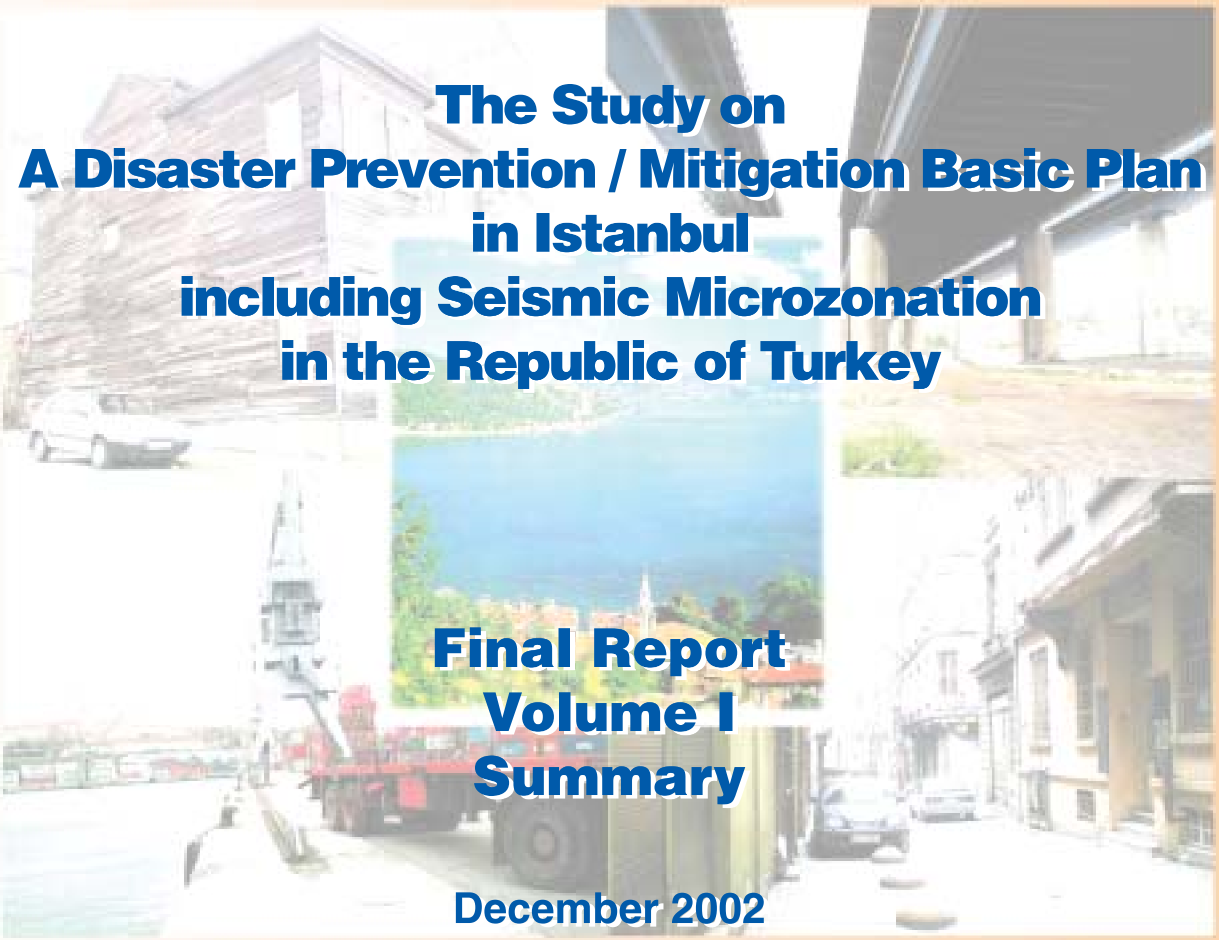
No.

The Istanbul Metropolitan Municipality
Directorate of Soil and Earthquake Research

Japan International Cooperation Agency



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

Final Report
Volume I
Summary

December 2002

Pacific Consultants International

OYO Corporation

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

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COMPOSITION OF THE FINAL REPORT

Volume I	**Summary**
Volume II	**Main Report**
Volume III	**GIS Maps**
Volume IV	**Summary in Turkish**
Volume V	**Main Report in Turkish**
Volume VI	**Summary in Japanese**
CD I	**PDF Files of Summary and Main Report, Supporting Report and Data**
CD II	**GIS Data**

The following foreign exchange rate is applied on this study report;

US$1.00=TL1,650,000

(September 2002)

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 to 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 consisted of Pacific Consultants International and Oyo Corporation to the Republic of Turkey, four times between March 2001 and September 2002. In addition, JICA set up an advisory committee headed by Dr. Ken Sudo, Professor of University of Tokyo between April 2001 and March 2002 and by Dr. Yoshimori Honkura, Professor of Tokyo Institute of Technology between March 2002 and September 2002, which examined the study from specialist and technical point of view.

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, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship 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 study.

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 November 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 three volumes, "Main Report", "Summary" and "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

EXECUTIVE SUMMARY

1. Background and Objectives of the Study

Because the phenomena of strong earthquake epicenters migrating from east to west along the North Anatolian Fault (NAF) continue to be observed, it is likely that sometime in the future another large earthquake will strike Istanbul, located on the western edge of the NAF. Moreover, since Istanbul is one of the largest cities in the Middle East, it is speculated that a large earthquake in or around Istanbul will cause a national catastrophe in Turkey.

Because of this possibility and in response to the request from the government of The Republic of Turkey, the government of Japan conducted the Study on Disaster Prevention / Basic Mitigation Planning in Istanbul, which has the following objectives: 1) to integrate and develop seismic microzonation studies in Istanbul as the scientific and technical basis for disaster prevention/mitigation planning; 2) to recommend a citywide prevention/mitigation program against building and infrastructure damages ; 3) to recommend disaster prevention considerations in the urban planning of Istanbul City; and 4) to pursue the transfer of technology and planning techniques to Turkish personnel counterparts.

2. Assessment of the Present Status

As a starting point, the Study team collected data on natural and social conditions in the Study Area necessary to conduct an earthquake damage analysis, and it constructed a database using a Geographic Information System. The following data were obtained:

Natural conditions: earthquake history, list of earthquake and waveforms, geology map, fault distribution map, topography map, slope distribution map, and existing boring data.

