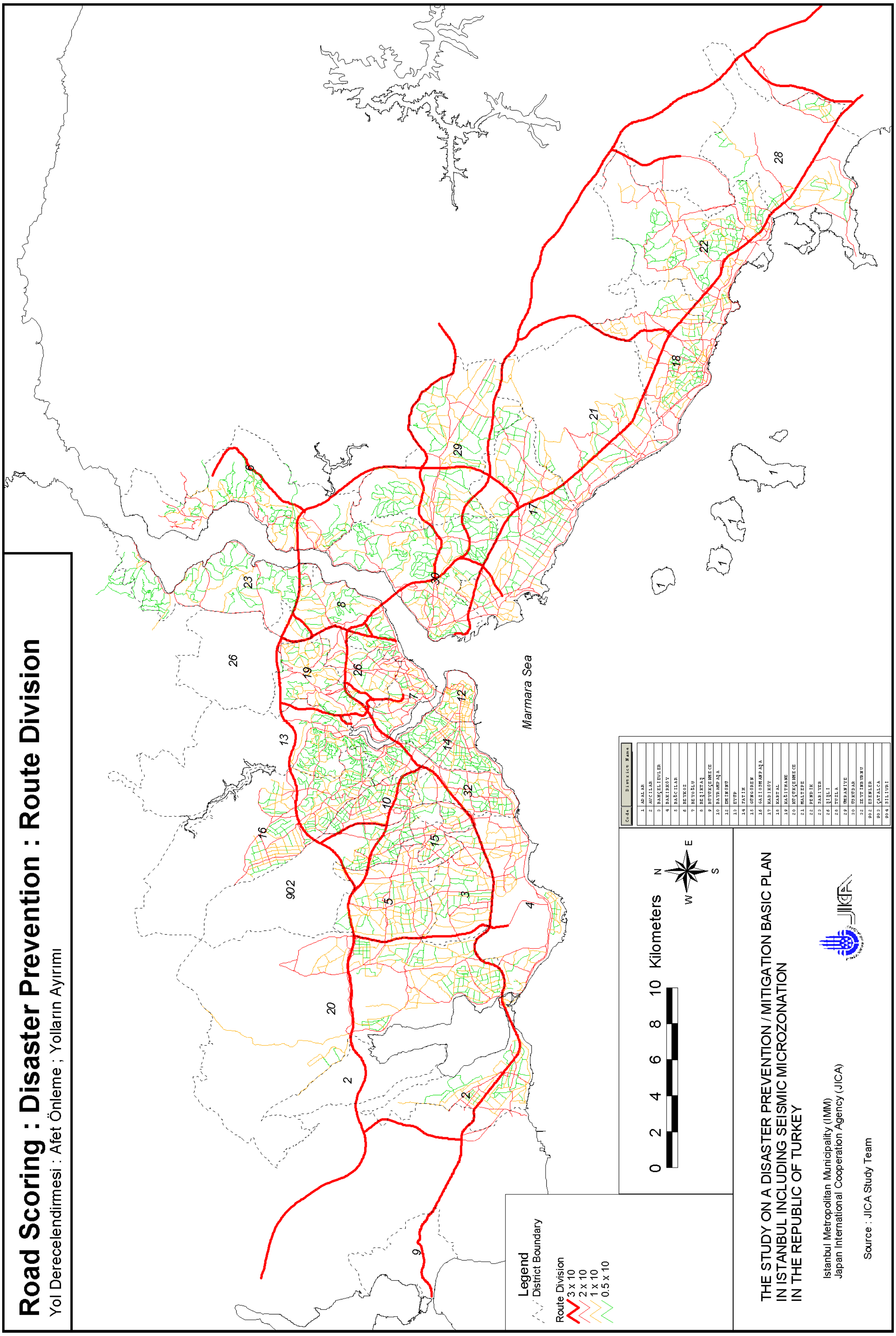


Figure 9.6.6 Road Scoring : Disaster Prevention : Route Division

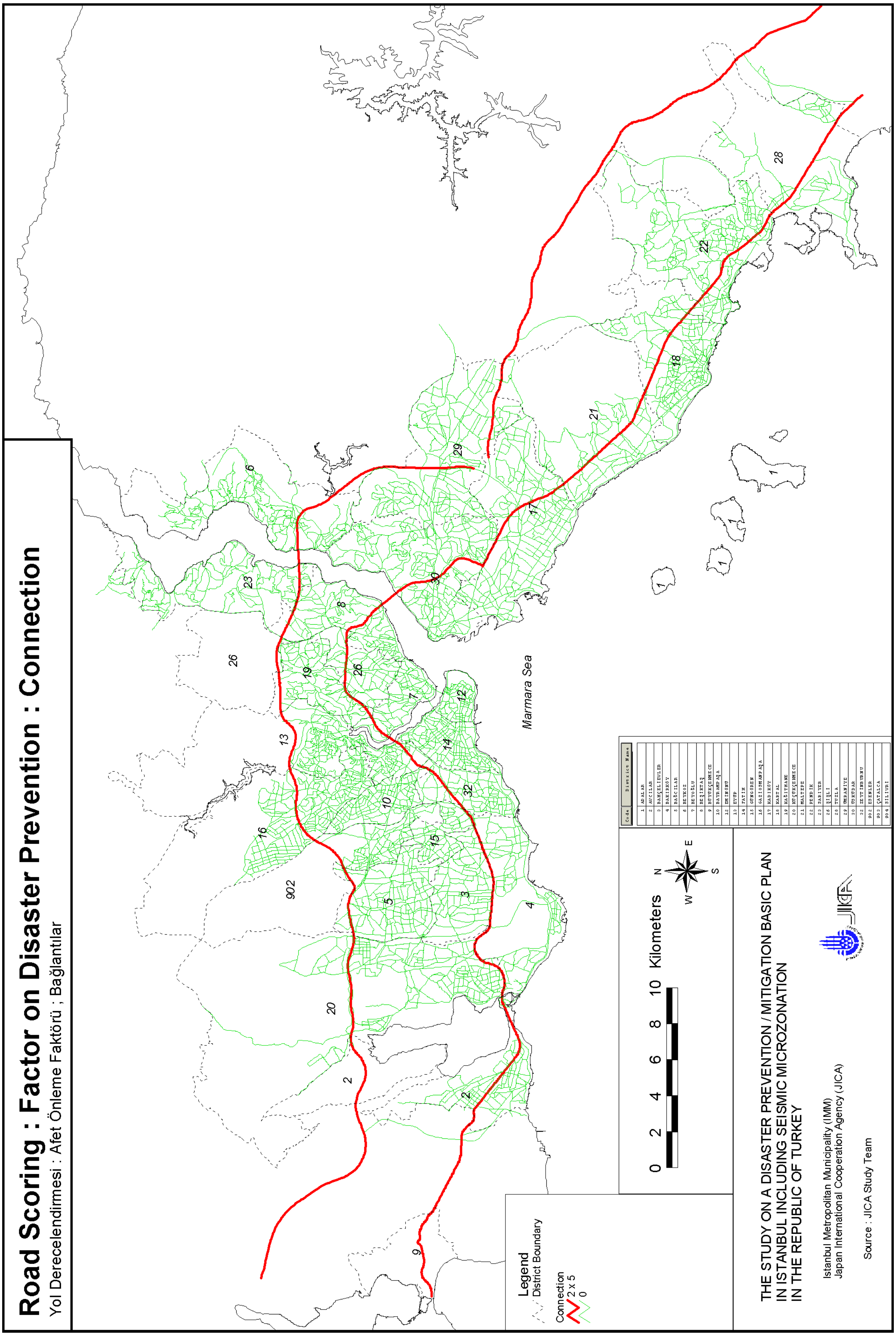


Figure 9.6.7 Road Scoring : Factor on Disaster Prevention : Connection

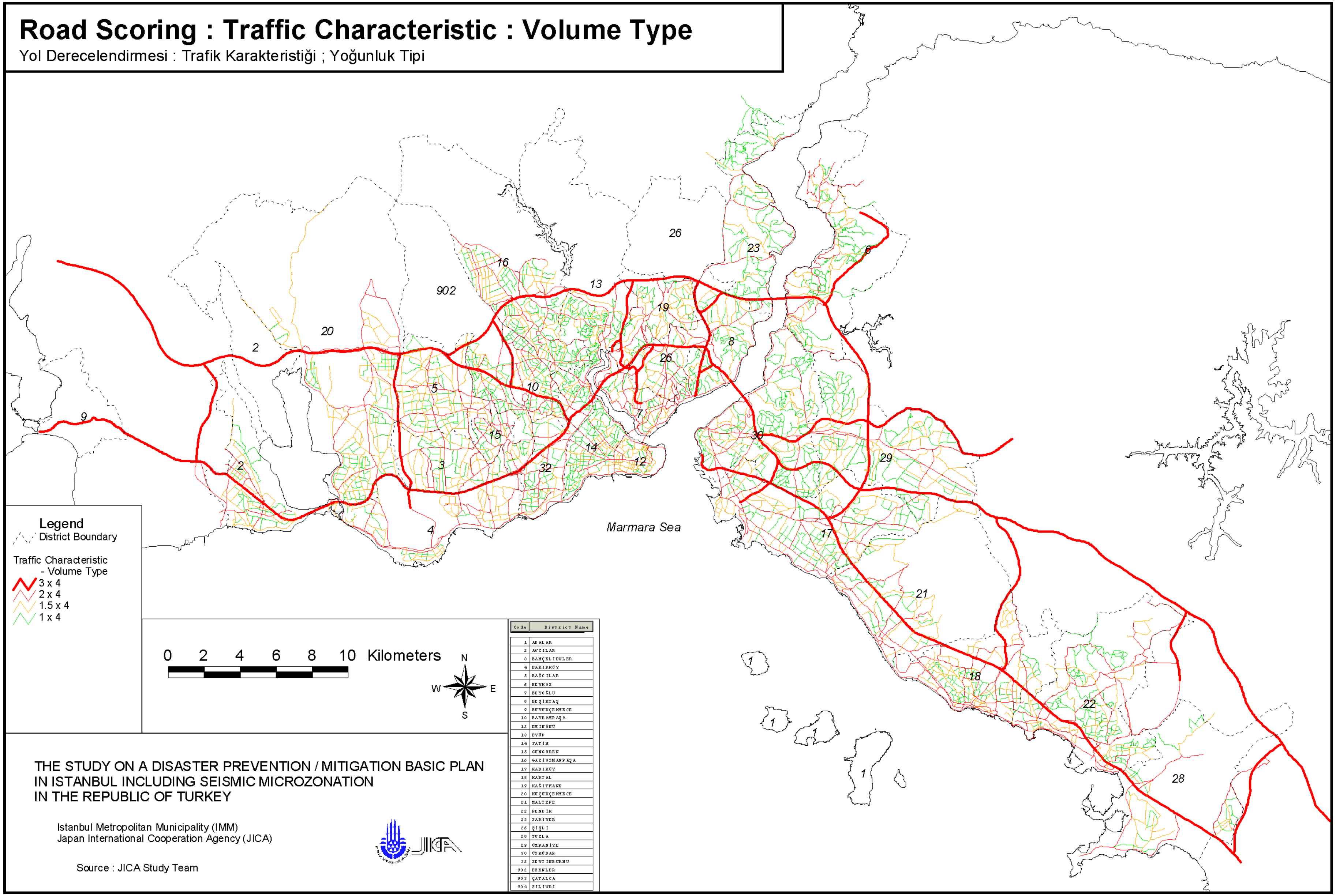


Figure 9.6.8 Road Scoring : Traffic Characteristic : Volume Type

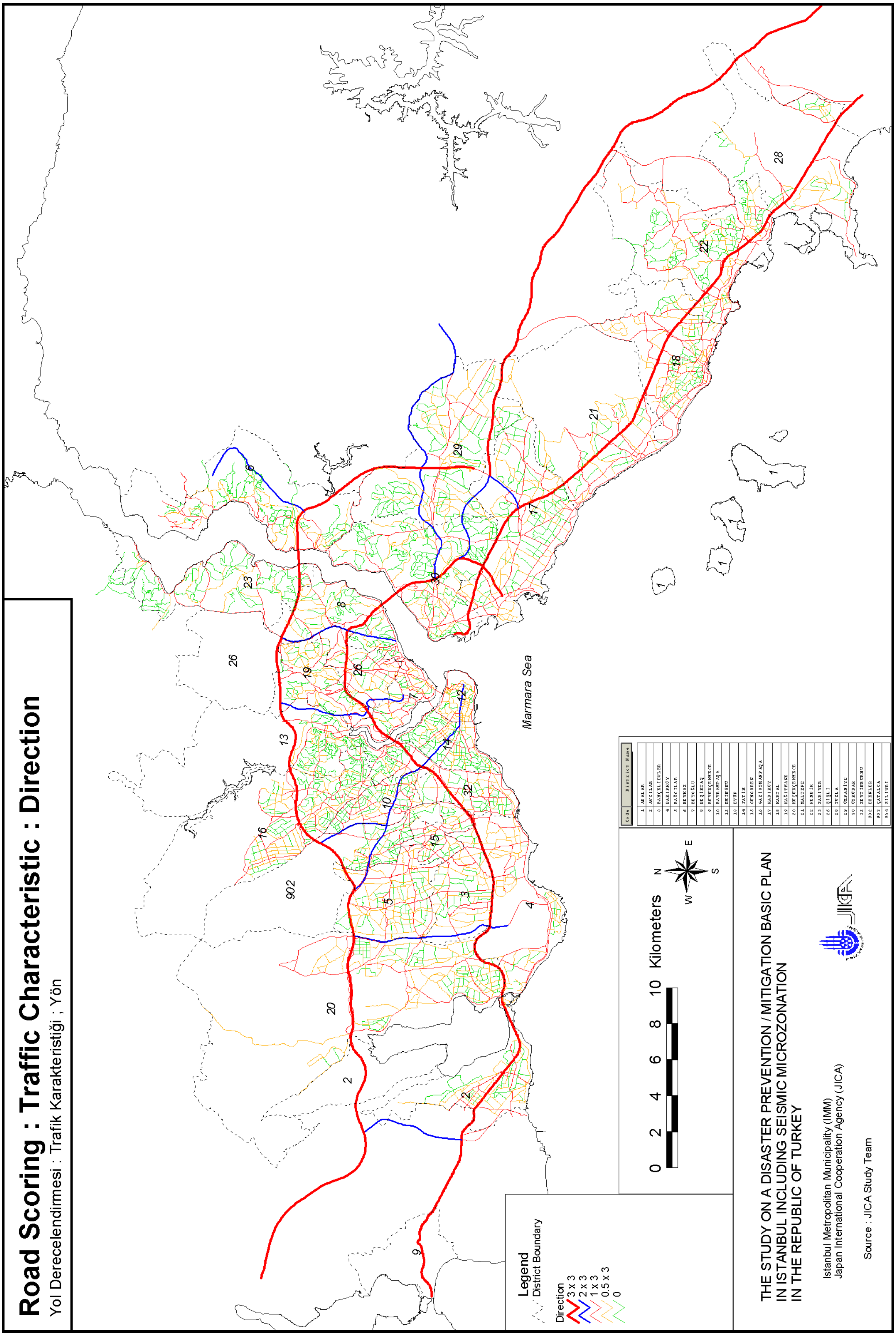
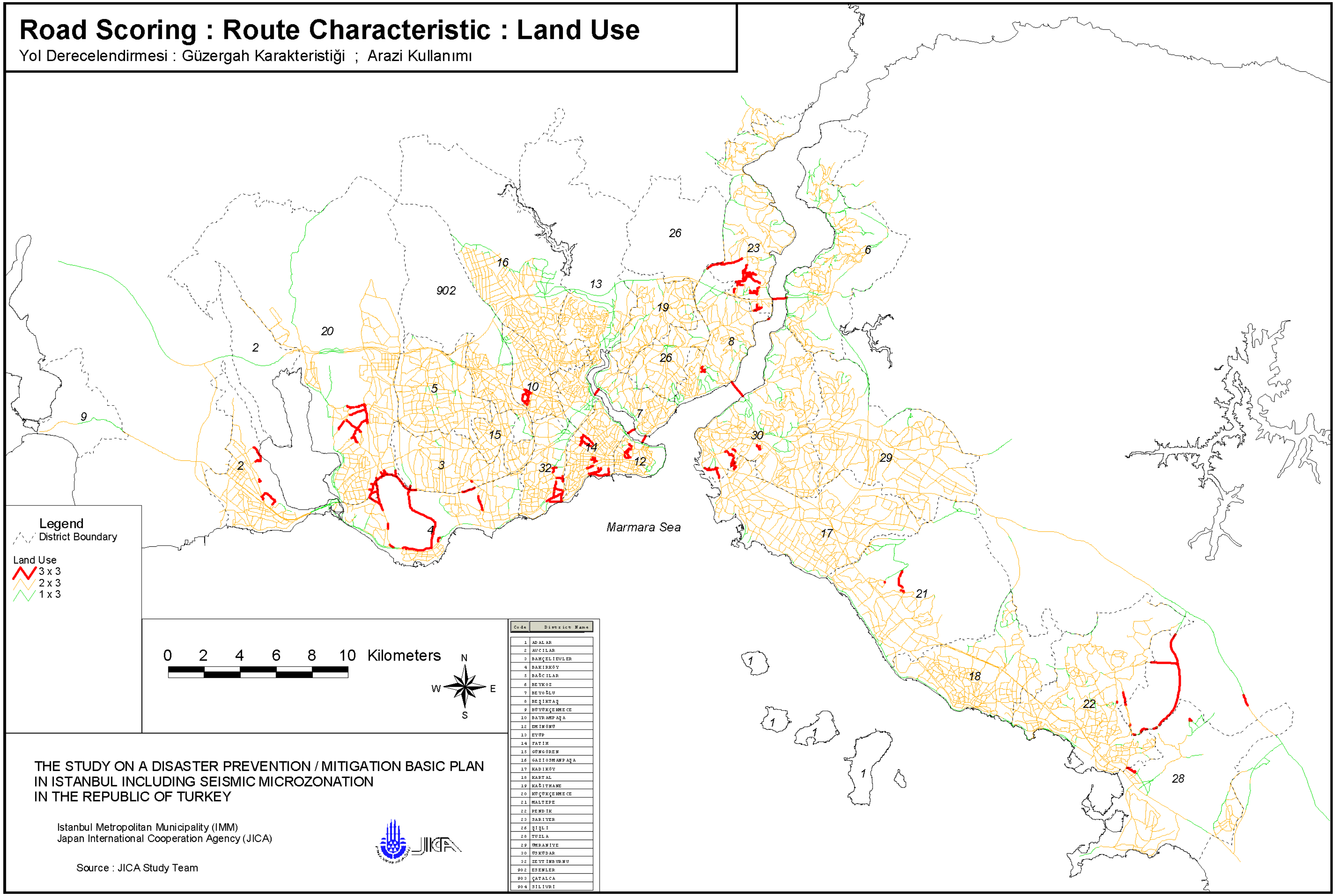


Figure 9.6.9 Road Scoring : Traffic Characteristic : Direction



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 9.6.10 Road Scoring : Route Characteristic : Land Use

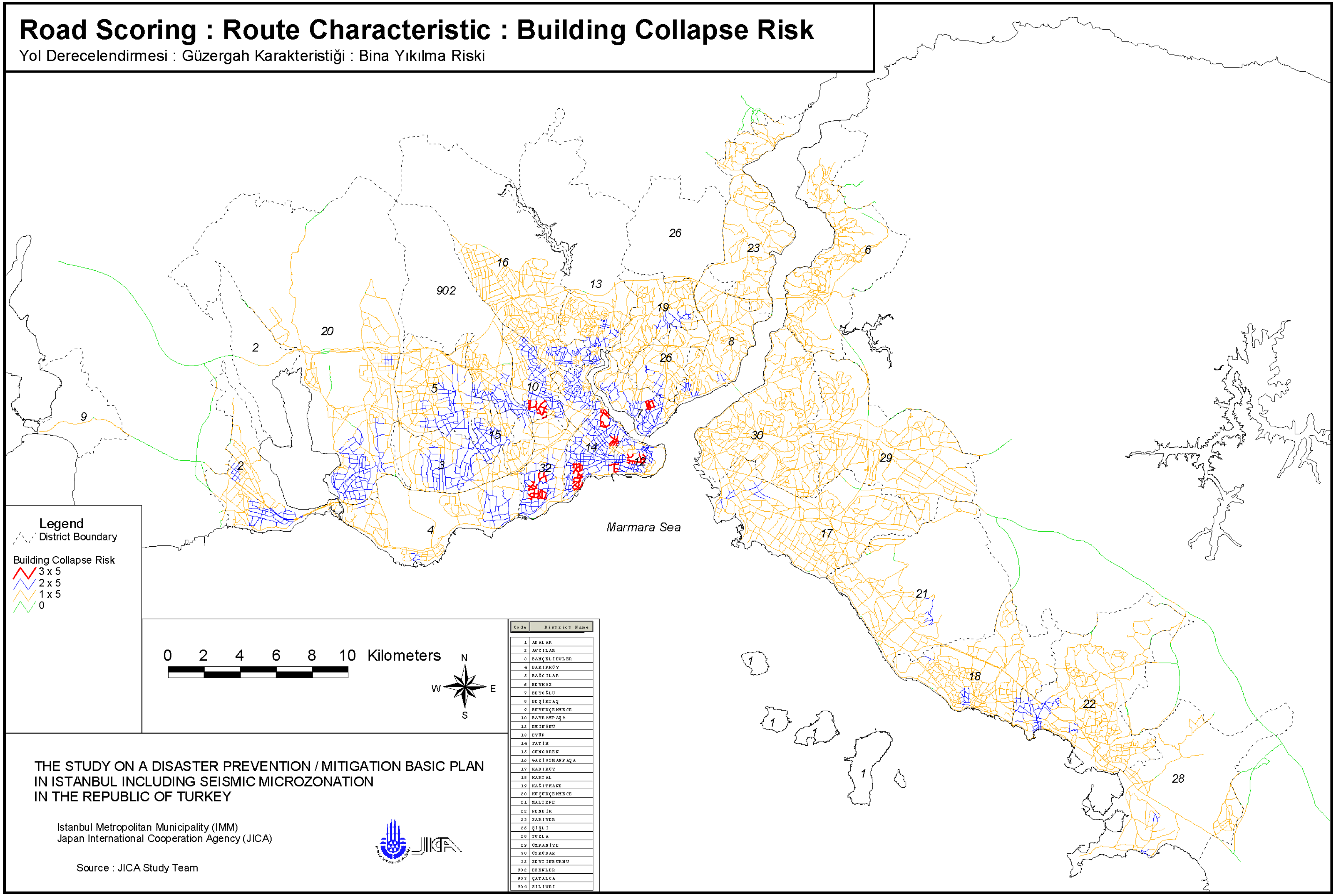


Figure 9.6.11 Road Scoring : Route Characteristic : Building Collapse Risk

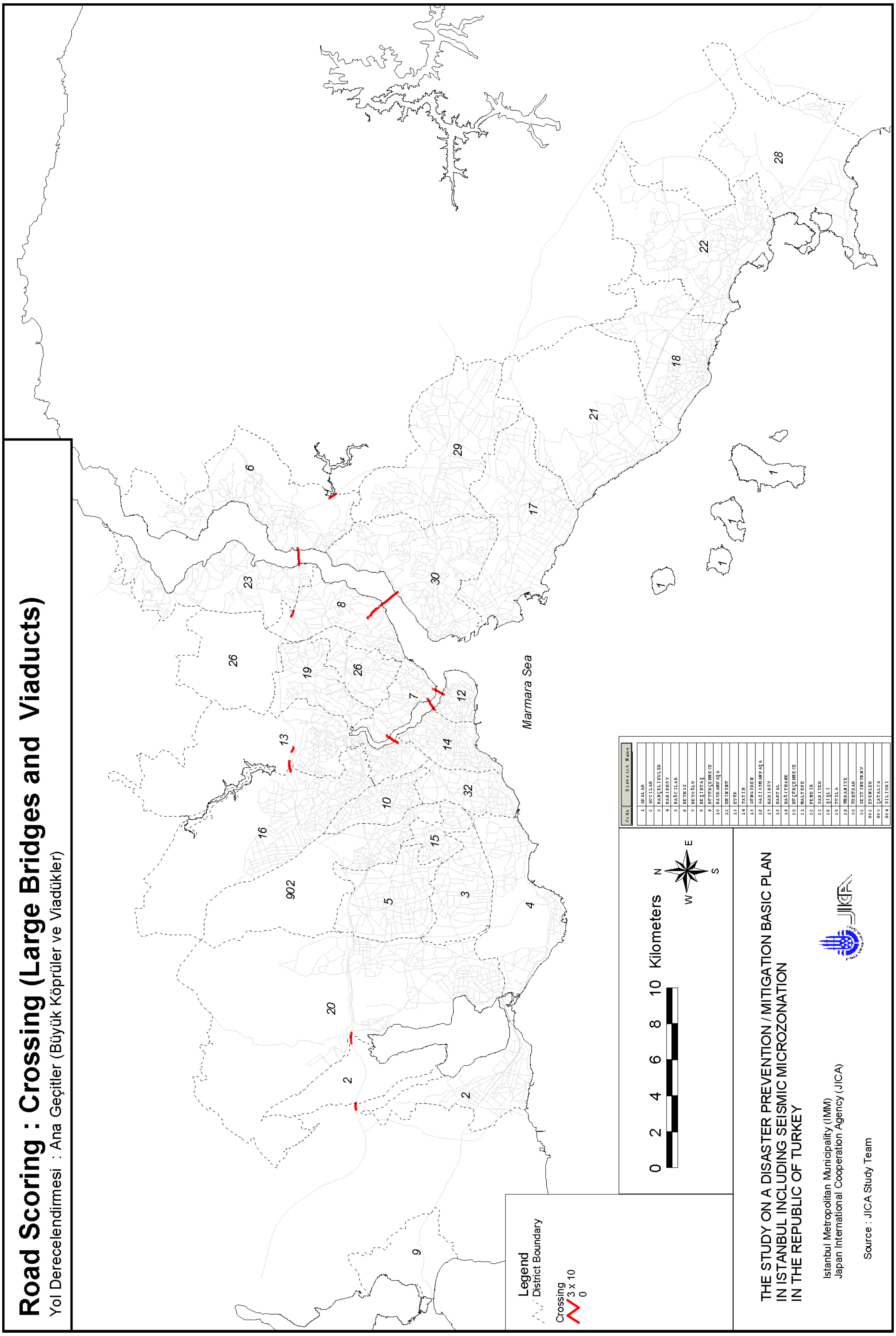


Figure 9.6.12 Road Scoring : Crossing (Large Bridges and Viaducts)

Table 9.6.1 Points in Evaluation and Coefficient Factor Weights

Factor			Points in Evaluation □j	Weight Coefficient □j
Factor on Disaster Prevention	Route Division	Type-1	3	10
		Type-2	2	
		Type-3	1	
		Type-4	0.5	
	Connection		2	5
Factor on Traffic Characteristic	Volume Type	Highway	3	4
		□st Degree Road □Highway is Excluded□	2	
		□st Degree Road	1.5	
		Collector Road	1	
	Direction	Main Loop Road	3	3
		Main Radial Road	2	
		□st Degree Road Except the Above-Mentioned	1	
		□st Degree Road	0.5	
		Others	0	
Factor on Route Characteristic	Land Use	Public Facility	3	3
		Transportation Facility		
		Residential Area	2	
		Industry		
		Park	1	
		Others		
	Building Collapse Risk	200□500	3	5
		100□200	2	
		50□100		
		20□50	1	
		1□20		
		0	0	
Crossing Such as the Main Rivers		Section where the Main River is Crossed	3	10
		Excluding the Above-Mentioned	0	
Total				40

Evaluation Result

Shown in Figure 9.6.13 and

Figure 9.6.14 are the results of analyses carried out under the above conditions. A score for the importance of each route and section has been calculated using the previously introduced formula, and Figure 9.6.13 shows the road distances at 10~100 points and accumulation frequency of distance. The importance in routes and sections is as shown in

Figure 9.6.14. The importance has been set up based on the score of importance, $I_{A,}$ of the main loop and radial lines and the distribution of I_A.

As a result of the evaluation of the importance of routes and sections based on their individual attributes, the main loop and main radial lines, both of which are highways, and the routes that connect with them have been extracted as the most important routes and sections. As secondarily important, the routes forming the rural traffic network have been extracted.

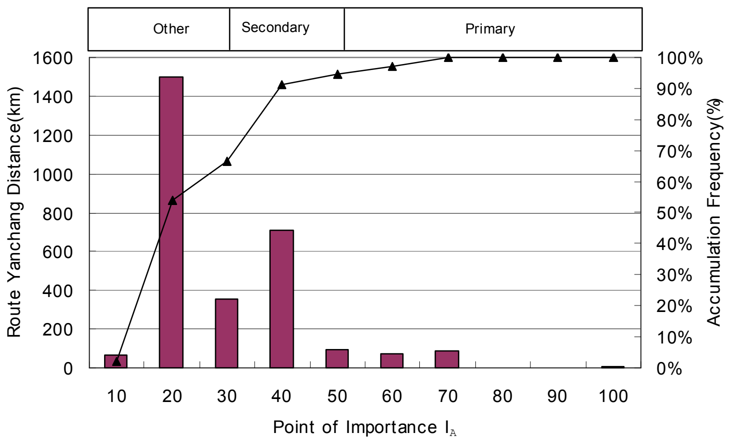


Figure 9.6.13 Point Distribution of Importance I_A in Route and Section Based on Attribute

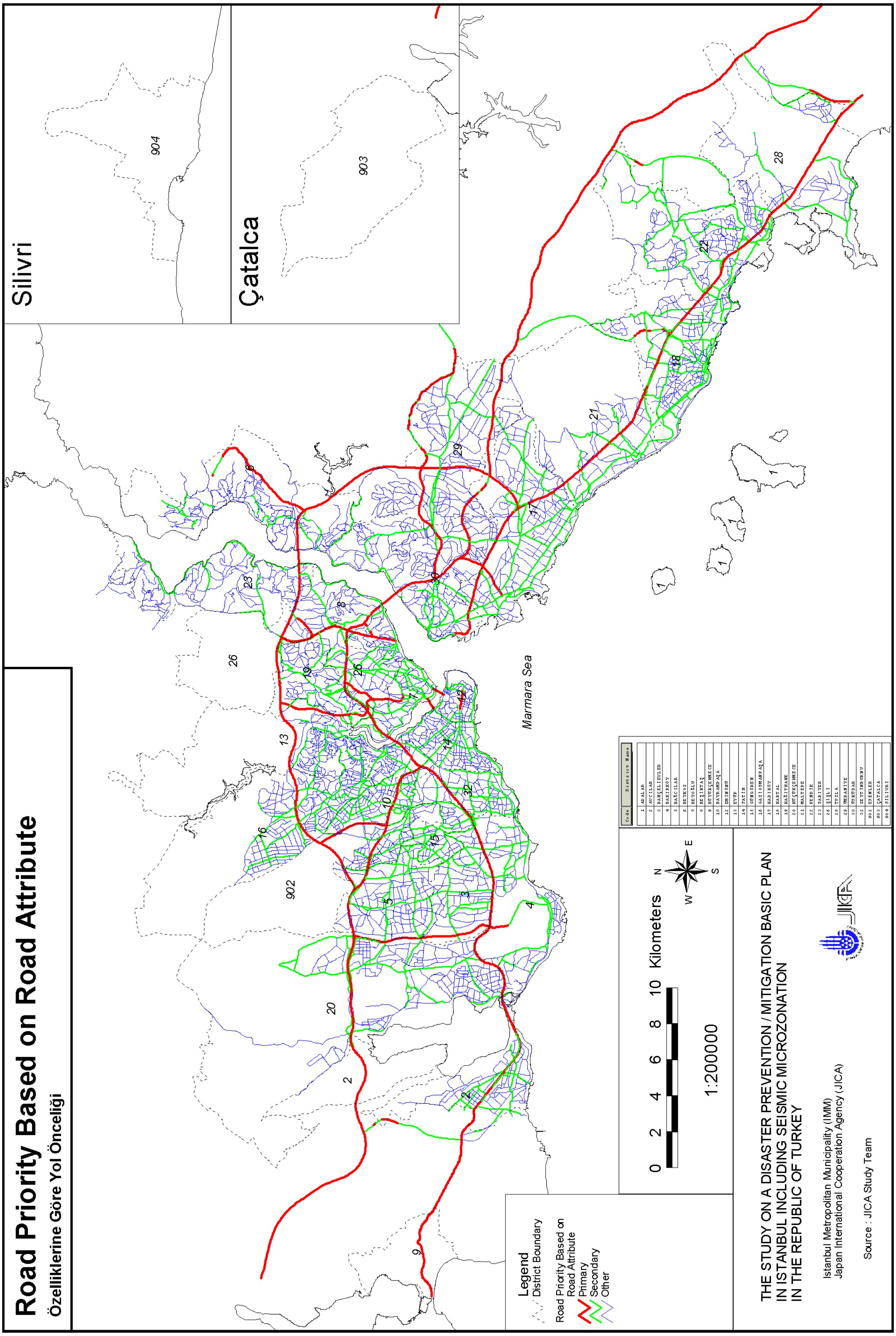


Figure 9.6.14 Road Priority Based on Road Attribute

b. Importance Evaluation Based on Road Network Characteristics

Importance based on road network characteristics should be evaluated at several stages including immediately after the earthquake, during the period of information gathering and rescue, and also during emergency restoration. To help see the road network from a broad perspective, factors to be taken into consideration in implementing the evaluation are current road utilisation, direction and volume of traffic, and characteristics of traffic and roadsides. Among the stages after an earthquake, the escape of refugees just after an earthquake is considered primarily as individuals' moving actions, and theirtrip lengths are generally short. Therefore, it is thought inappropriate to evaluate the function of road network immediately after an earthquake. From this point of view, the evaluation based on road network characteristics after an earthquake is implemented only for the stages of information gathering and rescue, as well as for the stage of emergency restoration.

Evaluation Method

The following evaluation method has been employed:

At any stage, certainty, meaning that traffic allows people to reach their desired destination within a prescribed time, is considered to be most important. In this respect, to begin with, the number of routes passed when one, taking the shortest possible route, moves between selected important facilities is counted, and frequency of utilisation of each route is evaluated. Then, the particularly noticeable routes and sections are extracted based on trends of utilisation frequency, and the same evaluation as above is carried out for cases when bridges on these routes cannot be used. From the results of these two evaluations, the comparative importance of the road networks are evaluated and classified as three grades.

I_N, the importance of the road network, is determined from the evaluation matrix shown in Table 9.6.2 which is prepared based on the results of the importance evaluation of each route and section during the stages of information gathering, rescue, and emergency restoration. The important facilities selected for use in the network analysis are listed in Table 9.6.3,

Figure 9.6.15 and

Figure 9.6.16. Among them, the facilities selected as the important ones during the periods of information gathering and rescue are shown in (1) in Table 9.6.3, and their locations in

Figure 9.6.15. The important facilities selected for the evaluation at the stage of emergency restoration are shown in (1) and (2) of Table 9.6.3 and their locations in

Figure 9.6.16.

Table 9.6.2 Evaluation Matrix of Importance Based on Road Network

		Emergency Restoration		
		Largeness	Inside	Smallness
Information Gathering – Rescue	Largeness	Primary		
	Inside		Secondary	
	Smallness			Other

Table 9.6.3 Facilities Targeted by Road Network Analysis

(1)Facilities of Rescue Period	Number of Point
Crisis Centers	4
IBB	1
District Municipality, Kaymakamılık	60
District Disaster Management Center	29
Airport	4
Ports	5
TOTAL	103
(2) Facilities of Emergency Restoration Period	Number of Point
Firebrigate	44
Health Facilities (Note: Including Hospital Emergency Health Service, Health Center)	95
Military	46
IBB Relief and Response Units	18
Main Gathering Centers for Machinery	2
1. Gathering Area for District Search-Rescue Teams	15
1. Gathering Area for District Machinery	9
1. Degree Heliport Areas : Existing and Planned	200
Piers	44

SUB_TOTAL	473
Logistic Support and Coordination Centers	2
Centers for Unloading and Loading : for Sea and Land Transport	6
Centers for Vehicle Unloading and Loading : Truck Terminal	9
Centers for Unloading and Loading Supply Materials	4
Centers for Unloading and Loading Vehicle Equipment	3
Loading Heavy Machinery	5
SUB_TOTAL	29

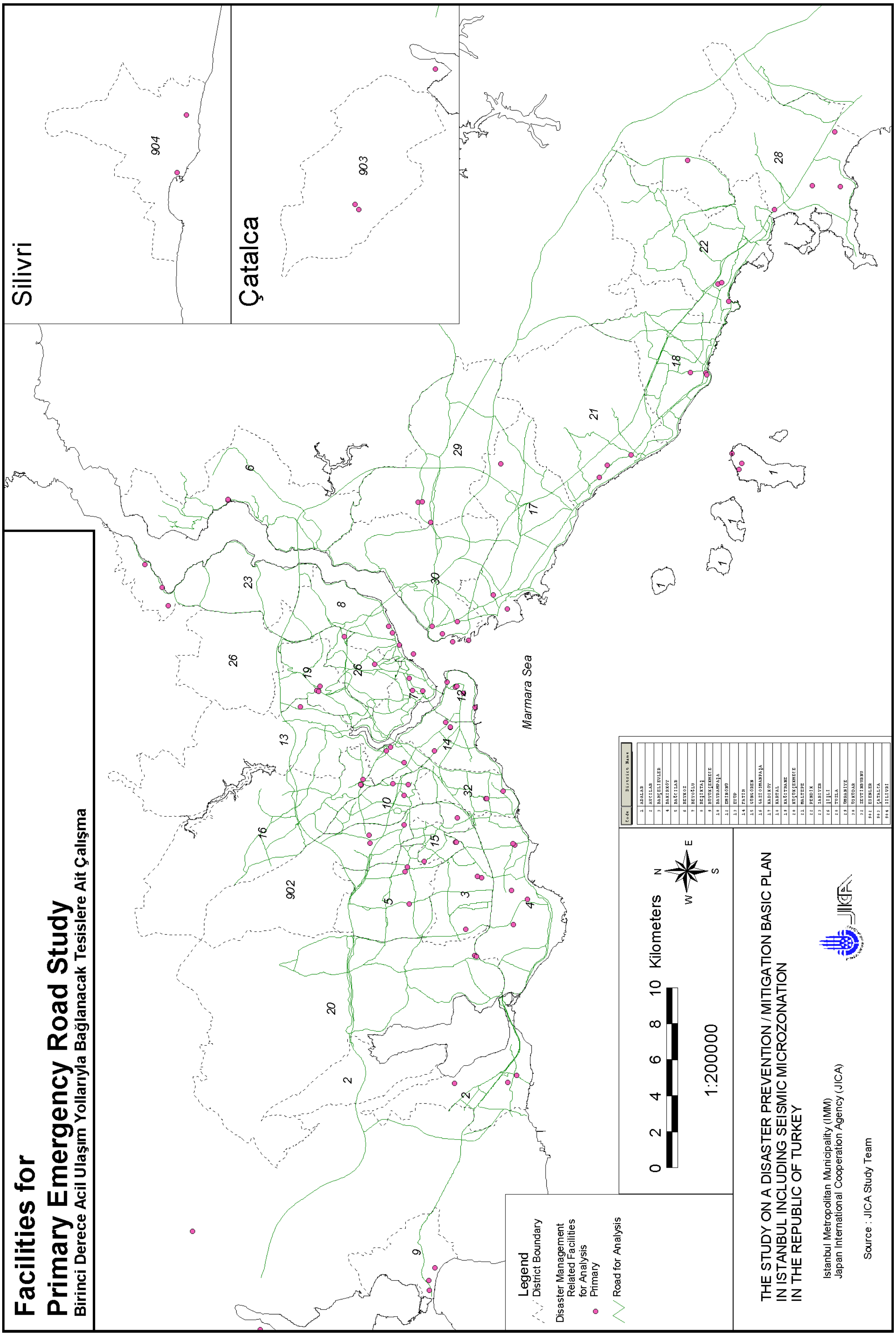


Figure 9.6.15 Facilities for Primary Emergency Road Study

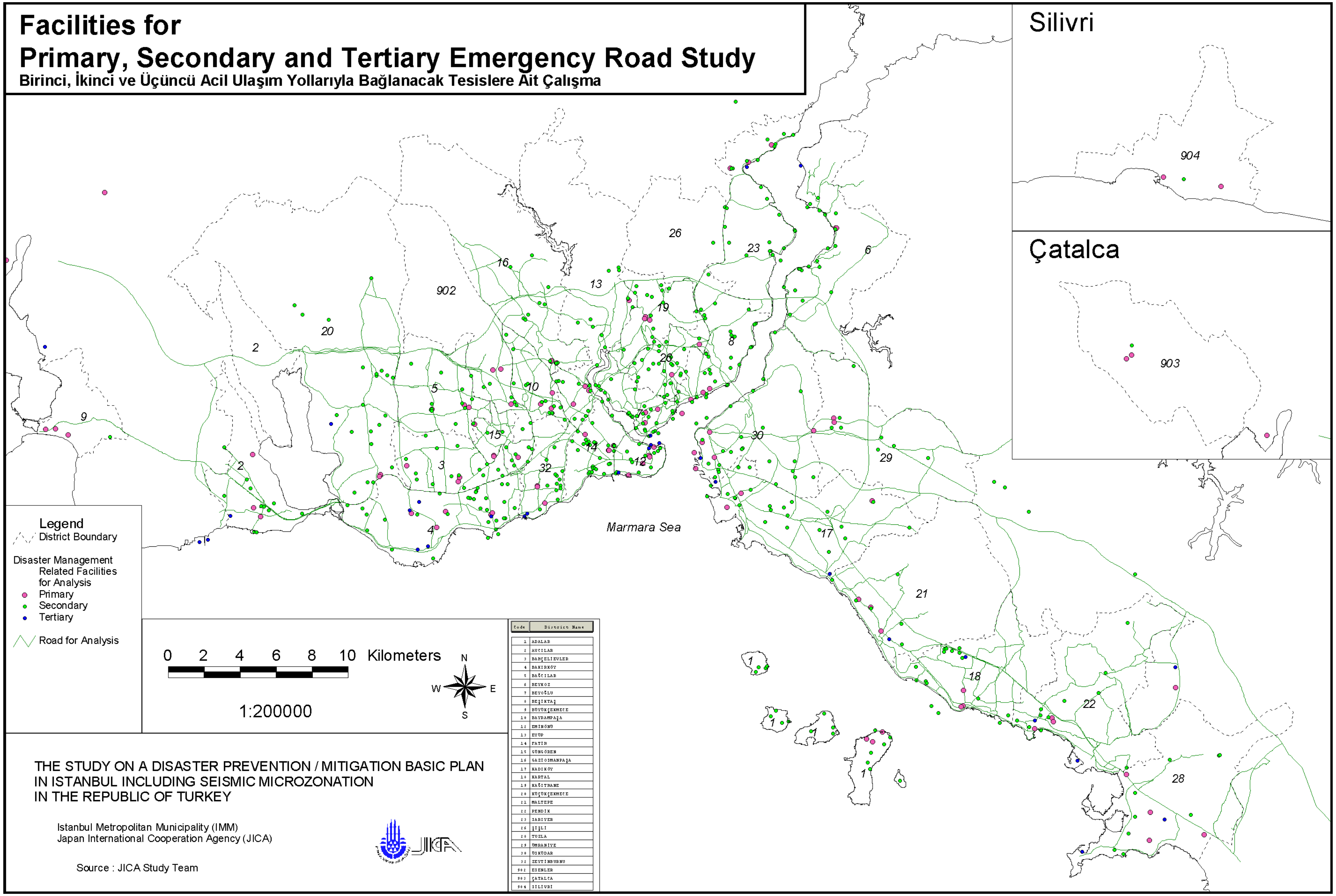


Figure 9.6.16 Facilities for Primary, Secondary and Tertiary Emergency Road Study

Evaluation Result

In the road network analysis, the same routes and sections as examined in the importance evaluation based on attributes were selected, and a network consisting of about 1,300 nodes was studied.

Figure 9.6.17 shows the network used for the analysis. Among these nodes, the important facilities shown in Table 9.6.3,

Figure 9.6.15 and

Figure 9.6.16 were selected as the starting points and destinations of the traffics. Ttraffic volume from all the facilities were presumed to be the same, and traffic speeds were set as shown below according to the road specifications and/or widths:

- Highway: 80km/h
- Breadth, 16m or wider: 40km/h
- Breadth, 7m~15m: 30km/h
- Breadth other than the above: 20km/h

The analysis result is explained in the following:

Information gathering period – rescue period

Figure 9.6.18 shows the model of network analysis for the information gathering and rescue stages. The heaviest traffic resulted in southern areas of the main loop (D100 to O-1). Namely, it can be said that the routes and sections to be extensively studied were those from the Golden Horn Inlet area to the No.1 Bosporus Bridge area. Therefore, as a next step, a network analysis was carried out on assuming that the bridge spanning the Golden Horn Inlet and the bridge on the European side, which is connected with the No.1 Bosporus Bridge, could not be used.

Figure 9.6.19 shows the network analysis model for the case when routes and sections are to be extensivelystudied, and the two bridges mentioned above cannot be traversed. According to the analysis result, in the case when the two bridges cannot be traversed, the traffic flow would move to the loop line to the north (O-2) and, at the same time, traffic on the radial lines connecting the southern and northern loop lines would increase.

Figure 9.6.20 shows the result of superimposing

Figure 9.6.18 and

Figure 9.6.19.

Emergency restoration period

Figure 9.6.21 shows the network analysis model for the emergency restoration stage. When compared with the results of the above analysis, in general, higher passing counts and longer sections with high counts are seen because of the increased number of selected facilities spread out over a wider area. However, the routes and sections having the heaviest traffic in this analysis extend from the Golden Horn Inlet area to the No.1 Bosporus Bridge area on the loop line in the southern area (D100 to O-1), which is the same section as resulting in the above analysis. Then, a network analysis was implemented, in the same manner as applied to the above analysis; that is, assuming that the bridge spanning Golden Horn Inlet and the bridge on the European side connected to the No.1 Bosporus Bridge, could not be traversed. The analysis result shown in

Figure 9.6.22 indicates the same trend of traffic flow as shown in the result of the above analysis; that is, because Route O-1, which spans the Golden Horn Inlet, cannot be traversed, the traffic passes onto the loop line in the north (O-2) via main radial lines before and after the bridge become main stream.

Figure 9.6.23 is the result of superimposing of

Figure 9.6.21 and

Figure 9.6.22.

Figure 9.6.24 illustrates I_N, which expresses the importance based on the network characteristics and is obtained through the integrated evaluation of the results of the two analyses utilising the evaluation matrix shown in Table 9.6.2. This result indicates a tendency for the importance of main loop lines and main radial lines connected to them to become relatively high..

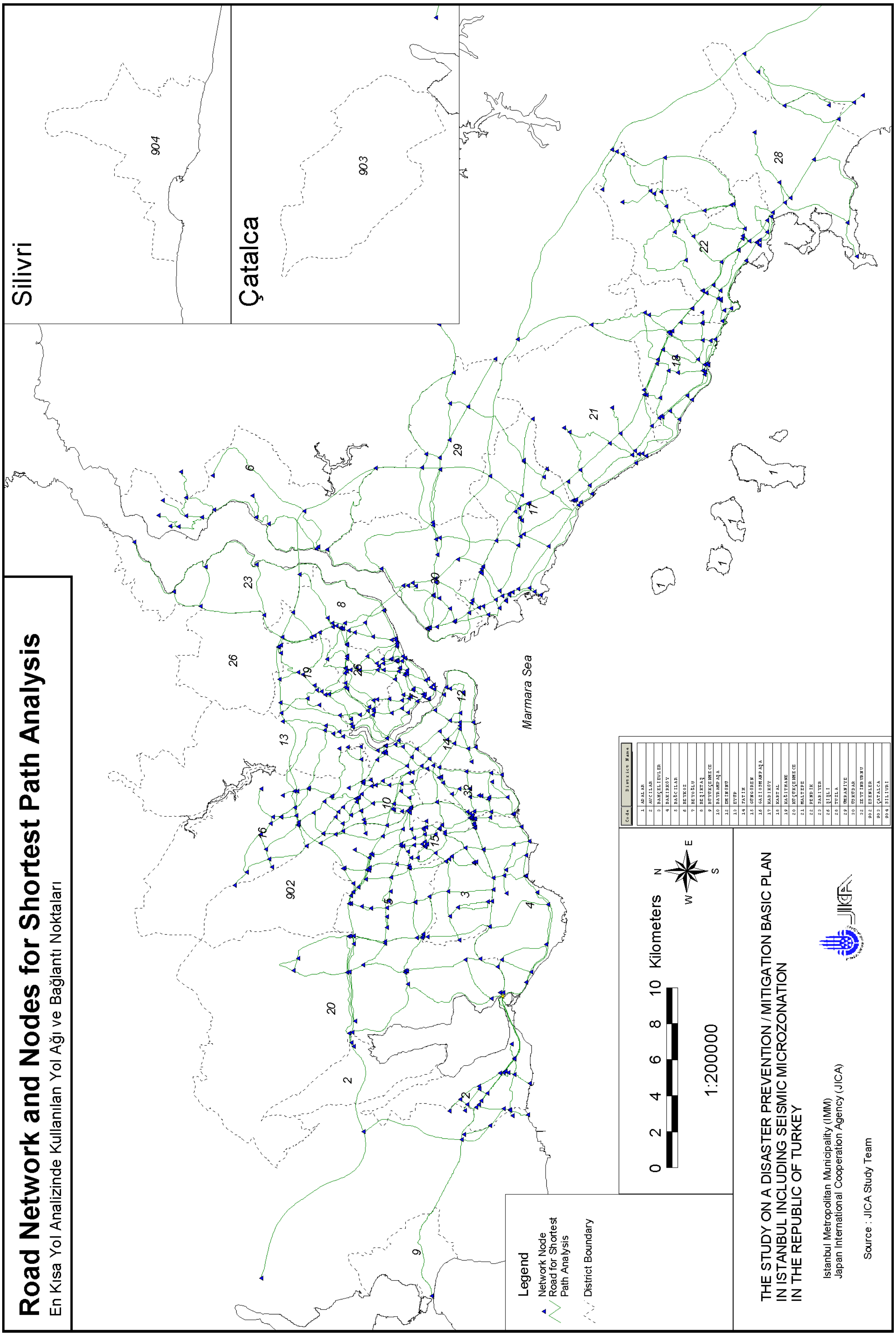


Figure 9.6.17 Road Network and Nodes for Shortest Path Analysis

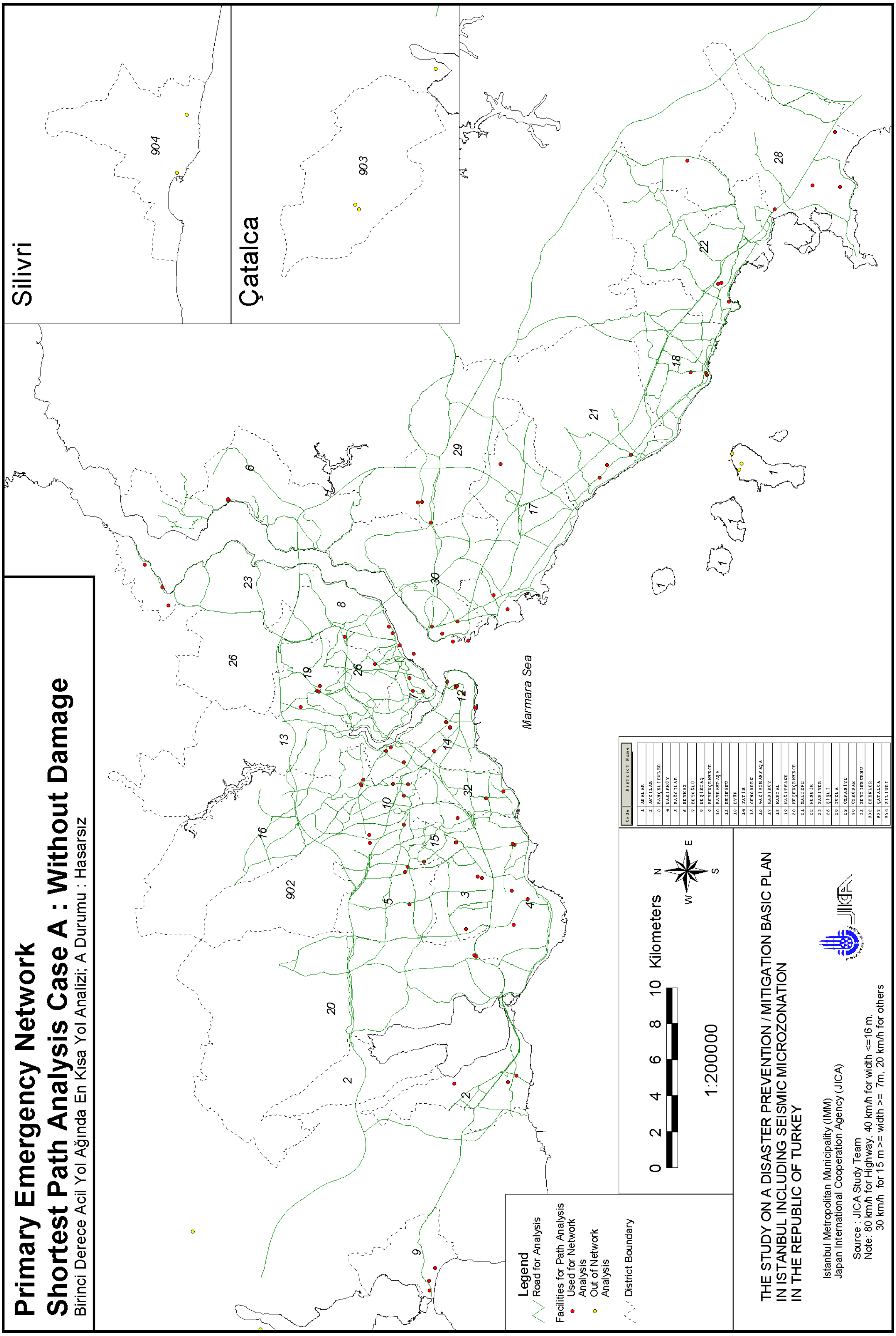


Figure 9.6.18 Primary Emergency Network Shortest Path Analysis Case A : Without Damage

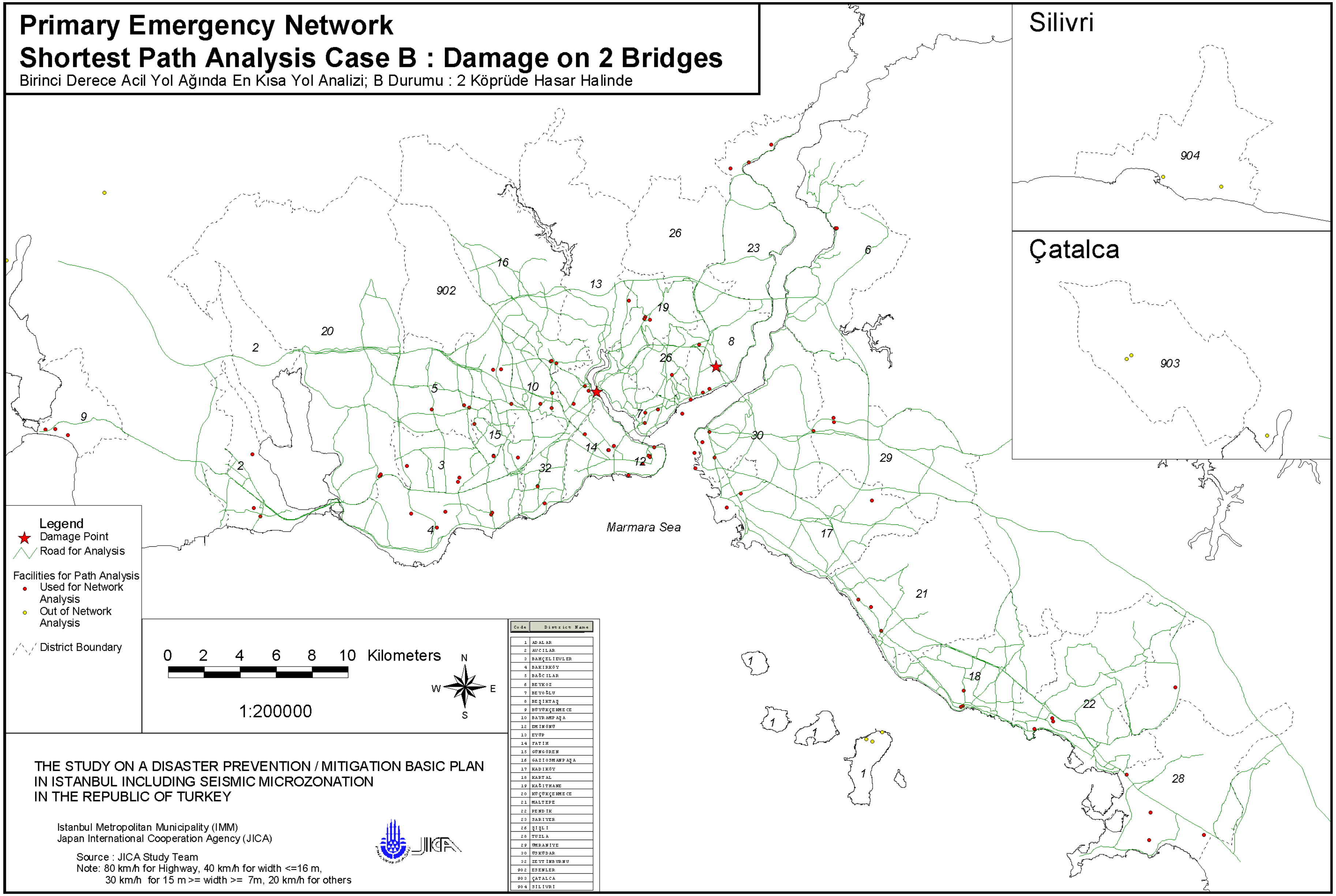


Figure 9.6.19 Primary Emergency Network Shortest Path Analysis Case B : Damage on 2 Bridges

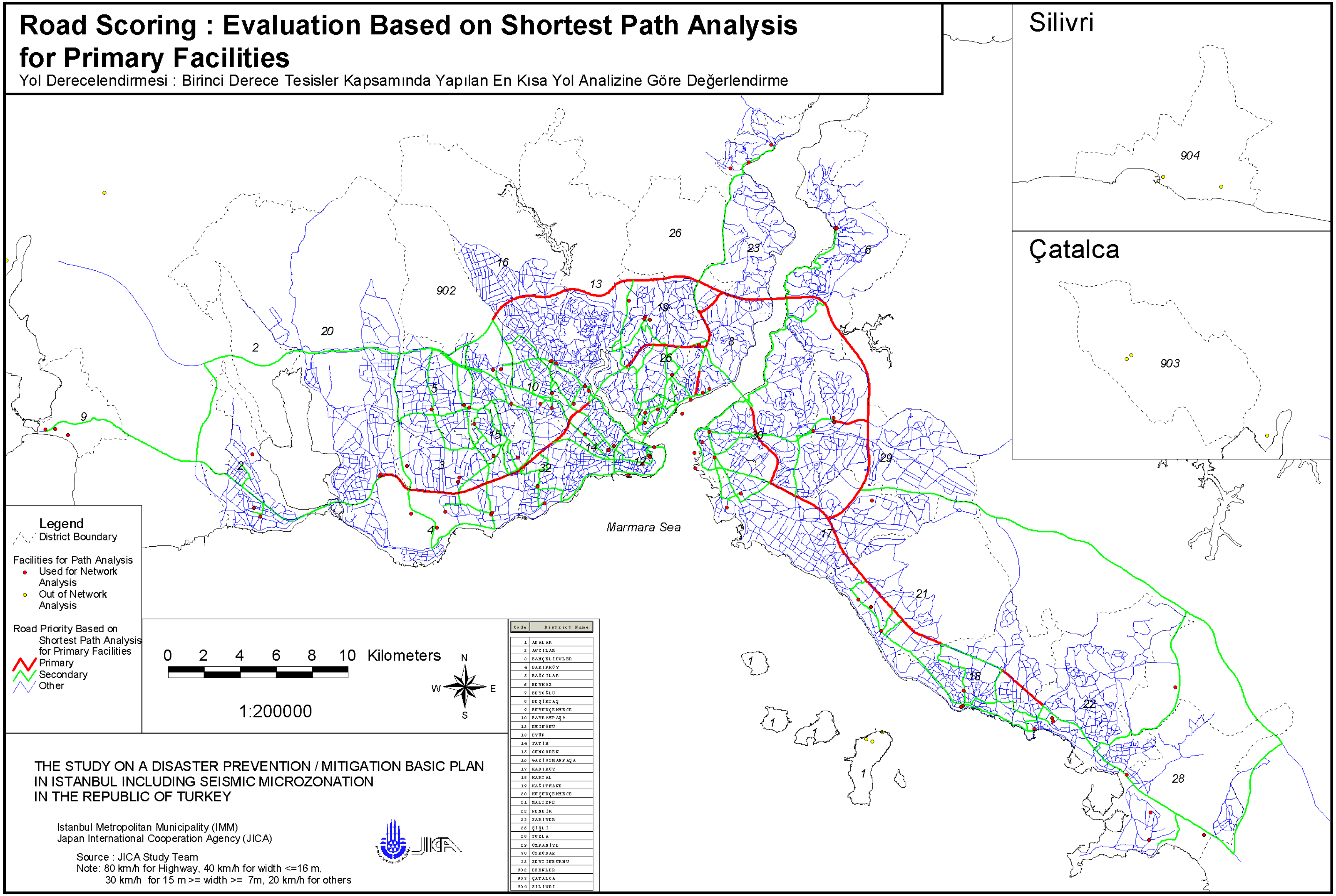


Figure 9.6.20 Road Scoring : Evaluation Based on Shortest Path Analysis for Primary Facilities

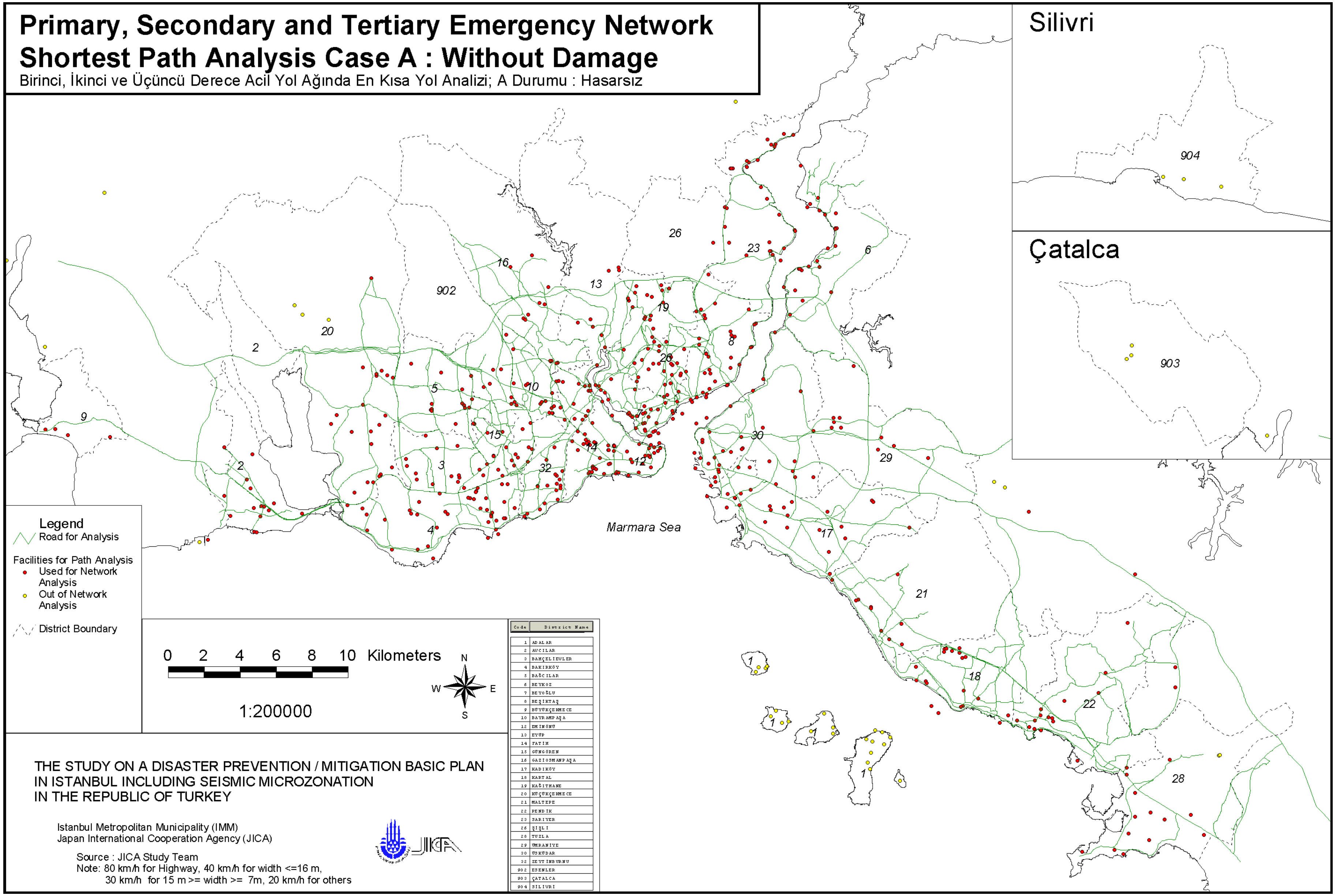


Figure 9.6.21 Primary, Secondary and Tertiary Emergency Network Shortest Path Analysis Case A : Without Damage

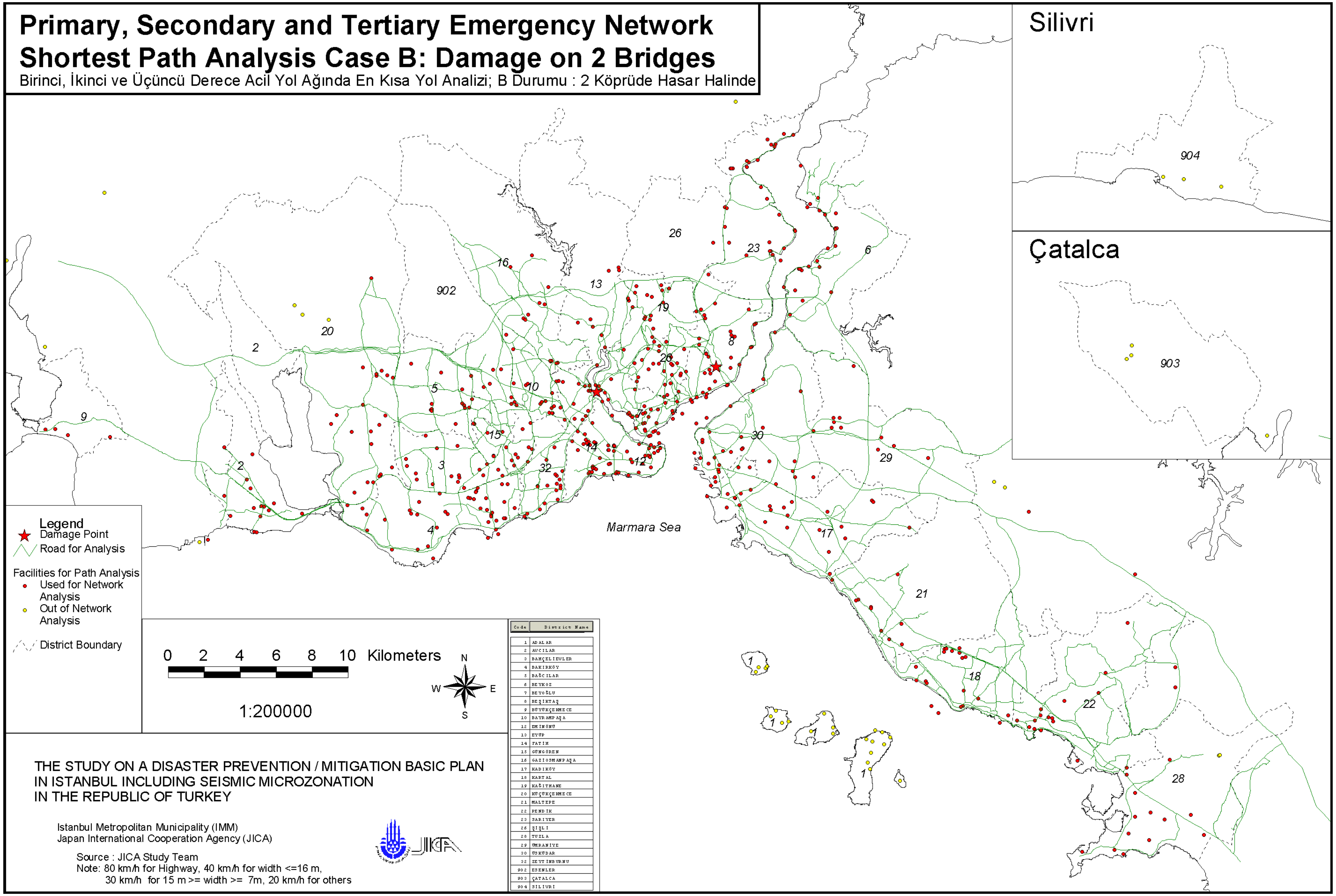


Figure 9.6.22 Primary, Secondary and Tertiary Emergency Network Shortest Path Analysis Case B: Damage on 2 Bridges

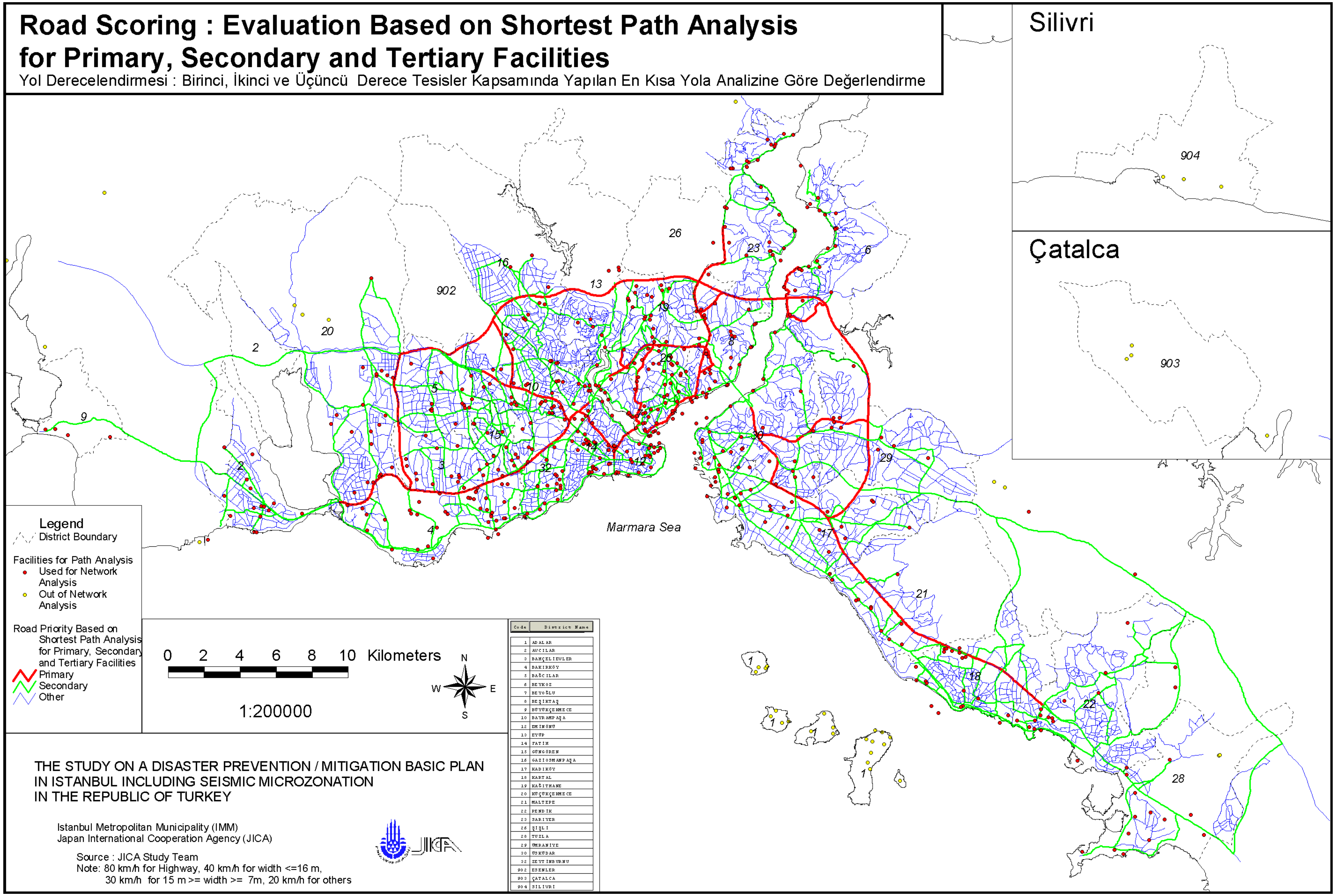


Figure 9.6.23 Road Scoring : Evaluation Based on Shortest Path Analysis for Primary, Secondary and Tertiary Facilities

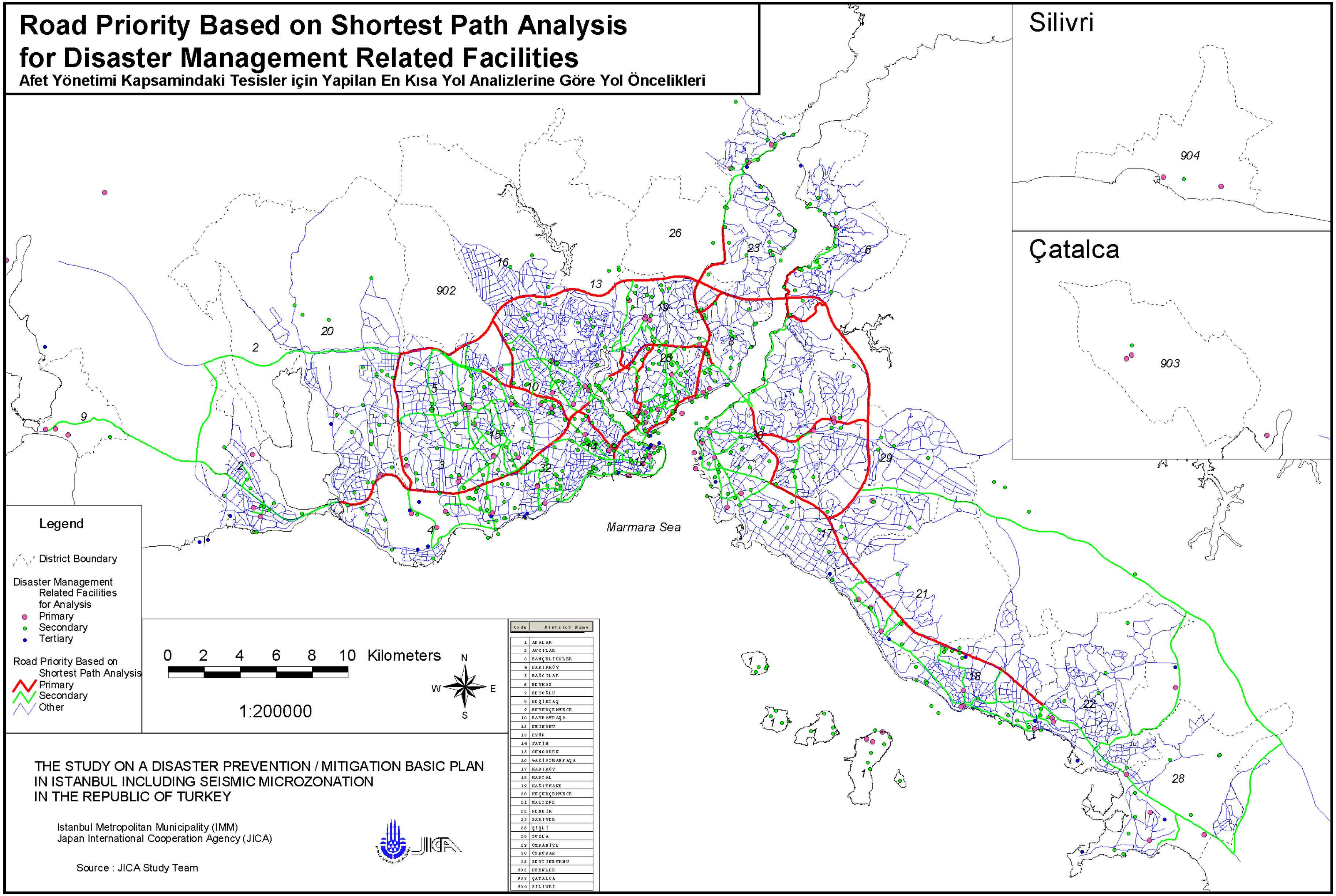


Figure 9.6.24 Road Priority Based on Shortest Path Analysis for Disaster Management Related Facilities

c. Importance Evaluation in Route and Section

IM, the integrated importance of routes and sections, is determined by applying the evaluation matrix shown in Table 9.6.4 to IA, the importance evaluation of routes and sections based on attributes, and to IN, the evaluation of routes and sections based on network characteristics. Based on the evaluation result, routes and sections are categorised as 3 classes: “most important,” “important,” and “general.”

Figure 9.6.25 shows the result of the importance evaluation of routes and sections based on such an evaluation matrix. Routes and sections of the roads in the surveyed area are categorised according to their importance as shown in

Figure 9.6.25. The result of the evaluation seems to be practical and reasonable: main loop lines, which are national traffic axes, and main radial lines connected to the loops are particularly important routes and sections. Thus, the most effective reinforcement and maintenance measures to protect roads from earthquake disasters become apparent by establishing a prioritisation order of the measures to protect bridges from earthquake disasters and road maintenance efforts. This order is based on the importance evaluation results of routes and sections.

Table 9.6.4 Evaluation Matrix of Importance of Route and Section

		Importance Based on Network Characteristic I_N		
		Very Important	Important	Relatively Important
Importance Based on Attribute I_A	Very Important	Primary		
	Important		Secondary	
	Relatively Important			Other

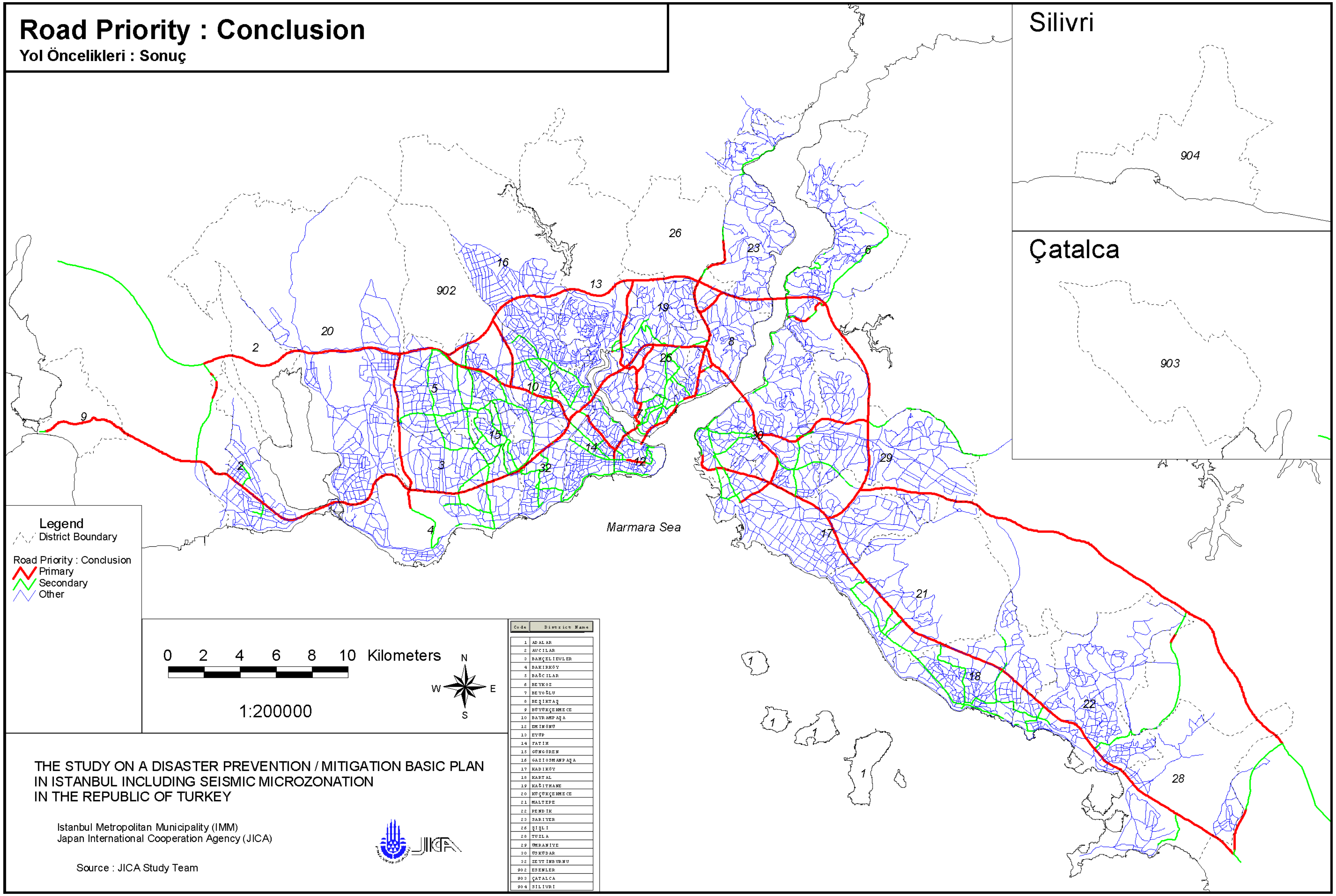


Figure 9.6.25 Road Priority : Conclusion

(2) Impact Evaluation of Bridge Collapse

Evaluation Method

In regard to the earthquake resistance of bridges, two types of bridges were extracted in section 9.5 Bridges as those that should be subject to earthquake-proof measures: 1) "bridges which will possibly collapse" and 2) "bridges built on alluvium having PGA >= 300g and piers longer than 10m."In this regard, to begin with, the prioritisation of earthquake-proof measures for these two types of bridges is evaluated. Then, the impact when the bridges are damaged is evaluated.

The extent of the impact when a bridge is damaged is evaluated by the extended influence caused by its collapse and/or the significantly damaged substructure of the bridge. The factors taken into consideration are whether there are long or large bridges on the main road and how the sites under the bridges are utilised. In this regard, the extent of the impact due to the bridge's damage, as well as the importance of the relevant routes and sections, are taken into consideration. The score for these factors are shown in section 9.5 Bridges, which have been extracted as the ones that require earthquake-proof measures, and the strength of the impact of a bridge collapse is expressed by the total sum of the products obtained by multiplying these scores, or points, by the weight coefficients. Namely, E, the impact of a bridge collapse, is expressed by the following formula:

$$E = \sum_{k=1}^{m} \sigma_k \cdot Y_k$$

E: The Bridge is an Impact when Struck

σ_k: Weight Coefficient of Factor k

Y_k: Points in Evaluation of Factor k

The higher the value of E, the larger the impact caused by a bridge's collapse. In evaluating its degree or extent, the impact is categorised into 3 groups, "extremely large," "large" and "general," referring to the histogram of the points E as shown in Table 9.6.5.

Shown in Table 9.6.6 are the factors, their total scores, or points, and the weight coefficients for individual factors used in the calculation of Impact E.

Table 9.6.5 Importance evaluation matrix on earthquake disaster prevention of bridge

		Importance of Earthquake-Proof Measures		
		Very Important	Important	Relatively Important
Impact when struck	Extremely Large	Very Important		
	Large		Important	
	General			Relatively Important

Table 9.6.6 Factor of Impact and Weight of Points in Evaluation

Factor			Points in Evaluation Xj	Weight Coefficient Wj
Type of Road Bridge	Long Bridge on Main Line	The importance in the route and the section is the most important.	3	10
		The importance in the route and the section is important.	2	
		The importance in the route and the section is general.	1	
		Others	0.5	
Railway Bridge	Long Bridge on Main Line	Traveler Line	2	10
Type Under Bridge	Road	The importance in the route and the section is the most important.	3	5
		The importance in the route and the section is important.	2	
		The importance in the route and the section is general.	1	
		Others	0.5	
	Railway		2	

Evaluation Result

Priority Evaluation based on Necessity of Earthquake-Proof Measures

Table 9.6.7 and Table 9.6.8 show the prioritisation evaluation matrixcs based on the need for earthquake-proof measures for " bridges which will possibly collapse" and "bridges built on alluvium having PGA >= 300g and piers longer than 10m." The figures in Table 9.6.7 are the number of bridges studied. There are 4 bridges having first priority with regards to need for earthquake-proof measures, 17 bridges with second priority, and 6 bridges with third priority..

Table 9.6.7 Priority based on Necessityof Earthquake-Proof measures

Table 9.3.7 Priority based on Necessity of Earthquake-Proof measures

		Judge1-1 ;Dropping Bridges		
		1	2	3
Judge1-2 ; Pier	1	4	2	2
	2	0	0	37
	3	15	4	Rest of Bridges

Impact Evaluation of Bridge Collaps

Figure 9.6.26 is a histogram showing the resulting impact whenbridges suffer earthquake damage. The degree of impact are grouped into 3 classes, "extremely large," "large" and "general," which are also shown in Figure 9.6.26.

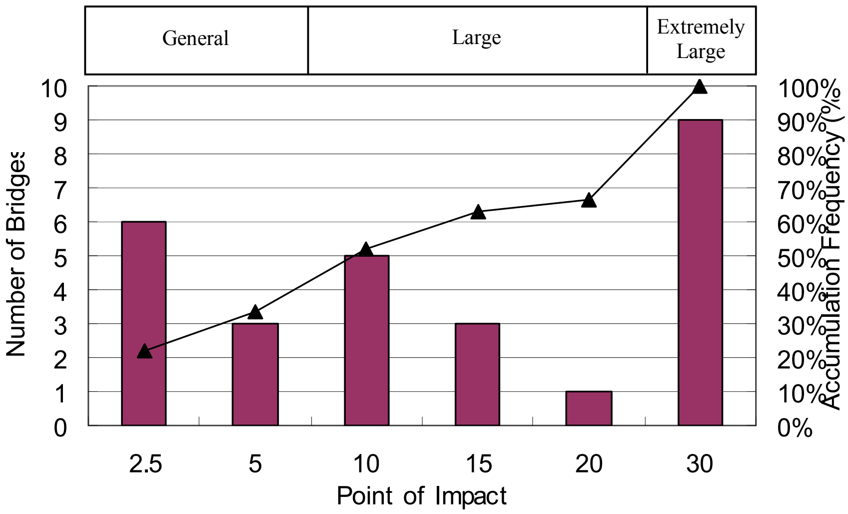


Figure 9.6.26 Distribution of Point of Impact by Bridge Collapse

Table 9.6.8 Earthquake-Proof Evaluation and Priority Evaluation of Bridges

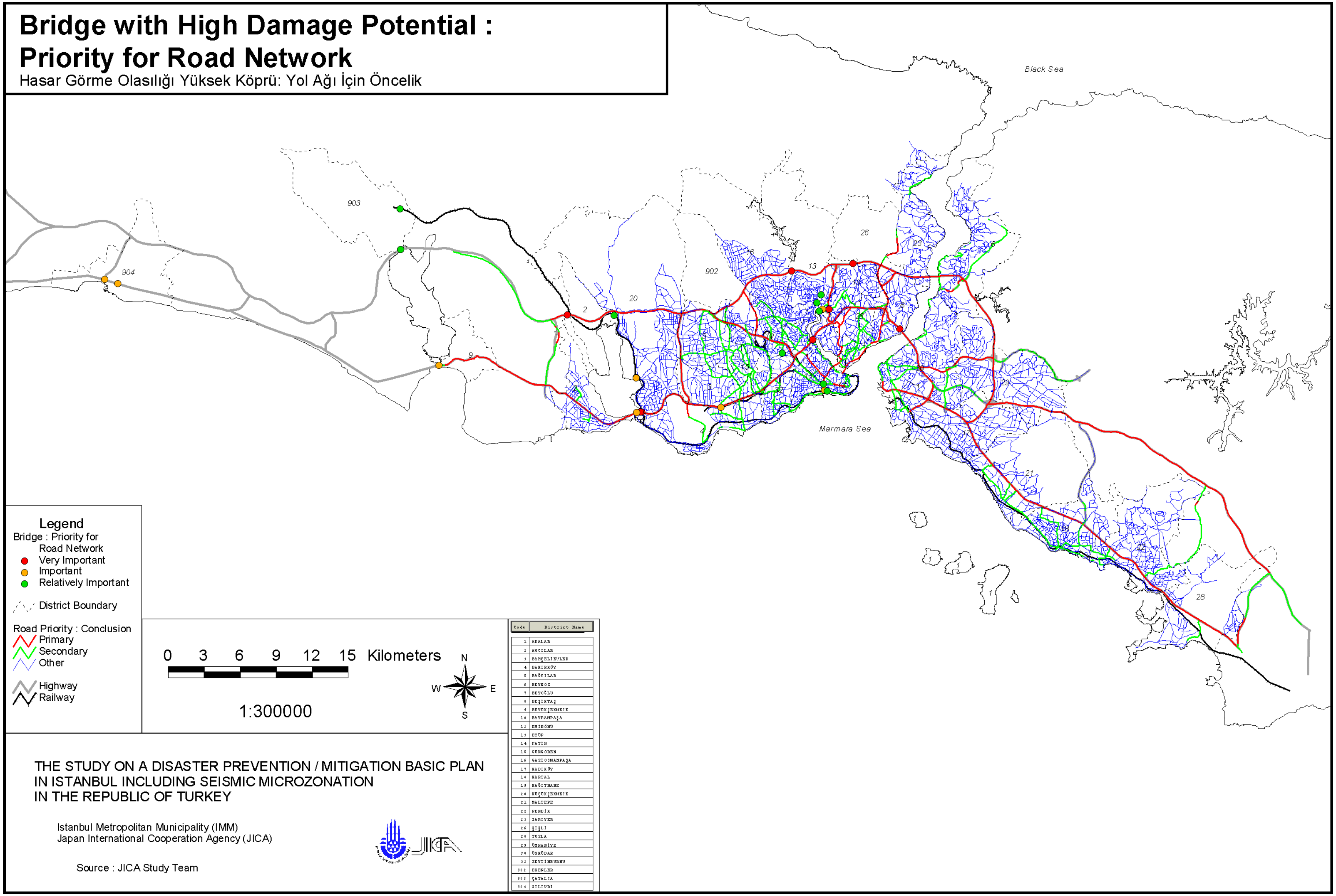
ID	BRIDGE_NO	Dropping Bridges			Pier			Earthquake-Proof	Impact of collapse		Priority
		Evaluation_A	Evaluation_C	Judge1-1	10m or more	PGA_GAL_model_C	Judge1-2	Judge1	Score	Judge2	
94	1	B	B	2	1	333.5	1	2	30	1	1
223	52	A	A	1	1	480.1	1	1	30	1	1
103	55	B	B	2	1	325.1	1	2	30	1	1
95	57	A	A	1	1	456.4	1	1	30	1	1
89	58	A	A	1	1	473.6	1	1	30	1	1
88	89	A	A	1	0	475.5	3	2	20	2	2
143	188	A	A	1	1	479.3	1	1	30	1	1
157	190	A	A	1	0	326.9	3	2	2.5	3	3
114	191	A	A	1	0	352	3	2	5	3	3
262	AK3	C	A	2	0	473.2	3	3	2.5	3	3
264	AK4	C	A	2	0	471.4	3	3	2.5	3	3
265	AK5	A	A	1	0	476.1	3	2	2.5	3	3
308	MT110	A	A	1	0	329.2	3	2	15	2	2
310	MT112	A	A	1	0	328.4	3	2	15	2	2
349	MT86	A	A	1	0	476	3	2	30	1	1
350	MT87	A	A	1	0	476	3	2	30	1	1
351	MT88	A	A	1	0	476	3	2	15	2	2
355	MT94	A	A	1	0	419.4	3	2	30	1	1
380	T28A	A	A	1	0	413.2	3	2	10	2	2
381	T28B	A	A	1	0	413.2	3	2	10	2	2
384	T30	B	B	2	0	479.5	3	3	2.5	3	3
386	T33	A	A	1	0	302.6	3	2	2.5	3	3
388	T4	A	A	1	0	402.4	3	2	5	3	3
389	T5	A	A	1	0	493.8	3	2	10	2	2
434	UAS17	C	B	2	0	470.4	3	3	10	2	3
279	M1-3-A	C	C	3	1	307.6	1	3	10	2	3
455	YIM5	C	C	3	1	379.9	1	3	5	3	3

Then, the results of the prioritisation evaluation based on the need for earthquake-proof measures and the impact when bridges are damaged are evaluated by means of the matrices shown in Table 9.6.9 and

Figure 9.6.27. The bridges classified as having high priority for earthquake-proof measures and causing an extremely strong impact when damaged are those that are on the main loops, spanning valleys, etc.

Table 9.6.9 Importance Evaluation of Bridge

		Judge1 ; Importance of Earthquake-Proof Measures		
		Very Important	Importanct	Relatively Important
Judge2 ; Impact when Struck	Extremely Large	52, 57, 58, 188	1, 55, MT86, MT87	
	Large		89, MT110, MT112, MT88, MT94,T28A, T28B, T5	M1-3-A
	General		190, AK5, T33, T4	AK3, AK4, T30, UAS17,YIM5



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 9.6.27 Bridge with High Damage Potential : Priority for Road Network

(3) Importance Evaluation on Earthquake Disaster Prevention of Road and Bridge

As understood from the evaluation results described above, the main loop lines and main radial lines connected to them can be regarded as the most important roads in the area studied. As explained previously, these loop and radial lines are the routes that form the national traffic axes, and the evaluation results reflect the actual traffic situation in general. The routes that have been extracted as secondarily important are the roads in the modernised city that are actually functioning as primary urban traffic, and the evaluation result reflects their actual traffic situation in general, too.

The importance evaluation of roads considers earthquake disaster prevention. As described above, the evaluation results generally coincide with the forms, operations, and functions of actual roads. It is desirable, therefore, that road maintenance work and earthquake-proof during normal times and in preparing against earthquakes be proceeded with according to the prioritised order identified by the importance evaluation.

Then, the prioritised order regarding earthquake-proof measures for bridges is established from the results of the importance evaluations of road networks and bridges. Also taking into consideration the impact suffered when bridges are damaged by an earthquake, the importance of bridges needing earthquake reinforcement was evaluated and results are shown in Table 9.6.10. Roads and bridges are collectively evaluated by means of the matrix shown in Table 9.6.11, which was prepared based on the above result and the importance of routes and sections. Namely, the priority of earthquake-proof measures for bridges is decided based on this evaluation's result.

Table 9.6.10 Importance Evaluation of Bridge

Importance of Bridge	Bridge No.		Number of Bridges
	Height of Pier H>=10m	Height of Pier H<10m	
Most Importance	52, 57, 58, 188, 1, 55	MT86, MT87, MT94	9
Importance		89, MT110, MT112, MT88, T28A, T28B, T5	7
General	M1-3-A, YIM5	190, 191, AK5, T33, T4, UAS17, AK3, AK4, T30	11

Collectively shown in

Figure 9.6.28 are the evaluation result from the matrix in Table 9.6.11 and the result of the importance evaluation of road network. The highest priority regarding need for earthquake-proof measures for bridges is given when the importance of the bridge is high and that of the road is high. Table 9.6.12 shows the 5 levels of priority regarding earthquake-proof measures, and each level includes about 6 bridges. The most effective result for disaster prevention is achieved when earthquake reinforcement is systematically implemented based on this obtained priority order.

Table 9.6.11 Importance Evaluation on Earthquake Disaster Prevention

		Importance in Route and Section		
		Primary	Secondary	Other
Importance Evaluation of Bridge	Very Important	Primary		
	Important		Secondary	
	Relatively Important			Tertiary

Table 9.6.12 Priority Level of Earthquake-Proof Measures

Stage of measures	Bridge No.	Number of Bridges
1	52, 57, 58, 188	4
2	MT86, MT87, MT94, 1, 55	5
3	89, MT110, MT112, MT88, T28A, T28B, T5	7
4	190, 191, UAS17, M1-3-A, AK5, T33, T4	7
5	YIM5, AK3, AK4, T30	4

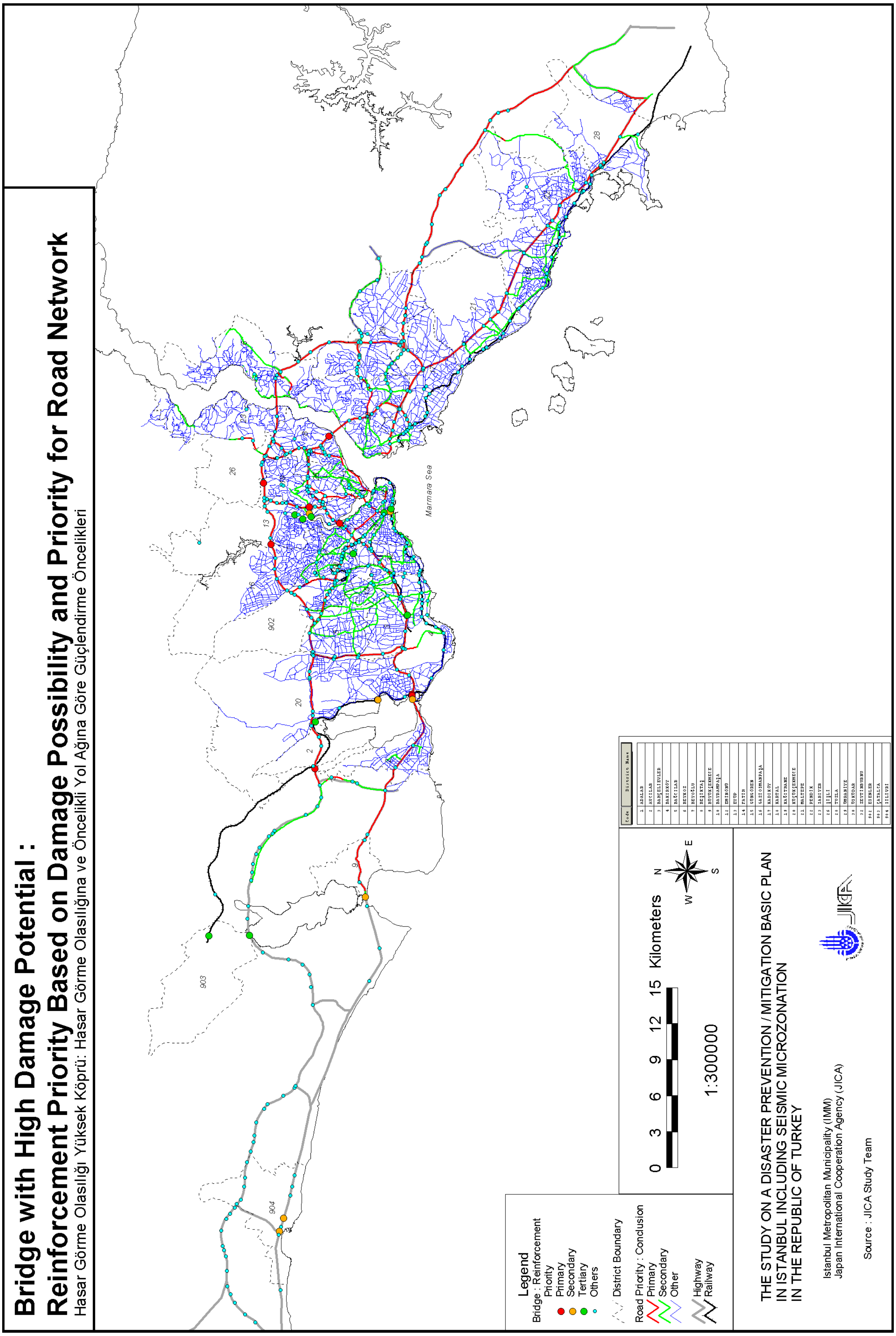


Figure 9.6.28 Bridge with High Damage Potential : Reinforcement Priority Based on Damage Possibility and Priority for Road Network

9.6.3. Estimation of Probable Road Blockage by Collapsed Buildings

Roads have both a traffic function and a space function, and serve for traffic of automobiles and walking persons, as access to various facilities along the roads or as spaces to accommodate infrastructures (for power supply, telephones, gases, etc.) under normal circumstances. On the other hand, in case of emergency like a disastrous earthquake, they serve for traffic of emergency vehicles and as spaces for evacuation or prevention of fire spreading. Therefore, arrangement for preventing roads from being blocked is required to secure an adequate road function in case of emergency. Especially in the City of Istanbul, roads are the most important transportation medium to support a function as a metropolis. Therefore, it is desirous to estimate in advance to what extent a road function can be secured in case of emergency and to promote a plan for arrangement of roads and urban areas in the future based on the result of estimation. From this point of view, the estimation of probable road blockage due to collapsed buildings will be discussed based on an estimate on probable damages to the buildings. The term of "road blockage" in this report is defined as a case where a passage wider than three (3) meters cannot be secured to allow the smallest vehicles to go through after the buildings, etc. are collapsed (Figure 9.6.29).

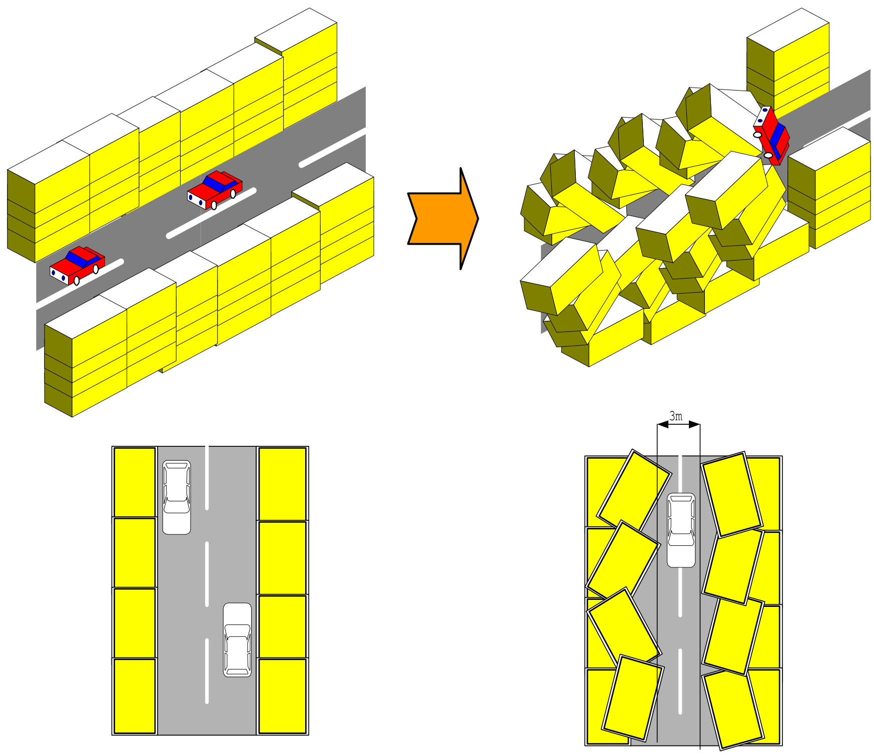


Figure 9.6.29 Definition of Road Blockage

(1) Estimation Procedures of Probable Road Blockage

It is possible to estimate whether a road will be blocked by buildings collapsed as a result of a disastrous earthquake or not from various factors such as conditions of the buildings, width of the collapsed buildings and conditions of the roads and routes. In other words, various factors as shown in Figure 9.6.30 are related.

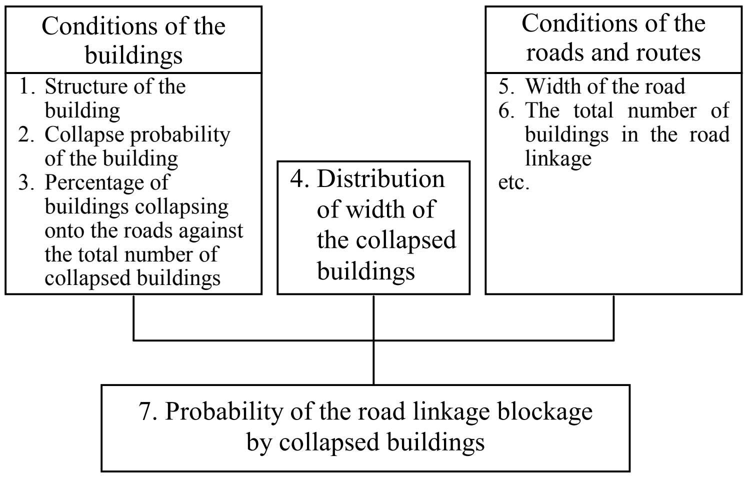


Figure 9.6.30 Factor of Road Blockage

The probability of the road blockage can be estimated by hypothesizing some conditions and the corresponding values for each of the above-mentioned factors. We set the following conditions and values herein to estimate the road blockage probability.

- The road blockage probability will be estimated for each grid of 500 meters square.
- The building collapse probability in each grid of 500 meters square shall be in the case of Model-C earthquake motion.
- The probability of buildings collapsing onto the roads will be hypothesized as 100%.
- Roads as an object of this report are ones of 2 to 6 meters, 7 to 15 meters and of 16 meters or more, as already classified.
- Road linkage shall be a total extension of the roads in a grid of 500 meters square, and buildings are hypothesized to connect to the routes.

In other words,

- The probability of buildings collapsing onto roads is equal to the building collapse probability in a grid of 500 meters square × 1.0.