Social conditions: census for the year 2000, cadastral data for buildings, public facilities, land use, hazardous facilities, lifelines, road networks, mahalle (sub district) boundaries, laws and organizations, and plans for disaster prevention.

3. Geological Study and Definition of Scenario Earthquake

A numerical ground model using 500m grids was developed for the whole Study Area. The model was developed using a combination of 1,076 existing borings and 48 drillings, which the Study Team conducted to study dynamic properties of the ground.

Four scenario earthquakes (models A, B, C, and D) were determined based on discussions with researchers from the scientific community serving on the project's scientific committee and researchers from relevant institutes, as well as on recent research on the NAF. These models were used to make appropriate damage estimations for disaster prevention planning. These scenario earthquakes are modeled along the NAF in the Marmara Sea, and the difference between each earthquake is the length of its respective fault segment.

4. Earthquake Hazard Analysis

Ground motion at the seismic bedrock was calculated based on the fault model with a selected empirical attenuation formula that explains the data observed during the 1999 Izmit earthquake. The amplification factor of seismic motion due to subsurface soil was classified by the average shear wave velocity of surface soil.

Ground motion at the ground surface was calculated by multiplying by the amplification factor. Model A is regarded as the most probable case, and model C is regarded as the worst case. Scenario earthquake of model A and model C are used for further analysis because these two scenarios represent the most general picture of the hazard conditions. In addition, liquefaction potential and the slope stability were evaluated.

5. Building Damage and Casualties Estimation

Buildings were classified according to structure, number of stories, and their construction year in order to estimate building damage due to the scenario earthquake. The number of buildings of each type per mahalle were then counted using building Census 2000.

The theoretical relationship between seismic motion and the damage state of buildings was constructed using a capacity spectrum model and adjusted to fit real damages observed in recent earthquakes in Turkey. The number of damaged buildings according to the three damage states was then calculated for all building types.

The number of deaths was estimated using the number of heavily damaged housing units, through examination of empirical relationships between building damage and casualties based on the damages observed in recent earthquakes in Turkey. The number of severely injured was also estimated using number of deaths observed in recent earthquake events in Turkey.

6. Evaluation of Urban Vulnerability

After carrying out building surveys, the seismic index of structures was evaluated for two schools designed by the school building standard. It was found that that these buildings may collapse or be heavily damaged under conditions similar to those of the 1992 Erzincan Earthquake. It is presumed that almost all school buildings may have similar earthquake resistance shortcomings.

Damage estimations for public facilities were conducted, and it was observed that the estimated damage rate of major public facilities is similar to that of all buildings.

The study also found that the possibility of large fires is small because the wooden building coverage area ratio of all mahalles stands at less than 10%. Nonetheless, many fires occur immediately after an earthquake, and it can take a fire-fighting team a long time to reach a fire because of roadblocks caused by debris.

Damage to lifelines such as water pipelines, sewage pipelines, gas pipelines, gas service boxes, and electricity cables were also estimated.

The possibility of bridge collapse was evaluated for 480 bridges using a Japanese method commonly used for preliminary screening purposes. Based on these evaluations, a prioritized list of necessary detailed bridge inspections was developed.

The prioritization of the road network was also evaluated, based on the review of road network and on the effect of damaged bridges. Road blockages due to collapsed buildings were estimated using the results of the study's building damage estimation.

7. Preparedness Measures to Strengthen Vulnerable Buildings and Urban Structures

Executing an earthquake damage assessment served to assess urban vulnerability against earthquake disaster and improvement issues were then identified. Land availability per mahalle was assessed by considering the mahalle's built-up area ratio and its average building coverage ratio.

8. Recommended Measures for Earthquake Disaster Mitigation

Necessary earthquake disaster mitigation measures are presented as short- and medium- to long-term perspectives. Short-term measures basically include retrofitting important facilities and infrastructure to secure their operational function. Medium- to long-term measures involve non-structural recommendations.

Basic concepts of urban structure improvements are the redevelopment of high population density areas, the widening of narrow roads, and the review of existing land-use to have more open space areas. Finally, the coordination and/or development of appropriate legal, institutional, and operational systems are also recommended.

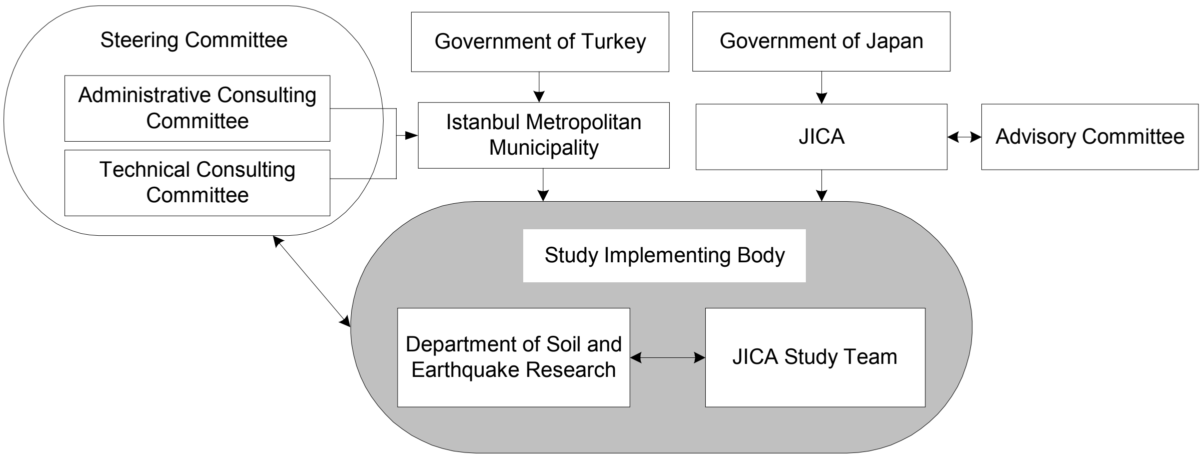
OUTLINE OF THE STUDY

1. Introduction

1.1 Study Organisation

The figure shown below outlines the organization of the Study's implementation.

Study Title:	*The Study on A Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey*
Implementing Agency:	*Japan International Cooperation Agency*
Counterpart Agency:	*The Directorate of Soil and Earthquake Research, The Istanbul Metropolitan Municipality*
Study Period:	*From March 2001 to November 2002*



1.2 Background of the Study

In 1999, two large earthquakes occurred in Izmit and Adapazari causing tremendous harm to human lives and damage to properties in the area. These earthquakes occurred along the North Anatolian Fault (NAF), which is a large-scale fault line, more than 1,000 km long from east to west, in the northern territory of Turkey. Historically, many strong earthquakes have occurred along this fault line.

There is an obvious phenomenon that the epicentres of these strong earthquakes are migrating from east to west along the NAF, and it is pointed out that another big earthquake may hit Istanbul, located on the western edge of the NAF.

Istanbul is one of the biggest cities in the Middle East, representing a centre of economic and industrial activities and serving as a popular tourist destination in modern-day Turkey. Therefore, if a large earthquake were to occur in or around Istanbul, the event would be a catastrophic national emergency for Turkey.

In order to manage the potential earthquake disaster in Istanbul, it is necessary to prepare mid- to long-term seismic disaster prevention or mitigation plans, emergency rescue plans, and restoration plans for the earthquake stricken area.

1.3 Objectives and Contents of the Study

The objectives of the Study are the following: 1) integrate and develop seismic microzonation studies in Istanbul as the scientific and technical basis for disaster prevention/mitigation planning; 2) recommend a citywide prevention/mitigation program against building and infrastructure damages; 3) recommend disaster prevention considerations in the urban planning of Istanbul City; and 4) pursue the transfer of technology and planning techniques to Turkish personnel counterparts.

2. Lessons from Past Experience

There are many common lessons to be learned from the 1999 Izmit Earthquake and 1995 Kobe Earthquake. Both earthquakes occurred in large urban areas and, thus, the experience and information gained from them may serve as lessons for future earthquakes in Istanbul.

3. Administrative Conditions for Earthquake Disaster Management

The idea of disaster prevention should be introduced in the Reconstruction Act's section regarding land-use. The Disaster Law should introduce the idea of mitigation efforts before the occurence of a disaster to reduce damage. Emergency aid regulations should include civic organisations and public awareness of disaster information. A special act is necessary for disaster prevention in Istanbul. Districts or mahalles should be empowered to respond independently for the first days following an earthquake disaster. Disaster Management Center, Governership of Istanbul (AYM) should be restructured with a review and revision of its membership and interdependent tasks. The link between the district chief and the mayor of a district municipality should be strengthened with the establishment of organisations that include residents and volunteers from each mahalle. Additionally, the disclosure of a damage estimation study's results to the public and the provision of disaster prevention resource information collected by AYM and Disaster Coordination Center, Istanbul Metropolitan Municiparity (AKOM) would be a key to strengthening the link.

The seismic strengthening of public facilities should be the top priority. The privatisation of construction inspections would be effective in this case. Increasing instruction to trainers and constructing feasible training programs for the public is an effective way to increase the number of trainers available. The utilisation of professional engineers for damage inspection will help increase the number of public facilities receiving seismic strengthening. Along these lines, the inclusion of the mass media into disaster management to aid with communication dissemination and the preparation for the acceptance of international aid are also necessary in order to fulfill this top priority

4. Civil Society Organisations for Disaster Management

The role of civil society organisations as disaster management organisations in Istanbul were studied, especially in the Kadıköy Municipality. Recommendations on various types of organisations to aid in the many stages of a disaster were proposed.

A simplified legal framework for non-profit organisations should be developed, and all the civil society organisations should be classified into a single category of disaster management service. Proper resource utilisation and management will be a key factor for their sustainability. Appropriate allocation of responsibility should be placed among public authorities and civil society organisations. Civil society organisations can play a significant role in motivating people to support the strengthening of buildings.

5. Public Awareness and Education for Disaster Management and Preparedness

The current status of public awareness and education on earthquake disasters in Istanbul has been evaluated. The following recommendations were made:

Information on hazard, risk assessment, and disaster maps should be shared at the community level. The media should be used to disseminate appropriate information and to sensitise the community to issues related to earthquake preparedness. Citizen participation during the planning process should be promoted. Community space for daily activities should be created. Disaster mitigation tools should be prepared at the community level. The promotion and implementation of building retrofitting should be made a community initiative. Muhtar, an elected chief of the mahalle, can play a key role as a hub for the provincial government and the district municipality.

6. Earthquake Analysis

6.1 Scenario Earthquake

Based on discussions with relevant institutes and researchers, as well as on the recent increase in research on the North Anatolian Fault (NAF), four (4) scenario earthquakes were determined so that the appropriate damage estimation is taken into consideration in disaster prevention planning. These scenario earthquakes are along the NAF in the Marmara Sea, and the difference between each earthquake is the length of its respective fault segment.

Parameters of Scenario Earthquake

	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

6.2 Ground Motion

Based on the fault model, peak acceleration, peak velocity, and acceleration response spectrum were calculated with a selected empirical attenuation formula that can explain the data observed during the August 17, 1999 Izmit Earthquake.

Subsurface amplification was evaluated by an amplification factor for each site class, which was classified by the average S wave velocity in the upper 30 m (AVS30) of surface soil. The amplification factor was then multiplied to get the peak ground acceleration (PGA), peak ground velocity (PGV), and acceleration response spectrum (Sa) at the ground surface.

6.3 Evaluation of Liquefaction Potential

A combination of the F_L method and the P_L method was used in the Study. The evaluation focused on the identification of manmade ground and Quaternary deposits. A 500 m grid system, used in the earthquake analysis, was prepared for modeling.

Küçükçekmece, Eyüp, Avcilar and Beyoğlu are four (4) districts in the area evaluated as having "very high" (Model C) liquefaction potential areas , wider than 40 ha..

6.4 Evaluation of Slope Stability

The slope stability of each 50 m grid was judged using Siyahi's equation taking the peak ground acceleration value and strength of soil into account. Then, in a 500 m grid system, the stability was evaluated as the score of the grid.