- The probability of buildings on both sides of the roads collapsing onto the roads is equal to the second power of the collapsing probability of buildings in a grid of 500 meters square multiplied by 1.0.
- The width of a passage that the smallest vehicles can go through after building collapse is hypothesized as 3 meters.
- The probability that a sum of the width of collapsed buildings exceeds the width of remaining road is hypothesized to be 98% for roads of 2 to 6 meters wide, 11% for roads of 7 to 15 meters wide and 0.3% for roads wider than 16 meters respectively from the cases obtained in the Kobe Earthquake

(2) Estimation of Road Blockage Probability of Each Road Type

a. Road Blockage Probability of Roads of 2 to 6 Meters Wide

Estimates of the road blockage probability of roads of 2 to 6 meters wide are shown in

Figure 9.6.31. Areas where the road blockage probability is estimated higher than 50% are supposed to be south of the European side and the Asian side. These areas are heavily inhabited areas and road blockage occurs at an area where the building collapse probability is estimated high. Such narrow roads are developed in areas where buildings stand close together, and they are being used as street. Therefore, it is worried that the road blockage caused by collapsed buildings may give serious difficulties to evacuation and rescue activities.

b. Road Blockage Probability of Roads of 7 to 15 Meters Wide

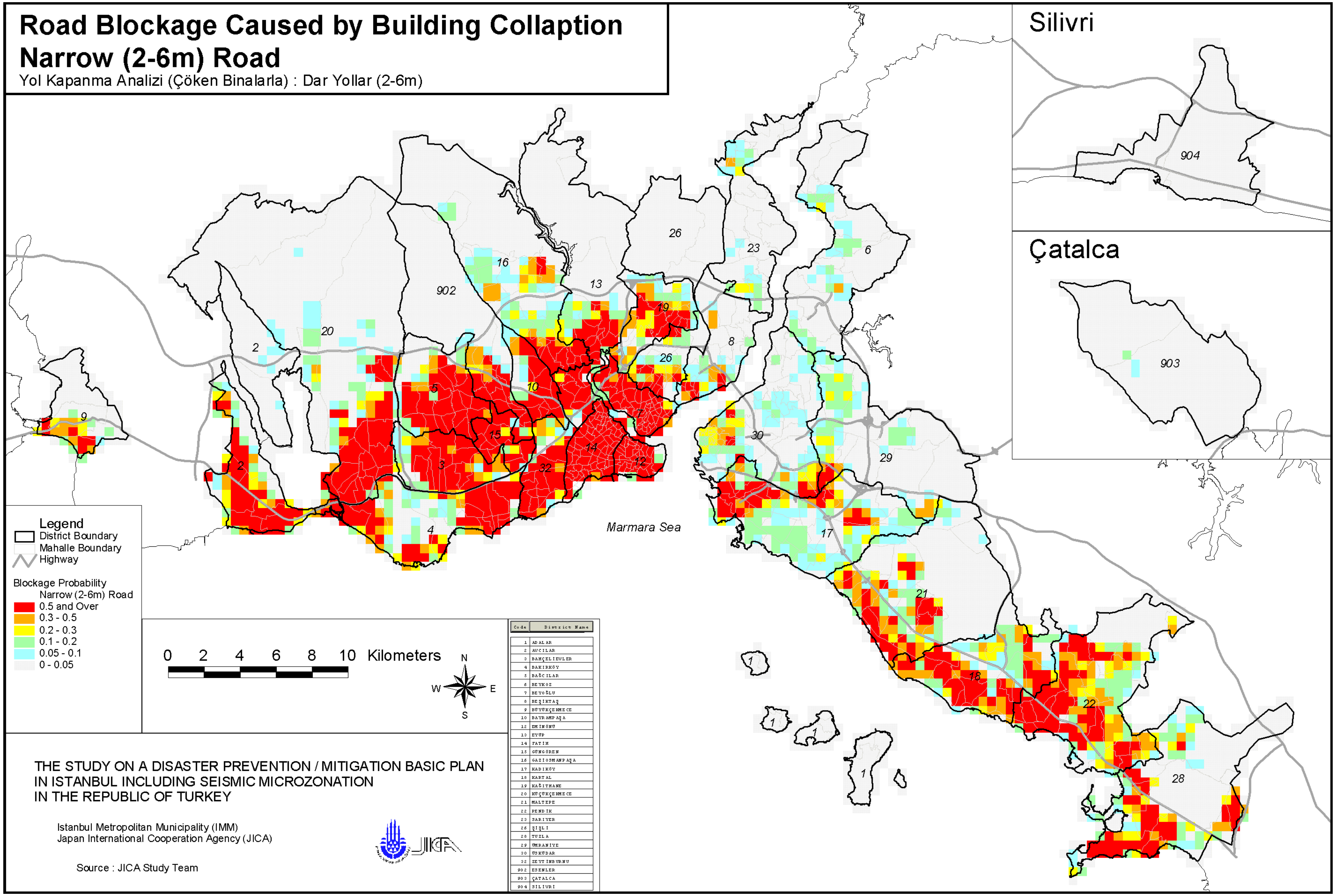
Estimates of the road blockage probability of roads of 7 to 15 meters wide are shown in

Figure 9.6.32. Areas where the road blockage probability is estimated higher than 50% are supposed to be a part of the European side. Although roads of 7 to 15 meters wide have neither a function of principal road nor a function of a wide network, they have access to the principal roads and are placed inside and around the residential areas. Therefore, access to the living quarters and others will become difficult and some areas will be isolated, if roads having such functions were blocked.

c. Road Blockage Probability of Roads of 16 Meters Wide or More

Estimates of the road blockage probability of roads of 16 meters wide or more are shown in

Figure 9.6.33. Roads over 16 meters in width are supposed to hardly encounter road blockage due to collapsed buildings. Therefore, such roads are supposed to have little possibility of encountering difficulties for transit of vehicles, even if buildings fell down onto roads.



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902	ESENLER
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904	SİLİVRİ

Figure 9.6.31 Road Blockage Caused by Building Collaption Narrow (2-6m) Road

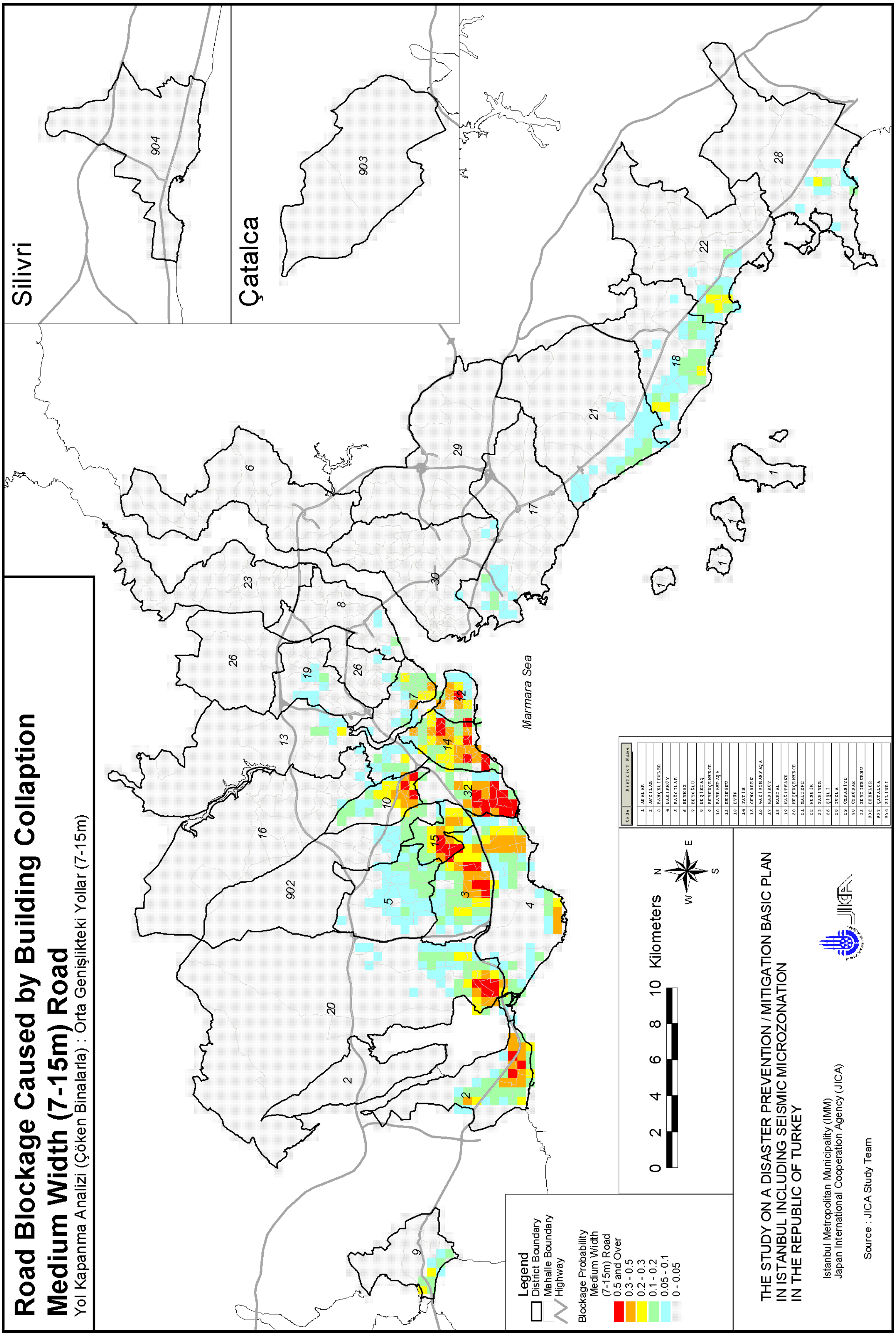


Figure 9.6.32 Road Blockage Caused by Building Collaption Medium Width (7-15m) Road

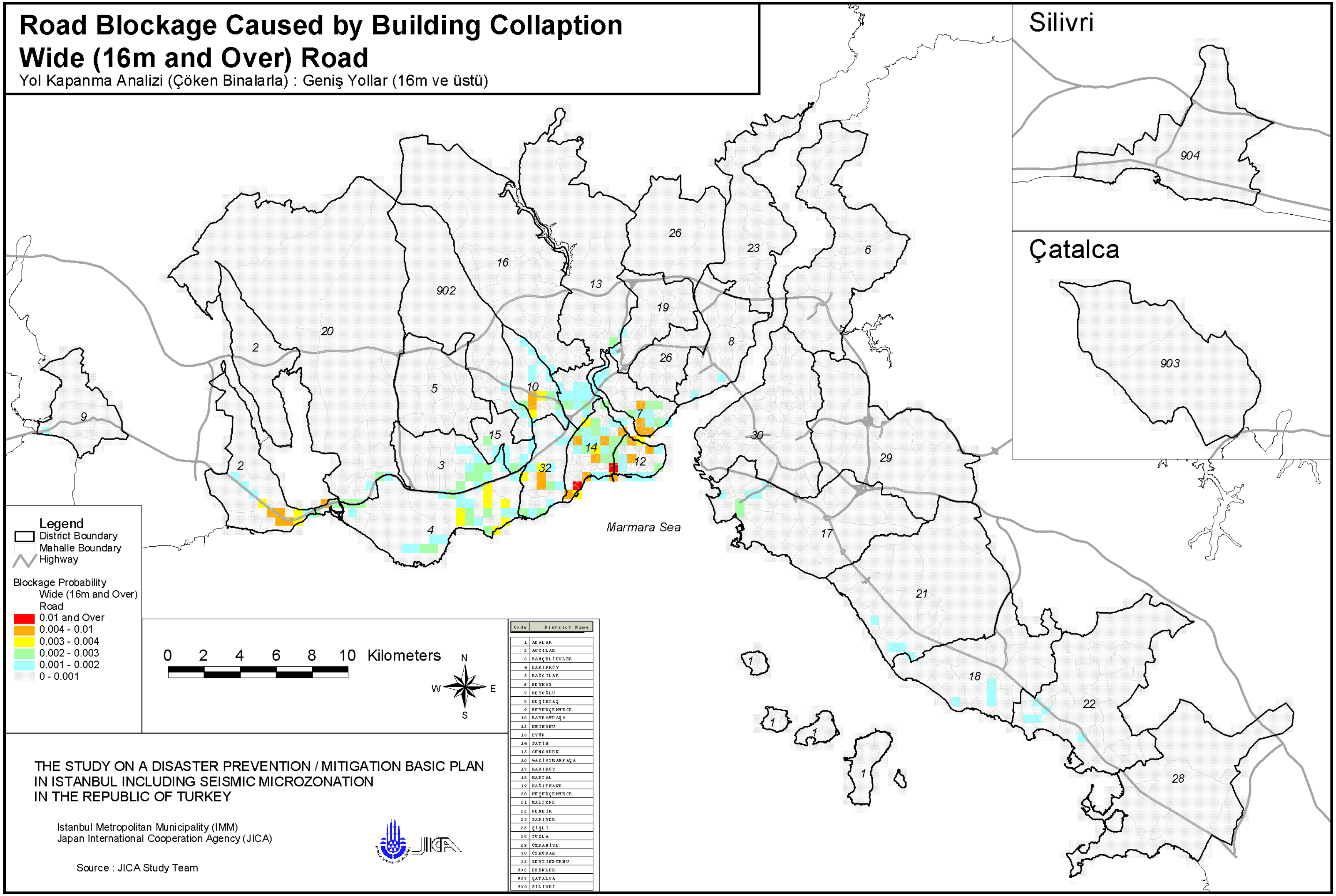


Figure 9.6.33 Road Blockage Caused by Building Collaption Wide (16m and Over) Road

(3) Presumption of Isolation District According to Road Blockage

Possibility of isolation especially by road blockage was assessed based on the results obtained from the estimates of road blockage due to collapsed buildings as above-mentioned. Estimation results were sorted to four indices, namely “Very risky”, “Risky”, “Slightly risky” and “Low risk”. Relations between indices and road blockage assessment were estimated as follows:

Table 9.6.13 Relation between Index and Road Blockage of Evaluation

<table>
<tr><th rowspan="2">Risk of isolation</th><th colspan="2">State of road blockage</th></tr>
<tr><th>Road of 2–6 meters wide</th><th>Road of 7-15 meters wide</th></tr>
<tr><td rowspan="3">Very risky</td><td>Most of roads are blocked.</td><td>□</td></tr>
<tr><td>Blockage probability is higher than 50%.</td><td>No road of 7-15 meters wide exists.</td></tr>
<tr><td>Blockage probability is higher than 50%.</td><td>Blockage probability is higher than 50%.</td></tr>
<tr><td>Risky</td><td>Blockage probability is higher than 50%.</td><td>Blockage probability is 30 to 50% or higher.</td></tr>
<tr><td rowspan="2">Slightly risky</td><td>Blockage probability is 30 to 50% or higher.</td><td>No road of 7-15 meters wide exists</td></tr>
<tr><td>Blockage probability is higher than 50%.</td><td>Blockage probability is 10 to 20% or higher.</td></tr>
<tr><td>Low risk</td><td>Other than above-mentioned</td><td>Other than above-mentioned</td></tr>
</table>

Areas that are supposed to be isolated by road blockage are shown in

Figure 9.6.34, based on the assessment indices shown in Table 9.6.13. According to this assessment, many areas on the south of the European side are supposed to be isolated. In such areas that are isolated by road blockage, remarkable difficulties will be encountered in evacuation and rescue activities, removal of collapsed buildings and transportation of commodities. Therefore, a new policy on road arrangement and improvement of land utilization will be required to reduce a risk of isolation.

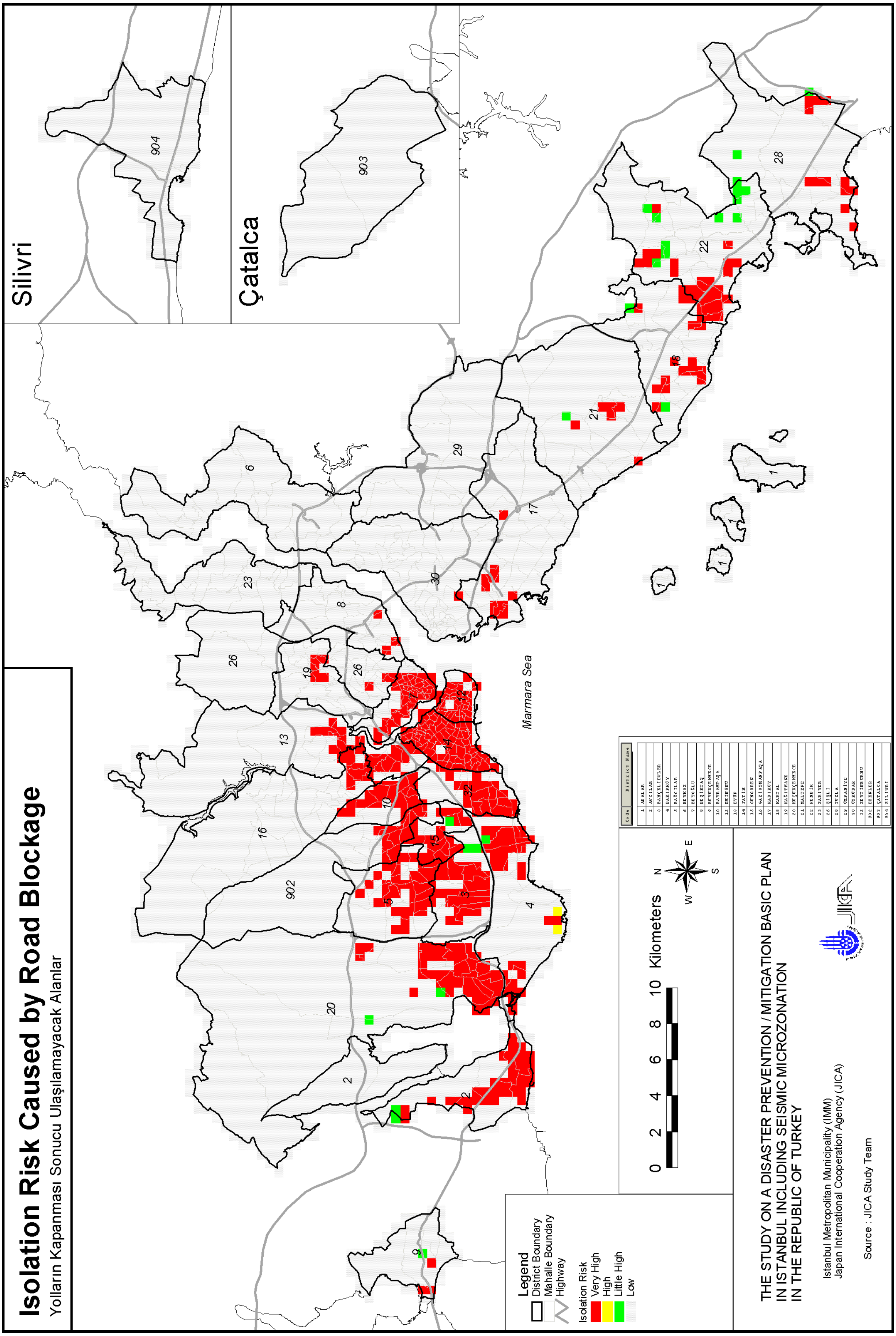


Figure 9.6.34 Estimated Isolated Area by Road Blockage

9.6.4. Considering Earthquake Resistance in Road Development Efforts

This section explains how earthquake resistance should be considered in future road development. These suggestions have been derived from the results of the road network importance evaluation and the study on the influence of road blockades caused by the collapse of roadside buildings.

(1) Layout of road network

Ahighly reliable road network should meet the following two conditions:

1) The road system should have redundant capacity in its network: this means the construction of the road system should have high redundancy, which secures the reliability of the system in terms of connecting traffic by providing alternative routes in an emergency. Road structures, such as bridges, that are earthquake resistant preserve the function of the road system even when hit by an earthquake or when experiencing some other emergency.

2) Roads should have redundant capacity in cross sectional layout: this capacity contributes to the higher reliability of respective road sections. Namely, the least necessary road function should be secured even when roadside buildings have collapsed due to an earthquake.

From the above two viewpoints, how the road system in future should be is explained in the following:

a. Road system network with redundant capacity

Based on the layout of the current road network and the previously described results of the importance evaluation, it is recommended to improve the road system as follows:

- Two highways, which run east and west and form the main loop, and other highways, which run north and south and form radial lines connecting the main loop, are the so-called “national traffic axes.” These axes provide the functions of alliance, connection and interchange. These highways have sufficient width and function as principal roads covering a wide area. However, because the national highway (D-100), which horizontally connect east and west at the southern part of the European side, is also utilised by inner-city traffic, it is necessary to plan another route to separate the national traffic axes and city traffic.

- The above is also assumed from the analysis result of the road network for the case when an earthquake strikes. Namely, it is noted that, after an earthquake, the traffic flow on the European would be extremely concentrated on the southern part of the main loop(D-100 to O-1), causing a large-scale traffic jam. The analysis presented here is based on the traffic flow between principal facilities, which are important duringrelief and emergency restoration periods. However, because such roads are also utilised for emergency escape, it is necessary to construct additional roads to help avoid traffic jams when the area is struck by an earthquake.

- As understood from the results of the importance evaluation, 1st degree roads designated by IMM are main roads constituting the road network in the area. While most of them are wide enough to fulfill their required functions, some of them are narrow in width. Therefore, in the sections where road width is insufficient, it is necessary to plan the securing of sufficient road width and to construct additional roads.

- Roads are linear systems with structures such as bridges, etc. located along their lengths. Particularly, in constituting important road networks, some bridges require earthquake resistant or disaster preventive mesures.. However, it is difficult to implement all of these earthquake resistant measures at the same time because of practical construction work schedules and budget constraints. Therefore, as pointed out previously, it is necessary to carry out the measures against earthquake according to the level of importance of each measure and a well-planned time schedule. While only bridges are targeted in this study, it is desirable to conduct similar studies on other structures, such as retaining walls, etc., in the future.

- Building debris and other waste materials produced by disasters can exacerbate traffic conditions. In terms of easing traffic conditions during early stages and other subsequent restoration activities, it is very important to treat and dispose of the waste produced by the earthquake as early as possible. Therefore, it is necessary to previously designate a road or set up a route that is not part of the ordinary road network for the treatment and disposal of the disaster.

- According to the analysis results onfrequency of road network utilisation, the activities during relief and emergency restoration periods primarily utilise the existing roads that connect principal facilities. It is also anticipated that traffic during these periods will be concentrated along main loop lines and radial lines connected to them. Regarding the treatment and transportation of disaster waste, one proposed option is to secure seaside dumps for disposal of the waste by means of marine transportation. Thus, because comparatively less traffic concentration is expected along seaside roads after an earthquake and since some harbor facilities already exist, it is desirable to develop roads and harbor facilities as follows:

- To reinforce existing roads running north and south and connecting principal roads at seaside (to secure enough road width, etc.).
- To construct new facilities, which are capable of temporary accumulation and shipping of the disaster waste, in the existing main harbors.
- To transport the disaster waste from the temporary dump to the site for waste treatment and disposal via seaways.
- While it is not clear at this moment where the location for the final treatment and disposal of waste will be, an abandoned coal mine on the coast of the Black Sea is thought to be a candidate site for it. Though details about the abandoned mine are not known, it is thought effective to transport the waste by sea to the harbor facility near the mine and then to the mine by dump trucks, etc.

b. Development of roads with redundant capacity in cross-sectional layout:

Regarding road blockages caused by the collapse of roadside buildings, it has been presumed that risk is highest for sections having roads narrow in width. In sections where the density of narrow roads is high and buildings stand close together, isolation of sections caused by road blockages is expected as well. Therefore, in order to prevent road blockages caused by the collapse of roadside buildings, the development of road such as those described below is necessary:

- It is necessary to secure that roads have sufficient width in order to avoid road blockages. What has been learned from the experiences in the earthquake that struck the southern part of Hyogo Prefecture is that at least 11 to 12m of road width is necessary to ensure that, even with the collapse of a roadside building, the minimum road width of 3m can be counted on for vehicular traffic to be able to pass through.. And it is desirable that the roads, which are used for emergency escape and transportation of relief supplies, have cross sectional layout with redundant capacity for pedestrians and automobile traffic in an emergency.
- Very narrow roads having only 2 to 6m width should be improved, taking the current utilisation of roadside land into consideration as well. It is most desirable to develop an urban district into an area where roads and buildings are earthquake resistant through redevelopment of densely built–up areas.

- In Istanbul, many cars park on the streets in the urban district. Even when roads have redundant capacity in their cross-sectional layout, it is expected that the cars on the streets will disturb relief and restoration activities. Therefore, it is necessary to construct public parking facilities (for example, large-scale underground parking facilities), in addition to working on the improvement of roads and urban districts.

Regarding the reliability of road systems, the hierarchy of road networks is considered to be another important factor in addition to the 2 items explained above. In Istanbul, road networks such as the national traffic axes system, inner-city traffic system and inner-section traffic system are seen according to their functions. Currently, however, the national traffic axes and inner-city traffic systems are combined in a mixed-up manner, and the inner-city traffic system is formed by random networks. Therefore, the construction of road networks having hierarchy has to be taken into consideration in the development of road networks in the future.

(2) Alliance with marine traffic after an earthquake

As Istanbul is surrounded by sea, marine traffic plays an important role in the transportation of materials and movement of people even during ordinary times. Once the areas are hit by an earthquake, it is expected that very crowded roads due to concentrated traffic will significantly disturb restoration activities and transportation of relief materials. Therefore, it is thought that an alliance between road and marine traffic is important for relief of concentrated road traffic, better transportation of relief supplies, and the transportation of disaster waste previously mentioned. From this point of view, it is necessary to develop harbor facilities, which can be responsible for transportation of goods, and roads leading to the harbors, based on a well-planned schedule.

Harbor facilities, which are bases for marine traffic, are also effective as disaster prevention centres. This subject is discussed in Section9.7., “Port and Harbors.”

9.7. Port and Harbours

9.7.1. Realities of Harbors Facilities

As Istanbul faces the Bosporus Strait and Maramara Sea, many harbors are located along its waterside line.

Figure 9.7.1 shows the locations of the main ports. While the details of the ports shown in

Figure 9.7.1 (such as their functions, sizes and wharf structures) are yet to be known, the largest one is Haydarpaşa Port. The following is a summary of the current status of the Haydarpaşa Port:

Haydarpaşa Port is a harbor under control of TCDD and is one of the most important harbors in Turkey. Table 9.7.1 provides general information on the harbor facilities controlled by TCDD.

Table 9.7.1 Harbor of TCDD

PORTS OF TCDD	BERTH LENGTH (m)	PORT AREAS (*1000M2)	MAX DRAUGHT (m)	NUMBER OF WORKERS	TOTAL SHIP RECEIPT (Ships/year)	HANDLING CAPACITY (*1000Tons/Year)	BERTH CAPACITY (*1000 TEUS/Year)	CONTAINER BERTH EQUP.CAPACITY (*1000 TEUS/Year)	STORAGE CAPACITY	
									GENERAL CARGO (*1000 Tons/Year)	CONTAINER (*1000 TEUS/Year)
Haydarpaşa	2,765	320	-12	827	2,651	5,427	8,558	354	689	269
Mersin	4,605	994	-14.5	1,186	4,692	5,560	10,967	266	8,505	371
İzmir	2,959	902	-13	554	3,640	5,439	11,100	443	884	343
Samsun	1,756	588	-12	322	1,130	2,380	4,300	40	6,866	50
Bandırma	2,788	246	-12	282	4,280	2,771	7,008	40	2,013	50
Derince	1,092	312	-15	289	862	2,288	2,991	40	2,984	100
İskenderun	1,426	750	-12	567	640	3,247	6,097	20	9,286	146
Total	17,391	4,112		4,027	17,895	27,112	51,021	1,203	31,227	1,329

Source : TCDD THE GENERAL DIRECTORATE OF TURKISH STATE RAILWAYS PORTS DEPARTMENT

According to this table, Haydarpaşa Port handles approximately 20% of the total containers handled in Turkey though its port areas are smaller than some of the others'. Therefore, it is expected that when such port is struck by an earthquake and becomes unable to maintain its functions as a major port, the impact to not only Istanbul but to the whole Turkish economy would be very significant.

As a matter of fact, several facilities at harbors distributed on the seashore of Izmit Bay were seriously damaged by the Eastern Marmara Earthquake (EME) in 1999. While the extent of the damages varied depending on the sizes and types of the harbor structures and the ground conditions, 3 out of the 21 harbor facilities were seriously damaged and 9 were partially damaged. At Haydarpaşa Port, the damage by that earthquake was slight; namely, the earthquake only caused some cracks on the wharfs, and no port functions were influenced. However, the structure of the wharf at Haydarpaşa Port is of the gravity cellular block - pile type, the same type structure as the one at Derince Port which was heavily damaged by Izmit Earthquake, and particularly because the back side of the gravity cellular block is filled with sand, liquefaction of sand and sliding destruction are expected.

For this reason, it is desirable to evaluate the resistance against earthquakes of Haydarpaşa Port and other major ports and to enhance or reinforce their structures as required in order to prevent damages from future earthquakes.

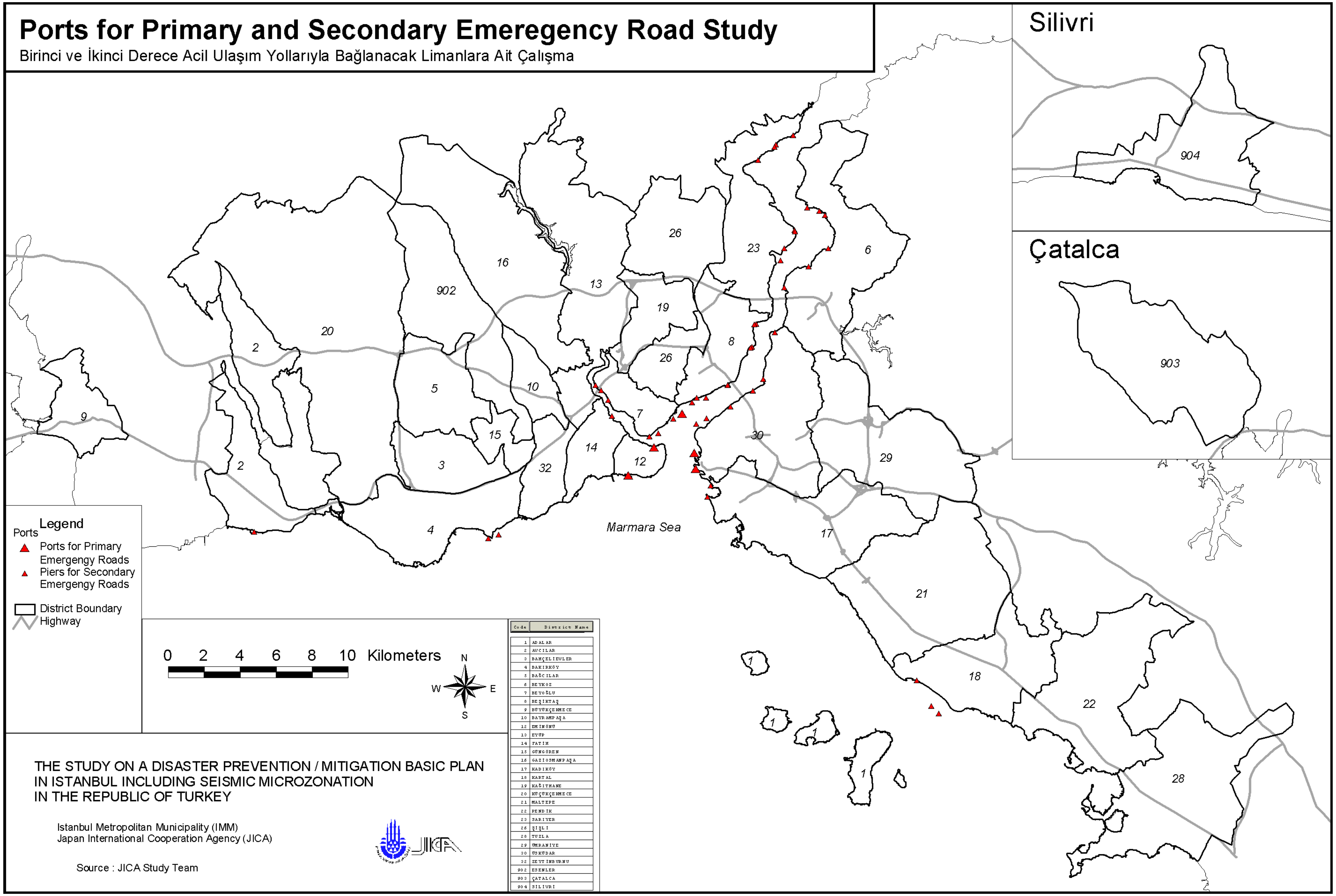


Figure 9.7.1 Ports for Primary and Secondary Emeregency Road Study

9.7.2. Role of Port in Emergency

The Kobe-Awaji Earthquake seriously damaged many harbor facilities. The damage caused by the earthquake significantly influenced economic and social activities over a wide area, but because the harbor, as the centre for promoting resuscitation and reconstruction, was increasingly utilised in various ways recovery efforts made progress, the importance of the harbor has been recognised among people once again. As a result of this recognition, not only has the harbor's function been enhanced, but also several measures to strengthen the harbor as the disaster prevention centre have been carried out.

In Istanbul, the main traffic systems, which serve to move people and to transport goods, include roads that connect the east and west areas (the national traffic axes), airports, and harbor facilities. Because of Istanbul's geographical conditions (it is surrounded by seas and has a continuous waterside line), many small and large harbor facilities have been constructed there. Some of these harbor facilities serve asstorage terminals for handling international cargos, wharfs for large passenger ferries and other small ferries, and facilities for fishing boats. Such being the situation, when the area is struck by an earthquake and road functions become paralyzed or dead, harbors are expected to perform various functions such as storage of external relief supplies, transport of supplies to the disaster areas, treatment and transport of debris and garbage, providing of shelter, etc. In order for harbor facilities to perform their functions as expected after an earthquake, the following maintenance of harbors is required:

Establishment and enhancement of harbor facility's earthquake-resistance based on importance

In addition to the ordinary functions which have to be fulfilled as part of daily operations, a harbor facility is required to serve various functions after an earthquake. These include services needed during the stages of evacuation, rescue, restoration, resuscitation, etc. Therefore, it is necessary to establish preventive measures against earthquakes taking into consideration the importance of the functions required after an earthquake and the eases of restoration, in addition to the importance of the functions required for daily operations. Furthermore, in order for a harbor to be able to perform as a terminal immediately after an earthquake, it is necessary that its harbor facilities be properly laid out and that its resistance against earthquakes be strengthened. To achieve this, it is necessary to enhance the earthquake resistance not only of wharfs but also of facilities for storage and landing, as well as access routes.

Enhancement of harbor's functions as disaster prevention base

Because sea traffic is comparatively stable against earthquakes and can handle a large volume transportation, harbors have excellent characteristics that would make them suitbale as bases for transportation immediately after an earthquake. In Istanbul, several harbors have the conditions under which this function can be expected thanks to the geographical advantage that its urban districts face the waterside line. These harbor facilities have space that is flexible and available for the land use requests to serve various purposes from the periods immediately after an earthquake to the stages of restoration and recovery. In order to broadly contribute to the restoration and recovery efforts in the disaster areas, it is important to enhance the functions of harbors as the transportation bases for relief supplies and as the bases for restoration and recovery activities, taking advantage of the fact that harbors have such space. In this case, it is also important not only to enhance harbor facilities, such as wharfs, but also to ensure the preservation or development of space behind the facilities ready for emergency use, so that facilities and this space can be utilised as one unit to cope with the disaster.

Establishment of cooperation system among harbor facilities

As explained above, many harbor facilities are located in Istanbul, and it is important to strengthen the harbor system so that, after an earthquake, all harbor facilities cooperate with each other and play individual roles according to their sise and function.

9.7.3. Improving Earthquake Resistance of Harbor Facilities

In Turkey, harbor facilities are not classified according to their functions or importance. However, it is possible to classify them into "important ports in the international sea transportation network," "important ports in the domestic sea transportation network," and "others," as shown below:

Highly Important Ports: Samsun (TCDD), Kdz. Ereğli, H.Paşa (TCDD), TDİ İstanbul Salıpazarı Yolcu Limanı, Ambarlı Liman Tesisleri, Derince (TCDD), Sedef Liman Tesisleri, Gemlik, Bandırma (TCDD), İzmir Alsancak (TCDD), Kuşadası, Antalya, Mersin (TCDD), Yumurtalık-ATAŞ (Fueloil Port), İskenderun (TCDD) Limanları sayılabilir.

Important Ports: Hopa, Rize, Trabzon, Giresun, Sinop, Zonguldak, Bartın (now on going project and construction), Tekirdağ, Çanakkale, İzmir-Aliağa (Cargo-Fueloil), Mersin-Taşucu, İskenderun-İsdemir Limanları sayılabilir.

Local Ports: other facilities which provide sight-seeing services and fishing ports.

Regarding the enhancement and reinforcement of earthquake resistant harbor facilities, activities aimed at earthquake-proofing harbors seem to have been continuously carried out at TCDD's Mersin and İzmir Alsancak Ports, etc., but it is also necessary to take measures to improve the earthquake resistance of both facilities, such as wharfs, and disaster prevention bases from now on.

In improving the earthquake resistance of harbor facilities, not only is the improvement of wharfs and other harbor facilities necessary, but also the improvement of harbors as awhole. Namely, it is also necessary to thoroughly study the improvement of earthquake-proof access routes that connect harbors and the cities behind them, as well as the maintenance of routes from various viewpoints.

9.7.4. Importance of Developing Disaster Prevention Bases in Harbors

Many of harbor facilities have open spaces such as green tracts of lands and terminals. These open spaces can be used for many purposes, such as a construction base for restoration activities, a site for temporary houses, a makeshift dump yard for debris of buildings and garbage, etc. It is, therefore, extremely effective to develop the harbor space as a disaster prevention base thoroughly recognising its excellent characteristics. Explained in the following are basic suggestions regarding the maintenance of harbors to be utilised as disaster prevention bases:

Maintenance of Disaster Prevention Base

Harbors have open spaces which can be used for many purposes, several attached facilities (such as berths, cranes, etc.), harbor roads adjacent to the open spaces, etc. Taking these characteristics into consideration, it is desirable to proceed with the development and maintenance of harbors as disaster prevention bases. These bases havefacilities for storage of emergency supplies to cope with the earthquake disaster, for the relaying of communication and information, and for temporary disposal of debris and garbage, if the the harbor's existing open spaces, facilities, and roads are utilised according to their layout.

Maintenance of Shelter Green Tract of Land

It can be expected that green tracts of land in harbor facilities function as seaside green parks, making the surrounding scenery better during ordinary times. In emergency cases such as during an earthquake, the green tract of land itself becomes a facility having a disaster preventive function. From this viewpoint, it is desirable to positively proceed with the maintenance of green tracts of land, giving consideration to the layout of facilities, various lines of flows, open spaces, etc.

Importance of Disaster Prevention of Harbors Space

Some harbors have facilities such as storage tanks of flammable materials, which can contribute to a secondary disaster after an earthquake. Furthermore, when a tsunami strikes, the harbor facility itself can be damaged. Such being the case, it is necessary to give careful consideration to secure harbor facilities from these potential dangers. Also, in order to be able to easily support the restoration activities when secondary disasters occur, it is important to secure safe spaces by utilising water and greenery and through the maintanence of harbor facilities and wide roads connected to the facilities.

In Istanbul, relatively large harbor facilities are located at both sides of the Bosporus Strait. In addition, many small and large harbor facilities are found on the coasts of the Golden Horn Inlet and Malmara Sea. Such being the situation, it is thought that more effective disaster prevention measures can be achieved through cooperation among harbor facilities in times of emergency, as well as through the proper maintenance of the individual disaster prevention bases. The network formed by small and large harbor facilities in times of emergency makes it possible to implement properly organised relief activities. Such activities include the transportation of debris and restoration materials by large ships and that of miscellaneous goods by small ships, so that a comparatively smooth transportation of goods to urban districts can be secured even in an emergency. As Haydarpaşa Port has a transportation facility for container cargos and can be connected to relatively wide harbor roads, it is thought that more effective disaster prevention function can be secured by recognising Haydarpaşa Port and its surrounding areas as primary disaster prevention facility. A network which connects Haydarpaşa Port and its surrounding areas with other harbor facilities should also be established. Incidentally, Haydarpaşa Port and its surrounding areas have a continuous seaside line facing the Bosporus Strait, and historical buildings and rows of houses on the other side can be seen from there. Therefore, it can be expected that well-maintained disaster prevention bases having open spaces and green tracts of land can be utilised as resources for sight-seeing because they can function as waterside parks, etc., in ordinary times.

Chapter 10. Preparedness Measures to Strengthen Vulnerable Buildings and Urban Structures

10.1. Vulnerability Analysis of Buildings and Urban Structures in Istanbul

10.1.1. Relationship between Greater Earthquake Disaster Damages and the Vulnerability of Buildings and Urban Structures

In the case of an earthquake disaster affecting the IMM, identified vulnerable conditions of buildings and urban structures will not only cause direct damages to buildings and lifelines and cause human casualties, but these will also contribute to secondary disasters. These secondary disasters will expand disaster damages into a greater region-wide catastrophe, owing to delayed emergency response systems. Areas with potential for serious damage have been identified as follows:

- **Estimated Strong Earthquake Motion Area:** coastal area and islands of Marmara Sea are in the precarious situation of being near the active fault of north Anatolia.
- **Estimated High Building Damage Area:** lack of seismic resistant structures (squatter and irregular development areas) located in the estimated strong seismic motion area.
- **Lack of Safety Evacuation Routes:** lack of sufficiently wide evacuation routes.
- **Lack of Safety Evacuation Spaces:** lack of or limited parks and open spaces to provide evacuation spaces to residents protecting them from second and third earthquake motions.
- **Lack of Access Roads for Emergency Vehicles**: areas normally connected by inappropriately narrow roads will be isolated and probably will not be reached by proper emergency response operations, such as rescue, fire fighting, first aid, emergency medical care, and emergency food/water supply.
- **Lack of Emergency Response Resources:** lack of emergency centres and required manpower, machinery, and others for rescue, fire fighting, first aid, emergency medical service, and the provision of emergency supplies.
- **Vulnerable Lifeline Network Systems:** residents will not survive without lifeline services (even those refugees in buildings without serious damage).

- **Hazardous Areas of Secondary Disasters:** concentrated hazardous facilities and liquefaction potential areas will trigger fire outbreaks and explosions due to hazardous materials, natural gas pipeline networks, and electric power supply networks lacking proper security system.
- **Lack of Reliable Primary Damage Information Collection System:** without reliable information, limited emergency response resources will not be properly dispatched or distributed, which, if inappropriately mobilized, will result in more serious human casualties and secondary disasters in heavily damaged areas.

The relationship between disaster damages and vulnerabilities depicted by the following flow chart brought out issues to warrant the formulation of an urban disaster prevention plan:

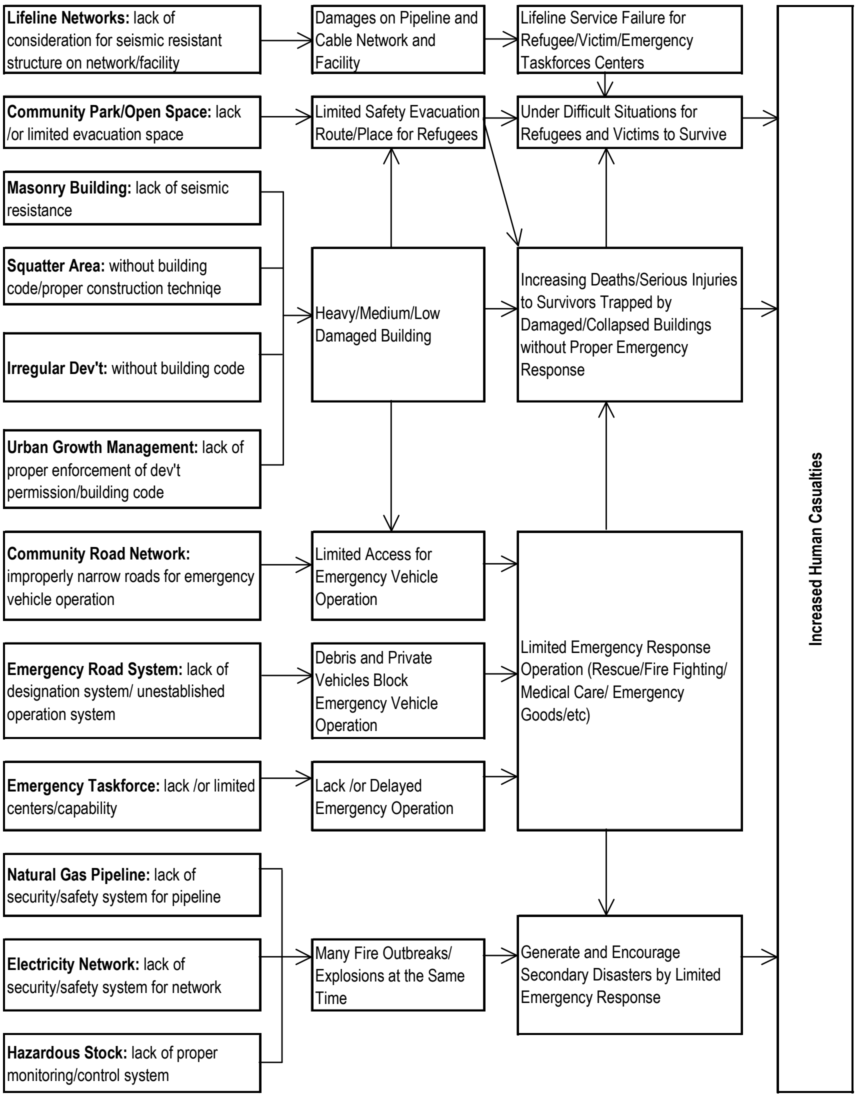


Figure 10.1.1 Relationship between Greater Disaster Damage and Vulnerable Buildings and Urban Structure

Source: The JICA Study Team

10.1.2. Analysis Flow for Building and Urban Structure Vulnerability

The following study is recommended in order to formulate measures to strengthen vulnerable buildings and urban structures in order to mitigate disaster damages.

In the Study, factors of vulnerability are assessed with regards to two main areas: building structures and urban structures. In addition, a land availability analysis is included to identify areas for future urban structure improvement and required urban redevelopment.

Recommended measures are as follows:

	Vulnerable: Building/Urban Structure	Not So Vulnerable: Building/Urban Structure
Available: Land for Urban Structure Improvement	Building/Urban Structure Improvement Area	Building Improvement Area
Not Available: Land for Urban Structure Improvement	Urban Redevelopment Area	Building Improvement Area

The vulnerability study is implemented and assessed on the basis of 642 mahalles, which are the statistical units in Istanbul. The databases utilized for 8 analytical exercises on 3 main fields are as follows:

1) Present Vulnerability of Buildings:

- Estimated Building Damage: the result (sum of the estimated heavily and moderately damaged building ratios for each mahalle) of the JICA Microzonation Study. The estimated building damages are the result of a complex analysis of the earthquake motion (estimated on earthquake scenarios, ground condition, etc.) and building condition (with damage function) for each mahalle.
- Trend of Building/Urban Structure Renewal: the results (year of construction data) of the 2000 Building Census and the Chronological Urban Expansion Map in the Master Plan of IMM.

2) Present Vulnerability of Urban Structures:

- Excessively High Land/Building Use by Urban Development Type: the results (data on plot area, building coverage area, and number of floors) of the 2000 Building Census.
- Road Density (m/ha) in Urbanized Area: GIS road network database, updated GIS mahalle map, and GIS building/built-up/urbanized area database compiled by the JICA Study Team.

- Narrow Roads Ratio: GIS road network database with road width information and GIS mahalle map developed by the JICA Study Team.
- Availability of Parks and Open Space for the Required Community Evacuation Areas: the list of parks and open spaces in Istanbul, which was created by the study of parks/open space availability in Istanbul (through Istanbul University supported by the Mapping Directorate of the IMM).
- Cut-off Point for Necessity of Strategic Improvement Measures: the complex factor of earthquake and building vulnerability (less than 10% of heavily/ moderately damaged building ratio for each mahalle)

3) Land Availability for Urban Structure Improvements:

- Built-up Area Ratio in Urbanized Area: the results (plot area data) of the 2000 Building Census and GIS building/built-up/urbanized area database compiled by the JICA Study Team.
- Average Net Building Coverage Ratio in Built-up Area: the results (plot area data and building coverage area data) of the 2000 Building Census.

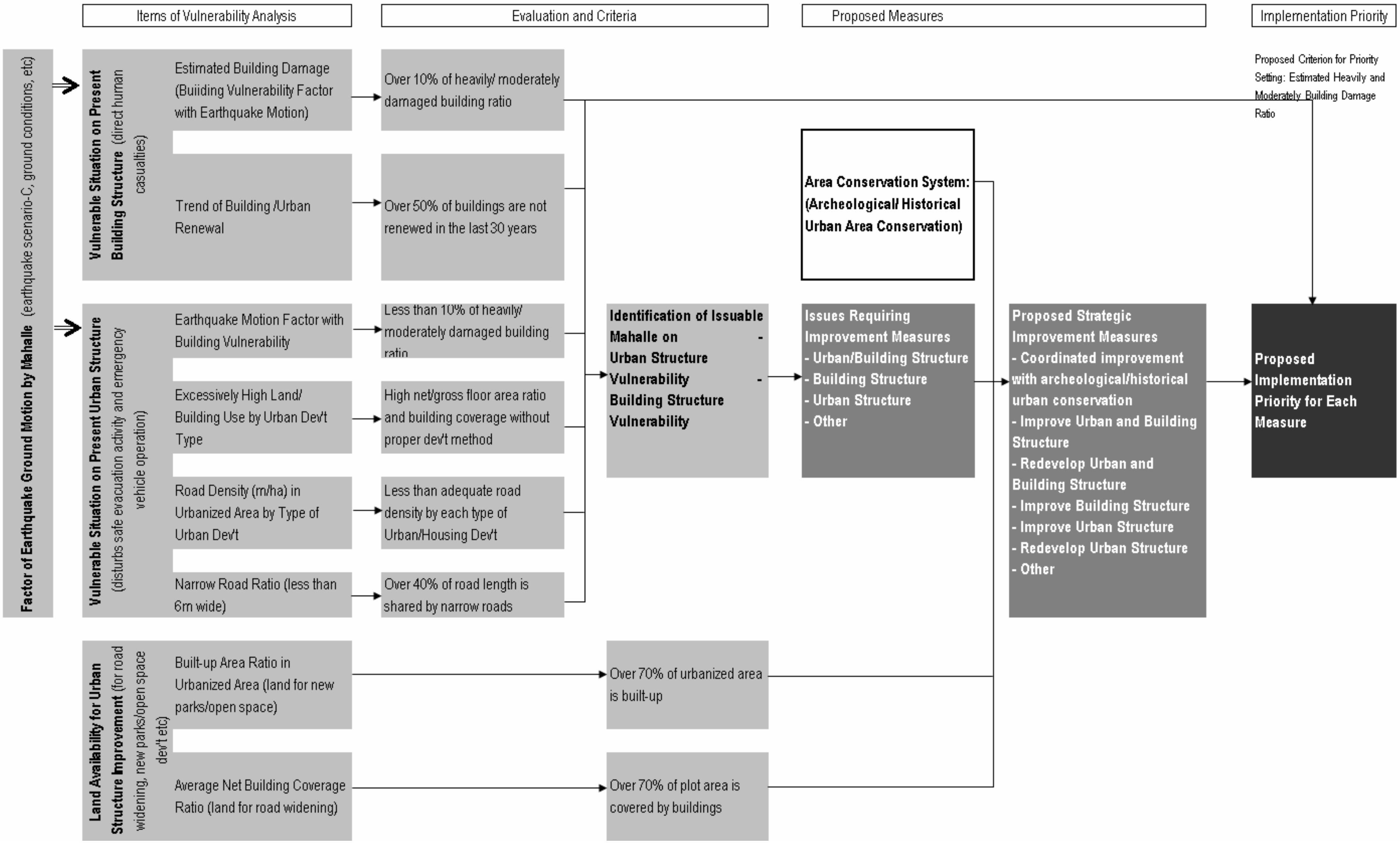


Figure 10.1.2 Flow Chart of Vulnerability Analysis of Buildings and Urban Structures

Source: The JICA Study Team

10.1.3. Estimated Building Damages

In the JICA Microzoning Study, building damages are estimated for each of the four earthquake scenarios. In the Study, the estimated building damages of Model C, which is the worst scenario for Istanbul, are used in the building vulnerability study. Building share of the estimated heavily and moderately damaged buildings in each mahalle is categorized and assessed according to the vulnerability of building structure, which will require strengthening of seismic resistance in the future with appropriate public assistance by the implementation of technical, financial, and taxation measures.

Based on the estimated heavily and moderately damaged building percentages, the mahalle building damages can be categorized as follows:

1) over 40% (over 63% total): catastrophically damaged mahalle

2) 30 to 39% (52 to 68% total): heavily damaged mahalle

3) 10 to 29% (26 to 58% total): moderately damaged mahalle

In the analysis, percentages 10% and above of heavily and moderately damaged buildings denote mahalles as those with vulnerable building structures.

Table 10.1.1 Share of the Estimated Building Damage by Mahalle: Model C

Sum of Heavily and Moderately Damaged	Heavily Damaged	Moderately Damaged	Partially Damaged	Total Damaged Buildings	Damage Situation	
over 50%	33 - 41%	18 - 23%	18 - 22%	74 - 80%	Catastrophic Damaged Mahalle	Vulnerable Building Structure
45 - 50%	24 - 31%	17 - 23%	20 - 28%	66 - 76%		
40 - 45%	20 - 27%	17 - 22%	21 - 28%	63 - 73%		
35 - 40%	17 - 22%	15 -22%	22 - 29%	58 - 68%	Heavily Damaged Mahalle	
30 - 35%	14 - 18%	14 - 18%	21 - 29%	52 - 63%		
25 - 30%	12 - 16%	13 - 16%	21 - 29%	47 - 58%	Moderately Damaged Mahalle	
20 - 25%	8 - 12%	11 - 15%	20 - 28%	41 - 53%		
15 - 20%	6 - 9%	8 - 12%	19 - 26%	34 - 46%		
10 - 15%	3 - 7%	6 - 9%	16 -24%	26 - 38%		
5 - 10%	2 - 4 %	3 - 6%	11 - 20%	16 - 30%		
0 - 5%	0 - 2%	0 - 3%	3 -15%	4 - 20%		

Source: The JICA Study Team

The results of the building vulnerability analysis are as follows:

1) **Catastrophically Damaged Mahalles**: 54 mahalles (8% of total) are located only in The Historic District, on the Marmara Coast and Inland Area of the European side and on the Adalar Islands.

2) **Heavily Damaged Mahalles**: 105 mahalles (16% of total) are more widely distributed, except in the northern Bosphorus areas.

3) **Moderately Damaged Mahalles**: 298 mahalles (46% of total) are distributed in almost all districts except Çatalca and Adalar (all mahalles with settlements in these districts are assessed as Catastrophically or Heavily Damaged Mahalles).

The number of mahalles assessed as having vulnerable building structures are 457, which account for 71% of the 642 mahalles in the Study Area. The assessed vulnerable mahalles are concentrated in The Historic District (143 mahalles, 97% of mahalles in the area), on the Marmara Coast of the European side (58 mahalles, 98% of mahalles in the area), in the Inland Area of the European side (52 mahalles, 87% of mahalles in the area), and the Marmara Coast and Islands of the Asian side (105 mahalles, 88% of mahalles in the area), as follows:

Table 10.1.2 Building Damage Situation and Building Vulnerability by Mahalle

Area	District		Number of Mahalles							
	Code	Name	Catastrophic Damaged		Heavily Damaged		Moderately Damaged		Vulnerable Mahalle	
			Mahalle	%	Mahalle	%	Mahalle	%	Mahalle	%
Old Town	12	EMINÖNÜ	6	18	7	21	17	52	30	91
	14	FATİH	11	16	41	59	17	25	69	100
	7	BEYOĞLU	6	13	8	18	30	67	44	98
	Sub-Total		23	16	56	38	64	44	143	97
Europe: Marmara Coast	32	ZEYTİNBURNU	8	62	3	23	2	15	13	100
	4	BAKIRKÖY	10	67	4	27	1	7	15	100
	15	CÜNGÖREN	0	0	8	73	3	27	11	100
	3	BAHCELİEVLER	1	9	7	64	3	27	11	100
	2	AVCILAR	4	44	3	33	1	11	8	89
	Sub-Total		23	39	25	42	10	17	58	98
Europe: Bosphoras	8	BESİKTAS	0	0	1	4	9	39	10	43
	19	KAĞITANE	0	0	0	0	10	53	10	53
	26	SİSLİ	0	0	0	0	11	39	11	39
	23	SARIYER	0	0	0	0	1	4	1	4
	Sub-Total		0	0	1	1	31	33	32	34
Europe: Inland	13	EYÜP	0	0	1	5	14	70	15	75
	16	GAZİOSMANPASA	0	0	0	0	13	45	13	45
	10	BAYRAMPASA	1	9	5	45	4	36	10	91
	902	ESENLER	0	0	2	11	11	61	13	72
	5	BAĞCILAR	0	0	0	0	21	95	21	95
	20	KÜCÜKCEKMECE	3	13	4	17	13	57	20	87
	Sub-Total		4	3	12	10	76	62	92	75
Total/Average of European Side			50	12	94	22	181	43	325	77
Asian: Marmara	1	ADALAR	4	36	2	18	0	0	6	55
	17	KADIKÖY	0	0	1	4	25	89	26	93
	21	MALTEPE	0	0	1	5	16	76	17	81
	18	KARTAL	0	0	0	0	19	95	19	95
	22	PENDİK	0	0	3	10	24	83	27	93
	28	TUZLA	0	0	2	18	8	73	10	91
	Sub-Total		4	3	9	8	92	77	105	88
Asian: Bosphoras	30	ÜSKÜDAR	0	0	0	0	16	30	16	30
	6	BEYKOZ	0	0	0	0	2	11	2	11
	29	ÜMRANİYE	0	0	0	0	2	14	2	14
	Sub-Total		0	0	0	0	20	23	20	23
Total/Average of Asian Side			4	2	9	4	112	54	125	60
Outside IMM	9	BÜYÜKCEKMECE	0	0	2	33	3	50	5	83
	903	CATALCA	0	0	0	0	0	0	0	0
	904	SİLİVRİ	0	0	0	0	2	40	2	40
	Sub-Total		0	0	2	15	5	38	7	54
Total			54	8	105	16	298	46	457	71

Source: The JICA Study Team

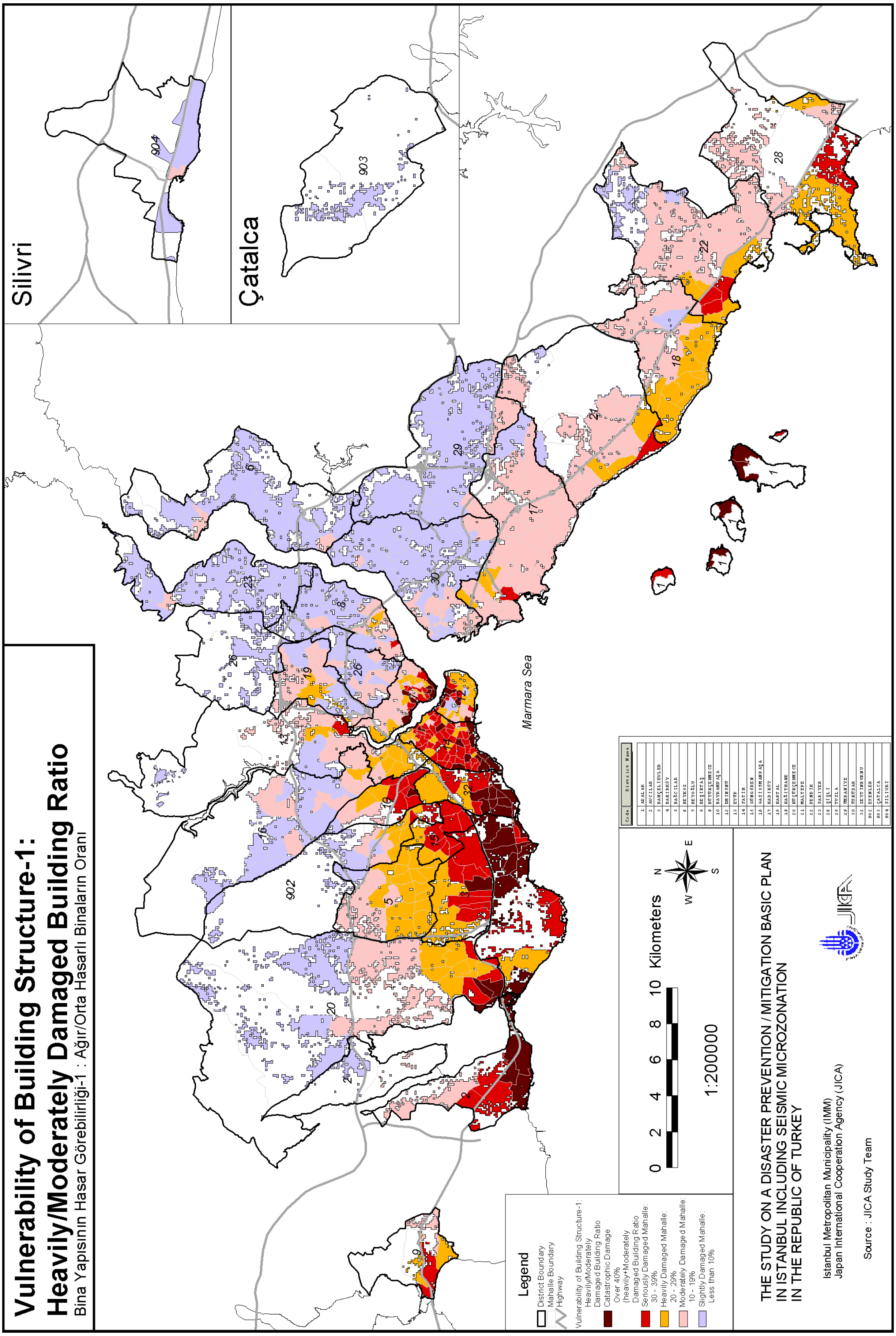


Figure 10.1.3 Heavily/Moderately Damaged Building Ratio

10.1.4. Trends of Building/Urban Renewal

Past trends of building reconstruction activities in each mahalle represent enhanced socio-economic activities to adapt to the needs of modern society. Also, those trends could be understood as upgrading to better building structures and representing progress of urban renewal with appropriate road and urban infrastructure improvements in each mahalle.

As part of the analysis, the superposition of the Chronological Urban Expansion Map of the IMM's Master Plan and the construction year data from the 2000 Building Census show building reconstruction and urban renewal trends for each mahalle over the past three decades. However, a major part of the presently urbanized mahalles are shared and were developed after the year 1970, which is categorized as a developing stage to maturity of urbanization in the past three decades. Building reconstruction and urban renewal trends could not be assessed for those mahalles based on limited data.

In the study, trends of building reconstruction and urban renewal over the past 3 decades are assessed into 3 categories, as follows:

- **Mahalle Characterized by Low and Delayed Urban Renewal:** more than half of buildings have not been reconstructed.
- **Mahalle Characterized by Moderate Urban Renewal Mahalle:** 50 to 75% of buildings have been reconstructed.
- **Mahalle Characterized by High Urban Renewal Mahalle:** over 75% of buildings have been reconstructed in the period.

In areas of the Bosphorus Strait and The Historic District and its surroundings, , areas developed before the 20th century were designated as archeological world heritage sites and historical conservation areas by the Government of Turkey and UNESCO. Many weak traditional urban structures and traditional alleyways, which are presently protected under the conservation regulation, remain in these designated areas. Furthermore, these building structures could not be assessed as to their earthquake resistance for the forecasted earthquake motion, and so, it is estimated that these areas will suffer heavy building damage. The national conservation policy for historical urban area is required to reconsider its regulation from the following point of views:

- To provide a safe environment for citizens in the event of an earthquake disaster
- To support the private sector's reconstruction activities to strengthen the presently weak buildings by technical, financial, and taxation measures

- To provide and introduce a safer road network for residents in the area (the current traditional alleyway system cannot be used for evacuation routes by citizens or as roads for emergency response operations (areas will be isolated)
- The historical urban areas' strict conservation system, without additional supporting measures, is creating slums and ghost towns. Current alleyways cannot adapt to the needs of a modern society, which is discouraging a trend of self-reconstruction of buildings in the area.

Table 10.1.3 Status of Building and Urban Renewal Trends by Mahalle

Area	District		Low Reconstruction Rate less than 50%		Medium Reconstruction Rate 50 to 75%		High Reconstruction Rate over 75%		Newly Urbanized Mahalle		Total of District	
	Code	Name	Mahalle	Area (ha)	Mahalle	Area (ha)	Mahalle	Area (ha)	Mahalle	Area (ha)	Mahalle	Area (ha)
Old Town	12	EMINÖNÜ	20	312	10	134	3	62	0	0	33	508
	14	FATİH	29	422	26	419	14	205	0	0	69	1,045
	7	BEYOĞLU	28	356	11	290	6	243	0	0	45	889
	Sub-Total		77	1,090	47	843	23	510	0	0	147	2,443
Europe: Marmara Coast	32	ZEYTİNBURNU	1	142	0	0	10	940	2	67	13	1,149
	4	BAKIRKÖY	4	1,488	4	799	6	307	1	357	15	2,951
	15	CÜNGÖREN	0	0	1	83	0	0	10	636	11	718
	3	BAHÇELİEVLER	0	0	0	0	0	0	11	1,661	11	1,661
	2	AVCILAR	0	0	5	819	0	0	4	3,042	9	3,861
	Sub-Total		5	1,630	10	1,701	16	1,248	28	5,762	59	10,340
Europe: Bosphoras	8	BESİKTAŞ	3	231	12	991	8	588	0	0	23	1,811
	19	KAĞITANE	0	0	2	64	3	352	13	945	18	1,362
	26	ŞİŞLİ	11	357	9	508	4	163	4	2,516	28	3,543
	23	SARIYER	1	136	9	1,242	2	352	11	1,045	23	2,774
	Sub-Total		15	724	32	2,805	17	1,455	28	4,506	92	9,489
Europe: Inland	13	EYÜP	1	42	10	721	6	1,500	1	142	20	5,050
	16	GAZİOSMANPAŞA	2	93	7	364	0	0	19	2,310	29	5,676
	10	BAYRAMPAŞA	0	0	1	23	10	936	0	0	11	958
	902	ESENLER	0	0	0	0	0	0	18	3,890	18	3,890
	5	BAĞCILAR	0	0	7	375	0	0	15	1,819	22	2,194
	20	KÜÇÜKÇEKMECE	0	0	3	273	1	132	18	9,501	23	12,173
	Sub-Total		3	136	28	1,756	17	2,567	71	17,663	123	29,942
Total/Average of European Side			100	3,579	117	7,104	73	5,780	127	27,930	421	52,214
Asian: Marmara	1	ADALAR	3	201	1	48	2	151	0	0	11	1,100
	17	KADIKÖY	1	60	6	485	16	2,398	5	1,185	28	4,128
	21	MALTEPE	0	0	0	0	13	1,714	6	1,324	21	5,530
	18	KARTAL	0	0	1	145	2	448	17	2,542	20	3,135
	22	PENDİK	0	0	0	0	1	78	28	4,653	29	4,731
	28	TUZLA	0	0	0	0	0	0	10	3,959	11	4,998
	Sub-Total		4	261	8	678	34	4,788	66	13,664	120	23,621
Asian: Bosphoras	30	ÜSKÜDAR	4	204	20	972	18	1,177	12	1,429	54	3,783
	6	BEYKOZ	8	1,583	7	881	0	0	4	1,692	19	4,156
	29	ÜMRANİYE	0	0	0	0	0	0	14	4,561	14	4,561
	Sub-Total		12	1,787	27	1,854	18	1,177	30	7,682	87	12,500
Total/Average of Asian Side			16	2,048	35	2,532	52	5,965	96	21,345	207	36,121
Total of IMM			116	5,627	152	9,636	125	11,745	223	49,276	628	88,335

Source: The JICA Study Team

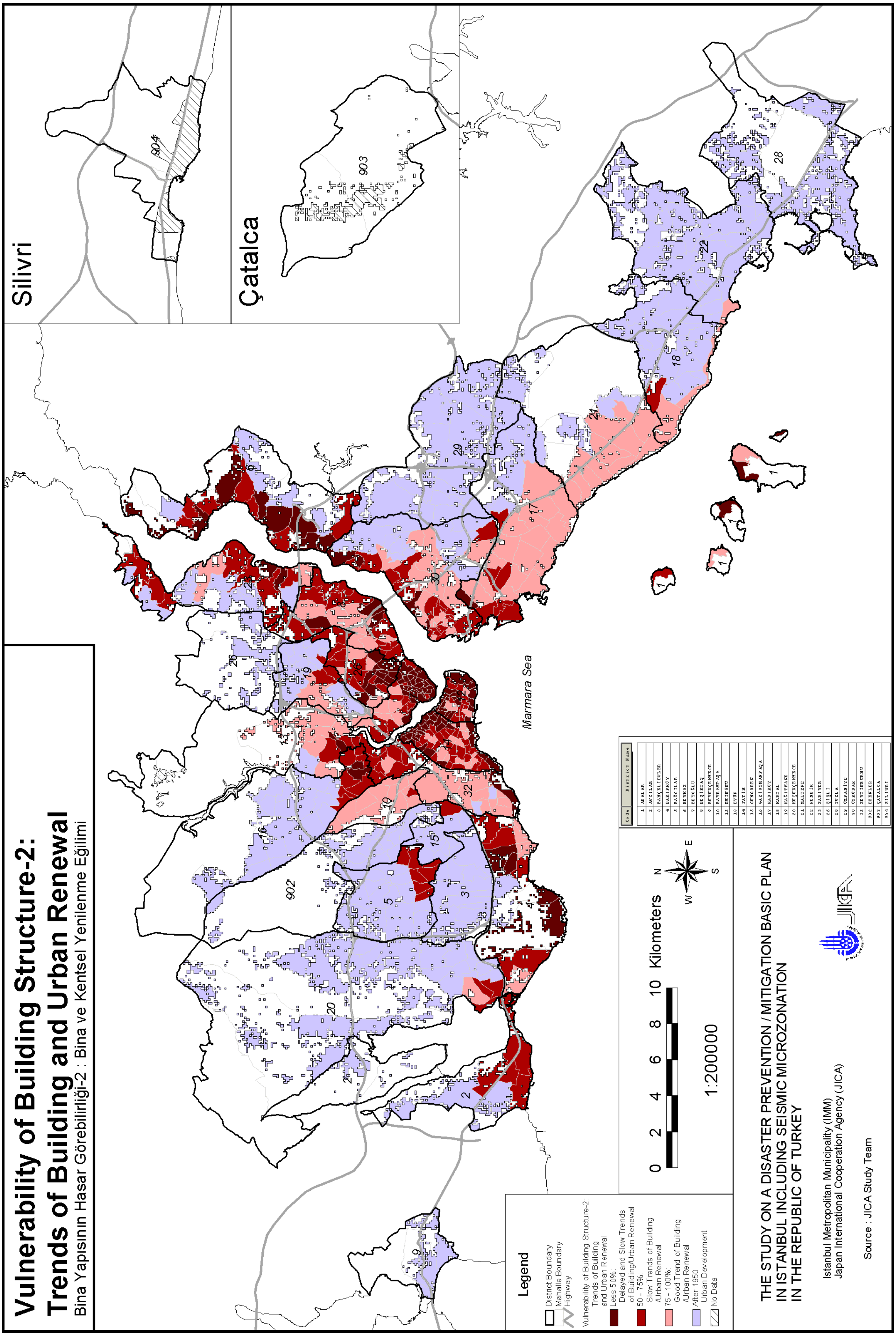


Figure 10.1.4 Building and Urban Renewal Trends

10.1.5. Excessive Land and Building Use: Strict Urban Land Use

Excessive urban land utilization can exacerbate earthquake disaster damages as follows:

- **Evacuation routes blocked by collapsed buildings –can increase the number of human casualties:** the case of high ratios of tall building development in an area.
- **Emergency roads blocked by collapsed buildings– can disturb emergency response operations:** the case of high ratios of tall building development in an area. **A lack of evacuation areas for residents –can increase the number of human casualties:** the case of middle or high-rise building development without proper public and/or private open spaces.

For the analysis, building floor area ratio and building coverage area ratio are used to assess excessive land utilization conditions.

Net Floor Area Ratio is estimated by the JICA Study Team as total floor area, which is based on data of building coverage area, number of stories, and plot area data from the 2000 Building Census. *Building Coverage Area Ratio* is also estimated by the JICA Study Team based on the data of building coverage area and plot area from the results of the 2000 Building Census.

Evaluation criteria of excessive land use area with regards to type of building and housing are as follows:

Building Coverage Ratio	Floor Area Ratio by Type of Housing (%)														
	Multi-story Housing								Row/Town House			Detached Housing			
	Over 500	500-400	400-350	350-300	300-250	250-200	200-150	150-46	over200	200-150	150-60	over100	100-75	50-75	50-25
over 90%	5: Extremely Excessive Land Use														
85-90															
80-85									5						
75-80									4						
70-75									3						
65-70									2						
60-65	4:Excessive Land Use														
55-60															
50-55												4			
45-50	3: Slightly High Land Use											3			
40-45															
35-40												2			
30-35	2: Better Land Use								1:						
25-30															
20-25															
15-20	1: Good Land Use Condition														
10-15												1:			

Source: JICA Study Team

Based on the data and criteria, excessive land use mahalles are identified as follows:

- **Extremely high land use condition**: 102 mahalles (16% of total) and around 2,000 ha (4% of the urbanized area), which are concentrated on the European side of Istanbul's The Historic District, Marmara Coast and the Bosphorus Strait Area and Üsküdar on the Asian Side.
- **High land use condition**: 119 mahalles (19% of total) and around 4,300 ha (8% of the urbanized area), which are also concentrated in almost all districts on the European side, except Avcılar and Sarıyer, and the two districts of Kadıköy and Üsküdar on the Asian Side.
- **Slightly high land use condition**: 120 mahalles (19% of total) and around 9,700 ha (19% of the urbanized area), which are widely spread out over almost all districts, except the five districts of Bakırköy, Adalar, Kartal, Tuzla, and Çatalca.

Three districts in Istanbul's Historic District are seen to have the most crucial land-use issues to address in mitigating disaster damage, with 36%, 37%, and 13% of their urbanized areas categorized as having extremely high, high, and slightly high land uses, respectively.

Five districts on the European Marmara Coast also have serious urban land use conditions, where extremely high, high, and slightly high land use percentages of urbanized areas are 7%, 13%, and 19%, respectively.

Four districts in the European Bosphorus area have 12%, 10%, and 20% of their urbanized areas categorized as having extremely high, high, and slightly high land uses.

Six districts in the European inland area do not have urbanized areas categorized as having extremely high land use, but high and slightly high land use areas were observed with shares of 16% and 37%, respectively.

Six districts on the Asian Marmara Coast do not have extremely high land use, but limited high and slightly high land use areas were found.

In three districts in the Asian Bosphorus Area, most of the areas are assessed as not having serious urban land use issues, but the part of Üsküdar is categorized as having extremely high and high urban land use areas.

Three districts outside of the IMM do not have serious urban land use conditions.

Table 10.1.4 Excessive Land Use Status

Area	District		District Area (ha)		Extremely High		High		Slightly High		Total of High Land Use Mahalle				Other Mahalle	
	Code	Name	Total	Urban Area	No. of Mahalle	Urban Area(ha)	No. of Mahalle	Urban Area(ha)	No. of Mahalle	Urban Area(ha)	No. of Mahalle	share (%)	Urban Area(ha)	share (%)	Good Mahalle	Better Mahalle
Old Town	12	EMİNÖNÜ	508	453	18	199	8	100	3	30	29	88	329	73	3	1
	14	FATİH	1,045	982	27	382	28	392	9	121	64	93	895	91	2	3
	7	BEYOĞLU	889	828	21	225	14	341	6	152	41	91	718	87	3	1
	Sub-Total		2,443	2,263	66	806	50	833	18	303	134	91	1,942	86	8	5
Europe: Marmara Coast	32	ZEYTİNBURNU	1,149	939	4	121	3	188	3	391	10	77	701	75	1	2
	4	BAKIRKÖY	2,951	1,429	2	46	5	240	0	0	7	47	286	20	4	3
	15	GÜNGÖREN	718	677	1	95	3	137	3	130	7	64	362	53	1	3
	3	BAHÇELİEVLER	1,661	1,430	2	164	2	188	3	208	7	64	560	39	1	3
	2	AVCILAR	3,861	1,531	0	0	0	0	1	407	1	11	407	27	7	1
	Sub-Total		10,340	6,006	9	426	13	753	10	1,136	32	54	2,315	39	14	12
Europe: Bosphoras	8	BESİKTAŞ	1,811	1,517	4	70	2	74	2	135	8	35	279	18	9	6
	19	KAĞITANE	1,443	1,221	7	339	6	248	5	461	18	100	1,048	86	0	1
	26	ŞİŞLİ	3,543	1,476	11	352	7	281	6	393	24	86	1,026	69	1	3
	23	SARIYER	2,774	2,096	0	0	0	0	4	262	4	17	262	12	11	8
	Sub-Total		9,570	6,311	22	761	15	603	17	1,250	54	59	2,615	41	21	18
Europe: Inland	13	EYÜP	5,050	1,522	0	0	5	267	2	133	7	35	400	26	6	5
	16	GAZİOSMANPAŞA	5,676	2,458	0	0	2	140	18	1,541	20	69	1,681	68	5	3
	10	BAYRAMPAŞA	958	766	0	0	5	282	5	384	10	91	666	87	1	0
	902	ESENLER	3,890	1,022	0	0	10	541	4	157	14	78	698	68	4	0
	5	BAĞCILAR	2,194	1,939	0	0	9	531	8	599	17	77	1,130	58	1	4
	20	KÜÇÜKÇEKMECE	12,173	4,139	0	0	2	133	8	1,581	10	43	1,714	41	6	6
	Sub-Total		29,942	11,846	0	0	33	1,894	45	4,394	78	63	6,288	53	23	18
Total/Average of European Side			52,295	26,426	97	1,993	111	4,083	90	7,083	298	71	13,159	50	66	53
Asian: Marmara	1	ADALAR	1,100	376	0	0	0	0	0	0	0	0	0	0	5	1
	17	KADIKÖY	4,128	3,530	0	0	2	129	1	53	3	11	182	5	21	4
	21	MALTEPE	5,530	2,317	0	0	0	0	3	261	3	14	261	11	13	3
	18	KARTAL	3,135	2,619	0	0	0	0	0	0	0	0	0	0	18	2
	22	PENDİK	4,731	3,559	0	0	0	0	5	419	5	17	419	12	17	7
	28	TUZLA	4,998	1,980	0	0	0	0	0	0	0	0	0	0	9	1
	Sub-Total		23,621	14,381	0	0	2	129	9	733	11	9	862	6	83	18
Asian: Bosphoras	30	ÜSKÜDAR	3,783	3,299	5	42	6	105	10	416	21	39	563	17	24	9
	6	BEYKOZ	4,156	2,340	0	0	0	0	2	313	2	11	313	13	14	3
	29	ÜMRANİYE	4,561	3,600	0	0	0	0	4	849	4	29	849	24	9	1
	Sub-Total		12,500	9,239	5	42	6	105	16	1,578	27	31	1,725	19	47	13
Total/Average of Asian Side			36,121	23,619	5	42	8	234	25	2,311	38	18	2,587	11	130	31
Outside IMM	9	BÜYÜKÇEKMECE	1,474	446	0	0	0	0	3	273	3	50	273	61	2	0
	903	ÇATALCA	5,263	426	0	0	0	0	0	0	0	0	0	0	2	0
	904	SİLİVRİ	3,828	841	0	0	0	0	2	50	2	40	50	6	3	0
	Sub-Total		10,565	1,713	0	0	0	0	5	323	5	38	323	19	7	0
Total			98,981	51,759	102	2,035	119	4,318	120	9,717	341	53	16,069	31	203	84

Source: The JICA Study Team

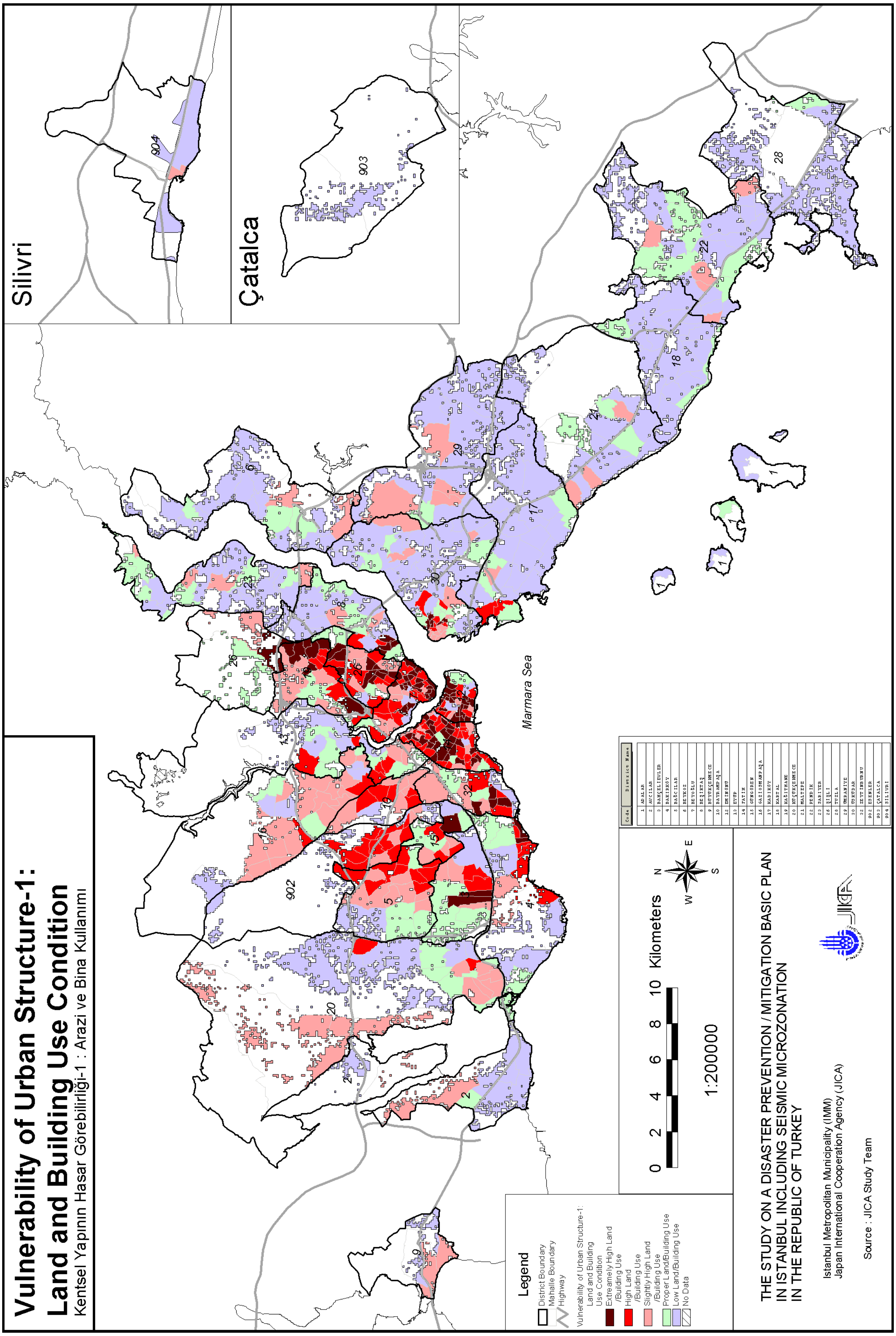


Figure 10.1.5 Land and Building Use Status by Mahalle

10.1.6. Road Density (m/ha) in Urbanized Areas

(1) Existing Road Conditions and Structures in Istanbul

The regional main road (highway) network is well developed, serving as the main road network structure of Istanbul in the last two decades. On the other hand, the hierarchical urban road network system, which is composed of urban arteries, collector roads, and access road networks, is not well developed and structured; it was constructed without proper planning and geometric design and brought about by illegal and irregular urban development trends after 1950.

4) Existing Condition of Hierarchical Road Structure

The existing condition of the road network in Istanbul can be thought of in upgrading stages towards the establishment of a hierarchical road system. Road length and share of urban arteries and collector roads are insufficient to support the socioeconomic activities of the metropolitan area. Also, narrow roads are part of regional roads, urban arteries, and collector roads and have been identified as follows:

- **Type 1 - Regional Road:** the present length and share of regional roads are sufficient. However, the road width of two-thirds of the road length is inappropriately narrow (less than 6 m: 5%, 7 – 15m: 58%).
- **Type 2 - Urban Artery:** the present road length, share, and width are insuffícent, and narrow roads are inappropriately assuming major road functions.
- **Type 3 - Collector Road:** the present road length, share, and width are also insufficient, and more than half of the road length is inappropriately narrow (less than 6 m in width).
- **Type 0 - Access Road:** the present road length and share are very high. Some existing access roads will require upgrading to urban arteries and collector roads. However, the present road width condition could not be said to be really narrow.

Table 10.1.5 Share of Road Length by Width and Type of Road and Narrow Road Length and Share

Area	District		Total Road Length (km)	Type-1: Regional Road (1,109km 8%)				Type-2: Urban Artery (835km, 6%)				Type-3: Collector Road (908km, 7%)				Type-0: Access Road (10,848km, 79%)					All Narrow Road	
	Code	Name		2-6m	7-15m	Over 16m	NA	2-6m	7-15m	over 16m	NA	2-6m	7-15m	over 16m	NA	0-1m	2-6m	7-15m	over 16m	NA	Length (km)	share (%)
Old Town	12	EMINÖNÜ	118	0	23	77	0	34	66	0	0	76	24	0	0	0.0	78	14	1	7	72	61
	14	FATİH	268	3	30	67	0	6	94	0	0	72	27	1	0	0.0	87	12	0	0	196	73
	7	BEYOĞLU	241	8	46	47	0	44	56	0	0	75	25	0	0	0.4	86	13	0	1	178	74
	Sub-Total		627	5	36	59	0	27	73	0	0	73	26	1	0	0.1	85	13	0	2	446	71
Europe: Marmara Coast	32	ZEYTİNBURNU	235	2	57	41	0	2	93	6	0	14	82	4	0	0.0	66	29	0	5	113	48
	4	BAKIRKÖY	350	2	43	55	0	14	85	0	0	21	75	1	3	0.2	62	32	2	4	169	48
	15	CÜNGÖREN	186	10	66	24	0	0	100	0	0	19	80	0	0	0.0	44	55	0	1	67	36
	3	BAHÇELİEVLER	373	1	56	43	0	3	93	4	0	19	77	4	0	0.0	61	37	1	1	186	50
	2	AVCILAR	432	0	49	50	0	18	82	0	0	46	54	0	0	0.0	74	18	2	6	270	62
	Sub-Total		1,575	3	52	45	0	10	88	2	0	25	72	2	0	0.0	64	31	1	4	804	51
Europe: Bosphoras	8	BESİKTAŞ	326	1	60	39	0	6	94	0	0	37	63	0	0	0.0	65	30	1	4	166	51
	19	KAĞITANE	344	4	64	32	0	16	84	0	0	41	58	0	0	0.1	79	20	0	1	216	63
	26	ŞİŞLİ	475	2	51	46	1	27	60	13	0	38	59	3	0	0.0	72	24	0	4	301	63
	23	SARIYER	497	1	75	24	0	27	70	0	2	74	25	0	0	0.0	87	11	0	2	388	78
	Sub-Total		1,642	2	61	37	0	18	79	2	1	57	43	0	0	0.0	76	20	0	3	1,072	65
Europe: Inland	13	EYÜP	488	2	54	44	1	21	77	2	0	62	38	0	0	0.1	78	17	0	4	323	66
	16	GAZİOSMANPAŞA	862	7	38	50	5	19	81	0	0	45	55	0	0	0.1	81	18	0	1	609	71
	10	BAYRAMPAŞA	235	6	49	41	5	2	87	7	4	43	56	0	0	0.0	64	26	3	6	120	51
	902	ESENLER	517	0	55	41	4	13	87	0	0	66	31	0	2	0.0	84	14	0	2	395	76
	5	BAĞCILAR	562	0	74	26	0	14	86	0	0	37	63	0	0	0.0	74	22	0	4	345	61
	20	KÜÇÜKÇEKMECE	1,256	3	71	26	0	27	72	1	1	50	50	0	1	0.0	77	21	1	1	863	69
	Sub-Total		3,920	3	58	37	2	20	79	1	1	52	48	0	0	0.0	78	19	0	2	2,655	68
Total/Average of European Side			7,764	3	55	41	1	18	81	1	0	51	48	1	0	0.0	75	21	1	3	4,977	64
Asian: Marmara Coast	1	ADALAR	123													0.1	80	19	0	0	99	81
	17	KADIKÖY	733	8	60	32	0	19	76	5	0	22	76	1	0	0.0	67	31	0	2	395	54
	21	MALTEPE	740	5	59	36	0	18	82	0	0	17	83	0	0	0.0	70	28	0	1	464	63
	18	KARTAL	612	4	74	22	0	7	90	3	0	36	64	0	0	0.0	66	30	1	3	323	53
	22	PENDİK	741	16	71	12	0	30	64	6	0	79	21	0	0	0.0	87	11	1	1	562	76
	28	TUZLA	558	9	67	24	0	30	70	0	0	75	25	0	0	0.0	74	20	2	3	383	69
	Sub-Total		3,508	9	67	25	0	20	77	3	0	48	51	0	0	0.0	73	24	1	2	2,226	63
Asian: Bosphoras	30	ÜSKÜDAR	757	4	54	42	0	18	82	0	0	48	52	0	0	0.0	79	19	0	2	499	66
	6	BEYKOZ	556	18	50	16	16	65	35	0	0	69	31	0	0	0.2	85	12	0	3	429	77
	29	ÜMRANİYE	982	1	56	43	0	11	88	1	0	43	55	1	0	0.1	78	21	1	1	659	67
	Sub-Total		2,295	7	54	35	4	27	73	1	0	51	48	0	0	0.1	80	18	0	1	1,587	69
Total/Average of Asian Side			5,803	8	62	28	1	23	75	2	0	50	50	0	0	0.0	76	22	1	2	3,813	66
Outside IMM	9	BÜYÜKÇEKMECE	133	0	0	100	0									0.0	56	35	1	8	72	54
	903	ÇATALCA	NA																			
	904	SİLİVRİ	NA																			
	Sub-Total		133	0	0	100	0									0.0	56	35	1	8	72	54
Total			13,700	5	58	36	1	20	79	2	0	51	49	0	0	0.0	75	22	1	2	8,861	65

Source: Original GIS road network was provided by IMM. Road width data were included on the GIS base map of the IMM by the JICA Study Team.

(2) Road Density

In ordinary times, road networks with supporting infrastructure serve a very important function for all socioeconomic urban activities. During an urban disaster, appropriate road densities are required in order to operate proper emergency response activities and to provide evacuation routes for citizens.

The existing road density of urbanized areas was assessed and divided into 5 categories (*extremely low, low, slightly low, proper density*, and *sufficient density*) based on the GIS road network database for each mahalle and types of urban and building structures.

The results of the road density analysis were found not to be very critical as described below:

- **Extremely Low Density** (less than 50% of required road density): only 3 mahalles (0.5% of a total of 628 mahalles in the IMM) were categorized as such and are located in the Emınonu, Sarıyer, and Beyköz districts with 160 ha (0.3% of total urbanized area). The assessed mahalles of this category are almost negligible.
- **Low Density** (50 to 75% of required road density): 40 mahalles (6% of the total) in Eminonu, Beyoglu, Sarıyer, Eyüp, Gaziosmanpasa, Adalar, Pendik and 3 districts of the Asian Bosphorus area with 3,460 ha (7% of total urbanized area).
- **Slightly Low Density** (75 to 99% of required road density): 54 mahalles (8% of the total) widely distributed over 16 districts with 4,785 ha (9% of total urbanized area).
- **Proper Road Density** (100 to 125% of required road density): 52 mahalles (8% of the total).
- **Sufficient Road Density** (over 125% of required road density): 470 mahalles (75% of the total).

A total of 97 mahalles (15% of the total number of mahalles in the IMM) are assessed as having extremely low, low and slightly low road density with 8,400 ha (18% of the urbanized area in the IMM).

Table 10.1.6 Assessed Existing Road Density by Mahalle

Area	District		Extremely Low		Low		Slightly Low		Total of Low Road Density				Other Mahalle	
	Code	Name	Mahalle	Urbanized area	Mahalle	Urbanized area	Mahalle	Urbanized area	Mahalle	Share in district	Urbanized area	Share in district	Proper Density	Enough Density
Old Town	12	EMINÖNÜ	1	64	8	127	0	0	9	27	191	42	1	20
	14	FATİH	0	0	0	0	3	41	3	4	41	4	7	59
	7	BEYOĞLU	0	0	1	44	2	48	3	7	91	11	1	41
	Sub-Total		1	64	9	171	5	89	15	10	324	14	9	120
Europe: Marmara Coast	32	ZEYTİNBURNU	0	0	0	0	1	262	1	8	262	28	0	12
	4	BAKIRKÖY	0	0	0	0	1	64	1	7	64	4	3	11
	15	CÜNGÖREN	0	0	0	0	0	0	0	0	0	0	1	10
	3	BAHÇELİEVLER	0	0	0	0	0	0	0	0	0	0	1	10
	2	AVCILAR	0	0	0	0	0	0	0	0	0	0	1	8
	Sub-Total		0	0	0	0	2	326	2	3	326	5	6	51
Europe: Bosphoras	8	BESİKTAŞ	0	0	0	0	0	0	0	0	0	0	2	21
	19	KAĞITANE	0	0	0	0	0	0	0	0	0	0	1	18
	26	ŞİŞLİ	0	0	0	0	0	0	0	0	0	0	8	20
	23	SARIYER	1	10	2	158	10	620	13	57	788	38	0	10
	Sub-Total		1	10	2	158	10	620	13	14	788	12	11	69
Europe: Inland	13	EYÜP	0	0	7	649	5	370	12	60	1,018	67	0	6
	16	GAZİOSMANPAŞA	0	0	1	175	5	323	6	21	498	20	2	20
	10	BAYRAMPAŞA	0	0	0	0	0	0	0	0	0	0	0	11
	902	ESENLER	0	0	0	0	2	76	2	11	76	7	0	16
	5	BAĞCILAR	0	0	0	0	0	0	0	0	0	0	1	21
	20	KÜÇÜKÇEKMECE	0	0	0	0	1	343	1	4	343	8	3	18
	Sub-Total		0	0	8	824	13	1,112	21	17	1,935	16	6	92
Total/Average of European Side			2	75	19	1,152	30	2,147	51	12	3,373	13	32	332
Asian: Marmara	1	ADALAR	0	0	1	99	3	220	4	36	318	85	0	2
	17	KADIKÖY	0	0	0	0	4	374	4	14	374	11	5	19
	21	MALTEPE	0	0	0	0	2	175	2	10	175	8	1	16
	18	KARTAL	0	0	0	0	0	0	0	0	0	0	0	20
	22	PENDİK	0	0	7	992	4	617	11	38	1,610	45	4	14
	28	TUZLA	0	0	0	0	0	0	0	0	0	0	2	8
	Sub-Total		0	0	8	1,091	13	1,386	21	18	2,477	17	12	79
Asian: Bosphoras	30	ÜSKÜDAR	0	0	2	106	6	537	8	15	643	19	3	43
	6	BEYKOZ	1	86	10	1,006	4	592	15	79	1,684	72	1	3
	29	ÜMRANİYE	0	0	1	105	1	124	2	14	229	6	3	9
	Sub-Total		1	86	13	1,217	11	1,253	25	29	2,556	28	7	55
Total/Average of Asian Side			1	86	21	2,308	24	2,639	46	22	5,032	21	19	134
Total			3	160	40	3,460	54	4,785	97	15	8,406	18	51	466
		share (%)	0.5	0.3	6.2	6.9	8.6	9.6					8.3	74.8

Source: The JICA Study Team

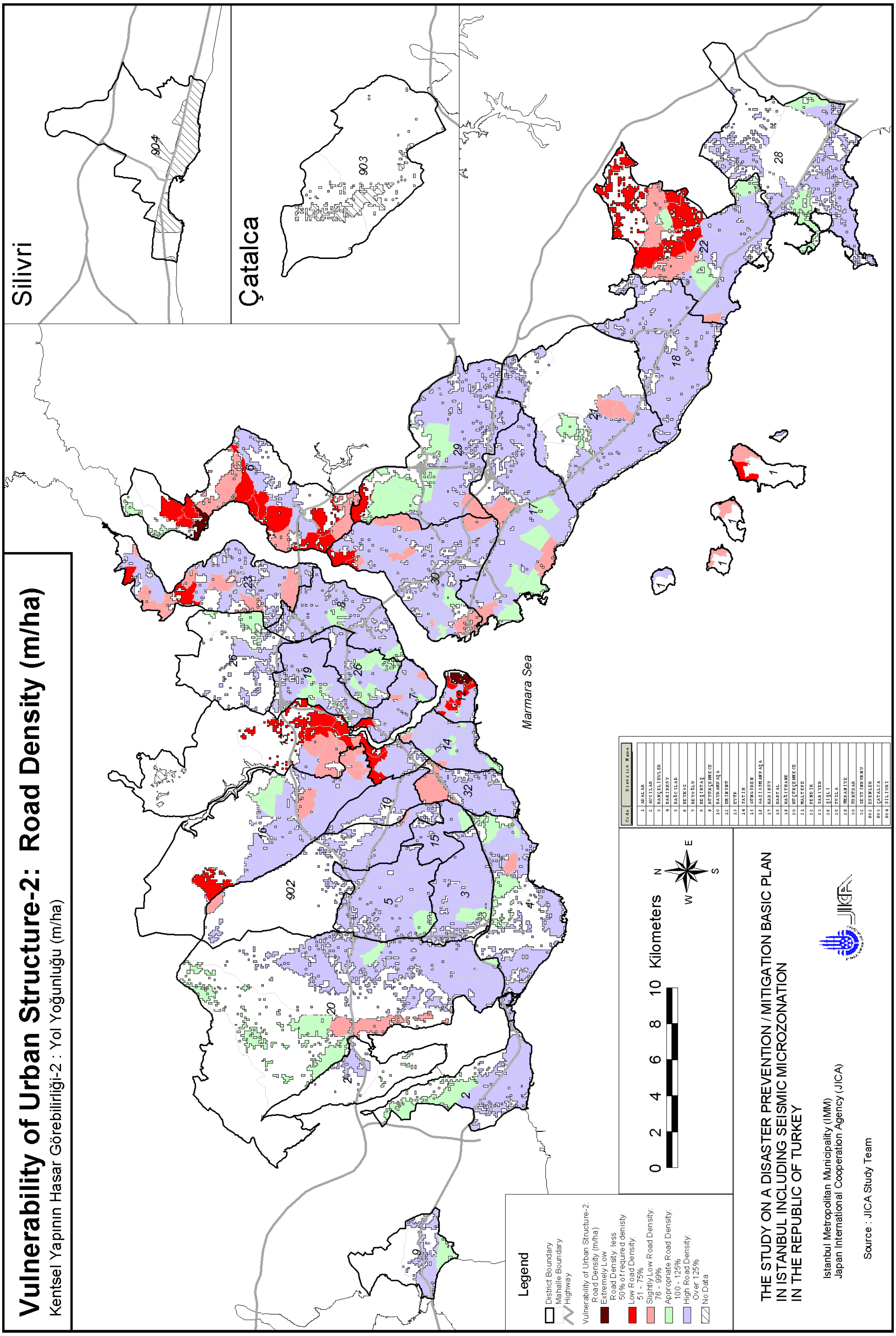


Figure 10.1.6 Road Density (m/ha)

10.1.7. Narrow and Inappropriate Road Conditions: Constraints for Evacuation and Emergency Response Operations

Safety issues related to existing road conditions were identified by taking into account the existence of narrow roads during an urban earthquake disaster. Narrow roads will be serious constraints for the safe evacuation of citizens and proper emergency vehicle operations as follows:

1) Narrow roads - less than 4 m wide

Even during normal times, roads less than 4 m wide cannot be properly used by emergency vehicles due to the following reasons:

- Improper geometric road design for vehicle operation (especially in the Old Town area); and
- Street parking that blocks emergency vehicular traffic.

Furthermore, in the case of an earthquake disaster, debris of collapsed and heavily damaged buildings along the street will cover and close more than 3 m of road width.

2) Narrow roads - 4 to 6 m wide

Under an earthquake disaster, roads less than 6 m wide will be closed and will not be used as routes of emergency vehicle or evacuation operations or .

Areas assessed as having high building damage and high narrow road ratios will be isolated, and eventually suffer damage of catastrophic proportions, if no rescue and other emergency response operation are undertaken.

There are 8,785 km (65% of 13,567 km of total road length) of narrow roads 2 to 6m wide or less in Istanbul. The narrow road ratio analysis by mahalle is categorized into 5 groups as follows:

- **Over 80%** of road length is made up of narrow roads: 149 mahalles (23% of the total), or 9,385 ha (19% of the total) of the urbanized area, will have high potential to be isolated based on building damage conditions.
- The categorized mahalles are widely spread out except on the European Marmara Coast and in Besiktas and Kadıköy.

- **61 – 80%:** 247 mahalles (38%) and 19,294 ha (38%) of the urbanized area will also have a potential to be isolated. The categorized 247 mahalles are more widely distributed in almost all of districts, except the district of Güngören.
- **41 – 60%:** 179 mahalles (28%) and 16,610 ha (33%) of the urbanized area will have evacuation activities and emergency vehicle operations disrupted, parts of the mahalles will be isolated due to closed roads. Thiscategory of mahalles are also widely spread out over all districts.
- **21 – 40%:** 50 mahalles (8%) and 4,657 ha (9%) of the urbanized area will not have evacuation and emergency vehicle operations free to navigate the roads, but substitute access routes were identified. This category of mahalles is limitedly distributed in the districts with better road conditions.
- **0-20%:** 0nly 10 mahalles (2%) and 731 ha of the urbanized area will have evacuation and emergency operation activities disrupted by road closures. These mahalles are mainly located in the districts on the European Marmara Coast.

Table 10.1.7 Narrow Road Ratio by Mahalle

Area	District		Total Length (km)	0ver 80%		61-80%		41-60%		21-40%		0-20%		Narrow Road	
	Code	Name		Mahalle	Urbanized area (ha)	Mahalle	Urbanized area (ha)	Mahalle	Urbanized area (ha)	Mahalle	Urbanized area (ha)	Mahalle	Urbanized area (ha)	Length (km)	Ratio (%)
Old Town	12	EMİNÖNÜ	118	8	63	14	178	8	133	2	71	1	7	72	61
	14	FATİH	268	27	340	24	377	14	223	4	41	0	0	196	73
	7	BEYOĞLU	241	20	345	16	274	7	190	2	19	0	0	178	74
	Sub-Total		627	55	749	54	829	29	547	8	132	1	7	445	71
Europe: Marmara Coast	32	ZEYTİNBURNU	235	0	0	3	183	7	320	2	353	1	83	113	48
	4	BAKIRKÖY	350	0	0	5	318	7	963	2	268	1	64	169	48
	15	CÜNGÖREN	186	0	0	0	0	4	322	4	199	3	156	67	36
	3	BAHÇELİEVLER	373	0	0	4	281	5	578	1	286	1	285	186	50
	2	AVCILAR	432	1	407	3	355	4	686	1	83	0	0	270	62
	Sub-Total		1,575	1	407	15	1,137	27	2,871	10	1,189	6	587	803	51
Europe: Bosphoras	8	BESİKTAŞ	326	0	0	9	455	9	604	5	459	0	0	166	51
	19	KAĞITANE	344	3	101	9	411	7	710	0	0	0	0	216	63
	26	ŞİŞLİ	475	5	372	11	449	6	353	6	303	0	0	301	63
	23	SARIYER	497	10	1,034	12	1,052	0	0	0	0	1	10	388	78
	Sub-Total		1,642	18	1,506	41	2,367	22	1,667	11	761	1	10	1,071	65
Europe: Inland	13	EYÜP	488	3	91	10	650	7	781	0	0	0	0	323	66
	16	GAZİOSMANPAŞA	862	7	526	13	1,081	8	824	0	0	1	27	609	71
	10	BAYRAMPAŞA	235	1	23	3	211	4	300	2	132	1	100	120	51
	902	ESENLER	517	7	302	9	663	2	57	0	0	0	0	395	76
	5	BAĞCILAR	562	1	62	13	987	7	568	1	322	0	0	345	61
	20	KÜÇÜKÇEKMECE	1,256	5	1,111	9	1,284	7	1,636	2	108	0	0	863	69
	Sub-Total		3,920	24	2,116	57	4,874	35	4,166	5	563	2	127	2,654	68
Total/Average of European Side			7,764	98	4,778	167	9,207	113	9,251	34	2,645	10	731	4,974	64
Asian: Marmara Coast	1	ADALAR	123	6	227	4	148	1	0	0	0	0	0	99	80
	17	KADIKÖY	733	0	0	9	980	13	1,709	6	841	0	0	395	54
	21	MALTEPE	740	4	542	4	222	10	1,083	3	470	0	0	464	63
	18	KARTAL	612	1	89	3	611	12	1,471	4	447	0	0	323	53
	22	PENDİK	741	12	1,575	11	1,245	6	738	0	0	0	0	562	76
	28	TUZLA	558	2	144	7	1,499	2	337	0	0	0	0	383	69
	Sub-Total		3,508	25	2,578	38	4,705	44	5,339	13	1,758	0	0	2,226	63
Asian: Bosphoras	30	ÜSKÜDAR	757	14	524	26	1,657	11	864	3	254	0	0	499	66
	6	BEYKOZ	556	11	1,222	6	906	2	211	0	0	0	0	428	77
	29	ÜMRANİYE	982	1	284	9	2,750	4	566	0	0	0	0	659	67
	Sub-Total		2,295	26	2,030	41	5,313	17	1,642	3	254	0	0	1,586	69
Total/Average of Asian Side			5,803	51	4,608	79	10,019	61	6,981	16	2,012	0	0	3,811	66
Outside IMM	9	BÜYÜKÇEKMECE	133	0	0	1	69	5	378	0	0	0	0	72	54
	903	ÇATALCA	NA	0	0	0	0	0	0	0	0	0	0	NA	NA
	904	SİLİVRİ	NA	0	0	0	0	0	0	0	0	0	0	NA	NA
	Sub-Total		NA	0	0	1	69	5	378	0	0	0	0	NA	NA
Total			13,567	149	9,385	247	19,294	179	16,610	50	4,657	10	731	8,785	65
		Share (%)		23	19	38	38	28	33	8	9	2	1		

Source: The JICA Study Team

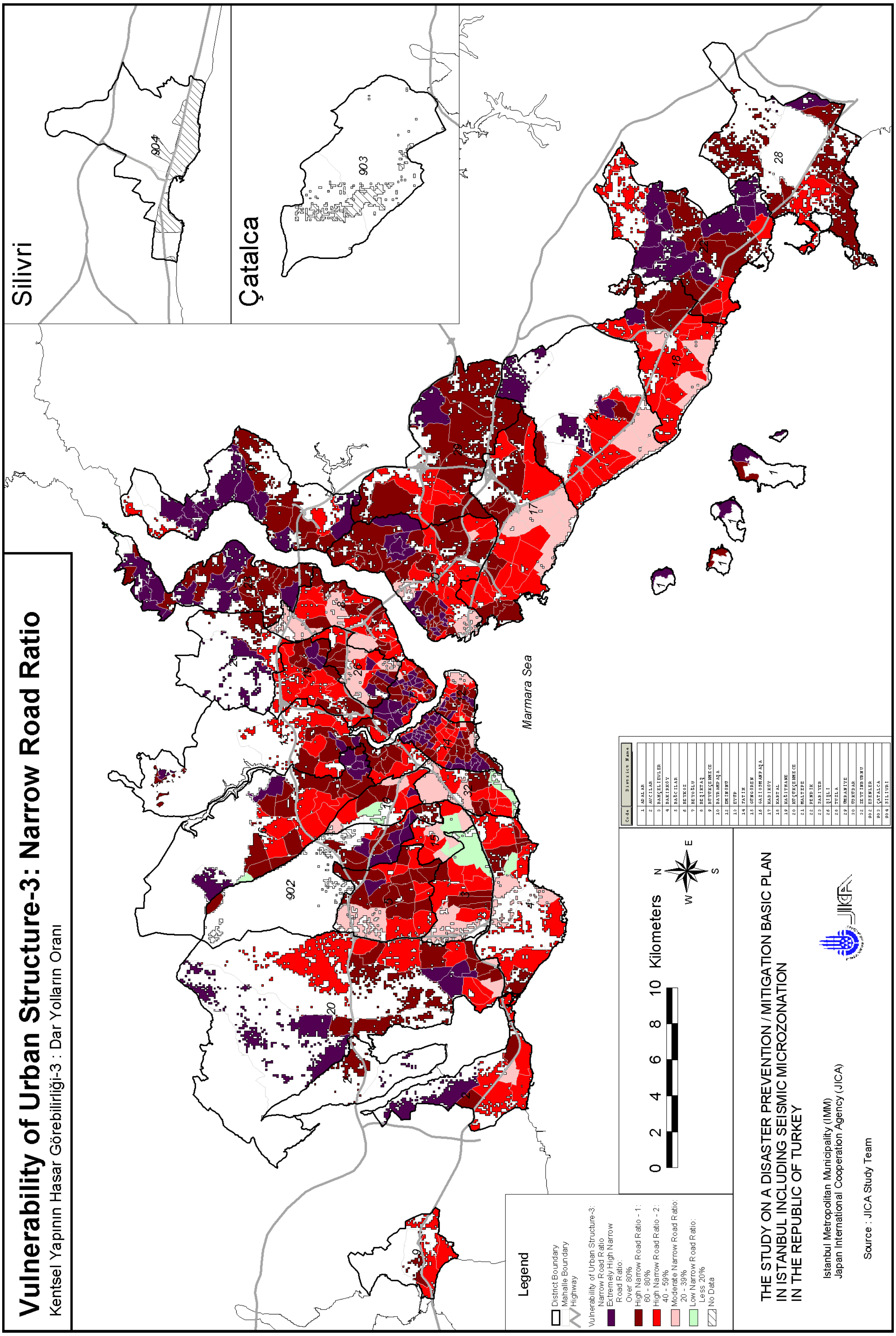


Figure 10.1.7 Narrow Road Ratio

10.1.8. Parks and Open Space Availability for Primary Safety Evacuation of Residents

Presently, an evacuation system has not been introduced or established in Turkey yet. On the other hand, the Tent Village System, which is an organized system of 486 small (less than 500m^2) to bigger sized designated tent villages, has been planned and established in Istanbul.