The scores were evaluated for each district. In the Büyükçekmece, Adalar, and Avcılar dıstrıcts, areas of "high risk" and "very high risk" were found to prevail. Some unstable areas also exist in the districts of Bahçelievler, Bakirköy, Güngören, Çatalca, and Silivri.

7. Estimation of Damages and Casualties

7.1 Buildings

The building inventory database was obtained from the compilation of data from the 2000 Building Census for each mahalle. "Heavy," "moderate," and "partial" damaged buildings are calculated for all building types. A summary of these results are shown in the table.

Damage of Buildings

		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%)		

7.2 Human Casualties

The relation between building damage and casualties was studied based on the past earthquake hazard in Turkey. An empirical relation between the number of deaths and severely injured was adopted in order to estimate the number of severely injured people. A summary of the results are shown in the table (Human Casualties) below. In this table, the results of a simulation for the Izmit Earthquake are also included.

Human Casualties

	Deaths		Severely Injured	
Model A	73,000	(0.8%)	120,000	(1.4%)
Model C	87,000	(1.0%)	135,000	(1.5%)

8. Evaluation of Urban Vulnerability

8.1 Buildings

Building surveys were carried out at two (2) schools, Üsküdar Ticaret Meslek Lisesi and Hazerfen Ahmet Çelebi İlköğretim Okulu. The Seismic Index of Structure, known as the *IS* value, was evaluated for these schools and it was found that that these buildings may collapse or be heavily damaged under conditions similar to those of the 1992 Erzincan Earthquake. Therefore, it is easily presumed that almost all school buildings may have similar earthquake resistance shortcomings, because the buildings investigated are designed based on the school building design standard. Thus, it is recommended that a detailed investigation of every public facility should be carried out, one by one.

8.2 Major Public Facilities

Damage estimations for public facilities were conducted. These included the following: 1) educational facilities: primary and high schools; 2) medical facilities: hospitals and clinics; 3) fire fighting facilities: fire fighting stations; 4) security facilities: district police departments (İlçeemniyet), police and gendarme (Jandarma); and 5) governmental facilities: ministries and provincial and municipality offices.

The damage rate of major public facilities is similar to that of all buildings with the exception of fire fighting facilities. The damage rate of the fire fighting facilities is lower than that of all other buildings. However, this does not mean that fire fighting facilities are stronger than other buildings.

8.3 Fire

The wooden building coverage area ratio of all the mahalles stands at less than 10%. This would seem to indicate that there would be a small possibility of large fires, as most buildings are constructed with concrete and brick. Nonetheless, it should be kept in mind that many fires occur immediately after the earthquake and it can take a fire fighting team a long time to reach a fire because of road blocks caused by debris.

8.4 Lifelines

Damage of water pipelines, sewage pipelines, gas pipelines, gas service boxes, and electricity cables have been estimated and are shown in the following table (Damage of Water Pipeline).

Damage of Water Pipeline

	Pipe Length (km)	Damage Points
Model A	7,568	1,400
Model C		1,600

Damage of Sewage Pipeline

	Pipe Length (km)	Damage Points
Model A	6,174	1,200
Model C		1,300

Damage of Gas Pipeline and Service Boxes

	Pipe Length (km)	Damage Points	Service Box Number	Damage Box
Model A	4,670	11	185,000	25,000 (14%)
Model C		13		29,000 (16%)

Damage of Electricity Cables

	Cable Length (km)			Damaged Cable Length (km)		
	Under Ground	Over Head	Total	Under Ground	Over Head	Total
Model A	14,500	18,500	33,000	280 (1.9%)	540 (2.9%)	820 (2.5%)
Model C				360 (2.5%)	710 (3.8%)	1080 (3.3%)

8.5 Bridges

An evaluation of the possibility of bridge collapse was conducted for 480 bridges using Katayama's method. The number of bridges that have a possibility of collapsing are as follows:

Estimated Number of Damaged Bridges

	High Probability of Collapse	Moderate Probability of Collapse	Low Probability of Collapse
Model A	18	3	459
Model C	20	4	

8.6 Road and Traffic

An evaluation aimed at identifying the importance of a road network that takes into account earthquake disaster scenarios was also carried out. This evaluation was based on a review of the total road network and on the influence damaged bridges had on the road network and traffic. Using the building damage estimation results, road blocks caused by building collapses were also estimated and evaluated. Based on the results of this evaluation, it was recommended that a comprehensive evaluation and investigation be carried out that focus on prioritised earthquake-resistant bridge reinforcement efforts and on future road development plans.

8.7 Port and Harbours

Port and harbour facilities are expected to have various functions during an emergency. Several recommendations are proposed to establish and strengthen the earthquake-resistant functions of these facilities as disaster prevention bases. Recommendations were also made to facilitate a cooperative system among the port and harbour facilities. In addition, the maintenance of disaster prevention bases and potential shelter areas of green space are discussed and proposed.

9. Preparedness Measures to Strengthen Vulnerable Urban and Building Structures

9.1. Vulnerability Analysis of Urban and Building Structures in Istanbul

The following analyses were conducted to evaluate the vulnerability of urban and building structures:

- The Causal Relationship between Expanded Earthquake Disaster Damages and Urban and Building Structure Vulnerabilities
- Analysis Flow for Urban and Building Vulnerabilities
- Estimated Building Damages
- Trends in Building/Urban Renewal
- Excessive Land- and Building-Use: Rigid Urban Land-Use
- Road Density (m/ha) in Urbanised Areas
- Narrow and Inappropriate Road Conditions: Constraints for Safety Evacuation and Emergency Response Operations
- Parks and Open Space Availability for Primary Evacuation of Residents
- Area Identification of Required Improvement Measures

9.2. Proposed Measures to Strengthen Vulnerable Urban and Building Structures

Based on the above discussions, countermeasures for the following items are proposed:

- Land Availability for Urban Structure Improvements
- Building and Urban Structure Improvements
- Urban Structure Improvements

- Urban Redevelopment and Historical Urban Conservation Areas
- Building Structure Improvement Areas

In addition, the following recommendations were prepared:
- Recommendation to Strengthen Urban Structures: Urban Redevelopment
- Recommendation to Strength Urban Structures: Improvement of Urban Structures
- Recommendation to Reorganise Land-Use Plan and Zoning
- Recommendation to Promote Seismic Resistant Buildings