To keep citizens safe, a new urban disaster emergency evacuation system is recommended for several reasons:

- To minimize human casualties from aftershocks,
- To minimize human casualties from secondary disasters, and
- To collect accurate primary damage information from evacuated residents for arrangement of appropriate response operation teams and emergency goods, etc.

The recommended evacuation system is made up community and regional evacuation areas, accessed by evacuation routes as follows:

1) Primary Evacuation Areas:

Primary evacuation and gathering places are not only recommended to focus on the safety of citizens but also to collect accurate primary damage information faster from the evacuated residents by the recommended self-organized community disaster task forces. This information will be most useful to organize and dispatch emergency task forces even without any instructions from the disaster management centre.

The evacuation areas are recommended to be located in each neighborhood unit and □□ □ are intended for all residents and citizens (gross minimum area: 1.5 m^2/person). Evacuation areas should be selected and designated from publicly-owned lands or facilities as follows:

- **Candidates:** parks, open spaces, schools, and religious facilities, which are most commonly and evenly distributed in each neighborhood community unit.
- **Seismically Resistant Building Structures**: at present, public schools and mosques are well distributed in neighborhood units, but the building structures of these facilities were not found to be sufficiently seismically resistant, except for some newly constructed schools.

- **Open Spaces:** parks and open spaces with areas bigger than 2000 m^2 (minimum 500 m^2) are the most appropriate candidates for primary evacuation areas in Istanbul.
- **Other Hazards:** unstable and steep slope areas (prone to landslide disasters) and the areas adjacent to hazardous facilities such as LPG/fuel stations, etc. (prone to secondary disasters of fire and explosion), and areas affected by building collapses.

2) Regional Evacuation Areas:

Regional evacuation areas can be thought of as undertaking almost the same functions as tent villages for victims in Istanbul. The Japanese standard of area distribution per victim is less than 5 m^2. However, the standard in Turkey is 9 to 10 m^2 per victim, which will require huge areas of tent villages in Istanbul.

3) Evacuation Routes:

It is also strongly recommended that evacuation routes for the safe evacuation of citizens be designated before a disaster.

In the analysis, land availability and shortage of parks and open spaces are assessed, along with the estimated demand of primary evacuation areas for all residents in each mahalle. Land availability of parks/open spaces for primary evacuation areas can be one indication of whether it would be safe or unsafe for mahalle residents in the event of an earthquake disaster.

The source database for the analysis of parks and open spaces was a survey developed by Ms. Aksoy[2] in cooperation with the Mapping and Research Directorate of the IMM. Then, the JICA Study Team proceeded with the update and establishment of the GIS Database of Parks and Open Spaces.

The result of the land availability analysis is categorized into 5 groups as follows:

- **Less than 25% of Demand:** The almost lack of parks/open spaces for primary evacuation areas was identified in 340 mahalles (53% of all mahalles). This category of mahalles were widely identified in 27 districts. Districts with a high number of these mahalles are Fatih, Beyoglü, Zeytinburunu, Güngören, Kagıtane, Sisli, Gaziosmanpasa, Esenler, Bagcılar, Küçükçekmece, Kadıköy, Maltepe, Kartal, Pendik, Umraniye, Çatalca, and Silivri.

- **25 to 49% of Demand:** 79 mahalles (12% of all mahalles) were found to have a limited number of parks and open spaces for primary evacuation areas. In the six districts of Bahçelievler, Avcılar, Kagıtane, Eyüp, Bayranpasa, and Ümraniye, this category of mahalles make up more than 20% of all mahalles.
- **50 to 99% of Demand:** 68 mahalles (11% of all mahalles) were found to have a shortage of parks and open spaces for primary evacuation areas.
- **100 to 150% of Demand:** 23 mahalles (4% of all mahalles) were found to have sufficient existing parks and open spaces for the demand of primary evacuation areas. However, net usable land for primary evacuation areas should be carefully examined considering the surrounding conditions in the district disaster management plan study.
- **Over 150% of Demand:** Existing areas of parks and open spaces were found to make up over 1.5 times of the area demand in 115 mahalles (18% of all mahalles). Also, it is recommended that net usable land be recommended in the district disaster management study.

Based on the above analysis, parks and open spaces had not been well developed and standardized in past urban developments, which may be due to squatter settlements and irregular housing developments in Istanbul. A total of 485 mahalles (76% of all mahalles) are categorized as *inhabitable mahalles*, capable of providing evacuation areas for residents. On the other hand, the present mahalles are not recognized as a standardized community unit. A primary evacuation should be established at the recommended self-organized community disaster task force level, for which the district disaster management plan formulation study is also recommended to be considered in detail.

Also, road islands, medians, and roadside slopes are currently categorized as parks by the Parks Department of the IMM. However, these areas function as road landscaping areas and not as parks and open spaces.

[2] Aksoy, Y., (2001) The Determination of Existing Green Area Situation in Istanbul, Ph.D. Thesis, I.T.U., Institute of Science and Technology, Urban and Regional Planning Department, Landscape Planning Programme, 2001, Istanbul, Turkey.

Table 10.1.8 Availability of Parks and Open Spaces for Required Primary Evacuation Areas by Mahalle

Area	District		less 25%		25 - 49%		50 - 99%		100 - 150%		over 150%		Unknown	Total
	Code	Name	mahalle	(%)	mahalle	(%)	mahalle	(%)	mahalle	(%)	mahalle	(%)	mahalle	mahalle
Old Town	12	EMINÖNÜ	13	39	2	6	2	6	1	3	15	45	0	33
	14	FATİH	43	62	5	7	5	7	3	4	13	19	0	69
	7	BEYOĞLU	31	69	0	0	4	9	2	4	8	18	0	45
	Sub-Total		87	59	7	5	11	7	6	4	36	24	0	147
Europe: Marmara Coast	32	ZEYTİNBURNU	7	54	2	15	3	23	0	0	1	8	0	13
	4	BAKIRKÖY	1	7	2	13	3	20	1	7	8	53	0	15
	15	CÜNGÖREN	8	73	2	18	1	9	0	0	0	0	0	11
	3	BAHÇELİEVLER	5	45	3	27	3	27	0	0	0	0	0	11
	2	AVCILAR	4	44	2	22	0	0	0	0	3	33	0	9
	Sub-Total		25	42	11	19	10	17	1	2	12	20	0	59
Europe: Bosphoras	8	BESİKTAŞ	5	22	2	9	3	13	3	13	10	43	0	23
	19	KAĞITANE	11	58	5	26	1	5	1	5	1	5	0	19
	26	ŞİŞLİ	21	75	2	7	2	7	0	0	3	11	0	28
	23	SARIYER	9	39	4	17	5	22	2	9	3	13	0	23
	Sub-Total		46	49	13	14	11	12	6	6	17	18	0	93
Europe: Inland	13	EYÜP	5	25	4	20	4	20	0	0	7	35	0	20
	16	GAZİOSMANPAŞA	22	76	5	17	0	0	0	0	1	3	1	29
	10	BAYRAMPAŞA	1	9	5	45	3	27	0	0	2	18	0	11
	902	ESENLER	14	78	1	6	1	6	1	6	0	0	1	18
	5	BAĞCILAR	17	77	4	18	1	5	0	0	0	0	0	22
	20	KÜÇÜKÇEKMECE	19	83	2	9	1	4	0	0	1	4	0	23
	Sub-Total		78	63	21	17	10	8	1	1	11	9	2	123
Total/Average of European Side			236	56	52	12	42	10	14	3	76	18	2	422
Asian: Marmara	1	ADALAR	0	0	1	9	1	9	1	9	2	18	6	11
	17	KADIKÖY	18	64	3	11	1	4	0	0	6	21	0	28
	21	MALTEPE	14	67	2	10	0	0	0	0	3	14	2	21
	18	KARTAL	12	60	3	15	4	20	0	0	1	5	0	20
	22	PENDİK	16	55	5	17	3	10	1	3	4	14	0	29
	28	TUZLA	2	18	1	9	3	27	4	36	0	0	1	11
	Sub-Total		62	52	15	13	12	10	6	5	16	13	9	120
Asian: Bosphoras	30	ÜSKÜDAR	19	35	9	17	9	17	3	6	14	26	0	54
	6	BEYKOZ	7	37	0	0	4	21	0	0	8	42	0	19
	29	ÜMRANİYE	9	64	3	21	1	7	0	0	1	7	0	14
	Sub-Total		35	40	12	14	14	16	3	3	23	26	0	87
Total/Average of Asian Side			97	47	27	13	26	13	9	4	39	19	9	207
Outside IMM	9	BÜYÜKÇEKMECE	0	0	0	0	0	0	0	0	0	0	6	6
	903	ÇATALCA	2	100	0	0	0	0	0	0	0	0	0	2
	904	SİLİVRİ	5	100	0	0	0	0	0	0	0	0	0	5
	Sub-Total		7	54	0	0	0	0	0	0	0	0	6	13
Total			340	53	79	12	68	11	23	4	115	18	17	642

Remark: Percentages in the head of columns show the ratio of land availability of parks and open spaces (bigger than 500 m2) in each mahalle (= park/open space area ÷ area demand for primary evacuation).

Source: The JICA Study Team

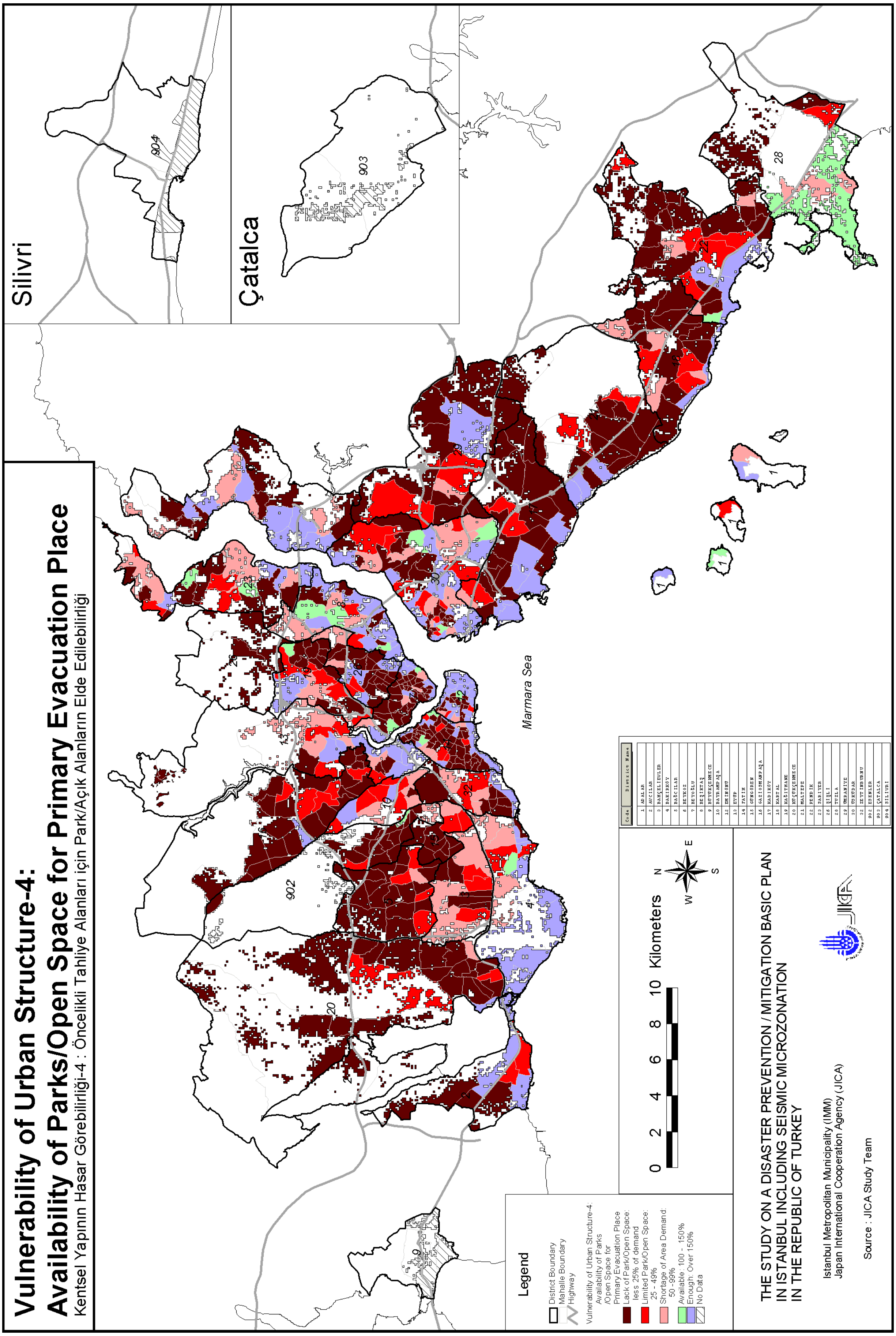


Figure 10.1.8 Availability of Parks/Open Spaces for Primary Evacuation Areas

10.1.9. Area Identification of Urban and Building Structure Issues

Based on the 6 vulnerability analyses of buildings and urban structures, vulnerabilities were assessed and compiled into 4 categories as follows:

1) Mahalles with Building and Urban Structure Vulnerabilities: 361 mahalles (56% of the Study Area).

This group of identified mahalles has both serious vulnerability issues of weak building structures and inappropriate urban structures. More than half of the mahalles in the districts along the Marmara Coast and inland areas of the European side belong to this category. In the 11 districts identified as most serious (Emınönü, Fatih, Beyoglu, Zeytinburnu, Güngören, Bagcılar, Küçükçekmece, Adalar, Maltepe, Pendik, and Tuzla), over 80% of the population or urbanized areas in each district reside in this category of mahalles.

A combination of drastic measures is required to strengthen both the vulnerabilities of buildings and urban structures for the identified 361 mahalles.

2) **Mahalles with Urban Structure Vulnerabilities**: 39 mahalles (6%).

400 mahalles found to have serious urban structure vulnerabilities are covered by the above category (1), "mahalles with building and structure vulnerabilities." The 39 mahalles without serious building structure issues are distributed over the central part of the Study Area.

3) **Mahalles with Building Structure Vulnerbailities**: 51 mahalles (8%).

412 serious mahalles with building structure vulnerabilities are covered by the above category (1), "mahalles with building and structure vulnerabilities." The 51 mahalles are widely distributed along the Marmara Coast of European and in Asian and European inland areas.

4) **Other Mahalles**: 191 mahalles (30%)

The 191 mahalles categorized as "other mahalles" do not have the above serious building and urban structure issues. However, these mahalles have the following issues and characteristics:

- Less than 10% of buildings in mahalle were estimated as having heavy or moderate building damages.

- Serious urban structure issues were not found in the mahalle, or the mahalle was not yet urbanized.
- Specific or detailed issues in the area should be considered in the development of the district urban disaster prevention plan.

Table 10.1.9 Identified Mahalle/Residents/Urbanized Area by Type of Building/Urban Structure Issues

Area	District		Issuable Mahalle on Building/Urban Structure					Issuable Mahalle on Urban Structure					Issuable Mahalle on Building Structure					Other Mahalles				
	Code	Name	Mahalle	Population (000s)	(%)	Urbanized Area (ha)	(%)	Mahalle	Population (000s)	(%)	Urbanized Area (ha)	(%)	Mahalle	Population (000s)	(%)	Urbanized Area (ha)	(%)	Mahalle	Population (000s)	(%)	Urbanized Area (ha)	(%)
Old Town	12	EMINÖNÜ	27	46	83	365	81	3	6	11	39	9	0	0	0	0	0	3	3	5	49	11
	14	FATİH	67	393	100	966	98	0	0	0	0	0	2	1	0	16	2	0	0	0	0	0
	7	BEYOĞLU	39	190	81	706	85	5	41	17	117	14	0	0	0	0	0	1	5	2	5	1
	Sub-Total		133	628	92	2,036	90	8	47	7	156	7	2	1	0	16	1	4	7	1	54	2
Europe: Marmara Coast	32	ZEYTİNBURNU	10	200	83	701	75	0	0	0	0	0	3	40	17	238	25	0	0	0	0	0
	4	BAKIRKÖY	9	68	33	537	33	0	0	0	0	0	6	139	67	1,076	67	0	0	0	0	0
	15	CÜNGÖREN	10	250	92	598	88	0	0	0	0	0	1	22	8	80	12	0	0	0	0	0
	3	BAHÇELİEVLER	8	352	75	676	47	0	0	0	0	0	3	118	25	754	53	0	0	0	0	0
	2	AVCILAR	6	174	75	1,069	70	0	0	0	0	0	2	44	19	297	19	1	14	6	165	11
	Sub-Total		43	1,043	73	3,581	58	0	0	0	0	0	15	362	26	2,445	39	1	14	1	165	3
Europe: Bosphoras	8	BESİKTAŞ	4	26	14	227	15	3	22	12	46	3	1	2	1	48	3	15	132	72	1,195	79
	19	KAĞITANE	6	100	29	279	23	2	33	10	98	8	2	43	12	362	30	9	167	49	483	40
	26	ŞİŞLİ	7	58	21	185	13	3	36	13	98	7	1	3	1	33	2	17	175	65	1,159	79
	23	SARIYER	0	0	0	0	0	1	5	2	56	3	0	0	0	0	0	22	208	98	2,040	97
	Sub-Total		17	0	0	691	11	9	96	12	299	5	4	47	6	444	7	63	683	83	4,878	77
Europe: Inland	13	EYÜP	7	90	39	652	43	6	64	28	304	20	2	8	4	174	11	5	70	30	391	26
	16	GAZİOSMANPAŞA	7	162	24	602	25	6	115	17	326	13	0	0	0	0	0	16	391	58	1,529	62
	10	BAYRAMPAŞA	7	147	62	432	57	0	0	0	0	0	3	74	31	279	37	1	16	7	50	7
	902	ESENLER	12	284	73	523	51	0	0	0	0	0	1	3	1	18	2	5	101	26	482	47
	5	BAĞCILAR	21	517	93	1,831	94	0	0	0	0	0	0	0	0	0	0	1	40	7	108	6
	20	KÜÇÜKÇEKMECE	19	505	86	2,414	58	0	0	0	0	0	1	12	2	114	3	3	72	12	1,611	39
	Sub-Total		73	1,705	64	6,455	55	12	179	7	631	5	7	98	4	585	5	31	690	26	4,171	35
Total/Average of European Side			266	3,376	60	12,763	48	29	322	6	1,085	4	28	509	9	3,489	13	99	1,395	25	9,268	35
Asian: Marmara Coast	1	ADALAR	6	18	100	356	100	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
	17	KADIKÖY	16	431	65	2,245	64	5	73	11	395	11	5	119	18	609	17	2	38	6	281	8
	21	MALTEPE	14	257	74	1,855	80	0	0	0	0	0	3	70	20	277	12	4	19	5	180	8
	18	KARTAL	14	242	73	1,995	76	0	0	0	0	0	5	76	23	480	18	1	14	4	144	6
	22	PENDİK	25	334	90	3,037	85	0	0	0	0	0	2	26	7	161	5	2	13	4	361	10
	28	TUZLA	8	82	81	1,622	82	0	0	0	0	0	2	19	19	337	17	1	0	0	21	1
	Sub-Total		83	1,363	75	11,110	77	5	73	4	395	3	17	309	17	1,865	13	15	85	5	986	7
Asian: Bosphoras	30	ÜSKÜDAR	7	28	6	144	4	5	37	7	115	4	2	40	8	183	6	40	392	79	2,805	86
	6	BEYKOZ	2	10	5	150	6	0	0	0	0	0	0	0	0	0	0	17	173	95	2,189	94
	29	ÜMRANİYE	2	72	16	368	10	0	0	0	0	0	0	0	0	0	0	12	371	84	3,232	90
	Sub-Total		11	110	10	662	7	5	37	3	115	1	2	40	4	183	2	69	936	83	8,226	90
Total/Average of Asian Side			94	1,473	50	11,772	50	10	109	4	510	2	19	349	12	2,048	9	84	1,021	35	9,212	39
Outside IMM	9	BÜYÜKÇEKMECE	1	0	NA	69	15	0	0	NA	0	0	4	0	NA	376	84	1	0	NA	2	0
	903	ÇATALCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	16	100	426	100
	904	SİLİVRİ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	44	100	841	100
	Sub-Total		1	0	0	69	4	0	0	0	0	0	4	0	0	376	22	8	60	100	1,268	74
Total			361	4,849	56	24,603	47	39	431	5	1,595	3	51	858	10	5,913	11	191	2,476	29	19,748	38

Source: The JICA Study Team

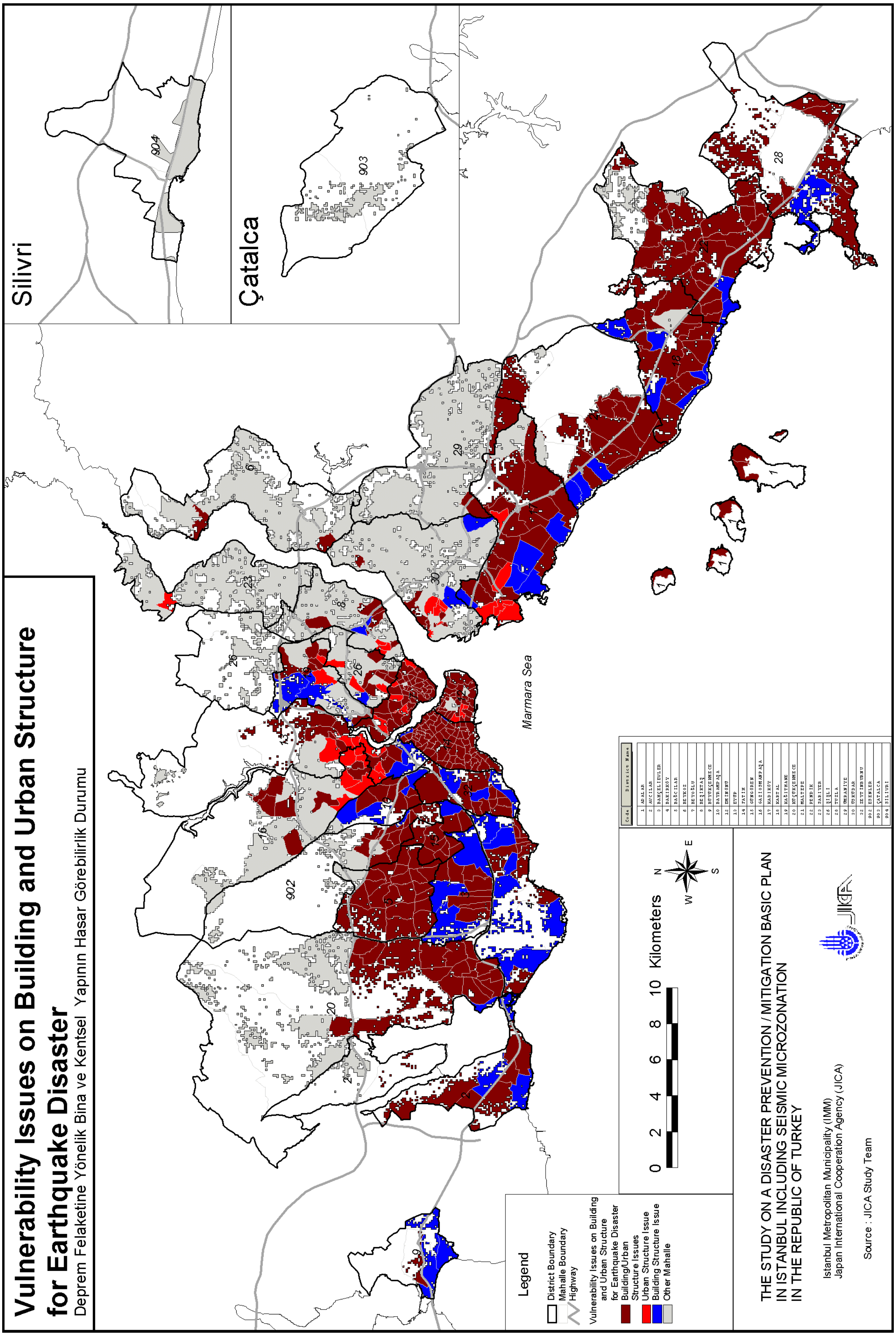


Figure 10.1.9 Building and Urban Structure Vulnerability Issues

10.2. Recommended Measures to Strengthen Vulnerable Buildings and Urban Structures

To address the assessed vulnerability issues, improvement measures for vulnerable buildings and urban structures are principally composed as follows:

1) Measures to Improve Vulnerable Building Structures

- Implementation of proper seismic-resistant diagnoses and formulation and implementation of building structure improvements for disaster management centres, emergency response centres, emergency goods related centres, and public facilities.
- Reinforcement of building structures of identified public and government facilities.
- Reconstruction of identified public and government facilities.
- The introduction, modification, and establishment of preliminary seismic resistance assessment systems for private housing.
- The implementation of preliminary seismic resistant assessments for private buildings.
- The acquisition of resources and establishment of a recyclable funding system for private sector building reinforcement and reconstruction (especially for weak building structures identified by the preliminary seismic resistant assessment).
- The implementation of building structure reinforcement or reconstruction projects for private housing/commercial buildings by groups of street blocks.
- All of the above required and improvement measures should be coordinated within the formulation of metropolitan and local (district) disaster prevention plans.

2) Measures to Improve Vulnerable Urban Structures

- Widening of narrow road (2 to 6 m in width) to the appropriate for evacuation and emergency operations.
- Widening of designated emergency road networks to function in an emergency case (without the need for debris removal).
- Widening and safety measures of designated evacuation routes (they should be set in the local/district disaster prevention plan).
- Standardized parks and open space development to provide safety evacuation areas and recreational spaces for citizens.

- Reducing excessive land/building use conditions (especially, high building coverage, which can negatively impact efforts of safety evacuation).

The assessed and identified vulnerability issues are grouped into 4 categories as follows:

- Issue 1: Urban/Building Structure Vulnerability
- Issue 2: Urban Structure Vulnerability
- Issue 3: Building Structure Vulnerability
- Issue 4: Particular Building Structure Vulnerability

The recommended principal measures to solve the issues of building and urban structure vulnerability should be well coordinated and combined to meet with the present characteristics of issues and their combinations.

Issue 1 Strategic Measures: two strategic measures will be required to solve the complex issues of building and urban structure vulnerability.

- Combined/coordinated measures to strengthen identified vulnerabilities of building structures and urban structures.
- Urban reconstruction measures to address the lack of available land for urban structure improvement projects.

Issue 2 Strategic Measures: the following strategic measures will also be required to solve issues of urban structure vulnerability.

- Intensive measures to strengthen urban structure vulnerability.
- Urban reconstruction measures to address the lack of available land for urban structure improvement projects.
- Supplemental measures for individual building structure improvements are also required to strengthen estimated building damages (10% to 30% of heavy and moderate).

Issue 3 Strategic Measures: the identified and recommended measures to improve building structures are fully required to be implemented on buildings of estimated high building damage (more than 30% of heavy and moderate). Also, some urban improvement measures will be required as supplements for non-serious urban structure issues, which should be also examined in detail during the formulation of the local disaster prevention plan.

Issue 4 Strategic Measures: some of the identified and recommended measures to improve building structures will be required to improve the individually estimated building damages (less than 10% of heavy and moderately damaged). Some urban improvement measures will be required as supplements for non-serious urban structure issues, which should be also examined in detail during the formulation of the local disaster prevention plan.

10.2.1. Specialized Improvement Measures for Designated Conservation Areas

Presently, identified archeological heritage, historical, and traditional works, and natural environmental resources are grouped into one of four categories of area conservation systems as follows:

- **Area Conservation 1:** Archeological Area (eastern top of the Istanbul Peninsula)

  All archeological heritage sites at ground level and underground within the designated areas are strictly protected and all activities of development or redevelopment are completely controlled by the boards of conservation.

- **Area Conservation 2:** Historical Urban Area (inside the Walled City, Beyoğlu, and Eyüp, and towns in Adalar islands, etc.)

  Designated historical buildings and their surrounding buildings and traditional alleyways are the main objects of conservation.

- **Area Conservation 3:** Historical Scenery Conservation Areas (along the Bosphorus Strait, includesdistricts of European and Asian Bosphorus areas)

  Façade control for waterfront buildings and height and scenery control for the hinterland within visible areas from the Bosphorus Strait sea level.

- **Area Conservation 4:** Natural Environmental Resources (hinterland of Area Conservation 3: Bosphorus, Adalar Islands, etc.)
- Mixed area conservation of the above

In addition, the Istanbul Peninsula and the Chronological Walled City of Constantinople/Istanbul, including the districts of Enınönü and Fatih, were registered as World Heritage sites by UNESCO in 1992.

Some recommended measures to improve the identified vulnerability issues of building and urban structures contradict the regulations of some area conservation systems (especially those of the Historical Urban Conservation Areas). Thus, specialized or modified improvement measures for identified vulnerabilities are required.

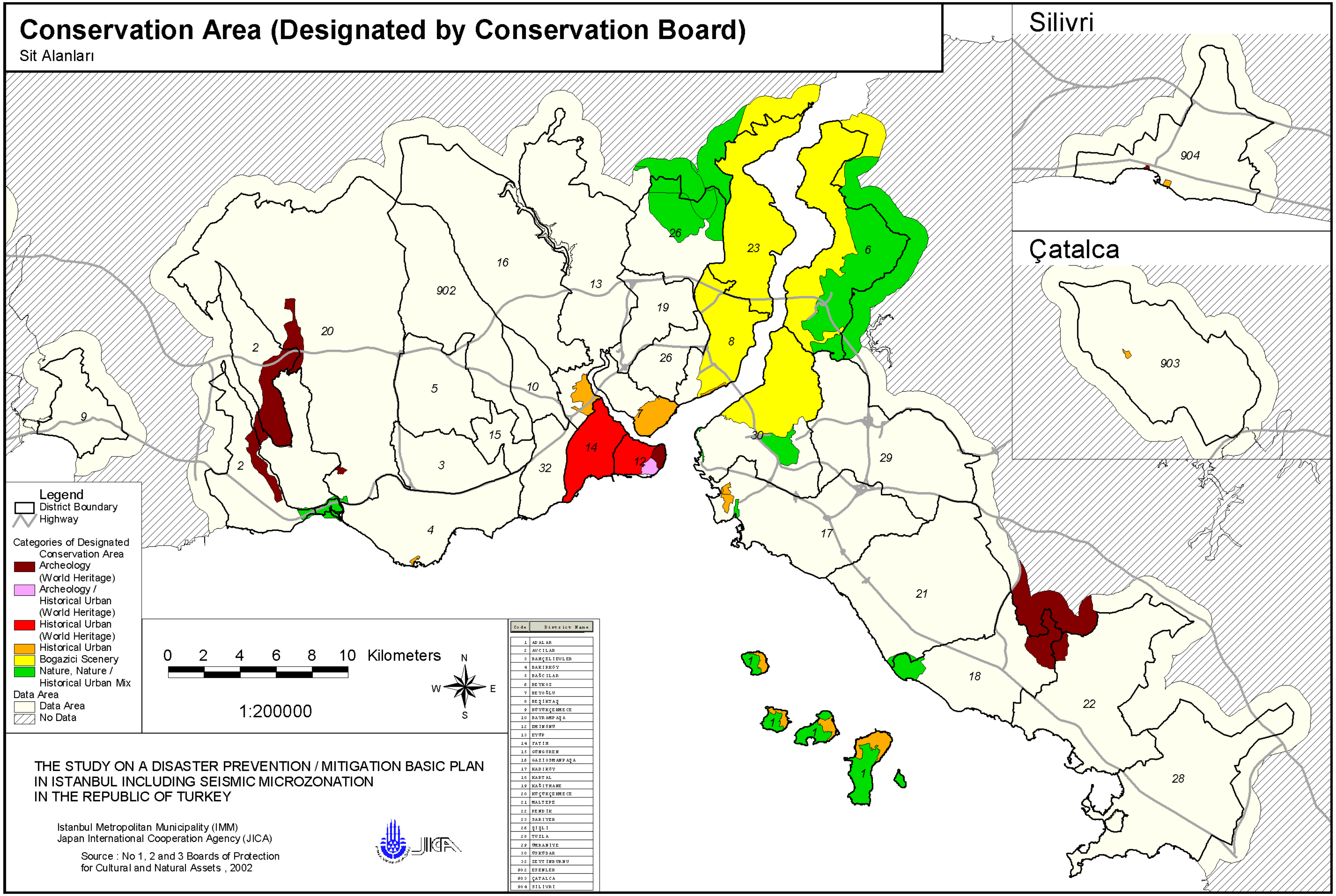


Figure 10.2.1 Conservation Areas (Designated by the Conservation Board)

(1) Archeological Area Conservation

Existing Condition: In the Study Area, 7 small and major archeological areas, in which all private and public development and improvements are strictly controlled by the Boards of Conservation, the IMM, and local governments, were identified.

The most serious contradiction between conservation and improvement measures identified concern the Tarihi Yarymada Archeological Conservation Area (Topkapi and its surroundings) and the Mixed Archeological/Historical Urban Conservation Area (Ayasofiya/Sultanahmet, Camii, and surroundings) at the top of the Istanbul Peninsula, which also includes areas registered as world heritage sites. Both designated areas are assessed as having mahalles with serious building and urban structure vulnerabilities.

Measures to improve the safety of the environment for residents (population of approximately 12,500) would be required of responsible agencies and of the IMM as follows:

- Reinforcement, restoration or reconstruction of assessed weak structures/buildings (public and private) by the authority.
- Modification of parks and gardens to serve as potential evacuation areas.
- Improvement of existing road/alleyway network to serve as evacuation routes and emergency vehicle access roads.
- The above required safety measures should be incorporated into the Archeological Conservation Plan and Programme for both areas (as part of a specialized disaster prevention plan for strictly controlled areas).

In addition, the following incentive measures to revitalize socioeconomic activities and to compensate for the strict control measures in the area are also recommended to the government authorities:

- Right to purchase properties by the authority.
- Subsidy for conservation/beautification activities.
- Exemption of real estate tax in the area, etc.

In the Avcilar district, huge areas on the west-coast of the lake are designated as Archeological Conservation areas, which are also planned and designated as tent village areas for homeless victims and as helipads within the Provincial Disaster Management Plan. Some infrastructure development (water pipes/tanks, sewage treatment facilities, and helipads) can negatively impact buried archeological heritages. The permanent and heavy weight facility development within a disaster management plan will be required to coordinate with the archeological conservation plan.

(2) Historical Urban Conservation

Designated Historical Urban Conservation areas are assessed and categorized as areas having serious building and urban structure vulnerabilities. In order to minimize and mitigate the estimated damage, improvement measures to strengthen the identified vulnerabilities are critical and describes as follows:

Vulnerability Issues	Required Improvement Measures	Regulation for Conservation
Old/weak structures/buildings: high building damage and human casualties ratio	Seismic resistance assessment, reconstruction/ reinforcement	Conserve historical building or building group
Narrow alleyways: cannot be used as safety evacuation routes or for emergency vehicle access	Road widening or additional (new) road development	Conserve alleyway streetscapes and no widening of roads or construction of new roads

The recommended improvement measures for buildings and urban structures are unacceptable according to the present and strict Historical Urban Conservation regulaion. Based on this situation, modification of the recommended improvement measures and, also, some modification of zoning regulations for the conservation areas would be required to harmonize conservation and disaster prevention as follows:

a. Existing Condition

Almost all of the designated historical urban conservation areas are assessed as having mahalles with the most serious building and urban structure vulnerabilities. The identified vulnerability issues contradict the objectives of the conservation of Istanbuls' traditional Historic District as follows:

- Non building set-back or alley overhang to create shaded alleyway
- Specialized arch-type with patio to create inner sphere
- Chaotic alley network reflecting an old society (before the 20 century)

All of these recommended earthquake disaster preparedness measures, which would contribute to the safety of residents in the 21st century, contradict conservation objectives. In addition, some of the nation's capital functions are located in and overlap on the designated conservation areas, and these areas will be considered as having national risk in the event of an earthquake disaster.

Based on the above condition, specialized improvement measures for designated Historical Urban Conservation reas are recommended as follows:

b. Istanbul Peninsula within City Wall (Eminonu and Fatih):

The designated areas, also registered as World Heritage sites were are part of the chronological walled capital from times of the Byzantine to Ottoman Empires. Istanbul citizens and Turkish people regard this area as the heart of Istanbul or Old Town. On the other hand, almost all of the mahalles in the area are assessed as having mahalles with serious building and urban structure vulnerabilities in the previous analysis. Under this condition, the IMM is formulating a conservation plan for the area under the regulation of the Conservation Board.

It is recommended that the following aspects be incorporated into the conservation plan:

Regulation: The current designated area is too large (15.5km^2, half million population, including some functions of a capital city) to be covered and managed by a single area conservation system. The following prioritized conservation zoning system, broken out by conservation areas, roadways, and specific locations, is recommended:

Areas: Two or three levels of archeological/historical conservation zoning systems are recommended. The Primary Zone, or the centrally important Istanbul Historic District, could be identified as the designated Tarihi Yaryamada Archeological/Historical Urban Conservation Area. The Secondary Zone of conservation could be 14 areas, which have been identified by the authority and IMM Study Team, as shown in the following figure. Lastly, the Tertiary Zone could be the other areas within the City Walls and would include regulations for building height, floor area ratio, and façade material/color control that would ensure a harmony with the historical urban surroundings.

Roadways: It is recommended that a traditional alley-scape conservation system be applied for prioritized and selected alley networks, which could be main radial alleys to the gates and some main north-south connection alleys. Conservation of all alleyways in the Historical Peninsula is a very important factor. However, it should only be applied selectively and not be applied to all alley networks. Otherwise it may generate serious impediments for the entire Historic District in the 21st Century.

Specific Locations: Historical monuments, buildings, and memorial places are registered and listed by the authority.

- **Measure to Enhance/Support Improvement Activities of Vulnerable Building Stock:** At present, the process has been started in part of the designated historical urban conservation area. Enhancement and/or supporting measures to reconstruct the remaining weakened buildings and non-seismic resistant buildings in the area (almost all estimated as heavily/moderately damaged buildings) are an indispensable requirement to stop the growth of slums and ghost towns.
- **Measure to Revitalize Istanbul's Historic District and to Provide Safety Network:** The implementation of physical measures, such as road and infrastructrue improvements, are an indispensable necessity to revitalize socio-economic activities in the area.

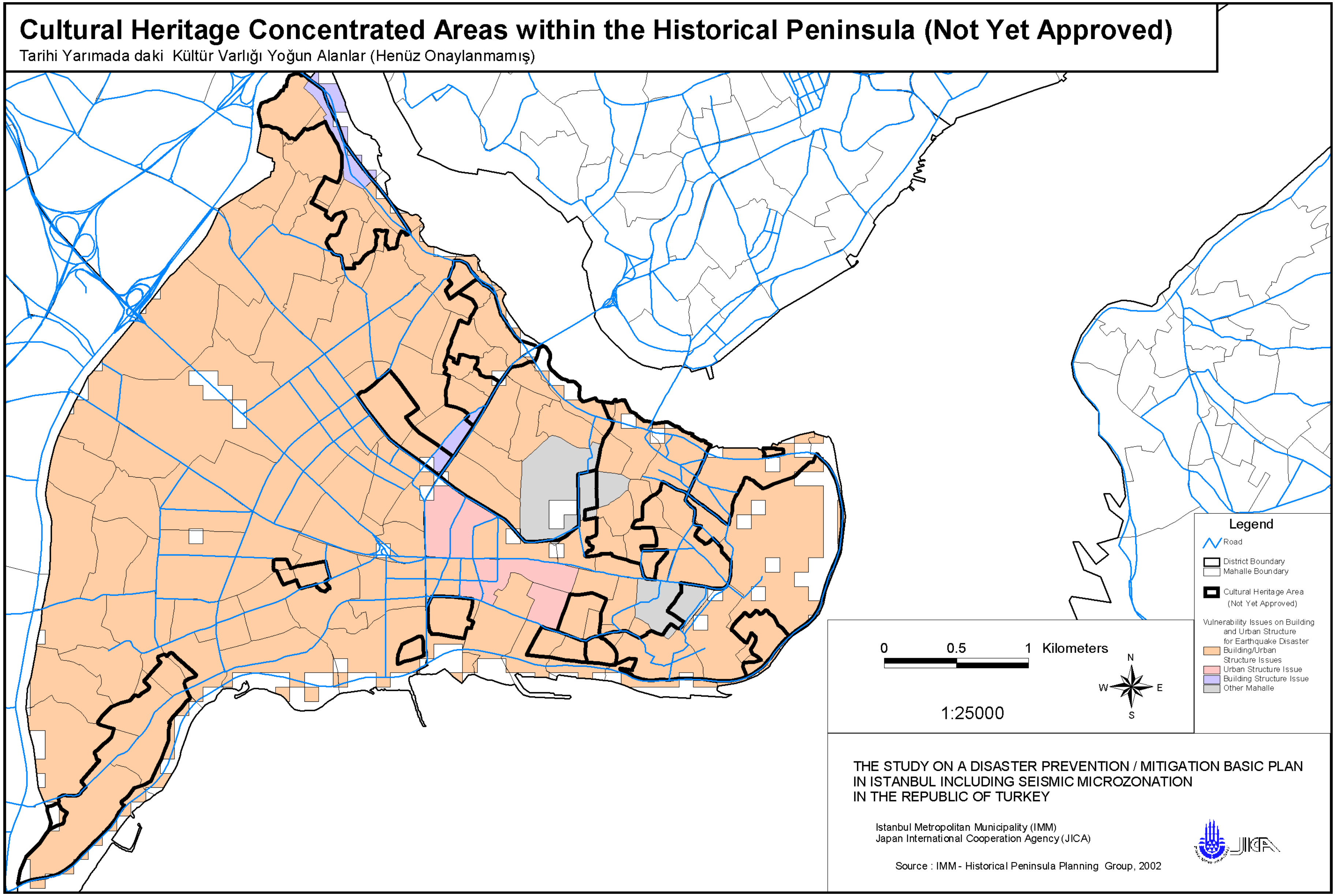


Figure 10.2.2 Cultural Heritage Concentrated Area within the Historical Peninsula

c. Deteriorated Urban/Building Structure in Beyoðlu:

Existing Condition: The designated area is also too large (approximately 3.6 km^2, population of 77,000 and including some government functions), to be covered and managed by a single method of area conservation system. Almost all of the mahalles in the area are assessed as having serious building and urban structure vulnerabilities. Only the areas along main streets have been reconstructed and revitalized by new arterial road development after 1900. However, in the other areas, building renewal has been overly delayed. The remaining weak buildings create slum and ghost town conditions, with some building collapses occurring on an ongoing basis. A conservation plan has not yet been formulated for this area.

The following measures are recommended to improve safety conditions for residents. The measures should be incorporated with the formulation of the conservation plan for the area in the near future.

- **Regulation:** The same area, road and location based zoning regulation systems are recommended as with the historical peninsula. recommended
- **Measures to Enhance/Support Improvement Activities of Vulnerable Building Stock:** Currently, the growth of slums and ghost towns has clearly occurred in a part of the designated historical urban conservation area. Enhancements or supporting measures to reconstruct the remaining old building stock in the area (estimated as heavily/moderately damaged buildings) are required indispensable measures to stop the growth of slums and ghost towns.
- **Measures to Revitalize the Historic District and to Provide a Safety Network:** The implementation of physical measures, such as road and infrasturcture improvements, are an indispensable necessity to revitalize socio-economic activities in the area.

d. Eyüp

It is also inappropriate to use a single conservation system for the designated area of Eyüp (1.8km2 with 30,000 residents). It is adjacent to the northern part of the historical peninsula area along Golden Horn Bay. The designated area is assessed into three categories of mahalles: building/urban structure, urban structure, and building structure. The authority is restoring the traditional wooden building construction in part of the designated area.

The same zoning regulation systems and improvement measures recommended for the historical peninsula are also recommended for this area.

e. Old Kadıköy

This designated area is not as large an area as the front of the bay. However, road and land use conditions are especially hazardous for the area, and have been assessed as having mahalles with the most serious susceptibility to earthquake disaster. In particular, narrow streets impair safety evacuations and emergency vehicle operation, especially when the debris of collapsed and damage buildings is piled along the sides of the streets. For this situation, measures to improve the identified issues may be select from the following possible solutions:

Solution 1: Reconstruct or reinforce all building structures in the area. This includes structures with seismic resistance sufficient to withstand the estimated earthquake motions, able to avoid building damage, and able to not disrupt road functions.

Solution 2: A moderate mix of Solution 1 and Solution 3.

Solution 3: The widening of narrow roads and the development of new parks to facilitate evacuation through the use of structural improvements or redevelopment measures. Additionally, building structure improvement measures to strengthen the estimated 10 to 20% of damaged buildings identified through the preliminary structural assessment.

f. Adalar Islands

The Adalar islands are designated as nature conservation areas (mountainous areas) or historical urban conservation areas (settlement areas), and were almost all developed in the 19^{th} century. Nonetheless, the assessed vulnerability of building and urban structures in this historical urban conservation areais very serious. The following is an overview of some of the problems:

- Estimated earthquake motion and building damages are worst in the Study Area. Damages are based on the location closest to the active fault.
- More than 80% of the existing roads in the islands are narrow.
- The port facilities are not strong enough structures to withstand the estimated seismic motion and liquefaction potential, Thus, there exists the potential for the islands to be isolated.

The same zoning regulation systems and improvement measures recommended above are also recommended for this area.

(3) Bosphorus Historical Scenery Conservation

The designated areas of the Bosphorus Historical Scenery Conservation include large tracts on both sides of the European and Asian continents. However, the objects of conservation and regulation for this category do not conflict with the recommended measures to improve the most serious building and urban structure vulnerabilities.

(4) Natural Environmental Resources Conservation

The designated nature conservation areas are typically natural forests or nature oriented land use areas. Issues of building and urban structure vulnerabilities are not identified in the designated nature conservation areas.

10.2.2. Land Availability for Urban Structure Improvements

The availability of land and current land/building use in each mahalle are key factors in selecting strategic measures of urban structure improvements and urban reconstruction. In this study, the analysis is composed of two fields: Built-up Area (urbanized area) Ratio and Building Coverage Ratio.

The Built-up Area Ratio will show the proportion between vacant land and the use of land without buildings in the mahalle. This may become a part of the formula for urban structure improvements, especially for parks and open spaces.

The Building Coverage Area Ratio will show the average frontage setback condition in the mahalle, which may also determine if a mahalle is a candidate for the widening of narrow roads, and/or the building of an emergency road network and evacuation routes. The statistical analysis used alone is limited in its ability to identify the required land available for road widening. Instead, it should be studied along with a base map as part of the formulation of metropolitan and local disaster prevention plans.

(1) Built-up Area Ratio

The built-up area is estimated based on the building database of the IMM GIS Base Map Information collected by the JICA Study Team. Results of the analysis are assessed and compiled into 5 categories as follows:

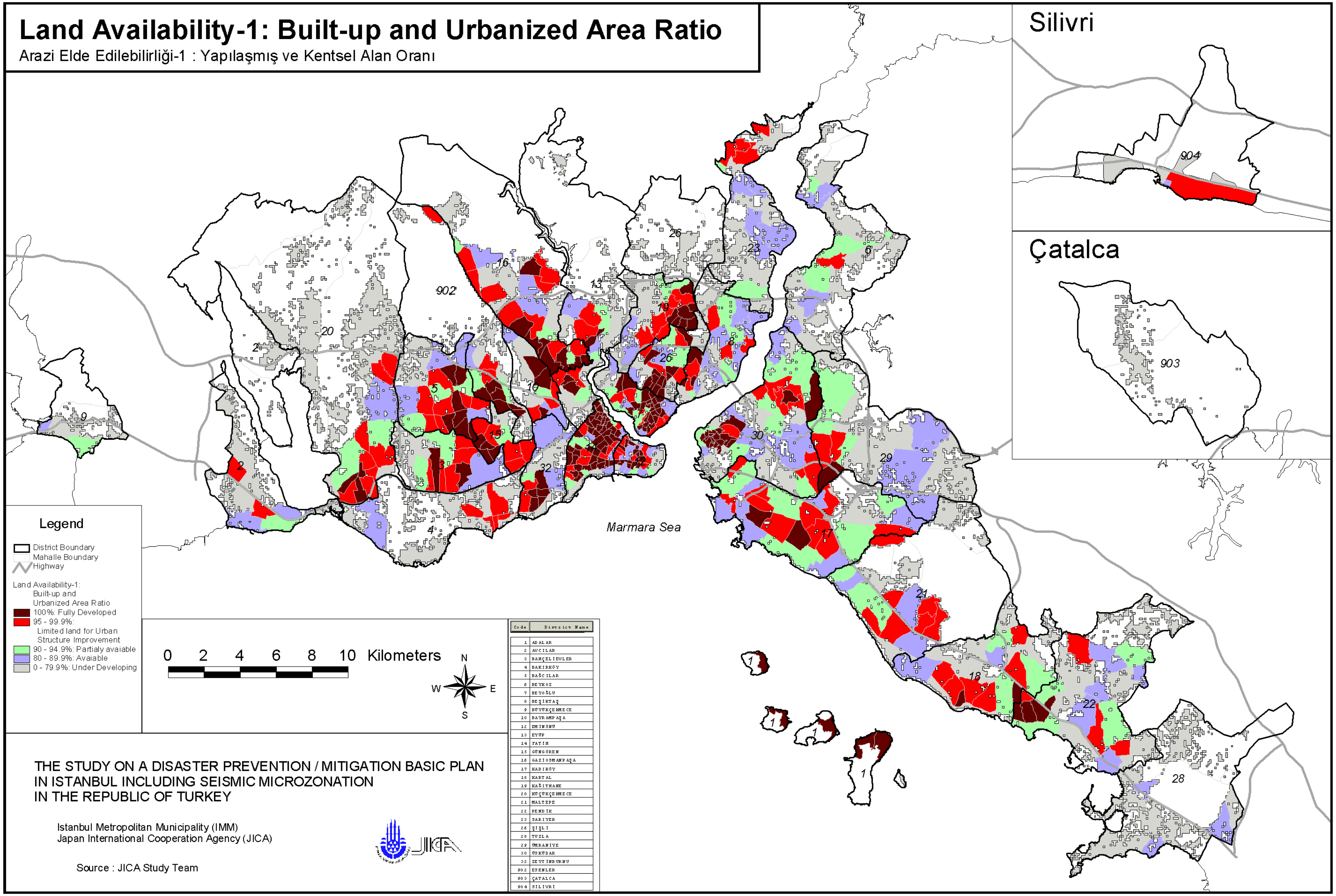
- **100% Developed:** 174 mahalles (27% of the Study Area) with 50 km^2 of urbanized areas are fully developed. In these mahalles, the required extra land for urban improvements is not available.

- **95-99% Developed:** 130 mahalles (13% of the Study Area) with 91 km^2 of urbanized area are almost fully developed. In these mahalles, the land availability condition is almost the same as that of the above category.
- **90-94% Limited Remaining Land:** in the 84 mahalles (13% of the Study Area) with 74 km^2 of urbanized area, 5 to 10% of undeveloped lands in these mahalles may be candidates for urban improvements.
- **80-89% Available Land:** in the 95 mahalles (15% of the Study Area) with 94 km^2 of urbanized area, 10 to 20% of undeveloped lands in these mahalles may be candidates for urban improvements.
- **Less 80%:** 154 mahalles (24% of the Study Area) with 210 km^2 of urbanized areas are understood to be in an underdeveloped stage. The identified urban structure issues may be solved in future development stages.

Table 10.2.1 Built-up (Urbanized) Area Ratio by Mahalle

Area	District		5. 100%			4. 95-99%			3. 90-94%			2. 80-89%			1. less 80%			Unknown	Total Urbanized Area
	Code	Name	Mahalle	Urbanized Area (ha)	share (%)	Mahalle	Urbanized Area (ha)	share (%)	Mahalle	Urbanized Area (ha)	share (%)	Mahalle	Urbanized Area (ha)	share (%)	Mahalle	Urbanized Area (ha)	share (%)		
Old Town	12	EMINÖNÜ	13	112	25	7	84	19	3	52	12	6	98	22	4	105	23	0	452
	14	FATİH	43	561	57	9	155	16	5	107	11	7	74	8	5	84	9	0	982
	7	BEYOĞLU	25	326	39	6	132	16	6	135	16	6	142	17	2	93	11	0	828
	Sub-Total		81	1,000	44	22	371	16	14	294	13	19	315	14	11	282	12	0	2,262
Europe: Marmara Coast	32	ZEYTİNBURNU	5	159	17	2	102	11	1	36	4	2	371	39	3	271	29	0	939
	4	BAKIRKÖY	0	0	0	5	260	16	0	0	0	1	258	16	9	1,095	68	0	1,613
	15	CÜNGÖREN	4	127	19	5	390	58	1	67	10	0	0	0	1	93	14	0	677
	3	BAHÇELİEVLER	2	189	13	4	279	20	3	391	27	1	285	20	1	286	20	0	1,430
	2	AVCILAR	0	0	0	2	176	11	0	0	0	3	392	26	4	963	63	0	1,531
	Sub-Total		11	476	8	18	1,208	20	5	494	8	7	1,305	21	18	2,709	44	0	6,191
Europe: Bosphoras	8	BESİKTAŞ	3	84	6	5	256	17	4	307	20	7	495	33	4	375	25	0	1,517
	19	KAĞITANE	7	219	18	6	348	28	1	99	8	2	147	12	3	408	33	0	1,221
	26	ŞİŞLİ	11	243	16	4	151	10	4	161	11	2	129	9	7	792	54	0	1,476
	23	SARIYER	0	0	0	4	268	13	3	181	9	5	578	28	11	1,069	51	0	2,096
	Sub-Total		21	546	9	19	1,023	16	12	749	12	16	1,350	21	25	2,643	42	0	6,311
Europe: Inland	13	EYÜP	3	113	7	4	315	21	3	171	11	2	160	11	8	762	50	0	1,522
	16	GAZİOSMANPAŞA	8	464	19	8	672	27	4	235	10	2	244	10	7	843	34	0	2,458
	10	BAYRAMPAŞA	3	188	25	2	126	17	0	0	0	3	170	22	3	277	36	0	761
	902	ESENLER	6	231	23	3	167	16	2	111	11	1	58	6	6	455	45	0	1,022
	5	BAĞCILAR	7	371	19	6	457	24	4	330	17	3	350	18	2	431	22	0	1,939
	20	KÜÇÜKÇEKMECE	3	138	3	8	579	14	4	532	13	1	313	8	7	2,577	62	0	4,139
	Sub-Total		30	1,505	13	31	2,316	20	17	1,380	12	12	1,296	11	33	5,344	45	0	11,841
Total/Average of European Side			143	3,526	13	90	4,918	18	48	2,916	11	54	4,265	16	87	10,979	41	0	26,605
Asian: Marmara Coast	1	ADALAR	5	346	97	0	0	0	0	0	0	0	0	0	1	9	3	5	356
	17	KADIKÖY	2	237	7	10	1,046	30	6	965	27	9	975	28	1	306	9	0	3,530
	21	MALTEPE	0	0	0	7	705	30	4	400	17	3	498	22	7	709	31	0	2,312
	18	KARTAL	2	85	3	6	710	27	4	550	21	2	330	13	6	944	36	0	2,619
	22	PENDİK	4	235	7	4	430	12	5	718	20	6	719	20	10	1,457	41	0	3,559
	28	TUZLA	0	0	0	0	0	0	0	0	0	3	284	14	8	1,696	86	0	1,980
	Sub-Total		13	904	6	27	2,891	20	19	2,634	18	23	2,806	20	33	5,121	36	5	14,356
Asian: Bosphoras	30	ÜSKÜDAR	17	432	13	9	516	16	10	812	25	8	746	23	10	742	23	0	3,247
	6	BEYKOZ	0	0	0	1	87	4	4	454	19	4	366	16	10	1,433	61	0	2,340
	29	ÜMRANİYE	1	124	3	2	249	7	3	618	17	3	1,024	28	5	1,585	44	0	3,600
	Sub-Total		18	556	6	12	852	9	17	1,883	21	15	2,136	23	25	3,759	41	0	9,186
Total/Average of Asian Side			31	1,460	6	39	3,743	16	36	4,517	19	38	4,942	21	58	8,880	38	5	23,542
Outside IMM	9	BÜYÜKÇEKMECE	0	0	0	0	0	0	0	0	0	2	145	32	4	302	68	0	446
	903	ÇATALCA	0	0	0	0	0	0	0	0	0	0	0	0	2	426	100	0	426
	904	SİLİVRİ	0	0	0	1	433	52	0	0	0	1	11	1	3	397	47	0	841
	Sub-Total		0	0	0	1	433	25	0	0	0	3	156	9	9	1,124	66	0	1,713
Total			174	4,986	10	130	9,094	18	84	7,434	14	95	9,363	18	154	20,983	40	5	51,860

Source: JICA Study Team



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 10.2.3 Built-up (Urbanized) Area Ratio

(2) Building Coverage Ratio

The average building coverage ratio of the mahalle is estimated by the JICA Study Team based on the plot area and building coverage area obtained from the 2000 Building Census. Results of the analysis executed to assess the land availability for urban structure improvements are compiled into the following five categories:

- **Over 90% - Full Coverage-:** In 40 mahalles (6% of the Study Area) with 6 km^2 of urbanized area, almost all of the plots are covered fully by buildings. In these mahalles, the required spare land for urban improvements is not available.
- **80-89% - High Coverage-1:-** In 72 mahalles (11% of the Study Area) with 15 km^2 of urbanized area, again, almost all of the plots are fully covered by buildings. In these mahalles, land availability conditions are the same as that of the above category.
- **70-79% - High Coverage-2:-** In 90 mahalles (14% of the Study Area) with 34 km^2 of urbanized area, some areas may be candidates for road widening projects. However, these areas will not be enough to meet the demand.
- **60-69% - Moderate Coverage:-** In 119 mahalles (19% of the Study Area) with 68 km^2 of urbanized area, 10 to 20% of the areas may be candidates for urban structure improvement.
- **Less than 60% - Moderate to Low Coverage: -**In 316 mahalles (49% of the Study Area) with 397 km^2 of urbanized area, the required available land for urban structure improvements may be identified in the setback areas. The availability of this land should be checked and planned in detail as part of the formulation of the local disaster prevention plan.

The mahalles with the highest building coverage ratio are almost all located on the European side of Istanbul, especially in the Historical Districts.

Table 10.2.2 Building Coverage Ratio by Mahalle

Area	District Code	District Name	5. Over 90% Mahalle	5. Over 90% Urbanized Area (ha)	5. Over 90% share (%)	4. 80-89% Mahalle	4. 80-89% Urbanized Area (ha)	4. 80-89% share (%)	3. 70-79% Mahalle	3. 70-79% Urbanized Area (ha)	3. 70-79% share (%)	2. 60-69% Mahalle	2. 60-69% Urbanized Area (ha)	2. 60-69% share (%)	1. Less 60% Mahalle	1. Less 60% Urbanized Area (ha)	1. Less 60% share (%)	Unknown	Total Urbanized Area (ha)
Old Town	12	EMINÖNÜ	14	118	26	8	120	26	7	145	32	1	10	2	3	59	13	0	452
	14	FATİH	5	48	5	28	433	44	17	217	22	14	198	20	5	87	9	0	982
	7	BEYOĞLU	10	88	11	14	230	28	10	242	29	8	202	24	3	67	8	0	828
	Sub-Total		29	254	11	50	782	35	34	604	27	23	409	18	11	213	9	0	2,262
Europe: Marmara Coast	32	ZEYTİNBURNU	0	0	0	2	50	5	4	271	29	4	380	40	3	238	25	0	939
	4	BAKIRKÖY	1	19	1	0	0	0	3	132	8	2	179	11	9	1,284	80	0	1,613
	15	CÜNGÖREN	0	0	0	1	95	14	0	0	0	4	163	24	6	419	62	0	677
	3	BAHÇELİEVLER	0	0	0	0	0	0	2	164	11	4	330	23	5	936	65	0	1,430
	2	AVCILAR	0	0	0	0	0	0	0	0	0	0	0	0	9	1,531	100	0	1,531
	Sub-Total		1	19	0	3	145	2	9	567	9	14	1,052	17	32	4,409	71	0	6,191
Europe: Bosphoras	8	BESİKTAŞ	0	0	0	3	48	3	1	22	1	3	121	8	16	1,326	87	0	1,517
	19	KAĞITANE	3	156	13	8	314	26	3	175	14	3	213	17	2	362	30	0	1,221
	26	ŞİŞLİ	3	142	10	4	74	5	8	259	18	5	232	16	8	770	52	0	1,476
	23	SARIYER	0	0	0	0	0	0	2	28	1	6	503	24	15	1,565	75	0	2,096
	Sub-Total		6	298	5	15	436	7	14	485	8	17	1,070	17	41	4,022	64	0	6,311
Europe: Inland	13	EYÜP	0	0	0	1	24	2	6	367	24	9	651	43	4	480	32	0	1,522
	16	GAZİOSMANPAŞA	0	0	0	0	0	0	1	86	3	17	1,265	51	11	1,107	45	0	2,458
	10	BAYRAMPAŞA	0	0	0	1	49	6	4	233	31	3	237	31	3	242	32	0	761
	902	ESENLER	0	0	0	0	0	0	10	541	53	4	157	15	4	324	32	0	1,022
	5	BAĞCILAR	0	0	0	0	0	0	3	141	7	11	748	39	8	1,051	54	0	1,939
	20	KÜÇÜKÇEKMECE	0	0	0	0	0	0	1	98	2	6	417	10	16	3,624	88	0	4,139
	Sub-Total		0	0	0	2	73	1	25	1,466	12	50	3,475	29	46	6,827	58	0	11,841
Total/Average of European Side			36	571	2	70	1,435	5	82	3,121	12	104	6,006	23	130	15,471	58	0	26,605
Asian: Marmara Coast	1	ADALAR	0	0	0	0	0	0	0	0	0	0	0	0	6	356	100	5	356
	17	KADIKÖY	0	0	0	0	0	0	2	102	3	2	147	4	24	3,281	93	0	3,530
	21	MALTEPE	0	0	0	0	0	0	0	0	0	1	84	4	20	2,228	96	0	2,312
	18	KARTAL	0	0	0	0	0	0	0	0	0	0	0	0	20	2,619	100	0	2,619
	22	PENDİK	0	0	0	0	0	0	0	0	0	0	0	0	29	3,559	100	0	3,559
	28	TUZLA	0	0	0	0	0	0	0	0	0	0	0	0	11	1,980	100	0	1,980
	Sub-Total		0	0	0	0	0	0	2	102	1	3	231	2	110	14,022	98	5	14,356
Asian: Bosphoras	30	ÜSKÜDAR	4	29	1	2	21	1	5	98	3	6	76	2	37	3,024	93	0	3,247
	6	BEYKOZ	0	0	0	0	0	0	1	72	3	1	125	5	17	2,142	92	0	2,340
	29	ÜMRANİYE	0	0	0	0	0	0	0	0	0	0	0	0	14	3,600	100	0	3,600
	Sub-Total		4	29	0	2	21	0	6	170	2	7	201	2	68	8,766	95	0	9,186
Total/Average of Asian Side			4	29	0	2	21	0	8	273	1	10	431	2	178	22,788	97	5	23,542
Outside IMM	9	BÜYÜKÇEKMECE	0	0	0	0	0	0	0	0	0	3	273	61	3	174	39	0	446
	903	ÇATALCA	0	0	0	0	0	0	0	0	0	0	0	0	2	426	100	0	426
	904	SİLİVRİ	0	0	0	0	0	0	0	0	0	2	50	6	3	791	94	0	841
	Sub-Total		0	0	0	0	0	0	0	0	0	5	323	19	8	1,390	81	0	1,713
Total			40	600	1	72	1,456	3	90	3,394	7	119	6,761	13	316	39,650	76	5	51,860

Source: JICA Study Team

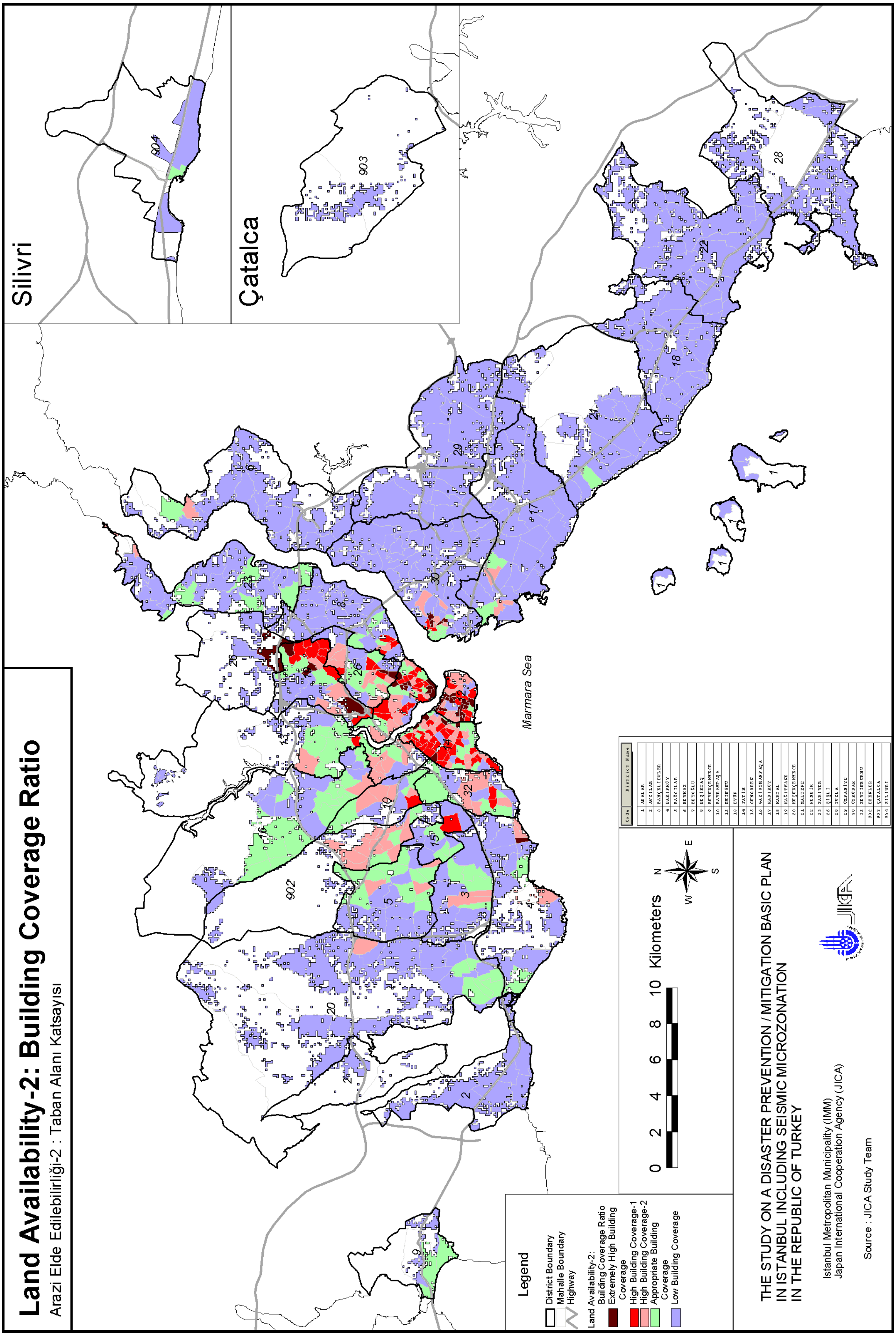


Figure 10.2.4 Building Coverage Ratio

(3) Land Availability for Urban Structure Improvement

Based on the two building coverage ratio and built-up area ratio analyses, the land availability in each mahalle can be represented by taking the average score of the two analyses. The resulting land availability analysis can be assessed as one of the following five categories:

- **Category –5 - Not Available:** In 77 identified mahalles (12% of the Study Area) with 11 km^2 of urbanized area (2% of the Study Area), both vacant land and frontage setback areas are not completely available for urban structure improvements, as most of the land is already fully developed. These identified mahalles are concentrated in the Historic District, the Marmara Coast, the Bosphorus on the European side, and in the Uskudar District.
- **Category –4 - Highly Not Available:** In the 119 identified mahalles (19% of the Study Area) with 37km^2 of urbanized areas (7% of the Study Area), land for urban structure improvements are also not available. There are, however, some vacant land or frontage setback areas available to fill part of the demand. These mahalles are also concentrated entirely in the districts on the European side and the Uskudar and Kadikoy districts on the Asian side.
- **Category –3 - Slightly Available:** There are 169 identified mahalles (26% of the Study Area) with 119 km^2 of urbanized area (23% of the Study Area) where vacant land for park developments or frontage setback areas for road widening are available. These mahalles are widely spread out over almost all districts except Tuzla in IMM.
- **Category –2 - Available –1:** There are 157 mahalles (24% of the Study Area) with 167 km^2 of urbanized area (32% of the Study Area) where urban development has not matured yet. Building coverage in these mahalles is not very high, and the required land for urban improvement could be identified within each mahalle.
- **Category –1 - Available 2:** There are 115 mahalles (18% of the Study Area) with 185 km^2 of urbanized area (36% of the Study Area) that may not have land availability issues for urban structure improvements.

Areas with serious issues of land availability are identified as follows:

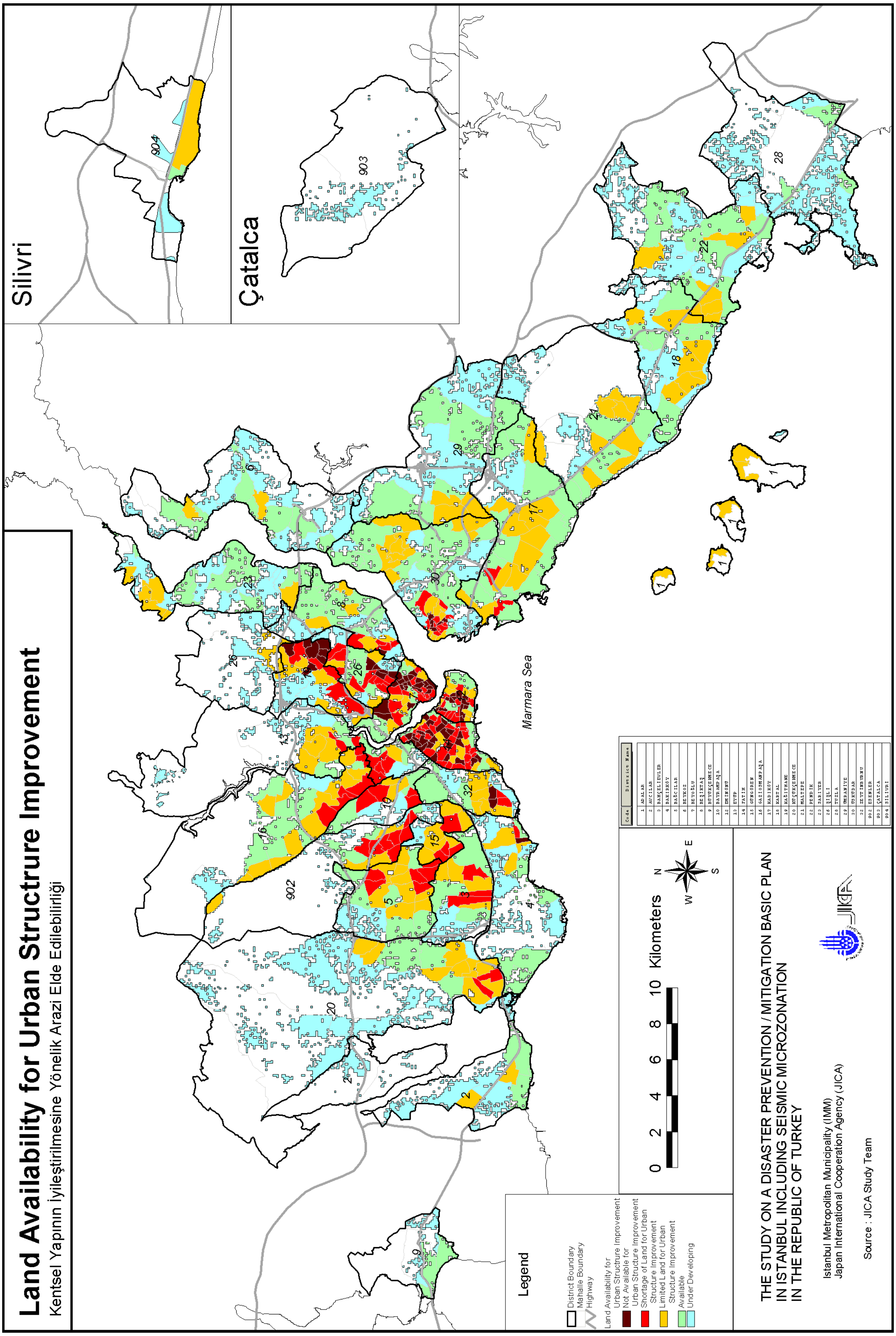
- **The Historic District Area**: In this area, categories 1 and 2together share 60% of the urbanized areas. Category 3 shares 19% of the urbanized areas. This, in turn, demonstrates that approximately 80% of the urbanized area may have to face issues of land availability with the required urban structure improvements.

- **European Marmara Coast**: Categories 1 and 2 together share 9% of the urbanized area. Category 3 follows with a share of 23%. Land availability constraints will be found in the Zeytinburnu and Güngören districts.
- **European Bosphorus**: In this area, Categories 1 and 2 together share 16% of the urbanized areas. Category 3 has a share of 19% .Areas with land use constraints amount to 35% of the land. Kagıtane and Şisli will face the most serious constraints in making land available for improvements.
- **European Inland**: In this area, Category 2 has a 13% share of the urbanized areas and Category 3 has a 27% share. Together they amount to 40% of the urbanized area. . The total share between Categories 2 and 3 ranges from 47 to 55% of the urbanized areas in each district except Küçükçekmece.
- **Asian Side**: Limited land availability issues may exist in the districts of Kadıköy and Üsküdar.

Table 10.2.3 Land Availability for Urban Structure Improvement Measures

Area	District		5. Not Available			4. Almost Not			3. Slightly Available			2. Available-1			1. Avaiable-2			Others	Total Urbanized Area
	Code	Name	Mahalle	Urbanized Area (ha)	share (%)	Mahalle	Urbanized Area (ha)	share (%)	Mahalle	Urbanized Area (ha)	share (%)	Mahalle	Urbanized Area (ha)	share (%)	Mahalle	Urbanized Area (ha)	share (%)		
Old Town	12	EMINÖNÜ	12	100	22	10	115	25	7	118	26	4	119	26	0	0	0	0	452
	14	FATİH	24	307	31	27	386	39	9	159	16	9	130	13	0	0	0	0	982
	7	BEYOĞLU	20	250	30	11	200	24	7	154	19	7	224	27	0	0	0	0	828
	Sub-Total		56	657	29	48	701	31	23	431	19	20	473	21	0	0	0	0	2,262
Europe: Marmara Coast	32	ZEYTİNBURNU	2	50	5	2	51	5	5	304	32	2	353	38	2	180	19	0	939
	4	BAKIRKÖY	1	19	1	1	22	1	3	219	14	5	547	34	5	807	50	0	1,613
	15	GÜNGÖREN	0	0	0	4	191	28	6	393	58	0	0	0	1	93	14	0	677
	3	BAHÇELİEVLER	0	0	0	3	245	17	4	314	22	3	585	41	1	286	20	0	1,430
	2	AVCILAR	0	0	0	0	0	0	2	176	11	3	392	26	4	963	63	0	1,531
	Sub-Total		3	69	1	10	510	8	20	1,408	23	13	1,876	30	13	2,329	38	0	6,191
Europe: Bosphoras	8	BESİKTAŞ	1	9	1	4	112	7	5	257	17	9	764	50	4	375	25	0	1,517
	19	KAĞITANE	7	220	18	5	321	26	5	318	26	0	0	0	2	362	30	0	1,221
	26	ŞİŞLİ	5	87	6	9	254	17	5	263	18	4	235	16	5	638	43	0	1,476
	23	SARIYER	0	0	0	0	0	0	6	387	18	10	841	40	7	868	41	0	2,096
	Sub-Total		13	316	5	18	688	11	21	1,225	19	23	1,840	29	18	2,243	36	0	6,311
Europe: Inland	13	EYÜP	0	0	0	6	240	16	5	481	32	5	321	21	4	480	32	0	1,522
	16	GAZİOSMANPAŞA	0	0	0	6	322	13	12	896	36	8	872	35	3	368	15	0	2,458
	10	BAYRAMPAŞA	0	0	0	4	236	31	2	123	16	3	237	31	2	164	22	0	761
	902	ESENLER	0	0	0	8	340	33	4	227	22	3	189	18	3	266	26	0	1,022
	5	BAĞCILAR	0	0	0	6	308	16	9	652	34	6	657	34	1	322	17	0	1,939
	20	KÜÇÜKÇEKMECE	0	0	0	2	113	3	11	824	20	3	625	15	7	2,577	62	0	4,139
	Sub-Total		0	0	0	32	1,559	13	43	3,204	27	28	2,900	24	20	4,177	35	0	11,841
Total/Average of European Side			72	1,042	4	108	3,457	13	107	6,267	24	84	7,090	27	51	8,749	33	0	26,605
Asian: Marmara Coast	1	ADALAR	0	0	0	0	0	0	5	346	97	0	0	0	1	9	3	5	356
	17	KADIKÖY	0	0	0	2	102	3	11	1,260	36	14	1,861	53	1	306	9	0	3,530
	21	MALTEPE	0	0	0	0	0	0	8	789	34	6	814	35	7	709	31	0	2,312
	18	KARTAL	0	0	0	0	0	0	8	795	30	6	880	34	6	944	36	0	2,619
	22	PENDİK	0	0	0	0	0	0	8	665	19	11	1,437	40	10	1,457	41	0	3,559
	28	TUZLA	0	0	0	0	0	0	0	0	0	3	284	14	8	1,696	86	0	1,980
	Sub-Total		0	0	0	2	102	1	40	3,856	27	40	5,276	37	33	5,121	36	5	14,356
Asian: Bosphoras	30	ÜSKÜDAR	5	36	1	9	149	5	16	813	25	14	1,507	46	10	742	23	0	3,247
	6	BEYKOZ	0	0	0	0	0	0	2	159	7	8	872	37	9	1,308	56	0	2,340
	29	ÜMRANİYE	0	0	0	0	0	0	3	373	10	6	1,642	46	5	1,585	44	0	3,600
	Sub-Total		5	36	0	9	149	2	21	1,345	15	28	4,021	44	24	3,634	40	0	9,186
Total/Average of Asian Side			5	36	0	11	251	1	61	5,201	22	68	9,298	39	57	8,755	37	5	23,542
Outside IMM	9	BÜYÜKÇEKMECE	0	0	0	0	0	0	0	0	0	3	273	61	3	174	39	0	446
	903	ÇATALCA	0	0	0	0	0	0	0	0	0	0	0	0	2	426	100	0	426
	904	SİLİVRİ	0	0	0	0	0	0	1	433	52	2	50	6	2	357	42	0	841
	Sub-Total		0	0	0	0	0	0	1	433	25	5	323	19	7	957	56	0	1,713
Total			77	1,078	2	119	3,708	7	169	11,901	23	157	16,711	32	115	18,461	36	5	51,860

Source: The JICA Study Team



Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE
30	ÜSKÜDAR
32	ZEYTİNBURNU
902	ESENLER
903	ÇATALCA
904	SİLİVRİ

Figure 10.2.5 Land Availability for Urban Structure Improvement Issues

10.2.3. Recommended Strategic Improvement Areas for Mahalles With Serious Building and Urban Structure Vulnerabilities

The mahalles with serious Building and Urban Structure vulnerabilities are identified as follows:

- **Mahalles with Building/Urban Structure Vulnerabilities:** 361 mahalles (56% of the Study Area) with 246 km^2 urbanized area (47% of the Study Area) and 4.8 millions residents (56% of the population).
- **Mahalles with Urban Structure Vulnerabilities:** 39 mahalles (6% of the Study Area) with 16 km^2 urbanized area (3% of the Study Area) and 0.4 millions residents (5% of the population).

These two categories are included in the strategic measures for improvement or reconstruction based on the previous land availability analysis. The identified strategic improvement areas, where spare land is available for projects to improve building and urban structure vulnerability are identified below:

- **Combined Strategic Improvement Measures for Building/Urban Structure Issues:** 214 mahalles (60% of all the identified mahalles with serious issues) with 213 km^2 urbanized area (87% of the Study Area) and 3.6 million residents (75% of the population).
- **Strategic Improvement Measure for Urban Structure Issues:** 19 mahalles (49% of all the identified mahalles with serious issues) with 11 km^2 urbanized area (66% of the Study Area) and 0.23 million residents (58% of the population).

(1) Combined Strategic Improvement Measure for Issues of BuildingUrban Structure

The identified 214 mahalles with 213 km^2 urbanized area and 3.6 million residents combine into 33% of the mahalles, 42% of all urbanized area and 42% of the population, which is the biggest share in the identified five strategic measures.

The mahalles identified for the five strategic measures share over 50% of urbanized area in 11 districts, which are located on both the Asian and European sides of the Marmara Coast, and Bağcılar and Küçkçekmece on the European Inland.

The recommended principal measure to strengthen building structures and urban structures must be applied under the formulated metropolitan and local district disaster prevention master plans. Also, all of the implementation measures and projects should be carefully prioritized and coordinated with each other and with the above plan formulation procedures.

The specialized and modified measures applied in designated Historical Urban Conservation Areas should be coordinated with the agencies responsible for conservation.

(2) Strategic Improvement Measure for Issues of Urban Structure

The 19 mahalles with 11 km^2 of urbanized areas and 0.24 million residents represent only 2 to 3% of mahalles, with the same percentages for urbanized areas and population in the Study Area. The identified 19 mahalles are spread out over 8 districts.

The recommended principal measures to strengthen urban structure issues must be applied intensely in the identified 19 mahalles. Supplemental measures for building structure issues are also required to strengthen the estimated number of damaged buildings (10% to 30% with heavy and moderate damage), in addition to the recommended preliminary seismic resistant assessments.

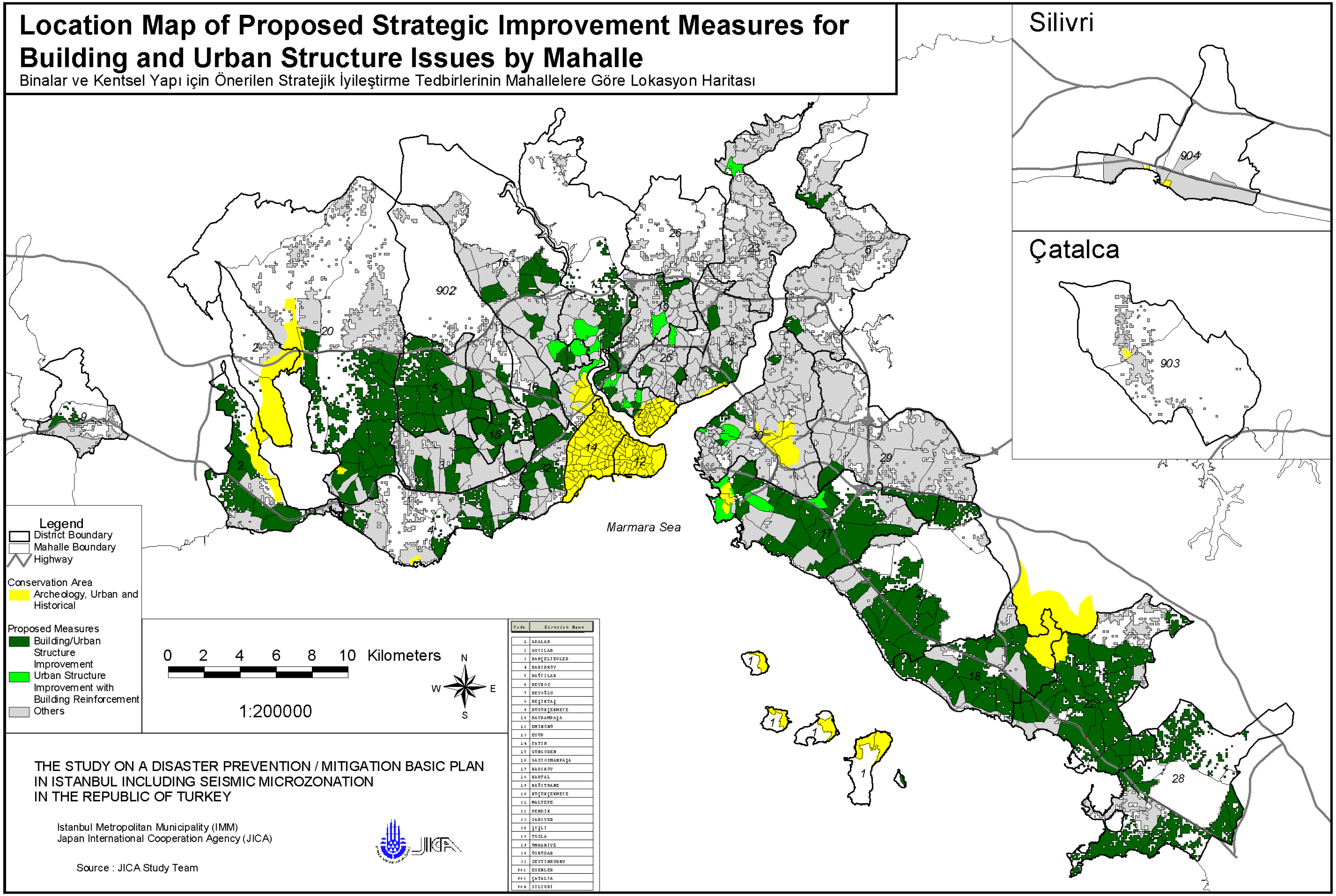


Figure 10.2.6 Location Map of Recommended Strategic Improvement Measures for Building and Urban Structure Issues by Mahalle

Table 10.2.4 Recommended Strategic Improvement Measures for Building and Urban Structure Issues by Mahalle

Area	District		Improvement Building/Urban Structure				Improvement Urban Structure			
	Code	Name	No. of mahalle	Urbanized Area In Mahalle (ha)	Area share (%)	Population in mahalle (000p)	No. of mahalle	Urbanized Area In Mahalle (ha)	Area share (%)	Population in mahalle (000p)
Old Town: historic urban	12	EMINÖNÜ	9	197	44	26	0	0	0	0
	14	FATİH	16	273	28	89	0	0	0	0
	7	BEYOĞLU	10	271	33	52	4	107	13	35
	Sub-Total		35	741	33	167	4	107	5	35
Europe: Marmara Coast	32	ZEYTİNBURNU	6	600	64	134	0	0	0	0
	4	BAKIRKÖY	7	497	31	55	0	0	0	0
	15	CÜNGÖREN	6	407	60	167	0	0	0	0
	3	BAHÇELİEVLER	5	431	30	192	0	0	0	0
	2	AVCILAR	6	1,069	70	174	0	0	0	0
	Sub-Total		30	3,003	49	722	0	0	0	0
Europe: Bosphoras	8	BESİKTAŞ	3	212	14	23	0	0	0	0
	19	KAĞITANE	2	145	12	26	1	78	6	20
	26	ŞİŞLİ	2	84	6	24	1	40	3	16
	23	SARIYER	0	0	0	0	1	56	3	5
	Sub-Total		7	441	7	74	3	174	3	41
Europe: Inland	13	EYÜP	4	510	33	51	3	207	14	36
	16	GAZİOSMANPAŞA	7	602	25	162	2	133	5	43
	10	BAYRAMPAŞA	3	196	26	52	0	0	0	0
	902	ESENLER	5	235	23	100	0	0	0	0
	5	BAĞCILAR	15	1,523	79	364	0	0	0	0
	20	KÜÇÜKÇEKMECE	17	2,301	56	463	0	0	0	0
	Sub-Total		51	5,367	45	1,193	5	340	3	79
Total/Average of European Side			123	9,552	36	2,156	12	620	2	154
Asian: Marmara Coast	1	ADALAR	6	356	100	18	0	0	0	0
	17	KADIKÖY	15	2,192	62	411	4	345	10	66
	21	MALTEPE	14	1,855	80	257	0	0	0	0
	18	KARTAL	14	1,995	76	242	0	0	0	0
	22	PENDİK	25	3,037	85	334	0	0	0	0
	28	TUZLA	8	1,622	82	82	0	0	0	0
	Sub-Total		82	11,057	77	1,343	4	345	2	66
Asian: Bosphoras	30	ÜSKÜDAR	4	120	4	19	3	95	3	29
	6	BEYKOZ	2	150	6	10	0	0	0	0
	29	ÜMRANİYE	2	368	10	72	0	0	0	0
	Sub-Total		8	638	7	101	3	95	1	29
Total/Average of Asian Side			90	11,695	50	1,444	7	440	2	95
Outside IMM	9	BÜYÜKÇEKMECE	1	69	15	0	0	0	0	0
	903	ÇATALCA	0	0	0	0	0	0	0	0
	904	SİLİVRİ	0	0	0	0	0	0	0	0
	Sub-Total		1	69	4	0	0	0	0	0
Total			214	21,316	41	3,600	19	1,060	2	249

Source: The JICA Study Team

Note: ☐ The designated Archeological and Historical Urban Conservation Areas are also included

10.2.4. Recommended Strategic Urban Redevelopment Measures and Specialized Measures for Historical Urban Conservation Areas

The strategic urban redevelopment measures are recommended in order to be applied to those specific mahalles that are fully developed and lack the spare land needed for the improvement of vulnerable urban structures. The identified 167 mahalles with 38.2 km^2 urbanized area and 1.6 millions residents represent 26% of mahalles, 7.5% of the urbanized area, and 18.8% of population in the Study Area. These identified areas are composed from the following three areas of strategic measures: 1) Strategic Urban Redevelopment Measures for Building/Urban Structure Issues, 2) Strategic Urban Redevelopment Measures for Urban Structure Issues, and 3) Specialized Improvement Measures for Historical Urban Conservation Area.

(1) Strategic Urban Redevelopment Measures for Building/Urban Structure Issues

The listed Redevelopment for Building/Urban Structure includes the designated archeological and historical urban conservation areas. These areas include approximately 85 mahalles (13% of Study Area) with 12km^2 urbanized areas (2% of the Study Area) and a population of 440,000 in the districts of Eyüp, Adalar, the Historic District, and Kadıköy.

The net area for Strategic Urban Redevelopment Measures is identified as approximately 82 mahalles (13% of the Study Area) with 26.2km^2 urbanized area (5% of the Study Area) and a polulation of 1.2 million (14% of the population). All of the recommended measures in the detailed study the Disctrict Disaster Prevention Plan formulation to improve urban structures should be carefully rechecked and project areas should be redefined in detail on the base map/aerophoto with the same vuinerability analysis that follows.

- Emergency Road Network Plan with road widening/improvement projects
- Evacuation Plan with the development of new evacuation centres and the improvement existing parks
- Widening and improvement of narrow roads
- Seismic Resistant Diagnosis for crisis management centres, emergency response centres, emergency good centres, and public facilities
- Reinforcement/Reconstruction Plans and Programmes for the above centres
- Preliminary Seismic Resistant Assessment with cadastral data for housing and private commercial buildings (the estimated building damage is over 30% of all buildings)
- Building Demarcation for the required reconstruction, reinforcement, and structural resistance

- Checking in detail of public and private land availablity for road and public facilities in order to designate urban redevelopment areasand urban sturucture improvement areas
- Action plans and implementation programmes for the above mentioned comprehensive projects

(2) Strategic Urban Redevelopment Measures for Urban Structure Issues

The listed redevelopment for urban structures also includes the designated archeological and historical urban conservation areas. These areas are composed of about 5 mahalles, 0.8 km^2 urbanized area and a population of 15,000 in the Historic District and the district of Kadıköy.

The net target area for strategic urban redevelopment measures is approximately 15 mahalles (2% of the Study Area) with 4.6 km^2 of urbanized area (1% of the Study Area) and 170,000 population (2% of the population). All of the recommended mesasures to improve urban structures in the study of the district disaster prevention plan formulation should be carefully rechecked and project areas should be redefined in detail on the base map/areophotomap through the vulnerability analysis that follows:

- Emergency road network plan with road widening/improvement projects
- Evacuation plan with the development of new evacuation centres and the improvement of existing parks Widening and improvement of narrow roads
- Seismic resistance diagnosis for crisis management centres, emergency response centres, emergency supply centres, and public facilities
- Reinforcement/reconstruction plans and programmes for the above centres
- Preliminary seismic resistant assessment with cadastral data for housing and private commercial buildings (the estimated building damage is 10 to 29% of all buildings)
- Building designation for the required reconstruction, reinforcement, and structural resistanceChecking in detail of public and private land availablity for road and public facilities in order to designate urban redevelopment areas and urban sturucture improvement areas
- Action plans and implementation programmes for the above mentioned comprehensive projects

(3) Specialized Improvement Measures for Historical Urban Conservation Area

The designated historical urban conservation areas in the assessed strategic urban reconstruction area may have difficulties in creating safer environments and urban structures for residents due to the following serious situations:

- Required land for urban structure improvement projects cannot be easily found under the old, rigid and mosaic land-use conditions.
- The existing alleyway network cannot only support the needed vehicle traffic demand for daily socio-economic activities in the area. Additionally, the existing alleyway network cannot support the traffic demands for the reconstruction/reinforcement activities of structurally weak buildings in the area.
- Under the strict regulations of the conservation system (conservation of all traditional alleyways, etc.), it is difficult to implement necessary changes.

Modified and specialized improvement measures, and modified zoning regulation systems as mentioned in 10.2.1, are recommended in order to improve, establish, and provide safer environments for residents.

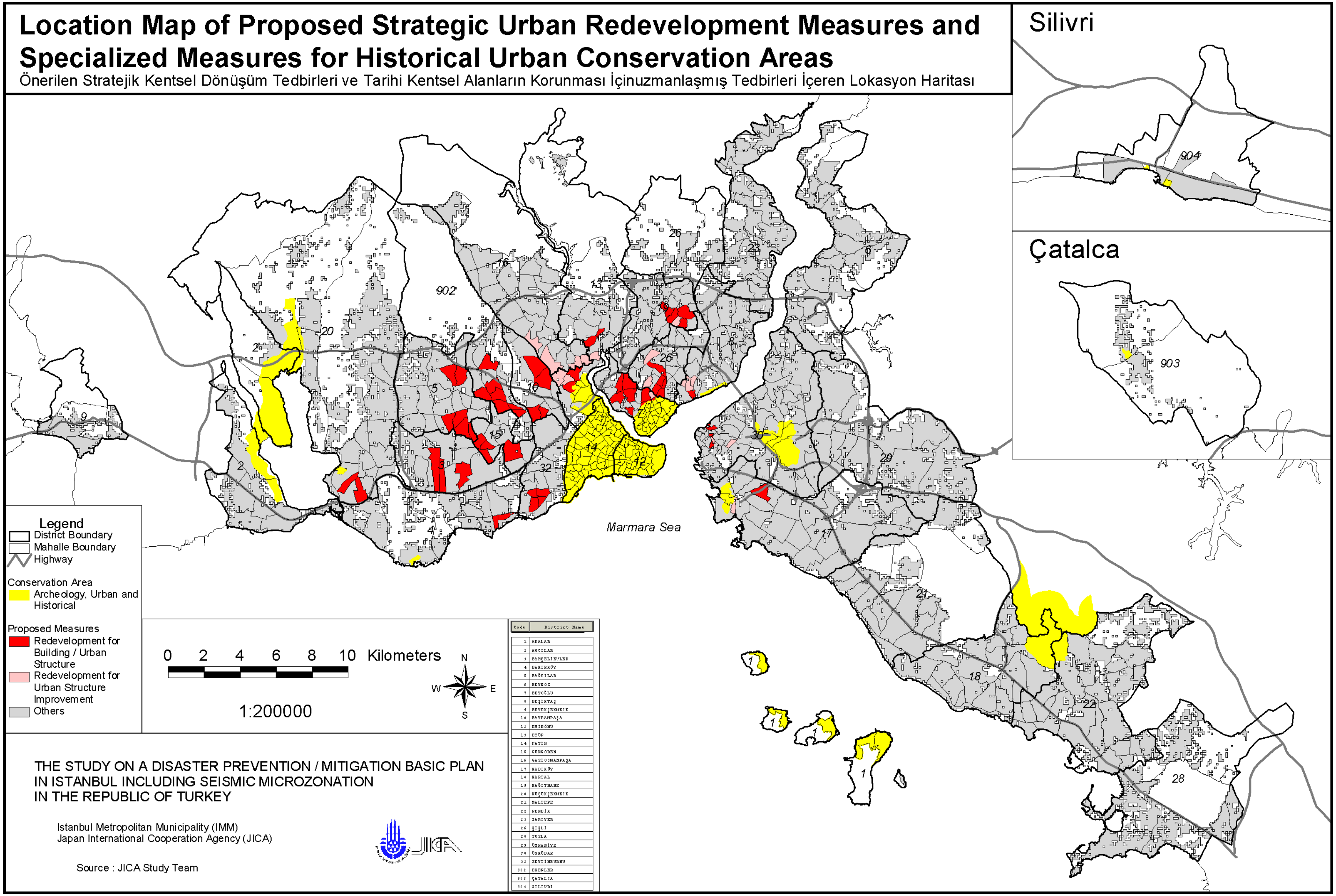


Figure 10.2.7 Location Map of Recommended Strategic Urban Redevelopment Measures and Specialized Measures for Historical Urban Conservation Areas

Table 10.2.5 Recommended Strategic Urban Redevelopment Measures and Specialized Measures for Historical Urban Conservation Area

Area	District		Building/Urban Structure Redevelopment				Urban Structure Redevelopment			
	Code	Name	No. of Mahalle	Urbanized Area In Mahalle (ha)	Area share (%)	Population in Mahalle (000p)	No. of Mahalle	Urbanized Area In Mahalle (ha)	Area share (%)	Population in Mahalle (000p)
Old Town: historic urban	12	EMINÖNÜ	18	168	37	20	3	39	9	6
	14	FATİH	51	693	71	304	0	0	0	0
	7	BEYOĞLU	29	434	52	138	1	11	1	6
	Sub-Total		98	1,295	57	461	4	49	2	12
Europe: Marmara Coast	32	ZEYTİNBURNU	4	101	11	66	0	0	0	0
	4	BAKIRKÖY	2	41	3	13	0	0	0	0
	15	CÜNGÖREN	4	191	28	83	0	0	0	0
	3	BAHÇELİEVLER	3	245	17	160	0	0	0	0
	2	AVCILAR	0	0	0	0	0	0	0	0
	Sub-Total		13	578	9	321	0	0	0	0
Europe: Bosphoras	8	BESİKTAŞ	1	15	1	2	3	46	3	22
	19	KAĞITANE	4	134	11	73	1	20	2	13
	26	ŞİŞLİ	5	101	7	34	2	59	4	20
	23	SARIYER	0	0	0	0	0	0	0	0
	Sub-Total		10	250	4	110	6	125	2	55
Europe: Inland	13	EYÜP	3	143	9	38	3	97	6	28
	16	GAZİOSMANPAŞA	0	0	0	0	4	194	8	73
	10	BAYRAMPAŞA	4	236	31	95	0	0	0	0
	902	ESENLER	7	288	28	184	0	0	0	0
	5	BAĞCILAR	6	308	16	153	0	0	0	0
	20	KÜÇÜKÇEKMECE	2	113	3	42	0	0	0	0
	Sub-Total		22	1,088	9	512	7	291	2	101
Total/Average of European Side			143	3,211	12	1,404	17	465	2	168
Asian: Marmara Coast	1	ADALAR	0	0	0	0	0	0	0	0
	17	KADIKÖY	1	53	1	20	1	50	1	6
	21	MALTEPE	0	0	0	0	0	0	0	0
	18	KARTAL	0	0	0	0	0	0	0	0
	22	PENDİK	0	0	0	0	0	0	0	0
	28	TUZLA	0	0	0	0	0	0	0	0
	Sub-Total		1	53	0	20	1	50	0	6
Asian: Bosphoras	30	ÜSKÜDAR	3	24	1	9	2	20	1	8
	6	BEYKOZ	0	0	0	0	0	0	0	0
	29	ÜMRANİYE	0	0	0	0	0	0	0	0
	Sub-Total		3	24	0	9	2	20	0	8
Total/Average of Asian Side			4	77	0	29	3	70	0	14
Outside IMM	9	BÜYÜKÇEKMECE	0	0	0	0	0	0	0	0
	903	ÇATALCA	0	0	0	0	0	0	0	0
	904	SİLİVRİ	0	0	0	0	0	0	0	0
	Sub-Total		0	0	0	0	0	0	0	0
Total			147	3,288	6	1,433	20	535	1	182

Source: The JICA Study Team

Note: ☐ The designated Archeological and Historical Urban Conservation Areas are also included

10.2.5. Recommended Strategic Building Structure Improvement Measures

Strategic building structure improvement measures are recommended for specific mahalles when the following conditions are met:

- The share of the estimated heavy and moderately damaged buildings equals more than 30% of the mahalle's total building stock, and
- The mahalle is not assessed as having serious urban structure vulnerability issues.

51 mahalles (8% of the Study Area) with 59.1 km^2 of urbanized area (12% of the Study Area) and 0.9 millions residents (10% of the population) are identified for the strategic building structure improvement area.

For the identified area, the recommended strategic measures to improve weak building structure are mentioned in 10.2 and should be intensively applied to the areas.

The areas without strategic improvement measure (191 mahalles with 197.5 km^2 of urbanized area and 2.5 millions residents) are assessed and identified without any of the five categories for strategic improvement measures. However, not one of 642 mahalles could avoid building damage from the estimated earthquake motion in the Study Area. The estimated building damage ratios in the identified mahalles range from the minimum case (4% of partially damaged buildings in the mahalle) to the maximum case (58% of heavily/moderately/partially damaged buildings in the mahalle). For the estimated building damage, supplemental building structure improvement measures are recommended for each mahalle through the seismic resistant assessment for the existing building stock. Additionally, in the identified mahalles, serious urban structure vulnerability issues are not obviously assessed and identified; however, some specific urban structure improvement projects, such as road widening and park developments, will be required to upgrade the safety of residents' environments.

Supplemental or specific improvement measures for building and urban structure vulnerabilities are recommended for the categorized mahalles in order to be examined with the detailed plan formulation studies of district disaster prevention plan.