10. Recommended Measures for Earthquake Disaster Mitigation

1) Short-Term Measures

The items listed below are recommended for implementation in the short- term.
- Retrofitting of Hospitals
- Retrofitting of School Buildings
- Retrofitting of Public Facilities, City Hall, and Government Buildings
- Retrofitting of Bridges
- Retrofitting of Port Facilities
- Retrofitting of Lifelines
- Construction of a Disaster Management Centre
- Disaster Prevention Awareness Raising Campaign

2) Medium- to Long-Term Measures

The items listed below are recommended for implementation in the medium to long term.
- Formulation of a Master Plan for Earthquake Disaster Prevention
- Formulation of an Urban Redevelopment Plan aimed at Establishing an Earthquake-Resistant City
- Promotion of Research on Earthquake-Resistant Buildings
- Establishment of a Credit System for Earthquake-Resistant Housing
- Institutional System Improvement for Disaster Management

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Chapter 1.
General

Chapter 1. General

1.1. Introduction

The Study Team, organized by JICA, commenced *The Study on A Disaster Prevention/ Mitigation Basic Plan* in Istanbul including seismic microzonation on March 13, 2001. The seven steps needed to conduct the Study took take approximately 19 months up to the official submission of the Final Report in December 2002. They are the following:

Step 1: Identification of study issues through the analysis and evaluation ofexisting data collection.

Step 2: Site investigation on ground conditions, population, building conditions, etc.

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 and seismic microzoning maps.

Step 7: Detailed examination of urban disaster prevention and mitigation plan.

This Summary Report describes the abstracts of the Final Report.

1.2. Scope of the Study

1.2.1. Study Objectives

The objectives of of this Study are: 1) to compile the seismic microzonation maps which can serve as the basis of the seismic disaster prevention/mitigation plan for Istanbul city and prefecture; 2) to make recommendations for construction of earthquake resistant urbanization; and 3) to conduct effective technical transfer to relevant planning techniques. Specifically, the Study intends to:

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

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

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

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

1.2.2. Study Area

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

1.2.3. Schedule of the Study

Figure 1.2.1 shows the work schedule of the tasks and shows the logical flow of the Study.

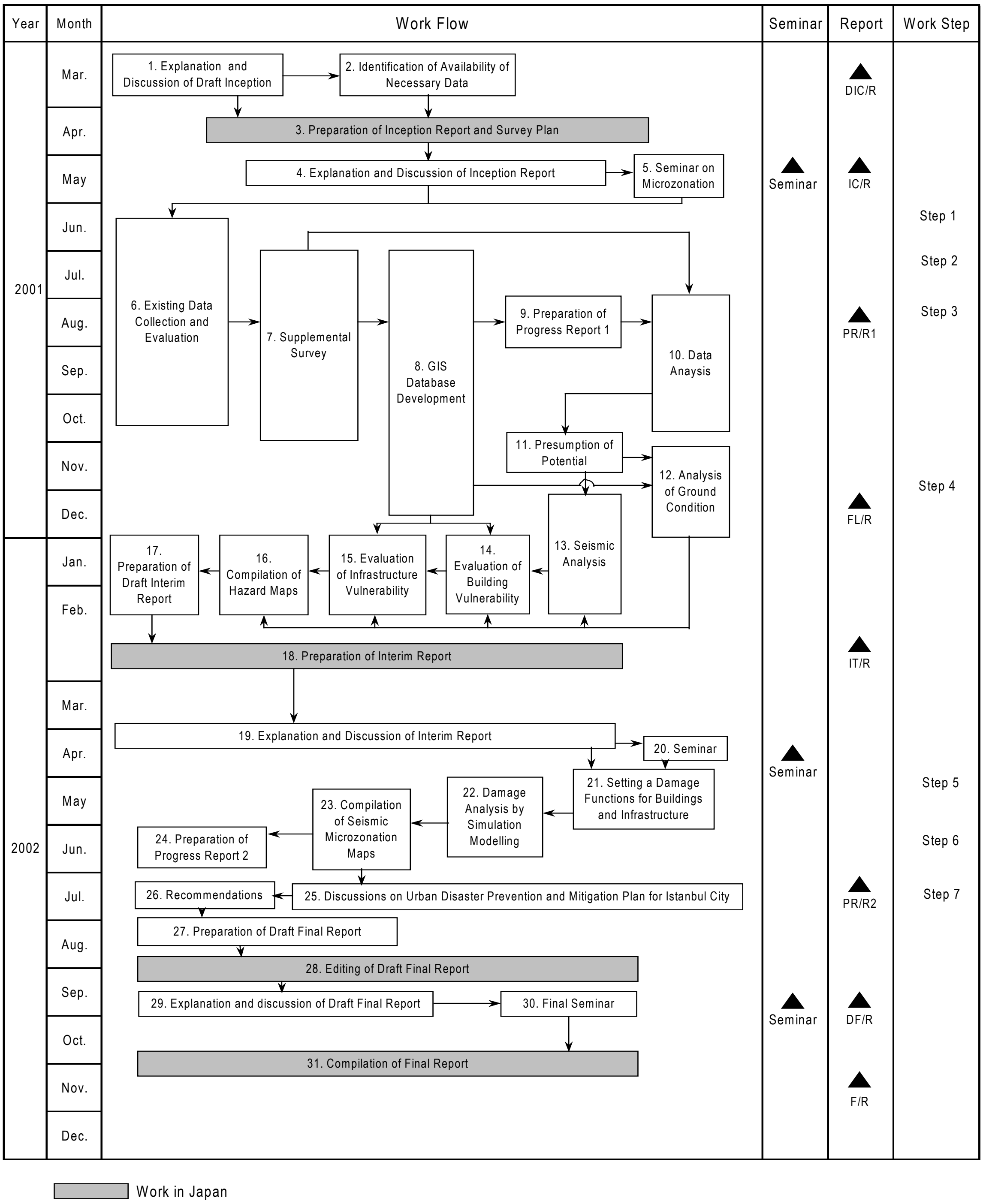


Figure 1.2.1 Work Flow of the Study

1.2.4. Implementation Organizations

The Turkish counterparts of the Study established two committees, the Administrative Consulting Committee and the Scientific Consulting Committee (as shown in Figure 1.2.2 to faciliate a smooth and successful implemenation of the Study. The Administrative Consulting Committee consists of representatives from both the IMM and the Istanbul Governorship. The Scientific Consulting Committee consists mainly of university professors covering the various areas of the Study's scope.

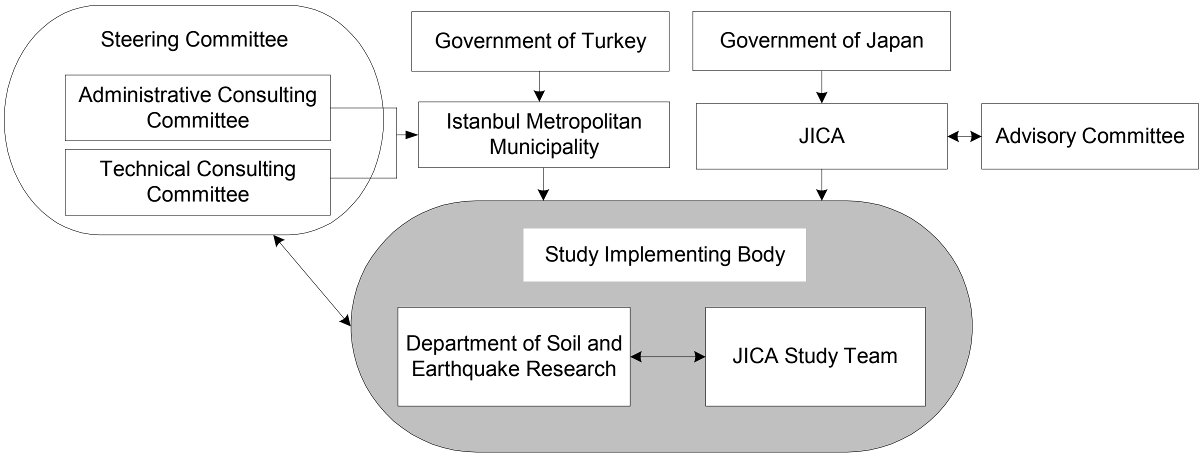


Figure 1.2.2 Study Organization

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 1.2.1.

To cover the various areas of the Study's scope, the Scientific Consulting Committee had been established as shown in Table 1.2.2.

Table 1.2.1 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 1.2.2 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	Mimar 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.

(1) Counterparts assigned

A total of 8 persons had been assigned as counterpart personnel in accordance with their special subjects as tabulated in Table 1.2.3.

Table 1.2.3 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

(2) Member of Japanese Side

Table 1.2.4 Member of Administrative Body of JICA

Name	Position
Mr. Toshio HIRAI	Director, First Development Study Division, Social Development Study Department (March 2001- July 2002)
Mr. Takeshi NARUSE	Director, First Development Study Division, Social Development Study Department (August 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. Kenshiro TANAKA	Staff, First Development Study Division, Social Development Study Department
Mr. Shinichi TANAKA	Staff, First Development Study Division, Social Development Study Department

Table 1.2.5 Member of Advisory Committee

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

Table 1.2.6 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

Chapter 2. Lessons from Past Experience

Lessons from the 1999 Izmit Earthquake and the 1995 Kobe Earthquake are itemized. Since the mode of the earthquake damage in both metropolitan areas is similar, the lessons learned from these earthquakes should be viewed in a fresh light against the backdrop of any future earthquake disasters in Istanbul.

2.1. Lessons from the 1999 Izmit Earthquake

- The large earthquake hit an industrial and populated area.
- Public buildings and infrastructure were not earthquake resistant.
- Governmental offices were damaged, and responsible staff persons were also victims.
- Initial communication was not possible.
- First few days were chaotic and rescue activity was carried out by local residents.
- Search and rescue was not organized nor effective.
- Rescue work targeting collapsed buildings was difficult.
- Building damage assessment efforts were not organized.
- Relief activities were not organized - food was mixed in with other supplies and spoiled since not delivered promptly.
- Unskilled first aid treatment of victims created more problems than it solved.
- Psychological problems were observed among many victims and rescue workers.
- International aid acceptance was difficult without translators.
- New permanent housing areas without social infrastructures pose a problem.

2.2. Lessons from the 1995 Kobe Earthquake

- The earthquake occurred in urban area causing the worst damage to have occurred the post-war era.
- Initial collection of damage information was difficult due to communication problems.
- Information from the mass media was quick, but it focused on the most severe damage.
- Initial response from government was slow in coming since officials were also victims.
- Insufficient traffic control caused traffic jams and delayed response activities.
- Initially, smaller heavy machinery proved to be more useful for debris removal.
- The major difficulty in rescue was to cut through steel bars in concrete buildings.
- Lack of initial screening of victims on-site caused flood of patients into hospitals.
- In evacuation shelters, it was necessary to maintain sanitation, to distribute limited food, and to handle dead bodies and human waste.
- External lifeline recovery assistance teams lacked adequate parking, housing, materials, and provision of information on the recovery status.
- Acceptance of external help was difficult due to the lack of available working facilities, experience, and organization of the local government.

Chapter 3.
Administrative Conditions for Earthquake Disaster Management

Chapter 3. Administrative Conditions for Earthquake Disaster Management

In this chapter, the laws, organization, and plans related to disaster management in Turkey, especially in Istanbul are reviewed. A comparison of disaster management systems in Turkey, Japan, and the USA is made. The following are recommendations on laws, organization, and plans for disaster management for Istanbul with an emphasis on local government.

3.1. Recommendations Related to Law

(1) Development Law

- The Law should cover the whole process of construction.
- The Law should include concerns for disaster mitigation.
- The Law should take integrated approaches to property management.
- The Law should control land use in an integrated manner.
- Planning control should be unified to avoid the diffusion of authorities.
- There should be a unified authority to pursue the uniform control of the contents and procedures of planning.