Table 10.2.6 Recommended Building Structure Improvement by Mahalle

Area	District		Building Structure Improvement Measures				Other Measure			
	Code	Name	No. of Mahalle	Urbanized Area In Mahalle (ha)	Area Share (%)	Population in Mahalle (000p)	No. of Mahalle	Urbanized Area In Mahalle (ha)	Area Share (%)	Population in Mahalle (000p)
Historic District:	12	EMINÖNÜ	0	0	0	0	3	49	11	3
	14	FATİH	2	16	2	1	0	0	0	0
	7	BEYOĞLU	0	0	0	0	1	5	1	5
	Subtotal		2	16	1	1	4	54	2	7
Europe: Marmara Coast	32	ZEYTİNBURNU	3	238	25	40	0	0	0	0
	4	BAKIRKÖY	6	1,076	67	139	0	0	0	0
	15	CÜNGÖREN	1	80	12	22	0	0	0	0
	3	BAHÇELİEVLER	3	754	53	118	0	0	0	0
	2	AVCILAR	2	297	19	44	1	165	11	14
	Subtotal		15	2,445	39	362	1	165	3	14
Europe: Bosphorus	8	BESİKTAŞ	1	48	3	2	15	1,195	79	132
	19	KAĞITANE	2	362	30	43	9	483	40	167
	26	ŞİŞLİ	1	33	2	3	17	1,159	79	175
	23	SARIYER	0	0	0	0	22	2,040	97	208
	Subtotal		4	444	7	47	63	4,878	77	683
Europe: Inland	13	EYÜP	2	174	11	8	5	391	26	70
	16	GAZİOSMANPAŞA	0	0	0	0	16	1,529	62	391
	10	BAYRAMPAŞA	3	279	37	74	1	50	7	16
	902	ESENLER	1	18	2	3	5	482	47	101
	5	BAĞCILAR	0	0	0	0	1	108	6	40
	20	KÜÇÜKÇEKMECE	1	114	3	12	3	1,611	39	72
	Subtotal		7	585	5	98	31	4,171	35	690
Total/Average of European Side			28	3,489	13	509	99	9,268	35	1,395
Asian: Marmara Coast	1	ADALAR	0	0	0	0	5	0	0	0
	17	KADIKÖY	5	609	17	119	2	281	8	38
	21	MALTEPE	3	277	12	70	4	180	8	19
	18	KARTAL	5	480	18	76	1	144	6	14
	22	PENDİK	2	161	5	26	2	361	10	13
	28	TUZLA	2	337	17	19	1	21	1	0
	Subtotal		17	1,865	13	309	15	986	7	85
Asian: Bosphorus	30	ÜSKÜDAR	2	183	6	40	40	2,805	86	392
	6	BEYKOZ	0	0	0	0	17	2,189	94	173
	29	ÜMRANİYE	0	0	0	0	12	3,232	90	371
	Subtotal		2	183	2	40	69	8,226	90	936
Total/Average of Asian Side			19	2,048	9	349	84	9,212	39	1,021
Outside IMM	9	BÜYÜKÇEKMECE	4	376	84	0	1	2	0	0
	903	ÇATALCA	0	0	0	0	2	426	100	16
	904	SİLİVRİ	0	0	0	0	5	841	100	44
	Subtotal		4	376	22	0	8	1,268	74	60
Total			51	5,913	11	858	191	19,748	38	2,476

Source: The JICA Study Team

Note: ☐ The designated Archeological and Historical Urban Conservation Areas are included

10.3. Recommendations for Land-Use Plan and Zoning

10.3.1. Recommended Land-Use Zoning Measures for Natural Hazard Areas

(1) Identified Risks of Natural Hazard

For the unstable ground conditions identified in Chapter 6, all superstructures and infrastructures in the area have the following high natural hazard risks:

- Unstable steep slopes
- Liquefaction potential areas along the coast

(2) Recommended Land-Use Zoning System

In order to mitigate and minimize foreseeable disaster damage in the area, a land-use zoning system with specialized building codes for natural hazards is an indispensable measure to guide and establish proper and suitable land-use in identified areas of natural hazard risks.

A land-use category of park and open space is principally recommended to avoid human casualties and economic loss in the identified hazardous areas of the present urbanized areas and its surroundings.

Additional zoning system for natural hazards is recommended with design codes and regulations for foundation and building structures. This will enable buildings to resist the estimated natural hazards. It will also have the added function of avoiding inappropriate building construction and development in the designated areas.

(3) Required Supporting Measures to Achieve Proper Land Use

Parts of the identified unstable slope areas have been illegally or irregularly developed into residential areas. Similarly, parts of liquefaction potential areas have also been developed into residential areas, ports, and related facilities. Supporting measures to achieve proper land-use in these natural hazard areas are required and recommended. The suggested category areas are listed as follows:

Residential Relocation/Park Development: It is proposed that the existing residential areas in the identified natural hazard risk areas be relocated to safer areas. Parks and open spaces may be developed in the remaining natural hazard areas after the relocation of residential areas by the metropolitan government.

Port/Related Facilities: In order to ensure emergency functions, special reinforcement and improvement measures are recommended for the facilities in the identified liquefaction potential areas that are selected and assigned as strategic major transportation nodes and/or emergency centres.

Bridge/Road Facilities: Bridges, traffic signals, street light poles and other road facilities in the identified liquefaction potential areas, as well as steep slope shoulders in the identified unstable slope should be reinforced and improved before a disasterous event occurs.

Infrastructure: The reinforcement and improvement of main water pipelines, natural gas and sewage lines, and main cable networks of electricity and telecommunication located in identified liquefaction potential areas is also recommended in order to maintain essential services and avoid secondary disasters under earthquake disaster conditions.

10.3.2. Recommended Land-Use Zoning and Related Measures for Hazardous Facilities

In the last century, all developed and accumulated manufacturing industries moved out from the metropolitan area. Some industries maintain only headquarter facilities; however there are some hazardous industries remaining in the metropolitan area.

Hazardous facilities are divided into two categories for the purpose of permission and registration with the Licensing Directorate of the IMM and each district's municipality. Major hazardous facilities, composed from the following five (5) categories of large-scale hazardous facilities and negative environmental impacts, are currently permitted and registered by the Licensing Directorate of IMM:

- Big LPG Storage (163 facilities)
- Paint and polish material factories (91 facilities)
- Chemical product warehouses (404 facilities)
- LPG filling stations (123 facilities)
- Liquid fuel filling stations (33 facilities)

The 814 registered hazardous facilities are widely distributed in 331 mahalles (52% of mahalles). Nonetheless, more than five (5) registered hazardous facilities are concentrated in 40 urbanized mahalles, mainly located in Bahçelievler (2 mahalles), Bagcılar (4 mahalles), Gaziosmanpasa (4 mahalles), Kadıköy (2 mahalles), Kartal (3 mahalles), Kagıthane (2 mahalles), Küçükçekmece (3 mahalles), Pendik (5 mahalles), Ümraniye (5 mahalles), and Zeytinburunu (4 mahalles).

The estimated number of fire outbreaks from the 814 hazardous facilities identified are 14 when considering earthquake scenario A and 16 when considering earthquake scenario C. The potential for fire to spread from those facilities is low (based on the limited data source). The estimated earthquake damages of hazardous facilities also appears to be moderate to low. However, land-use issues regarding hazardous facilities should be properly managed by the recommended land-use zoning system as follows:

- Careful review and revison of the designated existing industrial land-use within urbanized areas in order to maintain safer environments for surrounding communities.
- New designation and development of industrial areas for the relocation of unsuitable hazardous facilities out of urbanized areas (if necessary).
- Carefull review and revision of the existing land use regulations for hazardous facilities in and out of the designated industrial land use areas.
- The proper systemization and demarcation of the present system for approval, registration, monitoring, taxation, and execution of regulations for hazardous facilities by the appropriate agencies, e.g., Licensing Directorate, Flammable/Explosive Directorate, Fire Brigade Department, and the Civil Defence.

Table 10.3.1 Registered Hazardous Facilities and Estimated Fire Outbreak Points

Area	District		Number of Registered Establishments by Hazardous Material						Estimated Points of Fire Outbreak	
	Code	Name	Total	Big LPG Storage	Factory of Paint/ Polish Products	Warehouse of Chemical Products	LPG Filling Station	Liquid Fuel Filling St.	Case-A	Case-C
Historic District	12	EMINÖNÜ	7	4	0	3	0	0	0.3	0.3
	14	FATİH	29	13	0	12	4	0	1.8	2.0
	7	BEYOĞLU	22	4	1	14	1	2	0.3	0.3
	Subtotal		58	21	1	29	5	2	2.4	2.6
Europe: Marmara Coast	32	ZEYTİNBURNU	35	6	3	19	6	1	1.2	1.4
	4	BAKIRKÖY	19	0	0	17	2	0	0.4	0.4
	15	CÜNGÖREN	18	4	1	8	4	1	0.6	0.7
	3	BAHÇELİEVLER	36	7	0	11	16	2	1.6	1.9
	2	AVCILAR	17	3	0	10	4	0	0.6	0.7
	Subtotal		125	20	4	65	32	4	4.3	5.1
Europe: Bosphorus	8	BESİKTAŞ	18	7	0	10	1	0	0.1	0.2
	19	KAĞITANE	44	15	7	10	7	5	0.6	0.7
	26	ŞİŞLİ	33	9	2	18	3	1	0.2	0.2
	23	SARIYER	20	6	0	11	3	0	0.1	0.1
	Subtotal		115	37	9	49	14	6	1.0	1.1
Europe: Inland	13	EYÜP	29	6	7	10	4	2	0.6	0.6
	16	GAZİOSMANPAŞA	59	14	12	30	1	2	0.3	0.4
	10	BAYRAMPAŞA	21	2	1	8	5	5	0.5	0.6
	902	ESENLER	12	0	0	10	2	0	0.1	0.1
	5	BAĞCILAR	61	17	0	28	16	0	1.4	1.8
	20	KÜÇÜKÇEKMECE	43	9	10	16	6	2	0.6	0.7
	Subtotal		225	48	30	102	34	11	3.6	4.2
Total/Average of European Side			523	126	44	245	85	23	11.2	13.1
Asian: Marmara	1	ADALAR	NA	NA	NA	NA	NA	NA	NA	NA
	17	KADIKÖY	46	6	0	35	5	0	0.4	0.5
	21	MALTEPE	26	6	3	12	4	1	0.4	0.5
	18	KARTAL	46	9	9	22	5	1	0.7	0.8
	22	PENDİK	67	5	29	25	3	5	0.5	0.5
	28	TUZLA	6	1	0	5	0	0	0.1	0.1
	Subtotal		191	27	41	99	17	7	2.1	2.3
Asian: Bosphorus	30	ÜSKÜDAR	33	2	0	20	11	0	0.1	0.2
	6	BEYKOZ	13	0	0	11	2	0	0.0	0.0
	29	ÜMRANİYE	54	8	6	29	8	3	0.2	0.3
	Subtotal		100	10	6	60	21	3	0.4	0.5
Total/Average of Asian Side			291	37	47	159	38	10	2.4	2.8
Total			814	163	91	404	123	33	13.7	15.9

Source of hazardous facility: registered hazardous facility 2000 and 2001 from Licensing Directorate
Source of fire out-break point: JICA Study Team

10.3.3. Recommended Future Urban Development Directions for the Land Use Master Plan

The coastal areas along the Marmara Sea, within the IMM, are assessed as high-risk areas for earthquake disaster damages based on the estimated earthquake motion of the 4 earthquake scenarios in the JICA Study. Based on this finding, it is recommended that the future urban expansion direction of the IMM shift from the areas along Marmara Coast to the inland areas. This is especially true for the European side.

The designated urban expansion and densification areas along the Marmara Coast on the master plan and district land use zoning plans should be carefully reviewed and shifted away from the identified risks of earthquake disaster damages, especially like those found on the European side, and into safer inland areas. However, shifted urban expansion direction towards the inland areas should be well-coordinated with the present conservation areas for water resources and natural environmental resources on the inland areas. This is identified as one of key policy of IMM in the master plan.

10.3.4. Recommended Comprehensive Urban Growth Management System for Metropolitan Istanbul

The administrative area of Istanbul Metropolitan Municipality is legislated clearly in Law No. 3030. On the other hand, the power to execute urban planning and urban growth management by the Istanbul Metropolitan Municipality is currently limited to only covering the presently developed and urbanized areas within the area defined in Law No. 3030. Under this condition, almost all of the present urbanized areas in IMM were developed without urban development regulations, the standards of IMM, or consistent with the urban development master plan of IMM. The end results under these contradictions are that the administrative and urban planning areas are seriously generating an accumulation of uncontrollable chaotic urbanized areas in IMM.

(1) Recommended Administrative and Urban Planning Area for the Metropolitan Area

In order for proper urban management to aid in strengthening buildings and urban structures for earthquake disaster prevention and nature conservation in IMM, IMM must have a consistent system of administrative and execution power for urban planning/urban growth management. Currently, urban expansion trends of Istanbul Metropolitan exceed beyond the area defined in Law No. 3030. The proposed consistent administrative and urban growth management/planning area is wider than the area defined in Law 3030.

(2) Planning and Execution Powers for Urban Reconstruction Plan Before/After Disaster

Under Law No. 3030, all urban planning powers are clearly granted to the metropolitan municipalities. The master plan for the metropolitan area was formulated and enacted by IMM. Zoning plans are formulated and enacted by district municipalities under the guidance of IMM. However, the execution and planning powers of urban reconstruction after a disaster are not legally localized to the metropolitan municipalities by the Ministry of Public Works and Housing.

For the future, a preliminary urban reconstruction plan should be formulated in coordination with the metropolitan master plan before the occurrence of an urban disaster. After an urban disaster, the formulated preliminary urban reconstruction plan should be revised and finalized with actual disaster damage information and with the implementation programme of urban reconstruction works.

To establish the recommended future urban reconstruction system, planning and execution powers of urban reconstruction should be localized to the Metropolitan Municipality of Istanbul under the coordination of the Ministry of Public Works and Housing.

(3) Improvement and Capacity Buildings of Planning and Execution Functions for Urban Growth Management

Currently, the steps needed to move from the comprehensive master plan to the district implementation plans (zoning plans) are taking time and manpower resources in order to enforce the zoning plans.

- Comprehensive Master Plan of Metropolitan Istanbul: 1/50,000 formulated by IMM and approved by municipal assembly
- District Plans (narrowed down version of the above master plan): 1/25,000 formulated by IMM
- District Application Plans: 1/5,000 formulated by IMM
- District Implementation Plans: 1/1,000 formulated by district municipalities under guidance of the IMM and approved by district assembly

The present planning steps are recommended to simplify the district planning and the district application planning steps in a manner that will minimize the needs of the planning staffs and experts.

Human resources for formulation and execution of the above plans are distributed on a limited basis in the metropolitan municipality, especially in the district municipalities. For example:

- In the City Planning Directorate of the IMM, a technical staff of 150 urban planners and architects with temporary technical assistants are working to formulate a master plan, other district plans, district application plans, and also to provide support to district municipalities formulating implementation plans.
- In the Construction Directorate of the IMM, a technical staff of 37 architects and structural engineers, and additional 37 staff members, are working to provide supervision and guidance to district municipalities regarding building applications.
- In district municipalities, 15 technical staff members are working to check applications, issue building permits and site inspections on completion of the process.

For the IMM, the roles of planning and executing plans and regulations are clearly demarcated as those of City Planning and Construction Directorates. Top-down policy direction from the City Planning Directorate and bottom-up information and issues from the Construction Directorate should be well-coordinated with each other to establish a better unified planning and execution system in IMM.

Capacity building with respect to urban planning and implementation for the 28 district municipalities is not a crucial issue to establish the proper planning and execution system to cover all of the development and building applications within the metropolitan area.

10.4. Recommended Measures to Promote and Support Seismic Resistant Buildings

10.4.1. Recommended Strategic Measures to Improve Structurally Weak Building by the Private Sector

Most of the weak building structures in the metropolitan municipality are illegally and irregularly developed and constructed without any development and building permits. This occurs because of persistent optimistic views about earthquake disaster and lack of public awareness of the public on the high probability of an urban earthquake disaster. All of the experiences and wisdom regarding the power of earthquake damages handed down from generation to generation among the Istanbul population had not been transmitted to the present citizens. It is likely to have been forgotten in the past period of more than a century, in which residents lived without any earthquakes, and with the subsequent explosion of urban expansion in the past 3 decades.

However, these accumulated structurally weak buildings in the metropolitan area will be seriously and catastrophically damaged by the next estimated earthquake disaster. In order to mitigate and minimize building damages and related human casualties, the strengthening of the assessed structurally weak buildings may be identified as an indispensable measure and the only solution that would allow citizens to survive. The increase of public awareness of earthquake disaster damage mechanisms and understandings of structurally weak buildings will also be important to achieve, as well as to implement the appropriate strengthening measures. The subsequent public support will also be indispensable in enhancing and promoting heavy investment by the private sector to strengthen structurally weak buildings.

- **Preparation Measure 1:** Assessment of seismic resistant building structure for all private buildings by the local government with assistance from NGO experts. The results of this assessment should be to identify the required levels of reconstruction or reinforcement. The estimated building damages found in the JICA Study may be utilized to prioritize the assessment work deemed necessary.
- **Preparation Measure 2:** Preparation of funding resources and the establishment of a Seismic Resistant Building Fund that will create a rolling fund system for the following soft loan scenarios;
  - Estimated damaged building floor areas;

    Heavily: 36 million

    Moderately: 46 million

Total: 82 million m^2

- Estimated improvement costs (in the case of unit cost: \$100/ m^2);

Heavily: 3.6 billion

Moderately: 4.6 billion

Total: \$8.2 billion

- Required original fund sources (3 rolling shifts)

Heavily: 1.2 billion

Moderately: 1.5 billion

Total: \$2.7 billion -

- This estimated \$2.7 billion figure will be the minimum fund amount necessary to cover buidings assessed through Preparation Measure 1. **Preparation Measure 3:** Modification of real estate through a common ownership law to promote smooth reinforcement and reconstruction (change from common consent to majority of consent).

  - **Incentive 1**: To introduce a new reductive rate of earthquake disaster insurance for improved seismic resistant buildings.

  - **Incentive 2:** To exempt real estate tax for improved seismic resistant buildings (especially building tax).

  - **Incentive 3:** To apply a soft loan system for the assessed buildings to be reconstructed or reinforced by the Preparation Measure 1.

The resources of the established Seismic Resistant Building Fund are not only proposed to be utilized for the assessed structurally weak buildings, but also for the required urban reconstruction projects for areas with serious building and urban structure vulnerabilities.

10.4.2. Recommended Supporting Measures to Establish Effective Improvement Methods and Construction Industries

- Establishing an effective execution system requires supporting measures dealing with reinforcement and reconstruction technology, qualified and enhanced construction industries, and qualified technicians and workers. For example: **Measure for Technology:** To develop, establish, and apply effective reinforcement and reconstruction design, materials, and methods to reduce human casualties through cost efficient technology investments.

- **Measure for Construction Industry:** To upgrade quality standards in construction industries through the use of a proper construction registration system. This will enhance the capability of construction industries through taxation and financial measures. It will promote quality in the related industries of construction materials, machinery, etc., through regulations and supporting measures in the metropolitan area.
- **Measure for Qualified Manpower:** To upgrade technician and worker skill and quality by establishing an occupational training and registration system

10.5. Frameworks for Emergency Response and Rehabilitation Works

The Emergency Response System should be planned and organized primarily with the scientific estimated disaster damages for the worst case earthquake scenarios in an earthquake-prone region or nation. However, in metropolitan Istanbul, the present emergency response system could not be organized on scientifically estimated disaster damages because that information was not available until JICA carried the Study.

The demand or framework for each emergency response operation is based on the estimated damages of the worst earthquake scenario Model C. The following frameworks for emergency response and rehabilitation efforts are based on those estimated damages.

- **Framework for Community Evacuation Place:** Population of the damaged area
- **Framework for Emergency Debris Removal from the Proposed Emergency Road Network:** Estimated debris of heavily and moderately damaged building along emergency roads
- **Framework for Emergency Rescue Operation:** Estimated number of residents in estimated heavily and moderately damaged buildings
- **Framework for Emergency First Aid:** Estimated heavily and slightly injured population
- **Framework for Emergency Medical Care:** Estimated heavily injured population
- **Framework for Emergency Fire Fighting Operation:** Estimated fire outbreaks from identified and registered hazardous facilities
- **Framework for Emergency Portable Water and Foods Supply:** Estimated refugees and victims
- **Framework for Tent Village:** Estimated residents in heavily, moderately, and partially damaged building
- **Framework for Temporary Housing:** Estimated residents in heavily damaged buildings
- **Framework for Preparation of Cemetery, Funeral, and Burial Services:** Estimated number of dead
- **Framework for Emergency Lifeline Rehabilitation Works:** Damaged points and length of lifeline
- **Framework for Debris Removal:** Estimated total amount of debris from building damages

10.5.1. Framework for Community Evacuation Place

(1) Present Situation

Presently, the emergency evacuation system has not been introduced and established in metropolitan Istanbul and Turkey. Second or third aftershocks and secondary disasters will greatly increase the amount of human casualties after the initial earthquake. In order to mitigate and minimize human casualties, a community evacuation system is proposed to be introduce to metropolitan Istanbul. Also, proposed community evacuation and gathering places could be used to collect primary damage information from local residents to be used for organizing effective emergency operation taskforces.

(2) Recommended Community Evacuation Locations

A community evacuation and gathering area should be identified and designated for each neighborhood where building and other damages are estimated in the Microzonation Study. The estimated building damage is calculated for all 625 mahalles with settlements, where building damages range from the minimum 4% partially damaged building ratio to the maximum 80% heavily, moderately and partially damaged building ratio. Mahalles with no building damage were not identified in Earthquake Scenario C. Based on the above results, community evacuation and gathering locations are recommended for all neighborhood communities in the 625 mahalles.

- Recommended distribution standard: Primary school district of neighborhood community (300 to 500 dwelling units with 1,500 to 2,000 pop.)
- Recommended area standard: Identified and designated area should provide a minimum net area of 0.5 m^2/person (1.5 m^2/person minimum gross area) for all residents and citizens within the neighborhood community.

Candidates for the community evacuation location should be selected under the following conditions:,

- Stabilized land title, preferably publicly-owned land.
- Stabilized suitable land-use conditions such as public facilities and open space.
- Areas commonly distributed to neighborhood communities such as schools, religious facilities, and parks/open spaces.
- Seismically resistant buildings in the area. However, the existing public facilities could not be categorized as being sufficiently seismic resistant because of the limitation of data. This matter should be decided using the results of the seismic resistance diagnosis for all public facilities.

- Safety from surrounding building damage would make small and narrow parks and open spaces fall into an inappropriate category.
- Other safety conditions include not having any hazardous facilities in or around the areas.
- The evacuation location should be easily recognized and understood by the residents and citizens within the community.

In the metropolitan area, parks and open spaces should be selected as appropriate candidates for evacuation locations based on the above conditions.

(3) Availability of Parks and Open Space for Community Evacuation Locations

A database of neighborhood communities in the metropolitan area is currently not available. Availability of parks and open spaces for community evacuation and gathering place are analyzed and assessed on the available demographic and geographic data by mahalle under the following conditions:

The area demand of community evacuation areas is estimated to be around 1,320 ha for 8.8 million citizens in the metropolitan area. The existing parks and open spaces in the metropolitan area are counted at 1,425 and over an area of 1,782 ha. This is 1.35 times the estimated area demand of community evacuation areas. On the other hand, mahalle-based area availability of parks and open spaces for community evacuation place are as follows:

- 138 mahalles (22%): Existing area (park/open space) over the estimated demand.
- 68 mahalles (11%): Existing areas are 50% to 99% of the estimated demand.
- 419 mahalles (67%): Existing areas are less than 50% of the estimated demand.

Based on this assessment of availability, the total area of existing parks and open space in the metropolitan area is enough for the estimated total area demand for community evacuation areas. However, almost all mahalles are assessed as not having enough parks and open space for a community evacuation location. Based on both results, it is concluded that the existing parks and open spaces are not evenly developed and standardized because of past illegal and irregular urban development.

Table 10.5.1 Demand and Availability of Parks/Open Space for Community Evacuation Locations

Area	District		Demand: evacuation		Existing Park/Open Space in District			Mahalle by Level of Availability		
	Code	Name	1.Pop 2000	2.Evacuation area demand (ha)	3.No. of park/open space	4.Area (ha)	5.Area Supply/ Demand Ratio (4/2)	6.over 100% of demand	7.50% to 99% of demand	8.less than 50% of demand
Historic District	12	EMINÖNÜ	54,518	8	49	69	838	16	2	15
	14	FATİH	394,042	59	82	116	196	16	5	48
	7	BEYOĞLU	234,964	35	36	40	115	10	4	31
	Subtotal		683,524	103	167	225	219	42	11	94
Europe: Marmara Coast	32	ZEYTİNBURNU	239,927	36	29	30	83	1	3	9
	4	BAKIRKÖY	206,459	31	92	224	725	9	3	3
	15	CÜNGÖREN	271,874	41	30	8	20	0	1	10
	3	BAHÇELİEVLER	469,844	70	43	20	28	0	3	8
	2	AVCILAR	231,799	35	32	35	101	3	0	6
	Subtotal		1,419,903	213	226	317	149	13	10	36
Europe: Bosphorus	8	BESİKTAŞ	182,658	27	80	89	325	13	3	7
	19	KAĞITANE	342,477	51	44	231	449	2	1	16
	26	ŞİŞLİ	271,003	41	38	57	140	3	2	23
	23	SARIYER	212,996	32	53	70	218	5	5	13
	Subtotal		1,009,134	151	215	446	295	23	11	59
Europe: Inland	13	EYÜP	232,104	35	92	61	177	7	4	9
	16	GAZİOSMANPAŞA	667,809	100	91	22	22	1	0	27
	10	BAYRAMPAŞA	237,874	36	44	66	185	2	3	6
	902	ESENLER	388,003	58	15	5	8	1	1	15
	5	BAĞCILAR	557,588	84	44	12	15	0	1	21
	20	KÜÇÜKÇEKMECE	589,139	88	39	17	19	1	1	21
	Subtotal		2,672,517	401	325	184	46	12	10	99
Total/Average of European Side			5,785,078	868	933	1,172	135	90	42	288
Asian: Marmara	1	ADALAR	17,738	3	19	4	142	3	1	1
	17	KADIKÖY	660,619	99	66	89	90	6	1	21
	21	MALTEPE	345,662	52	38	57	110	3	0	16
	18	KARTAL	332,090	50	58	19	38	1	4	15
	22	PENDİK	372,553	56	43	130	232	5	3	21
	28	TUZLA	100,609	15	27	10	68	4	3	3
	Subtotal		1,829,271	274	251	309	113	22	12	77
Asian: Bosphorus	30	ÜSKÜDAR	496,402	74	168	100	135	17	9	28
	6	BEYKOZ	182,864	27	36	171	624	8	4	7
	29	ÜMRANİYE	443,358	67	37	30	45	1	1	12
	Subtotal		1,122,624	168	241	302	179	26	14	47
Total/Average of Asian Side			2,951,895	443	492	611	138	48	26	124
Outside IMM	9	BÜYÜKÇEKMECE	NA	NA	NA	NA	NA	0	0	0
	903	ÇATALCA	15,624	2	0	0	0	0	0	2
	904	SİLİVRİ	44,432	7	0	0	0	0	0	5
	Subtotal		60,056	9	0	0	0	0	0	7
Total			8,797,029	1,320	1,425	1,782	135	138	68	419

Source: JICA study team

(4) Recommended Measures to Establish Community Evacuation System

The following considerations and measures are recommended to be incorporated into proposed detailed disaster prevention plans by each district municipality.

- Set-up and designate each neighborhood community as a Community Evacuation Zone.

- Identify facilities, parks, and open space candidates to be designated as community evacuation locations within the designated Community Evacuation Zone.
- Create a community hazard map (including natural hazards, vulnerable buildings, narrow roads inappropriate for safety evacuation or emergency rescue vehicles, hazardous facilities, and vulnerable sub-populations (handicapped, elderly, children, etc.).
- Select and designate a community evacuation location from the identified candidates using the created community hazard map.
- Select safety evacuation routes to the community evacuation location from each residential block.
- Provide guides and signs along the selected routes and in the selected evacuation locations.

10.5.2. Framework for Emergency Debris Removal from the Proposed Emergency Road Network

The proposed emergency road network is around 782 km, which is 6% of the 14,700 km total road length in the metropolitan area. It is indispensable to keep the proposed emergency road network functioning for effective emergency operations and response after a disaster occurs. On the other hand, some designated emergency roads will likely be closed or cut off by collapsed road facilities and buildings in the following ways:

- Collapsed road facilities such as lighting poles, traffic signs/signals, fallen street tree, and bridges.
- Debris from collapsed and damaged buildings, fences and billboards along the road.
- Damaged poles and cables from electricity and telecommunication networks.

The biggest factor closing and cutting off emergency roads will be the debris of collapsed and damaged buildings in the metropolitan area. The total volume of debris by building damages is estimated at around 140 million tons in the metropolitan area. 2.6 million tons (1.8% of the estimated total) of debris may close down and cut off the emergency road network. This estimated debris on the emergency road network should be temporarily removed to surrounding areas in order to re-open roads for emergency vehicle operation within 3 days. The order of debris removal should be based on the emergency roads' priority (primary, secondary and tertiary).

Table 10.5.2 Framework for Debris Removal from Emergency Road

Area	District		Total Debris of Damaged Building (ton)	Road Length			Debris on Emergency Road		Required Machinery to Remove within 3 days	
	Code	Name		all road (km)	emergency road (km)	emergency road ratio	volume (ton)	share (%)	H.G.Vehicle (8ton/10/d)	Machinery (500ton/d)
Historic District	12	EMINÖNÜ	3,310,000	118	14	12	100,000	4	400	70
	14	FATİH	7,592,000	268	17	7	109,000	4	500	70
	7	BEYOĞLU	4,359,000	240	22	9	101,000	4	400	70
	Subtotal		15,261,000	626	53	8	310,000	12	1,300	210
Europe: Marmara Coast	32	ZEYTİNBURNU	7,229,000	235	25	11	150,000	6	600	100
	4	BAKIRKÖY	7,519,000	349	49	14	275,000	10	1,100	180
	15	CÜNGÖREN	5,946,000	186	16	9	144,000	6	600	100
	3	BAHÇELİEVLER	10,262,000	373	30	8	192,000	8	800	130
	2	AVCILAR	5,369,000	432	23	5	83,000	3	300	60
	Subtotal		36,325,000	1,575	142	9	844,000	33	3,400	570
Europe: Bosphoras	8	BEŞİKTAŞ	2,814,000	326	30	9	70,000	3	300	50
	19	KAĞITANE	2,999,000	344	20	6	38,000	2	200	30
	26	ŞİŞLİ	4,550,000	475	25	5	95,000	3	400	60
	23	SARIYER	1,123,000	496	25	5	16,000	1	100	10
	Subtotal		11,486,000	1,641	100	6	219,000	9	1,000	150
Europe: Inland	13	EYÜP	2,669,000	488	30	6	59,000	2	200	40
	16	GAZİOSMANPAŞA	5,103,000	861	22	3	38,000	2	200	30
	10	BAYRAMPAŞA	4,945,000	235	14	6	88,000	3	400	60
	902	ESENLER	4,363,000	517	20	4	60,000	2	300	40
	5	BAĞCILAR	7,974,000	562	30	5	106,000	4	400	70
	20	KÜÇÜKÇEKMECE	11,182,000	1,256	63	5	168,000	6	700	110
	Subtotal		36,236,000	3,919	180	5	519,000	20	2,200	350
Total/Average of European Side			99,308,000	7,761	474	6	1,892,000	74	7,900	1,280
Asian: Marmara	1	ADALAR	839,000	123	0	0	0	0	0	0
	17	KADIKÖY	10,688,000	733	60	8	225,000	9	900	150
	21	MALTEPE	5,190,000	740	30	4	91,000	3	400	60
	18	KARTAL	4,591,000	612	30	5	66,000	2	300	40
	22	PENDİK	5,175,000	741	40	5	90,000	3	400	60
	28	TUZLA	2,217,000	558	37	7	42,000	2	200	30
	Subtotal		28,700,000	3,508	197	6	514,000	20	2,200	340
Asian: Bosphoras	30	ÜSKÜDAR	5,078,000	757	52	7	108,000	4	400	70
	6	BEYKOZ	793,000	555	29	5	12,000	1	0	10
	29	ÜMRANİYE	3,548,000	982	29	3	27,000	1	100	20
	Subtotal		9,419,000	2,294	110	5	147,000	6	500	100
Total/Average of Asian Side			38,119,000	5,801	307	5	661,000	26	2,700	440
Outside IMM	9	BÜYÜKÇEKMECE	1,401,000	133	10	7	27,000	1	100	20
	903	ÇATALCA	181,000	NA	7	NA	NA	NA	NA	NA
	904	SİLİVRİ	927,000	NA	19	NA	NA	NA	NA	NA
	Subtotal		2,509,000	133	36	NA	27,000	1	100	20
Total			139,936,000	13,695	818	6	2,580,000	100	10,700	1,740

Source: JICA Study Team

10,700 heavy goods vehicles and 1,740 heavy machinery vehicles will be required to remove the estimated 2.6 million tons of debris from emergency roads to surrounding areas within 3 days. The present emergency response plan regarding emergency road should be reviewed and re-organized using the above detailed demand and frameworks.

10.5.3. Framework for Emergency Rescue Operation

(1) Estimated Candidates for Rescue Operation

Emergency rescue operations are not only required for the estimated 223,000 missing and seriously injured citizens, but also for the other residents in the estimated damaged buildings. Rescue operation demands are for residents or persons in heavily damaged buildings as well as for residents and persons in moderately and partially damaged buildings. The required formation of rescue taskforce teams depend on the conditions of trapped missing persons such as those crushed under a collapsed building, under overturned furniture, in a fixed door, or window, etc., and the following conditions:

a. Heavily damaged buildings: Approximately 712,000 residents

The majority of residents or persons in heavily damaged buildings will perish, be seriously injured, slightly injured, or remain trapped under the collapsed building.

Most of these residents and persons will only be rescued from collapsed or heavily damaged buildings through the use of specialized taskforces with heavy machinery. Specialized taskforce teams will be effectively supported by local information and knowledge.

b. Moderately damaged buildings: Approximately 912,000 residents

A portion of residents and persons in moderately damaged buildings will be will perish, be seriously or slightly injured or trapped under collapsed walls, furniture, or fixed doors/windows, etc.

All those residents and persons especially vulnerable to disaster can be rescued by either a community taskforce or a specialized taskforce.

c. Partially damaged buildings: Approximately 1,939,000 residents

A limited amount of residents and persons especially vulnerable to disaster will be slightly injured or trapped under overturned furniture or fixed doors and windows.

All of these residents and persons can be rescued by community taskforces.

(2) Frameworks and Recommended Measures for Rescue Operations

The estimated 222,700 of missing, dead, and heavily injured citizens will not be able to evacuate from a collapsed or heavily damaged building by themselves. Part of the estimated 405,300 slightly injureds will also need help to be able to evacuate from damaged buildings People especially vulnerable to disaster such as the handicapped, bedridden, aged, or infants will not be able to evacuate by themselves. Approximately 1 million citizens in the metropolitan area will require rescue operations.

Rescue operations for the majority of people missing or trapped will be heavily dependent on pinpoint information and the self initiated rescue operation work of surviving family members and residents in same community. It is proposed that Self-Community Disaster Taskforces be established and organized in each neighborhood community before an earthquake disaster occurs.

Additionally, a majority of missing and trapped people in heavily damaged buildings will not be rescued through self-community rescue without expert knowledge and machinery. Those difficult rescue operations will depend heavily on the specialized rescue taskforce teams of the Civil Defence, military forces, fire brigades, and other national and international teams.

As part of the emergency rescue operation planning efforts, a capability analysis should be carried out for each framework to further assess emergency response plans, organization and operational programmes.

Table 10.5.3 Framework of Candidate Population for Rescue Operation

Area	District Code	District Name	Residents in Heavily Damaged Buildings	Residents in Moderately Damaged Buildings	Residents in Partially Damaged Buildings	Total Residents	Total Death And Serious Injuries	Slight Injuries
Historic District	12	EMINÖNÜ	6,700	6,900	12,700	26,300	7,700	14,500
	14	FATİH	61,800	64,000	105,100	230,900	15,100	24,700
	7	BEYOĞLU	17,100	21,400	49,000	87,500	8,900	16,400
	Subtotal		85,600	92,300	166,800	344,700	31,700	55,600
Europe: Marmara Coast	32	ZEYTİNBURNU	47,700	49,300	67,500	164,500	12,900	22,400
	4	BAKIRKÖY	47,300	44,100	55,800	147,200	10,500	18,900
	15	CÜNGÖREN	39,500	48,100	79,500	167,100	9,500	17,300
	3	BAHÇELİEVLER	81,400	91,600	136,600	309,600	14,900	24,500
	2	AVCILAR	43,900	45,100	62,500	151,500	11,500	20,500
	Subtotal		259,800	278,200	401,900	939,900	59,300	103,600
Europe: Bosphoras	8	BESİKTAŞ	6,100	10,400	31,900	48,400	3,800	7,600
	19	KAĞITANE	10,700	18,700	58,800	88,200	4,900	9,800
	26	ŞİŞLİ	8,000	14,600	47,600	70,200	4,600	9,100
	23	SARIYER	2,200	4,600	22,300	29,100	1,200	2,400
	Subtotal		27,000	48,300	160,600	235,900	14,500	28,900
Europe: Inland	13	EYÜP	13,600	18,500	45,600	77,700	5,700	11,200
	16	GAZİOSMANPAŞA	18,900	35,700	118,300	172,900	7,000	13,300
	10	BAYRAMPAŞA	24,600	29,200	59,100	112,900	10,500	18,800
	902	ESENLER	30,400	43,500	96,300	170,200	8,700	16,100
	5	BAĞCILAR	48,500	69,000	144,200	261,700	12,500	21,900
	20	KÜÇÜKÇEKMECE	66,000	80,300	148,300	294,600	14,600	24,100
	Subtotal		202,000	276,200	611,800	1,090,000	59,000	105,400
Total/Average of European Side			574,400	695,000	1,341,100	2,610,500	164,500	293,500
Asian: Marmara	1	ADALAR	4,000	2,900	4,100	11,000	4,900	9,800
	17	KADIKÖY	32,600	54,000	144,900	231,500	10,200	18,400
	21	MALTEPE	21,000	31,900	79,400	132,300	7,000	13,300
	18	KARTAL	23,100	32,600	76,900	132,600	7,800	14,600
	22	PENDİK	22,400	32,800	81,500	136,700	8,200	15,300
	28	TUZLA	7,200	9,900	22,500	39,600	4,800	9,500
	Subtotal		110,300	164,100	409,300	683,700	42,900	80,900
Asian: Bosphoras	30	ÜSKÜDAR	12,900	25,100	85,700	123,700	5,300	10,500
	6	BEYKOZ	2,600	4,900	20,300	27,800	1,200	2,400
	29	ÜMRANİYE	9,400	19,200	68,300	96,900	3,900	7,800
	Subtotal		24,900	49,200	174,300	248,400	10,400	20,700
Total/Average of Asian Side			135,200	213,300	583,600	932,100	53,300	101,600
Outside IMM	9	BÜYÜKÇEKMECE	0	0	0	0	2,900	6,000
	903	ÇATALCA	400	700	2,400	3,500	100	200
	904	SİLİVRİ	2,100	3,400	9,100	14,600	1,900	4,000
	Subtotal		2,500	4,100	11,500	18,100	4,900	10,200
Total			712,100	912,400	1,936,200	3,560,700	222,700	405,300

Source: The JICA Study Team

10.5.4. Framework for Emergency First Aid

The estimated seriously injured in this Study are counted as approximately 135,000 people in the metropolitan area. Generally, slightly injured persons may be estimated at approximately 3 times the number of seriously injured people. In the total, approximately 540,000 people with injuries will require emergency first aid services with medicine and equipment on-site.

The required volume and variety of medicine and equipment for first aid services on site should be properly planned and stocked for the needs of the metropolitan, district, and local areas in the formulation of the emergency response plans. Each district municipality should programme and organize the dispatch of a commensurate amount of first aid service teams to meet the needs of the huge number of injuries. Furthermore, the metropolitan crisis management centre should prepare supporting programmes to establish an emergency storage system of medicine and equipment and organize supporting medical and first aid service teams for heavily and catastrophically damaged districts under the following framework:

Table 10.5.4 Framework and Estimated Injuries for Emergency First Aid Services

Area	District		Pop 2000	Seriously Injured	Slightly Injured	Total Injuries (person)	Share (%)
	Code	Name					
Historic District	12	EMİNÖNÜ	54,518	4,800	14,400	19,200	35
	14	FATİH	394,042	8,200	24,600	32,800	8
	7	BEYOĞLU	234,964	5,500	16,500	22,000	9
	Subtotal		683,524	18,500	55,500	74,000	11
Europe: Marmara Coast	32	ZEYTİNBURNU	239,927	7,500	22,500	30,000	13
	4	BAKIRKÖY	206,459	6,300	18,900	25,200	12
	15	GÜNGÖREN	271,874	5,800	17,400	23,200	9
	3	BAHÇELİEVLER	469,844	8,200	24,600	32,800	7
	2	AVCILAR	231,799	6,800	20,400	27,200	12
	Subtotal		1,419,903	34,600	103,800	138,400	10
Europe: Bosphoras	8	BEŞİKTAŞ	182,658	2,500	7,500	10,000	5
	19	KAĞITANE	342,477	3,300	9,900	13,200	4
	26	ŞİŞLİ	271,003	3,000	9,000	12,000	4
	23	SARIYER	212,996	800	2,400	3,200	2
	Subtotal		1,009,134	9,600	28,800	38,400	4
Europe: Inland	13	EYÜP	232,104	3,700	11,100	14,800	6
	16	GAZİOSMANPAŞA	667,809	4,400	13,200	17,600	3
	10	BAYRAMPAŞA	237,874	6,300	18,900	25,200	11
	902	ESENLER	388,003	5,400	16,200	21,600	6
	5	BAĞCILAR	557,588	7,300	21,900	29,200	5
	20	KÜÇÜKÇEKMECE	589,139	8,000	24,000	32,000	5
	Subtotal		2,672,517	35,100	105,300	140,400	5
Total/Average of European Side			5,785,078	97,800	293,400	391,200	7
Asian: Marmara	1	ADALAR	17,738	3,300	9,900	13,200	74
	17	KADIKÖY	660,619	6,100	18,300	24,400	4
	21	MALTEPE	345,662	4,400	13,200	17,600	5
	18	KARTAL	332,090	4,900	14,700	19,600	6
	22	PENDİK	372,553	5,100	15,300	20,400	5
	28	TUZLA	100,609	3,200	9,600	12,800	13
	Subtotal		1,829,271	27,000	81,000	108,000	6
Asian: Bosphoras	30	ÜSKÜDAR	496,402	3,500	10,500	14,000	3
	6	BEYKOZ	182,864	800	2,400	3,200	2
	29	ÜMRANİYE	443,358	2,600	7,800	10,400	2
	Subtotal		1,122,624	6,900	20,700	27,600	2
Total/Average of Asian Side			2,951,895	33,900	101,700	135,600	5
Outside IMM	9	BÜYÜKÇEKMECE	NA	2,000	6,000	8,000	NA
	903	ÇATALCA	15,624	100	300	400	3
	904	SİLİVRİ	44,432	1,300	3,900	5,200	12
	Subtotal		60,056	3,400	10,200	13,600	NA
Total			8,797,029	135,100	405,300	540,400	6

Source: JICA Study Team

10.5.5. Framework for Emergency Medical Care

The estimated 135,000 seriously injured will require proper emergency medical services to order to survive. However, the existing medical care facilities in the metropolitan area consist of 201 hospitals with 19,433 beds (approx. 100 beds/hospital) and 267 clinics. The capability of the present medical care facilities in a disaster will be limited in the following ways:

- More than half of the existing beds (12,000) will be occupied by patients already admitted before the disaster. s.
- Less than half of the existing beds (7,000) will be supplied for the estimated seriously injured.
- Extra beds (7,000) will be distributed to designated public and tented spaces in and around hospital buildings.

Based on the above two factors, only approx. 10% of the seriously injured will be cared for by the existing medical care facilities and their extra beds. Temporary field hospitals set up by the government and NGOs may be able to care for a portion of the remaining 90% of seriously injured. However, the major part of the remaining 90% of injuries should be transferred to the surrounding major metropolitan areas by ship and cared for in the better conditions with intact lifelines (water, gas, electricity, etc.).

The estimated building damage ratios of the existing medical care facilities are as follows: 1) 8% heavily damaged, 2) 10% moderately damaged, and 3) 21% partially damaged. This is about the same building damage ratio average in the rest of the metropolitan area. Medical care facilities must be sufficiently seismic resistant and have proper emergency back-up systems of water and electricity supply and telecommunication networks. This is the number one priority condition in the disaster prevention plan. Measures to strengthen the existing structurally weak buildings are recommended as follows:

- 16.5% of masonry buildings are recommended to be reconstructed.
- The remaining 83.5% of buildings require proper seismic resistance diagnosis.
- Based on the results of diagnosis, reinforcement and reconstruction works with emergency back-up systems are required through an implementation programme.

For disaster medical care on the framework, the following emergency storage and supply systems are also recommended:

- Improvement and establishment of a rolling storage system for the required volume and variety of medicines, blood, and blood products to meet the demands of the estimated seriously injured.
- Improvement and establishment of a storage system for other medical care materials and equipment to meet the demands of the estimated seriously injured.
- Establishment of a shared storage system of temporary beds and tents between the metropolitan municipalities.

Table 10.5.5 Framework for Disaster Medical Care

Area	District		Seriously Injured	Population share(%)	Existing Medical Care Facilities			Ratio of Beds/Injured
	Code	Name			Hospitals	Clinics	Beds	
Historic District	12	EMINÖNÜ	4,800	9	3	7	420	0.088
	14	FATİH	8,200	2	16	16	1,081	0.132
	7	BEYOĞLU	5,500	2	8	15	861	0.157
	Subtotal		18,500	3	27	38	2,362	0.128
Europe: Marmara Coast	32	ZEYTİNBURNU	7,500	3	6	10	1,325	0.177
	4	BAKIRKÖY	6,300	3	10	10	4,229	0.671
	15	GÜNGÖREN	5,800	2	6	1	207	0.036
	3	BAHÇELİEVLER	8,200	2	12	0	1,126	0.137
	2	AVCILAR	6,800	3	5	6	323	0.048
	Subtotal		34,600	2	39	27	7,210	0.208
Europe: Bosphoras	8	BESİKTAŞ	2,500	1	4	0	173	0.069
	19	KAĞITANE	3,300	1	3	0	285	0.086
	26	ŞİŞLİ	3,000	1	21	0	1,597	0.532
	23	SARIYER	800	0	3	15	510	0.638
	Subtotal		9,600	1	31	15	2,565	0.267
Europe: Inland	13	EYÜP	3,700	2	4	10	75	0.020
	16	GAZİOSMANPAŞA	4,400	1	11	0	491	0.112
	10	BAYRAMPAŞA	6,300	3	6	12	259	0.041
	902	ESENLER	5,400	1	3	11	147	0.027
	5	BAĞCILAR	7,300	1	4	23	177	0.024
	20	KÜÇÜKÇEKMECE	8,000	1	6	21	334	0.042
	Subtotal		35,100	1	34	77	1,483	0.042
Total/Average of European Side			97,800	2	131	157	13,620	0.139
Asian: Marmara	1	ADALAR	3,300	19	2	0	685	0.208
	17	KADIKÖY	6,100	1	20	42	1,127	0.185
	21	MALTEPE	4,400	1	5	2	85	0.019
	18	KARTAL	4,900	1	6	9	918	0.187
	22	PENDİK	5,100	1	5	11	244	0.048
	28	TUZLA	3,200	3	0	0	0	0.000
	Subtotal		27,000	1	38	64	3,059	0.113
Asian: Bosphoras	30	ÜSKÜDAR	3,500	1	17	16	2,036	0.582
	6	BEYKOZ	800	0	3	6	300	0.375
	29	ÜMRANİYE	2,600	1	4	24	87	0.033
	Subtotal		6,900	1	24	46	2,423	0.351
Total/Average of Asian Side			33,900	1	62	110	5,482	0.162
Outside IMM	9	BÜYÜKÇEKMECE	2,000	NA	4	0	134	0.067
	903	ÇATALCA	100	1	1	0	50	0.500
	904	SİLİVRİ	1,300	3	3	0	147	0.113
	Subtotal		3,400	6	8	0	331	0.097
Total			135,100	2	201	267	19,433	0.144

Source: Database of emergency response plan of the Crisis Management Centre and JIA Study Team

10.5.6. Framework for Emergency Fire Fighting Operation

There are 882 hazardous facilities registered in the metropolitan area by the Licensing Directorate of IMM for the years 2000 and 2001. The estimated fire outbreak points from the registered and identified 814 hazardous facilities on GIS are counted as 14 and 16 points for Earthquake Scenario A and C, respectively. Fire out-breaks and explosions from the damaged 13 points of natural gas pipelines and 28,700 service boxes in 185,000 subscribers could not be estimated in the JICA Microzonation Study because of a lack of data for past disasters. Additionally, fire out-breaks from electric power short circuits for the large number of estimated heavily/moderately damaged buildings could not be estimated for the same reasons. Many fire out-breaks were reported during the last earthquake disaster in Avcilar, but statistical data was not available.

Based on the available information, the estimated fire out-break points are a small number, reflective of the limited data availability. However, fire fighting taskforces should not be optimistic about the fire out-break and explosion factors of short-circuits or about the damages caused by natural gas service boxes.

Due to the difficulties mentioned above, the fire-spread potential was assessed by the analysis of wooden building coverage ratio in each mahalle. Because of this, fire-spread potential was not identified in the 642 mahalles in the metropolitan area.

Table 10.5.6 Estimated Fire Out-break Points from Registered Hazardous Facilities

Area	District Code	District Name	Registered Hazardous Facilities	Estimated Fire Out-break Points from Hazardous Facility: Scenario-A	Scenario-C	Fire Fighting Station
Historic District	12	EMINÖNÜ	7	0.3	0.3	0
	14	FATİH	29	1.8	2.0	1
	7	BEYOĞLU	22	0.3	0.3	2
	Subtotal		58	2.4	2.6	3
Europe: Marmara Coast	32	ZEYTİNBURNU	35	1.2	1.4	1
	4	BAKIRKÖY	19	0.4	0.4	1
	15	CÜNGÖREN	18	0.6	0.7	1
	3	BAHÇELİEVLER	36	1.6	1.9	1
	2	AVCILAR	17	0.6	0.7	1
	Subtotal		125	4.3	5.1	5
Europe: Bosphoras	8	BESİKTAŞ	18	0.1	0.2	1
	19	KAĞITANE	44	0.6	0.7	2
	26	ŞİŞLİ	33	0.2	0.2	2
	23	SARIYER	20	0.1	0.1	2
	Subtotal		115	1.0	1.1	7
Europe: Inland	13	EYÜP	29	0.6	0.6	2
	16	GAZİOSMANPAŞA	59	0.3	0.4	1
	10	BAYRAMPAŞA	21	0.5	0.6	2
	902	ESENLER	12	0.1	0.1	0
	5	BAĞCILAR	61	1.4	1.8	1
	20	KÜÇÜKÇEKMECE	43	0.6	0.7	2
	Subtotal		225	3.6	4.2	8
Total/Average of European Side			523	11.2	13.1	23
Asian: Marmara	1	ADALAR	NA	NA	NA	4
	17	KADIKÖY	46	0.4	0.5	2
	21	MALTEPE	26	0.4	0.5	1
	18	KARTAL	46	0.7	0.8	1
	22	PENDİK	67	0.5	0.5	1
	28	TUZLA	6	0.1	0.1	2
	Subtotal		191	2.1	2.3	11
Asian: Bosphoras	30	ÜSKÜDAR	33	0.1	0.2	2
	6	BEYKOZ	13	0.0	0.0	0
	29	ÜMRANİYE	54	0.2	0.3	1
	Subtotal		100	0.4	0.5	3
Total/Average of Asian Side			291	2.4	2.8	14
G. Total			814	13.7	15.9	37

Source: Fire Brigade Department of IMM, Licensing Directorate of IMM, and the JICA Study Team

Table 10.5.7 Estimated Damages to Natural Gas Supply System

Area	District		Estimated Damage		
	Code	Name	Point of Pipeline	Service Box	Damaged Box Ratio
Historic District	12	EMINÖNÜ	0	100	20
	14	FATİH	1	4,033	26
	7	BEYOĞLU	0	510	14
	Subtotal		1	4,643	24
Europe: Marmara Coast	32	ZEYTİNBURNU	1	700	33
	4	BAKIRKÖY	1	2,490	31
	15	CÜNGÖREN	0	1,653	23
	3	BAHÇELİEVLER	1	2,866	25
	2	AVCILAR	1	1,426	33
	Subtotal		4	9,134	28
Europe: Bosphoras	8	BESİKTAŞ	0	656	7
	19	KAĞITANE	1	133	7
	26	ŞİŞLİ	0	574	7
	23	SARIYER	0	151	2
	Subtotal		1	1,514	6
Europe: Inland	13	EYÜP	1	498	16
	16	GAZİOSMANPAŞA	0	631	8
	10	BAYRAMPAŞA	0	2,246	19
	902	ESENLER	0	589	16
	5	BAĞCILAR	1	807	17
	20	KÜÇÜKÇEKMECE	1	2,023	24
	Subtotal		3	6,794	17
Total/Average of European Side			9	22,084	19
Asian: Marmara	1	ADALAR	NA	NA	NA
	17	KADIKÖY	1	1,868	10
	21	MALTEPE	1	1,096	14
	18	KARTAL	1	1,272	16
	22	PENDİK	1	725	18
	28	TUZLA	0	28	19
		Subtotal	4	4,990	13
Asian: Bosphora	30	ÜSKÜDAR	0	1,325	6
	6	BEYKOZ	NA	NA	NA
	29	ÜMRANİYE	0	330	5
	Subtotal		0	1,655	6
Total/Average of Asian Side			4	6,645	10
Total			13	28,729	16

Source: IGDAS, the JICA Study Team (damages)

10.5.7. Framework for Emergency Potable Water and Foods Supply

Ensuring the avaialability of emergency potable water and foods supply for emergency response activities is an indispensable measure to support survivors of an earthquake disaster. After an earthquake disaster, ordinary food and water supply systems will not function as normal.

- **Foods supply system**: A majority of restaurants, shopping centres, and stores will be damaged and will remain closed due to lifeline damages.

- **Foods material and water supply system**: Transportation of food and water supplies will be severely hampered by damage and debris on road networks.

Under these conditions, emergency foods and potable water supply systems should be prepared and established for the two following stages:

- **First 3 Days - Initial Emergency Operation Period**: Almost all of the ordinary supply systems for food and water will be damaged and will not be functioning. Any remaining emergency foods and potable water should be supplied to citizens from emergency storage systems, which should be established and function at individual homes, self-community disaster taskforces, district municipality and metropolitan municipality levels.
- **First 1 to 3 Weeks - Emergency Operation Period**: Planned emergency foods supply systems should all be functioning and be based on the rehabilitation of emergency road networks for all victims and refugees in tent villages and all families in areas where lifeline services have failed.

The demands of the two periods of emergency foods/water supply are estimated as follows:

Table 10.5.8 Framework for Emergency Foods and Potable Water Supply

Area	District		First 3 Days:	1-3 Weeks: Demand of SurvivingRefugees in Tent Villages			
	Code	Name	Demand Pop 2000	Heavily Damaged Buildings (100%)	Moderately Damaged Buildings (50%)	Partially Damaged Buildings (10%)	Total Refugees
Historic District	12	EMINÖNÜ	54,518	4,100	3,300	1,200	8,600
	14	FATİH	394,042	63,900	32,600	9,900	106,400
	7	BEYOĞLU	234,964	17,400	11,800	4,800	34,000
	Subtotal		683,524	85,400	47,700	15,900	149,000
Europe: Marmara Coast	32	ZEYTİNBURNU	239,927	42,900	23,500	6,500	72,900
	4	BAKIRKÖY	206,459	41,400	20,900	5,500	67,800
	15	CÜNGÖREN	271,874	36,000	23,400	7,700	67,100
	3	BAHÇELİEVLER	469,844	70,600	43,300	13,300	127,200
	2	AVCILAR	231,799	38,400	21,700	6,100	66,200
	Subtotal		1,419,903	229,300	132,800	39,100	401,200
Europe: Bosphoras	8	BEŞİKTAŞ	182,658	6,200	5,600	3,200	15,000
	19	KAĞITANE	342,477	13,600	11,100	5,900	30,600
	26	ŞİŞLİ	271,003	8,400	7,800	4,600	20,800
	23	SARIYER	212,996	2,600	2,600	2,200	7,400
	Subtotal		1,009,134	30,800	27,100	15,900	73,800
Europe: Inland	13	EYÜP	232,104	14,600	9,900	4,400	28,900
	16	GAZİOSMANPAŞA	667,809	21,800	19,800	11,700	53,300
	10	BAYRAMPAŞA	237,874	27,300	15,300	5,600	48,200
	902	ESENLER	388,003	26,200	20,300	9,100	55,600
	5	BAĞCILAR	557,588	40,500	31,800	13,800	86,100
	20	KÜÇÜKÇEKMECE	589,139	62,300	37,400	13,800	113,500
	Subtotal		2,672,517	192,700	134,500	58,400	385,600
Total/Average of European Side			5,785,078	538,200	342,100	129,300	1,009,600
Asian: Marmara	1	ADALAR	17,738	3,000	1,500	400	4,900
	17	KADIKÖY	660,619	31,600	26,800	13,900	72,300
	21	MALTEPE	345,662	23,100	16,500	7,500	47,100
	18	KARTAL	332,090	27,600	17,900	7,400	52,900
	22	PENDİK	372,553	27,000	18,400	7,900	53,300
	28	TUZLA	100,609	8,200	5,500	2,200	15,900
	Subtotal		1,829,271	120,500	86,600	39,300	246,400
Asian: Bosphoras	30	ÜSKÜDAR	496,402	13,700	13,000	8,200	34,900
	6	BEYKOZ	182,864	2,900	2,700	2,000	7,600
	29	ÜMRANİYE	443,358	10,600	10,100	6,600	27,300
	Subtotal		1,122,624	27,200	25,800	16,800	69,800
Total/Average of Asian Side			2,951,895	147,700	112,400	56,100	316,200
Outside IBB	9	BÜYÜKÇEKMECE	0	NA	NA	NA	NA
	903	ÇATALCA	15,624	400	400	200	1,000
	904	SİLİVRİ	44,432	1,600	1,500	800	3,900
	Subtotal		60,056	2,000	1,900	1,000	4,900
Total			8,797,029	687,900	456,400	186,400	1,330,700

Source: The JICA Study Team

For the emergency foods and water supply, a centralized single centre system will work effectively in guiding, coordinating, and establishing an emergency foods/water stock system and procurement at each emergency stage. However, actual emergency foods and water distribution cannot be managed for the estimated huge scales of demands solely by a centralized single system. Therefore, it is recommended that an actual emergency foods and water supply system be established with the demand information supplied by each district municipality and self-community disaster taskforces.

10.5.8. Framework for Tent Village

In Turkey, a tent village system is established to supply emergency temporary shelter for refugees and victims of urban disasters, which is a regional evacuation place located in Japan. The demand for tent villages is estimated by the number of surviving people out of 100% of the residents in heavily damaged buildings, 50% of residents in moderately damaged buildings, and 10% of residents in partially damaged buildings. The total demand for tent villages is estimated at around 83 to 117 km^2 with 333,000 tents (families) for 1.3 million refugees. On the other hand, designated existing tent villages have an area of 100 km^2, which lie in the middle of Case 1 and Case 2 of the estimated area demands for tent villages. The designated tent villages are unevenly distributed in the 30 districts. It is recommended that existing tent village plans within the emergency response plan be revised according to the estimated demands in each district.

Table 10.5.9 Framework for Tent Village

Area	District		Demand of Tent Village				Designated Tent Village (ha)	Area Supply Ratio (designated/demand)	
	Code	Name	Total Refugee	Tent (family)	Case-1: 35m²/tent(ha)	Case-2: 25m²/tent(ha)		Demand Case 1	Demand Case 2
Historic District	12	EMINÖNÜ	8,600	2,200	7.7	5.5	0.0	0.0	0.0
	14	FATİH	106,400	26,600	93.1	66.5	10.4	11.2	15.6
	7	BEYOĞLU	34,000	8,500	29.8	21.3	14.9	50.1	70.1
	Subtotal		149,000	37,300	130.6	93.3	25.3	19.4	27.1
Europe: Marmara Coast	32	ZEYTİNBURNU	72,900	18,200	63.7	45.5	12.9	20.3	28.4
	4	BAKIRKÖY	67,800	17,000	59.5	42.5	5.8	9.7	13.6
	15	CÜNGÖREN	67,100	16,800	58.8	42.0	15.3	26.1	36.5
	3	BAHÇELİEVLER	127,200	31,800	111.3	79.5	0.0	0.0	0.0
	2	AVCILAR	66,200	16,600	58.1	41.5	6.8	11.7	16.3
	Subtotal		401,200	100,400	351.4	251.0	40.8	11.6	16.3
Europe: Bosphoras	8	BEŞİKTAŞ	15,000	3,800	13.3	9.5	4.5	33.5	46.9
	19	KAĞITANE	30,600	7,700	27.0	19.3	15.3	56.7	79.3
	26	ŞİŞLİ	20,800	5,200	18.2	13.0	26.3	144.6	202.5
	23	SARIYER	7,400	1,900	6.7	4.8	7.5	113.2	158.4
	Subtotal		73,800	18,600	65.1	46.5	53.6	82.3	115.2
Europe: Inland	13	EYÜP	28,900	7,200	25.2	18.0	5.7	22.4	31.4
	16	GAZİOSMANPAŞA	53,300	13,300	46.6	33.3	11.9	25.5	35.7
	10	BAYRAMPAŞA	48,200	12,100	42.4	30.3	19.8	46.7	65.4
	902	ESENLER	55,600	13,900	48.7	34.8	3.3	6.8	9.5
	5	BAĞCILAR	86,100	21,500	75.3	53.8	52.7	70.0	98.0
	20	KÜÇÜKÇEKMECE	113,500	28,400	99.4	71.0	34.9	35.1	49.2
	Subtotal		385,600	96,400	337.4	241.0	128.2	38.0	53.2
Total/Average of European Side			1,009,600	252,700	884.5	631.8	247.9	28.0	39.2
Asian: Marmara	1	ADALAR	4,900	1,200	4.2	3.0	6.2	147.1	206.0
	17	KADIKÖY	72,300	18,100	63.4	45.3	195.0	307.7	430.8
	21	MALTEPE	47,100	11,800	41.3	29.5	18.4	44.5	62.3
	18	KARTAL	52,900	13,200	46.2	33.0	26.4	57.2	80.1
	22	PENDİK	53,300	13,300	46.6	33.3	166.3	357.3	500.3
	28	TUZLA	15,900	4,000	14.0	10.0	7.4	52.9	74.1
	Subtotal		246,400	61,600	215.6	154.0	419.7	194.7	272.5
Asian: Bosphoras	30	ÜSKÜDAR	34,900	8,700	30.5	21.8	12.0	39.4	55.2
	6	BEYKOZ	7,600	1,900	6.7	4.8	14.5	217.3	304.3
	29	ÜMRANİYE	27,300	6,800	23.8	17.0	37.7	158.6	222.0
	Subtotal		69,800	17,400	60.9	43.5	64.2	105.4	147.6
Total/Average of Asian Side			316,200	79,000	276.5	197.5	483.9	175.0	245.0
Outside IBB	9	BÜYÜKÇEKMECE	NA	NA	NA	NA	173.8	NA	NA
	903	ÇATALCA	1,000	300	1.1	0.8	90.0	8,566.9	11,993.7
	904	SİLİVRİ	3,900	1,000	3.5	2.5	0.0	0.0	0.0
	Subtotal		4,900	1,300	4.6	3.3	263.7	5,796.2	8,114.7
Total			1,330,700	333,000	1,165.5	832.5	995.5	85.4	119.6

Source: Provincial Crisis Management Center, JICA Study Team

10.5.9. Framework for Temporary Housing

After an earthquake disaster, the assigned emergency taskforces for temporary housing should take the following measures for the residents in the heavily, moderately and partially damaged housing:

- Prepare, set-up, open, and operate tent villages.

- Provide an assessment of building damage conditions for all building (collapsed/heavily damaged/demolish, repair/usable, partially damaged, and not damaged).
- Support measures of finance and material supply to repair the assessed repairable housing.
- Register and select applicants for tent villages.
- Modify temporary housing plan and preparation works of lands and materials.
- Construct lifelines and temporary housing.
- Open and operate temporary housing.

In Japan, the target temporary housing number is set to 30% of heavily damaged housing and excludes victims moving out from the municipality and staying in relative's homes. The estimated demands of temporary housing are 516 ha with around 52,000 housing units for 207,000 victims, 30% of the estimated 688,000 residents in heavily damaged buildings. The following recommendations will help to minimize the demand for temporary housing:

- Proposed supporting measures to repair housing assessed as repairable.
- Supporting measures to help victims move out of the municipality.
- Supporting measures to help victims stay with relatives.

Table 10.5.10 Framework for Temporary Housing

Area	District Code	District Name	Pop 2000	Surviving Residents in Heavily Damaged Building	Pop. Demand of Temporary Housing (30% of Heavy Damage)	Demand of Temporary Housing Units (4 persons/ family)	Demand Temporary Housing Area (ha) (100 housing units/ha)
Historic District	12	EMINÖNÜ	54,518	4,100	1,200	300	3
	14	FATİH	394,042	63,900	19,200	4,800	48
	7	BEYOĞLU	234,964	17,400	5,200	1,300	13
	Subtotal		683,524	85,400	25,600	6,400	64
Europe: Marmara Coast	32	ZEYTİNBURNU	239,927	42,900	12,900	3,200	32
	4	BAKIRKÖY	206,459	41,400	12,400	3,100	31
	15	GÜNGÖREN	271,874	36,000	10,800	2,700	27
	3	BAHÇELİEVLER	469,844	70,600	21,200	5,300	53
	2	AVCILAR	231,799	38,400	11,500	2,900	29
	Subtotal		1,419,903	229,300	68,800	17,200	172
Europe: Bosphoras	8	BEŞİKTAŞ	182,658	6,200	1,900	500	5
	19	KAĞITANE	342,477	13,600	4,100	1,000	10
	26	ŞİŞLİ	271,003	8,400	2,500	600	6
	23	SARIYER	212,996	2,600	800	200	2
	Subtotal		1,009,134	30,800	9,300	2,300	23
Europe: Inland	13	EYÜP	232,104	14,600	4,400	1,100	11
	16	GAZİOSMANPAŞA	667,809	21,800	6,500	1,600	16
	10	BAYRAMPAŞA	237,874	27,300	8,200	2,100	21
	902	ESENLER	388,003	26,200	7,900	2,000	20
	5	BAĞCILAR	557,588	40,500	12,200	3,100	31
	20	KÜÇÜKÇEKMECE	589,139	62,300	18,700	4,700	47
	Subtotal		2,672,517	192,700	57,900	14,600	146
Total/Average of European Side			5,785,078	538,200	161,600	40,500	405
Asian: Marmara	1	ADALAR	17,738	3,000	900	200	2
	17	KADIKÖY	660,619	31,600	9,500	2,400	24
	21	MALTEPE	345,662	23,100	6,900	1,700	17
	18	KARTAL	332,090	27,600	8,300	2,100	21
	22	PENDİK	372,553	27,000	8,100	2,000	20
	28	TUZLA	100,609	8,200	2,500	600	6
	Subtotal		1,829,271	120,500	36,200	9,000	90
Asian: Bosphoras	30	ÜSKÜDAR	496,402	13,700	4,100	1,000	10
	6	BEYKOZ	182,864	2,900	900	200	2
	29	ÜMRANİYE	443,358	10,600	3,200	800	8
	Subtotal		1,122,624	27,200	8,200	2,000	20
Total/Average of Asian Side			2,951,895	147,700	44,400	11,000	110
Outside IMM	9	BÜYÜKÇEKMECE	0	NA	NA	NA	0
	903	ÇATALCA	15,624	400	100	0	0
	904	SİLİVRİ	44,432	1,600	500	100	1
	Subtotal		60,056	2,000	600	100	1
Total			8,797,029	687,900	206,600	51,600	516

Source: JICA Study Team

10.5.10. Framework for Preparation of Cemetery, Funnel, and Burial Services

Registered cemetery areas in the metropolitan areas have 442 ha in gross area and 221 ha in net area with a 1.15 million capacity, as estimated by the Directorate of Cemeteries of IMM. The existing net area unit per grave is estimated at approximately 1.9 m^2.

In the worst-case earthquake Model C, it is estimated that around 87,000 deaths will occur, requiring 9.5 to 22.3 ha of new net cemetery area within the metropolitan area.

Before the next disastrous event occurs, the following measures should be formulated and implemented into the emergency response plan to help the city cope with the number of fatalities.

- The required cemetery areas should be identified, purchased, and registered by the Directorate of Cemeteries of IMM.
- Procurement and supply systems of coffins, gravestones, and other related items should be formulated to deal with the massive demands.
- Mass funerals and burial systems should be formulated.

Table 10.5.11 Framework for Funeral and Cemetery

Area	District		Estimated Deaths	Cemetery Area Demand 1: 1.5 m²/p	Cemetery Area Demand 2: 3.5 m²/p
	Code	Name			
Historic District	12	EMİNÖNÜ	2,871	0.4	1.0
	14	FATİH	6,866	1.0	2.4
	7	BEYOĞLU	3,464	0.5	1.2
	Subtotal		13,200	2.0	4.6
Europe: Marmara Coast	32	ZEYTİNBURNU	5,455	0.8	1.9
	4	BAKIRKÖY	4,204	0.6	1.5
	15	GÜNGÖREN	3,703	0.6	1.3
	3	BAHÇELİEVLER	6,724	1.0	2.4
	2	AVCILAR	4,678	0.7	1.6
	Subtotal		24,764	3.7	8.7
Europe: Bosphoras	8	BEŞİKTAŞ	1,226	0.2	0.4
	19	KAĞITANE	1,662	0.2	0.6
	26	ŞİŞLİ	1,520	0.2	0.5
	23	SARIYER	372	0.1	0.1
	Subtotal		4,779	0.7	1.7
Europe: Inland	13	EYÜP	1,938	0.3	0.7
	16	GAZİOSMANPAŞA	2,526	0.4	0.9
	10	BAYRAMPAŞA	4,180	0.6	1.5
	902	ESENLER	3,358	0.5	1.2
	5	BAĞCILAR	5,167	0.8	1.8
	20	KÜÇÜKÇEKMECE	6,515	1.0	2.3
	Subtotal		23,685		
Total/Average of European Side			66,428	6.4	15.0
Asian: Marmara	1	ADALAR	1,648	0.2	0.6
	17	KADIKÖY	4,040	0.6	1.4
	21	MALTEPE	2,532	0.4	0.9
	18	KARTAL	2,905	0.4	1.0
	22	PENDİK	3,114	0.5	1.1
	28	TUZLA	1,597	0.2	0.6
	Subtotal		15,836	2.4	5.5
Asian: Bosphoras	30	ÜSKÜDAR	1,803	0.3	0.6
	6	BEYKOZ	374	0.1	0.1
	29	ÜMRANİYE	1,262	0.2	0.4
	Subtotal		3,439	0.5	1.2
Total/Average of Asian Side			19,275	2.9	6.7
Outside IMM	9	BÜYÜKÇEKMECE	926	0.1	0.3
	903	ÇATALCA	41	0.0	0.0
	904	SİLİVRİ	604	0.1	0.2
	Subtotal		1,571	0.2	0.5
Total			87,273	9.5	22.3

Source: JICA Study Team

10.5.11. Framework for Emergency Rehabilitation Works of Lifeline Services (Gas, Water, Electricity, etc).

The emergency response plans for each lifeline service have been formulated and submitted to the Provincial Crisis Management Centre by each lifeline company. However, the submitted emergency response plans were not quantitatively formulated because of the lack of magnitude of damage estimates, except the water and sewage company of IMM, which is called ISKI.

The submitted emergency response plans of the other lifeline companies should be reviewed based on the estimated lifeline damages of this Study and from the following point of views regarding preparedness, emergency response, and rehabilitation measures:

(1) Preparedness Measures

- Introduce and establish monitoring and control systems for electric power supply switches and natural gas supply valves. This will help to mitigate secondary disaster occurrences from damaged points on cables and pipelines, short-circuits, and service boxes.
- Establish procurement/storage systems for emergency response and rehabilitation measures.
- Establish prioritized emergency lifeline network systems for crisis management centres, emergency response centres, etc.

(2) Emergency Response Measures

- Temporary emergency potable water supply system in each proposed community evacuation area, tent village, and temporary housing area.
- Temporary emergency toilet systems at each of the proposed community evacuation areas, tent village, and temporary housing areas.
- Temporary telecommunication system to provide a public telephone centre also in the proposed community evacuation, tent village, and temporary housing areas. Implementation and emergency rehabilitation systems for the established emergency lifeline network systems for crisis management centres and emergency response centres, etc.

(3) Rehabilitation Measures

- Estimation of required rehabilitation taskforce teams needed to cover the estimated damages within the target period.

- Review of the present organization structure and task distributions for the identified taskforce teams.
- Estimation of required spare parts and materials needed to cover the estimated damages.
- Review of the present storage supplies, procurement, and goods circulation systems for the required spare parts, materialss and machinery needed for rehabilitation works within the target period.

Table 10.5.12 Framework for Lifeline Rehabilitation Works

Area	District		Damage length of electricity cable			Damages of natural gas supply system		Damage point of water pipeline	Damage point of sewage pipeline
	Code	Name	overhead	underground	total (km)	point of pipeline	service box		
Old Town	12	EMINÖNÜ	1	18	19	0	100	41	NA
	14	FATİH	2	56	59	1	4,033	122	NA
	7	BEYOĞLU	9	23	32	0	510	54	57
	Sub-Total		12	97	109	1	4,643	217	57
Europe: Marmara Coast	32	ZEYTİNBURNU	15	51	65	1	700	70	NA
	4	BAKIRKÖY	9	36	45	1	2,490	97	91
	15	CÜNGÖREN	8	51	59	0	1,653	70	NA
	3	BAHÇELİEVLER	11	58	68	1	2,866	115	162
	2	AVCILAR	44	31	75	1	1,426	66	85
	Sub-Total		87	226	313	4	9,134	417	339
Europe: Bosphoras	8	BEŞİKTAŞ	2	4	6	0	656	31	36
	19	KAĞITANE	7	9	16	1	133	27	70
	26	SİSLİ	6	8	14	0	574	21	23
	23	SARIYER	9	7	17	0	151	19	18
	Sub-Total		25	29	54	1	1,514	98	147
Europe: Inland	13	EYÜP	16	17	33	1	498	69	NA
	16	GAZİOSMANPAŞA	18	12	30	0	631	30	NA
	10	BAYRAMPAŞA	18	22	40	0	2,246	55	NA
	902	ESENLER	20	25	45	0	589	36	NA
	5	BAĞCILAR	22	47	69	1	807	98	136
	20	KÜÇÜKÇEKMECE	23	65	88	1	2,023	142	165
	Sub-Total		118	188	306	3	6,794	429	301
Total/Average of European Side			242	540	782	9	22,084	1,161	843
Asian: Marmara	1	ADALAR	NA	NA	NA	NA	NA	21	NA
	17	KADIKÖY	38	52	89	1	1,868	85	103
	21	MALTEPE	18	27	45	1	1,096	56	73
	18	KARTAL	14	23	37	1	1,272	71	81
	22	PENDİK	16	23	40	1	725	69	51
	28	TUZLA	8	14	21	0	28	32	47
	Sub-Total		94	138	232	4	4,990	334	354
Asian: Bosphoras	30	ÜSKÜDAR	17	19	36	0	1,325	42	46
	6	BEYKOZ	3	4	7	NA	NA	21	28
	29	ÜMRANİYE	8	9	17	0	330	19	28
	Sub-Total		28	32	60	0	1,655	82	102
Total/Average of Asian Side			122	171	292	4	6,645	416	456
Total			364	711	1,075	13	28,729	1,577	1,299

Source: The JICA Study Team

10.5.12. Framework for Debris Removal

After an earthquake disaster, urban reconstruction and the search for dead bodies require the removal of all collapsed/damaged building debris and other supper-/infrastructure debris in the metropolitan area. The majority of debris from the estimated building damages is estimated at approximately 140 million tons. The required machinery to remove the debris is estimated at around 44,000 to 73,000 heavy goods vehicles and 2,800 to 4,700 heavy machinery vehicles to keep the targeted periods of 60 or 100 days before the commencement of urban reconstruction activities.

Debris disposal sites are proposed in order to utilize vacant and unused lands of mining and quarry sites in the northern part of the IMM. The required disposal sites have an estimated area of 56 km^2, based on the 2.5 m average depth of those vacant sites. The traffic demand of the heavy goods vehicles needed to transfer the debris is estimated at around 175,000 to 292,000 daily trips, which requires 12 to 20 lane roads, to the northern disposal sites from damaged districts. The existing road network to the north cannot cater to the estimated traffic demand within the targeted periods of 60 to 100 days.

Additionally, the estimated traffic demand to remove debris will is well over the capacity of emergency road networks in the same catastrophic damaged districts. This in turn will disturb other emergency vehicle operations on the emergency road network.

Before another earthquake disaster occurs, the present emergency response plan for debris removals should be reconsidered and revised with the following preparedness measures in mind:

(1) Proposed Preparedness Measures

- Implementation of road widening projects for narrow designated emergency roads.
- Formulation of debris removal road networks to the northern disposal sites, which can later be effectively utilized for weekend recreational activities of citizens.

(2) Proposed Emergency Response Measures

- Programmes to acquire a huge number of heavy-goods dump trucks and power shovels from the private sector and with drivers and operators from outside the metropolitan area.
- Programmes to establish fuel and maintenance centres for heavy-goods vehicles and machinery.
- Programmes to utilize vacant mining and quarry sites as debris disposal sites.

Table 10.5.13 Framework for Debris Removal and Disposal

Area	District		Total Estimated Debris from Damaged Building (ton)	Required Machinery to Remove Debris within 60days		Required Machinery to Remove Debris within 100days	
	Code	Name		Heavy Good Vehicle (8t/4t/d)	Heavy Machinery (500t/d)	Heavy Good Vehicle (8t/4t/d)	Heavy Machinery (500t/d)
Old Town	12	EMINÖNÜ	3,310,000	1,724	110	1,034	66
	14	FATİH	7,592,000	3,954	253	2,373	152
	7	BEYOĞLU	4,359,000	2,270	145	1,362	87
	Sub-Total		15,261,000	7,948	509	4,769	305
Europe: Marmara Coast	32	ZEYTİNBURNU	7,229,000	3,765	241	2,259	145
	4	BAKIRKÖY	7,519,000	3,916	251	2,350	150
	15	CÜNGÖREN	5,946,000	3,097	198	1,858	119
	3	BAHÇELİEVLER	10,262,000	5,345	342	3,207	205
	2	AVCILAR	5,369,000	2,796	179	1,678	107
	Sub-Total		36,325,000	18,919	1,211	11,352	726
Europe: Bosphoras	8	BEŞİKTAŞ	2,814,000	1,466	94	879	56
	19	KAĞITANE	2,999,000	1,562	100	937	60
	26	ŞİŞLİ	4,550,000	2,370	152	1,422	91
	23	SARIYER	1,123,000	585	37	351	22
	Sub-Total		11,486,000	5,982	383	3,589	230
Europe: Inland	13	EYÜP	2,669,000	1,390	89	834	53
	16	GAZİOSMANPAŞA	5,103,000	2,658	170	1,595	102
	10	BAYRAMPAŞA	4,945,000	2,575	165	1,545	99
	902	ESENLER	4,363,000	2,272	145	1,363	87
	5	BAĞCILAR	7,974,000	4,153	266	2,492	159
	20	KÜÇÜKÇEKMECE	11,182,000	5,824	373	3,495	224
	Sub-Total		36,236,000	18,873	1,208	11,324	725
Total/Average of European Side			99,308,000	51,723	3,310	31,034	1,986
Asian: Marmara	1	ADALAR	839,000	437	28	262	17
	17	KADIKÖY	10,688,000	5,567	356	3,340	214
	21	MALTEPE	5,190,000	2,703	173	1,622	104
	18	KARTAL	4,591,000	2,391	153	1,435	92
	22	PENDİK	5,175,000	2,695	173	1,617	104
	28	TUZLA	2,217,000	1,155	74	693	44
	Sub-Total		28,700,000	14,948	957	8,969	574
Asian: Bosphoras	30	ÜSKÜDAR	5,078,000	2,645	169	1,587	102
	6	BEYKOZ	793,000	413	26	248	16
	29	ÜMRANİYE	3,548,000	1,848	118	1,109	71
	Sub-Total		9,419,000	4,906	314	2,943	188
Total/Average of Asian Side			38,119,000	19,854	1,271	11,912	762
Outside IMM	9	BÜYÜKÇEKMECE	1,401,000	730	47	438	28
	903	ÇATALCA	181,000	95	6	57	4
	904	SİLİVRİ	927,000	483	31	290	19
	Sub-Total		2,509,000	1,307	84	784	50
Total			139,936,000	72,884	4,665	43,730	2,799

Source: The JICA Study Team

10.6. Recommended Measures to Establish Emergency Road Network System

An emergency road network system has been introduced and planned in the metropolitan area by the crisis management centres at the metropolitan and district municipality levels. The first emergency road network was designated to follow the identified road hierarchy of level 1 to 3 as indicated in the Road Network Master Plan of metropolitan Istanbul. Presently, the first plan is reviewed from the proposed designation system of emergency roads as follows:

(1) Recommended Emergency Road Network System by the JICA Study Team

The emergency road network should be prioritized by emergency factors composed from the following responses: 1) disaster damage information collection/exchange; 2) proper emergency response operations; and 3) emergency goods circulation after the earthquake. The prioritized emergency road networks should link the crisis management centres, emergency response centres, and emergency goods circulation centres through proper road networks. For example:

- **Primary Emergency Road Network** should link all the identified crisis management centres at the province, municipality and district levels, and it should also link these to all of the major transportation nodes, such as airports and seaports.
- **Secondary Emergency Road Network** should add to the selected primary road network and also link all the identified emergency response centres.
- **Tertiary Emergency Road Network** should add to the selected primary and secondary road networks and link emergency goods storage sites, and gathering and circulation centres.

(2) Proposed Emergency Road Network

Based on the proposed system, the length of emergency road networks is composed of 455 km of primary emergency roads, 360 km of secondary emergency roads, and 3 km of tertiary emergency roads. These emergency road networks are linked with the identified crisis management centres, emergency response centres and emergency goods centres by the provincial crisis management centres as the following demonstrates:

Table 10.6.1 Identified Centers Linked by Emergency Road Network

	Identified Centres by Provincial Crisis Management Centre	No. Centre
Centres for Primary Emergency Road	Crisis Management Centres of Province/Department	4
	IMM Disaster Management Centre	1
	District Crisis Management Centre	30
	Related Government Offices	60
	Airport	4
	Ports	5
	Total facilities	104
Centres for Secondary Emergency Road	IMM Relief and Response units	18
	Gathering Area for District Search-Rescue Teams	23
	Fire Brigade	44
	Military	46
	Health Facilities	95
	Main Gathering Centres for Machinery	2
	Gathering Area for District Machinery	13
	Piers	44
	Heliport (helipad)	200
	Tent Village	486
	Total facilities	244
Centres for Tertiary Emergency Road	Loading Heavy Machinery	5
	Centres for Unloading and Loading Vehicle Equipment	3
	Centre for Unloading and Loading Supply Materials	4
	Centres for Vehicle Unloading and Loading: Truck Terminal	9
	Centres for Unloading and Loading : Sea and Land Transport	6
	Logistic Support and Coordination Centres	2
	Total facilities	29
G. Total		377

Source: Database was provided by the provincial crisis management centre. The identified centres were selected and categorized by JICA Study Team

Some identified centres for secondary and tertiary emergency roads are linked by proposed primary emergency roads or secondary emergency roads.

Table 10.6.2 Length and Width of Proposed Emergency Road

Area	District		Length of Proposed Emergency Road(km)				Length by Road Width (km)			
	Code	Name	Primary	Secondary	Tertiary	Total	2-6m	7-11m	12-15m	over 15m
Old Town	12	EMINÖNÜ	12	2	0	14	0	3	0	10
	14	FATİH	11	6	0	17	1	3	1	13
	7	BEYOĞLU	14	8	0	22	1	5	2	13
	Sub-Total		37	15	0	53	1	11	4	37
Europe: Marmara Coast	32	ZEYTİNBURNU	14	11	0	25	1	7	4	13
	4	BAKIRKÖY	30	19	0	49	3	18	2	26
	15	CÜNGÖREN	7	9	0	16	1	9	1	4
	3	BAHÇELİEVLER	15	14	0	30	0	9	9	11
	2	AVCILAR	16	6	1	23	0	8	4	11
	Sub-Total		82	59	1	142	5	51	19	66
Europe: Bosphoras	8	BEŞİKTAŞ	10	20	0	30	0	15	2	13
	19	KAĞITANE	13	7	0	20	0	3	7	10
	26	ŞİŞLİ	15	10	0	25	0	2	6	17
	23	SARIYER	8	17	0	25	1	10	8	6
	Sub-Total		46	54	0	100	1	30	22	46
Europe: Inland	13	EYÜP	14	16	0	30	0	8	5	17
	16	GAZİOSMANPAŞA	7	15	0	22	1	6	4	10
	10	BAYRAMPAŞA	13	1	0	14	1	5	1	8
	902	ESENLER	14	6	0	20	0	9	1	10
	5	BAĞCILAR	21	10	0	30	1	11	10	9
	20	KÜÇÜKÇEKMECE	13	50	0	63	3	39	5	16
	Sub-Total		82	98	0	180	7	78	25	70
Total/Average of European Side			248	226	1	474	15	171	71	218
		Share (%)	52	48	0	100	3	36	15	46
Asian: Marmara	1	ADALAR	0	0	0	0	0	0	0	0
	17	KADIKÖY	34	26	0	60	2	15	21	23
	21	MALTEPE	16	14	0	30	1	8	7	14
	18	KARTAL	19	10	0	30	1	8	7	14
	22	PENDİK	25	16	0	40	6	20	5	9
	28	TUZLA	14	21	2	37	3	19	6	8
	Sub-Total		108	87	2	197	13	70	46	68
Asian: Bosphoras	30	ÜSKÜDAR	25	27	0	52	1	16	10	25
	6	BEYKOZ	22	7	0	29	2	15	0	12
	29	ÜMRANİYE	16	13	0	29	0	1	9	19
	Sub-Total		63	47	0	110	3	32	20	56
Total/Average of Asian Side			171	134	2	307	16	102	65	124
		Share (%)	56	43	1	100	5	33	21	40
Outside IBB	9	BÜYÜKÇEKMECE	10	0	0	10	0	4	0	6
	903	ÇATALCA	7	0	0	7	1	2	1	4
	904	SİLİVRİ	19	0	0	19	0	0	0	19
	Sub-Total		36	0	0	36	1	6	1	28
Total			455	360	3	818	31	278	137	371
		Share (%)	56	44	0	100	4	34	17	45

Source: The JICA Study Team

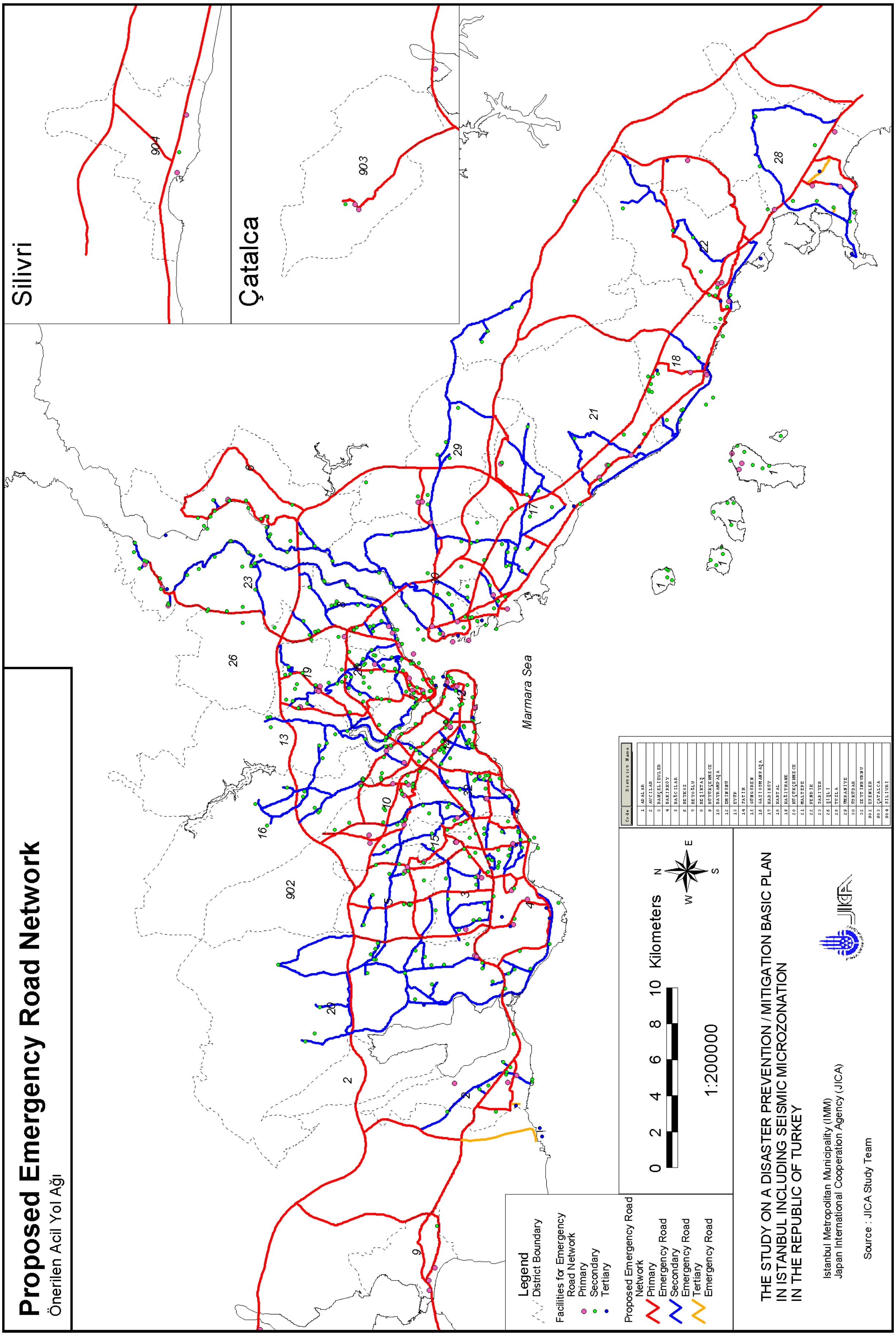


Figure 10.6.1 Proposed Emergency Road Networks

(3) Proposed Preparedness Measures to Establish Emergency Road Network

Preparedness measures are proposed to strengthen and establish proper emergency road networks. They should be effectively utilized by all emergency response activities during the disaster period. They include the following:

- The emergency road network plan should be periodically reviewed and updated to link the modified centres.
- Increased public awareness of emergency road network system, objectives, network, and regulations (strict control of street car parking, and private vehicle access during disaster periods).
- During ordinary times, provide signs to clearly demarcate emergency roads and control of on-street car parking.
- Reinforcement projects for crisis management centres, response centres, etc., that are assessed as structurally weak buildings.Widening projects for inappropriately narrow roads. The proper width of an emergency road is recommended to be over 15 m to minimize impacts from roadside debris. Prioritization of road widening projects is recommended as follows:
  - **Top priority**: 31 km of roads 2 to 6 m wide
  - **Second priority**: 278 km of roads 7 to 11 m wide
  - **Third priority**: 137 km of roads 12 to 15 m wide
- Recommended bridge reinforcement projects for bridges assessed as weak through seismic resistance diagnosis.

(4) Proposed Emergency Response Plan for Emergency Road Network

In order to maintain the emergency road network, the following emergency response tasks are recommended:

- **Tasks to maintain road function:** Collection and inspection of damages of the road. Setting up and communication of alternate routes to centres. Supply required taskforce teams with proper machinery/good vehicles. Dispatch debris removal/rehabilitation taskforce teams.
- **Tasks to control access to roads and private traffic on roads:** Provision of license to emergency vehicles. Checking the license and control of private vehicle access to the road prohibiting and removing private vehicle traffic from the roads.

- **Tasks to manage traffic on the road:** Monitor and collect traffic condition information on the roads. Identify the shortest time distance routes and inform emergency vehicles of shortest paths.

10.7. Proposed Measures to Strengthen Crisis Management Centres

10.7.1. Existing Condition of Crisis Management Centre

Emergency response operations are legally controlled by the national government system, such as ministries and their regional departments, provincial governorships, and district governorships. Presently, the local government system of the metropolitan municipality and district municipalities only take on portions of tasks necessary in emergency response operations. Task distribution for emergency response operations is centralized to the ministries and provincial governorships rather than district governorships. This centralized decision-making and ordering system has some disadvantages with regards to the quick and careful actions required. This is especially truewhere local demands are of a huge scale due to an urban earthquake disaster, such as in a megalopolis like Istanbul.

The existing crisis management centres in the metropolitan area are not properly organized nor are they properly located.

- Provincial Crisis Management Centre has a 24 hours operation system in a temporary prefabricated building in the provincial government compund. A new provincial crisis management centre is planned to be constructedwith the Centre of Civil Defence near the international airport.
- IMM constructed a new disaster management centre, sufficiently seismic resistant to withstand a foreseeable earthquake disaster.
- District crisis management centres had been organized and developed in each district by the district governorship or district municipalities. Almost all of the centres, which were organized and developed by district municipality, were subsequently transferred to the district governorship. The existing conditions of these centres are standardized with respect to organization, staff/experts, and building structure.

10.7.2. Recommended Measures to Establish Proper Crisis Management Centres

The decentralization of emergency response tasks and the organization of a joint operation system of central and local governments will help to establish a proper and effective emergency response effort. The following are some recommendations:

(1) Recommended Institutional Measures

- Clear and differentiated task responsibilities of crisis management centres at the national, provincial and district levels

- The organization and establishment of a joint operation system between the provincial crisis management centre of the governorship and that of the metropolitan municipality
- The organization and establishment of a joint operation system between the district crisis management centres of the governorship and that of the district municipalities.

(2) Recommended Physical Measures

- Development of a new proper Provincial Crisis Management Centre to serve as a earthquake disaster information centre, awareness centre, and training centre of community leaders.
- Existing district crisis management centers, district governorship offices, or district municipality offices are proposed to improve or reconstruct their buildings to ensure they are seismic resistant and can perform the required crisis management center functions and emergency foods/water storage functions in the event of an earthquake.
- Development and establishment of a specialized emergency communication system between all crisis management centres, emergency response centres and emergency goods centres.

10.7.3. Proposed Facilities for Establishing New Provincial Crisis Management Centres

The following recommendations for functions and facilities are for developing new provincial crisis management centres:

(1) Functions of Crisis Management Centre:

Crisis management centre should be able to keep functioning even if lifeline services are cut off by earthquake damage. The following facilities and functions are recommended:

- Main meeting and command room with audio-visual system supported by an information network
- Press and press-release rooms
- Meeting rooms for the emergency taskforce group with audio-visual system supported by an information network
- Rooms for all taskforce agencies with computers supported by an information network
- Multi-modal communication room with wireless, satellite, and other common communication networks
- Dining and kitchen facilities
- Rooms designated as rest areas

- Emergency foods and potable water storage
- Emergency back-up systems for lifelines (power generators, batteries, seismic resistant water reservoirs, seismic resistant fuel tanks, etc.).

(2) Functions of Earthquake Disaster Information Centre

- Database library of earthquake disaster information
- Research centre for earthquake disasters
- Earthquake disaster damage simulation model supported by seismograph system with telemeter network

(3) Functions of Awareness Centre of Earthquake Disaster for Citizens

(4) Functions of Training Centre for Community Leaders

10.7.4. Recommended Facilities for District Crisis Management Centre

(1) Functions of Crisis Management Centre

- Main meeting and command room with audio-visual system supported by an information network
- Rooms for all taskforce members with computers supported by an information network
- Multi-modal communication room with wireless, satellite and other common communication networks
- Dining and kitchen facilities
- Rooms designated as rest areas

(2) Functions of Emergency Back-up System for Lifelines

- Emergency foods and potable water storage
- Emergency back-up systems of lifeline services (power generators, batteries, seismic resistant water reservoirs, seismic resistant fuel tanks, etc.).

(3) Functions of Emergency Foods/Potable Water Storage/Circulation Centre for Refugees in Each District

Chapter 11. Recommended Measures for Earthquake Disaster Mitigation

11.1. Introduction

Turkish experts, especially earthquake researchers, have recognised that the danger of another earthquake striking the Istanbul area is likely to occur 15 years after the Kocaeli Earthquake. Already three (3) years have passed without any mitigation measures being done. The earthquake damage analysis of the Study calculated large-scale building damage and human casualties as well as infrastructure damage. By way of concluding the Study, measures to mitigate earthquake disaster are recommended herein based on the results of the study.

The necessary earthquake disaster mitigation measures are basically project-oriented and are laid out in short and medium to long-term perspectives. The short-term measures are to be implemented as soon as possible. The mid- to long-term measures are to be done within the next 5 to 10 years, or more. Short-term measures include retrofitting important facilities and infrastructure in order to secure their operational function in the event of an earthquake disaster. Middle to long-term measures involves non-structural recommendations. Basic concepts of methodology for urban structure improvements are the redevelopment of areas of high population density, the widening of narrow road networks, or the review of existing land use in order to have more open space areas with special consideration of the earthquake disaster preventive land use of Istanbul. The organisation of institutional systems for disaster management is also an important measure for the smooth and quick response to a large-scale earthquake disaster.

11.2. Short-Term Measures

(1) Retrofitting of Hospitals

According to the collected data, the total number of hospitals in the Study Area is 635. Those are established and managed by different entities such as national agencies, SSK, universities, the private sector, and the military. After the Erzincan Earthquake, the World Bank had a survey conducted on building resistivity against a high intensity earthquake for 59 hospitals in Izmir and Istanbul in 1994. The survey report concluded that the structural resistivity of the surveyed hospitals was quite vulnerable to a high intensity earthquake and retrofitting was recommended; however, this has not yet been undertaken.

It is a very important measure to secure the medical services function of hospitals in times of an earthquake disaster. Therefore, to begin, a diagnosis for building resistivity against earthquakes should be conducted, and this diagnosis should include a comprehensive evaluation. Based on that evaluation, the necessary retrofitting or reconstruction plan should be prepared by the relevant agencies as soon as possible, and the necessary actions (including practical implementation) should be undertaken.

(2) Retrofitting of School Buildings

Retrofitting project for school buildings in Istanbul has been started already; however, the implementation ratio is not very high. According to this study, the total number of schools is 2,252, of which some 300 buildings were constructed using the new school building design standard established in 1997. The Study Team conducted a preliminary diagnosis of the earthquake resistance of two school buildings based on design drawings provided by the relevant agency and an on site survey. In this diagnosis, mainly the building structure and material are checked in detail. Finally, all data prepared by the survey is input into a specific formula and calculated to get the IS value, which is an indicator of the building's resistance to earthquakes. The result shows that even a new building design standard is not enough to prevent a pancake-like collapse of school buildings. This collapse must be prevented from happening because of the many pupils in the classrooms during weekdays. Retrofitting school buildings should be accelerated to cover all buildings in Istanbul and the design standard should be also reviewed.

(3) Retrofitting of Public Facilities, City Hall, and Governmental Buildings

Istanbul City Hall has now been closed for more than a year in order to complete retrofitting. This is a good example of retrofitting for a typical public facility. In case of a large-scale earthquake disaster, the functions of public facilities such as City Hall, district offices, fire stations, and governmental buildings must be maintained, and the facilities must be utilised as centres for emergency rescue operations, or as disaster management centres. Therefore, these facilities must be safe against a strong earthquake. The earthquake resistance of existing public facilities should be checked, and necessary retrofitting or reconstruction plans should be implemented by relevant agencies.

(4) Retrofitting of Bridges

In this study, data on a total of 480 bridges was collected and site surveys were also conducted by the Study Team. Finally, collected data was filed into bridge inventories, except the first and the second Bosphorus Bridge and the Fathi Sultan bridges. Vulnerability of bridges was analyzed statistically based on Katayama's methodology. As a result of the analysis, 24 bridges were calculated as having a higher possibility of collapse and 2 bridges constructed as viaduct structures were calculated as having a higher vulnerability to a Model C earthquake. The retrofitting of bridges is necessary to secure transportation routes not only for emergency rescue operations but also to support restoration and reconstruction activities. Thus, bridge retrofittings should be evaluated based on their priority for necessity of transportation network in a large-scale earthquake disaster. Some bridges are slated for retrofitting this year; however, the rest of the highly vulnerable bridges should be retrofitted by relevant agencies as soon as possible.

(5) Retrofitting of Port Facilities

Retrofitting port facilities is also very important to secure maritime transportation routes in the event of an earthquake. After the Kocaeli Earthquake, the port facility of Izmit and its surrounding area were damaged seriously due to liquefaction. Piers were damaged and some cranes collapsed. Damage to the port facility and port area should be prevented in an earthquake occurrence because the port area is considered to be utilised as disaster prevention base. Large amount of rescue materials supplied by both domestic and foreign aid will be received through the port. These materials will be redistributed to damaged areas by smaller ships or land transportation systems. In Istanbul, the Haidar Pasya Port, which functions as a deep seaport, should continue to be maintained and operated even after a strong earthquake. The earthquake resistance of the port facility and existing ground conditions should be checked, and necessary improvements should be undertaken by the responsible agency.

(6) Retrofitting of Lifelines

In Istanbul City, urban utilities such as gas, water, electricity, sewage and telecommunication systems are operated by private or city-owned companies. Supply of water, gas, and electricity is essential to maintain the daily life of communities; however, in case of a strong earthquake, these pipeline networks or cables will be damaged in many places. The gas supply system, especially, should be automatically shut down to prevent a secondary disaster such as fire or explosion. Technical matters regarding integrated gas supply and pipeline management systems related to earthquakes should be discussed, starting with the feasibility of their implementation. Based on the feasibility study, an introduction of automatic shut down systems should be discussed.

Water pipelines in the Istanbul area have been constructed and renewed in the last ten years; however, many damage points were calculated based on ground conditions and pipeline material. Basic materials necessary for restoration of service in earthquake-damaged areas should be stocked at the appropriate stations to facilitate the recovery of the areas in a short period of time.

Underground electricity cables will be damaged in many points. Based on the result of damage analysis, recovery plans should be prepared by relevant agencies.

For the sewage system, the earthquake resistance of sewage treatment plants should be checked, and necessary improvements should be made.

(7) Construction of Disaster Management Centre

The Disaster Management Centre of Istanbul City was constructed in 2001 but installation of the necessary equipment related to disaster information collection and dissemination systems has not yet been completed. Construction of another disaster management centre is planned by the Governorship of Istanbul Prefecture, and its construction has just started. These are the main disaster management centres covering the Istanbul urban area and prefecture. In order to manage a large-scale earthquake disaster, these centres should be networked effectively with district offices or other disaster-related offices by telecommunication systems. These telecommunication systems must be maintained and operated at the time of an earthquake disaster occurrence to collect damage information, dispatch necessary orders for rescue operations, and communicate with each related agency. Therefore, construction plans of disaster management centres, including the main centre, back-up centre, and district centre, should be discussed. Basic functions and facilities for each disaster management centre should also be discussed. According to the Study, construction priority should be granted to higher damage estimated districts.

(8) Campaign for Raising Awareness on Disaster Prevention

An earthquake disaster prevention awareness campaign for citizens of Istanbul City should be held continuously through community-based information dissemination, rescue operation drills, and through the recognition of mutual help in cooperation with community organisations, NGOs, the municipal administration, and academic researchers. For disaster prevention, especially in the administration of first aid, community participation is indispensable. People’s awareness on disaster prevention should be raised even more by combining various activities and campaigns.

11.3. Medium- to Long-Term Measures

(1) Master Plan for Earthquake Disaster Prevention

Damage estimation and analysis of urban problem areas were conducted by this JICA Study. Structural problems of buildings were also analyzed. However, the study accuracy is still in the macro level, showing fairly detailed aspects of earthquake damage distribution covering the whole Study Area and recommendations for improvement of existing conditions for earthquake disaster management, including urban planning and institutional aspects. Based on these study results, a detailed earthquake disaster prevention plan such as district-wise plan for Istanbul City should be formulated. In this case, building statistics should be improved to assist in classifying more detailed categories for structures. Population data should also be improved as to clarify daytime and nighttime variations. This master plan should be deeply related to future land-use zoning to secure enough open spaces, road networks, environmental protection areas and locations of public facilities. Detailed plans should be examined and formulated for the following: the location of evacuation sites and routes, review of road network priority for emergency operations, necessary emergency storage supplies, community participation for rescue operations, medical equipment emergency systems, , and emergency communication systems.

(2) Formulation of Urban Redevelopment Plan Aimed at Earthquake-Resistant City

In addition to developing a detailed earthquake disaster prevention master plan, a redevelopment plan for higher damage estimated areas should be formulated based on a detailed area redevelopment plan as a model case. The methodology and concepts for this detailed area redevelopment plan should be prepared by joint collaborations between municipality and community organisations, with the approach of providing for the improvement of existing urban conditions to create an earthquake-resistant urban area. This detailed urban redevelopment plan should be applied to an area of extremely high population density on the European side first. However, it seems to take a rather long time to reach a basic agreement and consensus by stakeholders and people concerned for the practical implementation of redevelopment to occur. The municipality should provide the specific guidelines for these redevelopment plans.

(3) Promotion of Research on Earthquake-Resistant Buildings

Basic research on earthquake-resistant buildings including structure, material, and design standards should be promoted by the academic sector. If regulations for stronger building structures against earthquakes could be standardised in earthquake-prone areas, damage will be largely reduced. From this point of view, more research and recommendations concerning building structures and materials should be promoted by research institutes. Based on these activities, building code and design standards must be improved. The private sector engaged in housing should also be involved in these activities.

(4) Establishment of Credit System for Earthquake-Resistant Housing

It seems to be a very important policy to establish a financial assistance scheme for citizens who want to build an earthquake-resistant building. A long-term credit system by the government should be discussed to enhance and provide incentives to the people living in earthquake-prone areas. Special low interest rates for this credit scheme should be prepared for this purpose. Also, property taxation should be reviewed and improved to help those engaged in housing and construction. As a result of long-term accumulation of these activities, stronger houses and buildings could be continually constructed to realise an earthquake-resistant urban structure. Therefore, it is necessary to conduct a study and discussion on fund sources to realise this scheme.

(5) Institutional System Improvement for Disaster Management

The concept of disaster prevention should be introduced into the land-use system of the Reconstruction Act. The building code should mention other aspects, such as materials, and should cover comprehensive aspects regarding disaster prevention. A "Disaster Law" should introduce basic concepts of mitigation efforts that can be undertaken before a disaster occurs to reduce damage. Emergency aid regulation should include civic organisations and public relations on disaster information. Centralism has been strengthened under the 1982 Constitution, and so disaster management organisations have come into existence. However, since the population in one district in IMM is nearly equal to that of a neighboring province, and communication and transportation will likely be disrupted initially in case of a disaster, a centralised provincial governorship emergency office would not be likely respond quickly in case of a disaster. Therefore, a realistic plan should be made to empower a district or a community to respond independently to the event for the first several days. To realise this, the Provincial Governor's Disaster Management Centre should reorganise its members and tasks, especially its interdependent tasks, and then it should be restructured. At the district level, some key efforts include the strengthening of the linkage between the district chief and the mayor of the district municipality, the establishment of an organisation including residents and volunteers in mahalles, the disclosure of damage estimation study results to the public, and the provision of disaster prevention resource information collected in AYM and AKOM. A strong linkage between public service companies in IMM and each district would be necessary. The highest priority should be put on the seismic strengthening of public facilities so that they can function as emergency response centres. Privatisation of inspection of newly constructed buildings would be effective utilising engineers in public service companies of IMM. As for rescue and first aid training, providing training, increasing the number of trainers, and reducing the training hours in order to more efficiently train the public would be very effective. In order to ensure emergency preparation, the utilisation of professional engineers for damage inspections, the inclusion of mass media as part of disaster prevention organisations, utilising a strong public relations basis for providing disaster information, and the readiness to accept international aid is also necessary.