(2) Building Code Enforcement

a. Project Supervision

- Engineers in public service companies in IMM should be utilized to assist 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 damages or losses.
- Legal requirement should be made to have a site engineer for construction projects exceeding certain limits.
- A simplified check method should be developed for simple, ordinary designs.
- A distinction should be made between ordinary and unusual engineering projects.

b. Construction Supervision

- A professional qualification of the inspection engineer should be conducted.
- The inspectors should be empowered, and they should have liability insurance.
- The inspectors should be separated from contractors, and their minimum fees should be set.
- Qualification requirements of the contractors should be set.
- Building inspection process should be privatised to service companies.
- The seismic regulation should include other design aspects and building layout.

- Legal procedures should be simplified to ensure effective corrective action byauthorities.

(3) Laws Related to Illegal Housing Construction

- Disaster funds or catastrophe insurance pool funds should be allocated, in advance of the disaster, for the improvement of vulnerable housing or relocation of illegal housing.
- Small-scale development will be necessary to regulate new development.

(4) Disaster Law

- The efforts to mitigate the possible damage should be included in the law as a national strategy.
- Standardized emergency management should be necessary to discourage rash decisions and to encourage learning from any disaster.
- The law should differentiate between those who do not comply with development regulations and those who do comply.
- A specialised fund specific to earthquake disaster prevention or relief is necessary to avoid extended use by political operations.

(5) Emergency Aid Organization and Planning Regulations

- Actions to reduce the damages or reconstruction in the long-term should be mentioned. The necessity of education and disaster drills should also be included.
- The regulations should deal with different types of disasters separately.
- Recent topics in disaster responses should be included in the regulations.
- Special legislation for urban earthquake disaster should be made.

(6) Laws Related to Fire

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

(7) Earthquake Insurance

- Pricing adjustments for retrofitting efforts should be reflected in the insurance premium.
- More provinces should invest in earthquake insurance.

3.2. Recommendations Related to Organization

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

In case of a disaster, experience has demonstrated that the initial arrival of officials to the identified management centre would be slow, and that communication and traffic would be limited. Local offices should be able to manage working independently for the first few days, with little external help. Local offices should be empowered with resources, information, and authority.

The hierarchical, top-down nature of the system tends to discourage local initiative and undermines the role local authorities have in helping victims of an earthquake disaster.

(2) The link between central and local government should be clear.

Adequate coordination between provincial governors, provincial directorates of ministries, and respective ministries in central government should be made. The role of the regional disaster management centre should be well defined.

(3) Command system should be well defined.

The command system between the Prime Ministry's Crisis Management Centre and the General Directorate of Disaster Affairs (GDDA), and that between AYM and the provincial directorate of the Ministry of Public Works and Settlements, should be well defined. The command system to public service companies between AYM and AKOM should be made simple, since a few companies belong to both, while the rests are under AKOM.

(4) Weak links among organizations should be strengthened.

The links between AYM and AKOM, as well as between district heads and the mayor, are not necessarily strong. In general, provincial officials charged with disaster management are themselves not from the province where they work, and may be unfamiliar with the local situations. Strengthening the link between these organizations is very important because disaster response should essentially be done locally, especially during the initial period. Additionally, the link between IMM and each district municipality, which is currently made via AYM, is 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, can be major players in a disaster response because they are the ones closest to the disaster area and have the best knowledge of the local situation. However, they are a hidden resource in the current disaster management system. The total number of official rescue members may not be sufficient in the case of a large-scale earthquake because some of them may be also victims, and/or because official rescue members will have difficulties reaching the disaster area due to communication and traffic problems.

3.3. Recommendations Related to Disaster Management Plan

(1) Each member organization should make their own plans and check them for conformity.

Each organization responsible for emergency service should develop their own plans. Moreover, the chief organization in the corresponding service group and/or AYM should check the conformity of the plan within the service groups and emergency service as a whole. Making a responsibility matrix showing the relationship between each task and responsible organization should assist in this this process. This is necessary in order to clarify the responsibility of each member and to improve the coordination among member organizations.

(2) Communication within each service group should be ensured.

Communication among the service groups should be ensured. This kind of communication includes that between the head organization of the service group and the head organization of the subgroup, and communication between the subgroup organization and the member organization. If regular meetings are held among members for daily matters, disaster management should also be included in topics covered in the meeting. The additional advantage of this is that having personal contact before the disaster helps efforts to be carried out more efficiently during a disaster.

(3) Inter-organization cooperation should be considered.

Inter-organization cooperation should be considered to avoid sectionalism created by division of members into service groups.

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

The provision of information to service members as well as to the public should play an important role in disaster management. For this purpose, uses of existing means for public relations should be considered. The FM radio station in AYM should be fully utilized and the public should be made aware of its use during an earthquake. Internet web sites should have links to governmental sites, pages with information on the damage situation and pages with information in English for the international audience. Websites should be maintained within the disaster management centre.

(5) Training and simplified courses should be considered.

A common problem observed in the current first aid/search and rescue training efforts is the limited number of trainers. With more trainers, trainings can be more widely exercised. Additionally, current training takes more than 20 hours, which is sufficient but may be too long for the general population to take part in. More simplified courses may be necessary to graduate more trainees.

(6) Use of helicopters should be well planned.

The total number of helicopters in many organizations, and their purpose, capacities, and logistics support should be planned, and this information should be made available to each owner. In addition, air traffic control needs to be ensured so that helicopters can work in cooperation with rescue teams to preserve the silence needed at times in search and rescue.

(7) Resource inventories should be organized and checked.

Various resource attributes, such as types, capacity, and location should be inputted into a GIS inventory database for disaster management use. Collected data from various organizations should be cross-checked on a uniform basis, starting with their locations.

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

Drill should include AYM and AKOM members, volunteers, and citizens. Drills should be made simultaneously in various places. The inter-operation between different service groups should be tested. Use of key equipment, such as helicopters or radio, should be tested. Identifying issues and problems during the drill and improving the current system should be the main objective of these drills.

(9) Building damage inspection should be carried out in a shorter amount of time.

To conduct inspection more rapidly, professional engineers from Chambres of Engineering should be involved. Inspection done by professionals on a volunteerbasis can be used to meet the urgent demands of residents and may be used as a reference for the evaluation. In addition, theofficial results of evaluations should be provided to the municipality so that it has information to work with in its reconstruction efforts.

(10) Evaluation of ground study results should be properly used. .

After the Izmit Earthquake, ground studies before construction have become a requirement when deemed necessary. However, ambiguity still remains in the interpretation of the study results. Communication between civil engineers, geophysicists, and geologists working on ground studies should be required to make and ensure balanced engineering decisions.

Chapter 4.
Civil Society Organizations for Disaster Management

Chapter 4. Civil Society Organizations for Disaster Management

Civil societies are defined as autonomous social units and organizations, such as voluntary associations, private companies, families, professional associations, etc.

After the two earthquakes on the 17th of August and the 12th of November in the Marmara Region, many civil society organizations were newly established and existing ones had become active in developing their capacity to work with international development cooperation agencies and foreign civil society organizations. Civil societies, as defined above, are growing in size and influence.

More than 3 years have passed since the Izmit Earthquakes. In that time, some of the organizations that mushroomed during the disaster have had decreases in the number of their staff, thus shrinking their activities. Some have split up because of ideological differences among members. However, overall, civil society organizations have continued to develope their capacities through the emergency response and recovery process of the earthquake disasters.

Civil society organizations have different legal frameworks. Despite their limitations, they are searching for the best solutions to fit their aim and goals. The following recommendations are made to increase the effectiveness of the civil society organizations, with special reference to disaster management:

(1) Flexibility for civil society organizations

Disaster mitigation initiatives need a holistic approach, with participation from different parts of the society, and a strong network among communities. The current legal status of 'dernek' prohibits civil society organizations from taking part in more than one initiative at a time. This constrains the effective use of civil society organizations indisaster management activities.

The legal status of civil society organizations is rather complex in Turkey; which in turn causes problems and concern for their smooth activities. It is necessary to create a simplified legal framework for non-profit organizations. All the civil society organizations should be put into a single category according to their effective service to the society with regards to disaster management.

(2) Proper resource utilization and management for civil society organizations

Most civil society organizations run on voluntary contributions from their members, in terms of time and resources. Most members have other primary jobs, and civil society activities are part of their volunteer work. Any successful initiative needs professional input and involvement, and resources are one of the key factors for its sustainability. Thus, proper resource utilization and management will be the key factor for the sustainability of civil society organizations in disaster management.

(3) Appropriate allocation of responsibility

Focusing specifically on disaster management, it has been observed that there exist a considerable number of civil societies with the operation mandate of search and rescue (SAR). Also, there are operational focus overlaps between government organizations like fire-brigades, civil defense, the army, etc., and that of civil societies for SAR. There should be clear-cut and pre-defined roles for public authorities and civil society organizations, where the latter can play more effective roles in the "soft" aspects of the SAR.

(4) Motivation for strengthening buildings

It has been observed from recent earthquakes in Turkey and elsewhere that building collapse is the major cause of casualties, and, thus, the strengthening of buildings is needed to save the maximum number of lives. Awareness raising initiatives in the communities are needed, and civil society organizations can play a significant role in this aspect by helping to motivate people's support for this effort.

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

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

5.1. Proposal for Future Actions

The following strategies and actions are recommended for effective community-based disaster management in Istanbul, with a focus on community participation and interdisciplinary approaches:

Basic strategies are summarized in three areas: information sharing, resource management and networking, and institutionalization.

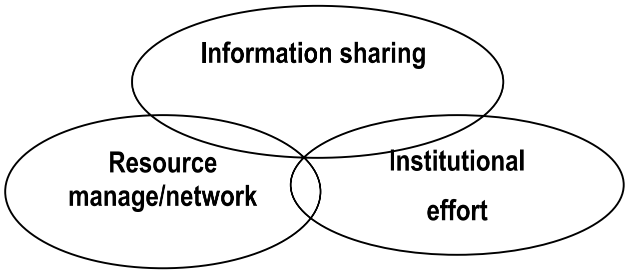


Figure 5.1.1 Strategy for Community-Based Disaster Management

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. Citizens, especially, need to be informed of the hazard and risk of each district. Based on these facts, a disaster management plan should be developed. Lessons learned from past earthquakes need to be integrated into the participatory planning process not only between public sectors and civil society of the locality, but also those of disaster affected areas and academic and professional societies. The following activities are proposed:

Activity 1.1: Publicize information on hazard and risk assessment to citizens.

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

Activity 1.3: Intergrate past earthquake experience and lessons into current planning efforts.

Activity 1.4: Promote participatory planning processes at the citizen level.

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

Strategy 2: Resource management and networking

Appropriate amounts of human resources, funding, and space are necessary to promote community-based activities in disaster management. Open space and community space for local activities could become a focal point in promoting community-based activities for the betterment of the local services. This in turn will lead to increased total resilience. The Disaster Management Centre of each district should be linked with other Disaster Management Cenyres as part of larger-area collaboration. Furthermore, local organizations need to be linked together.

In general, there has been a strong focus on SAR as a community initiative. While SAR is undoubtedly an important tool during a disaster, it is also necessary to provide more emphasis and resources into strengthening buildings and motivating people to action for creating a safer living condition before a disaster.

The natural flow between activities at normal and emergency times needs to be designed for effective disaster mititigation and management. The following activities are recommended for this purpose:

Activity 2.1: Create community spaces for daily activities.

Activity 2.2: Prepare disaster mitigation tools at the community level.

Activity 2.3: Promote and implement the retrofitting of buildings as a community initiative.

Activity 2.4: Enhance networking between disaster management centres.

Strategy 3: Institutionalization efforts:

It is important to institutionalize efforts by creating citizen groups and leaders in order to sustain community-based disaster management. The muhtars, or elected chiefs of each mahalle, can play key roles as part of a network hub among provincial governments, district municipalities, local institutions, and academic and private sectors, since muhtars have both a channel of communication to district municipalities and the provincial government through Kaymakam, and further personal contact networks in general.

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 recognize the units as their own and share and pursue common interests amongst the residents. One recommendation is that smaller units within each mahalle, such as neighborhood, street, or housing units or apartment buildings, be identified in a disaster management framework, and activities can be defined for each unit. Collective housing units are especially common in Istanbul and apartments can be the smallest unit for community-based activities.

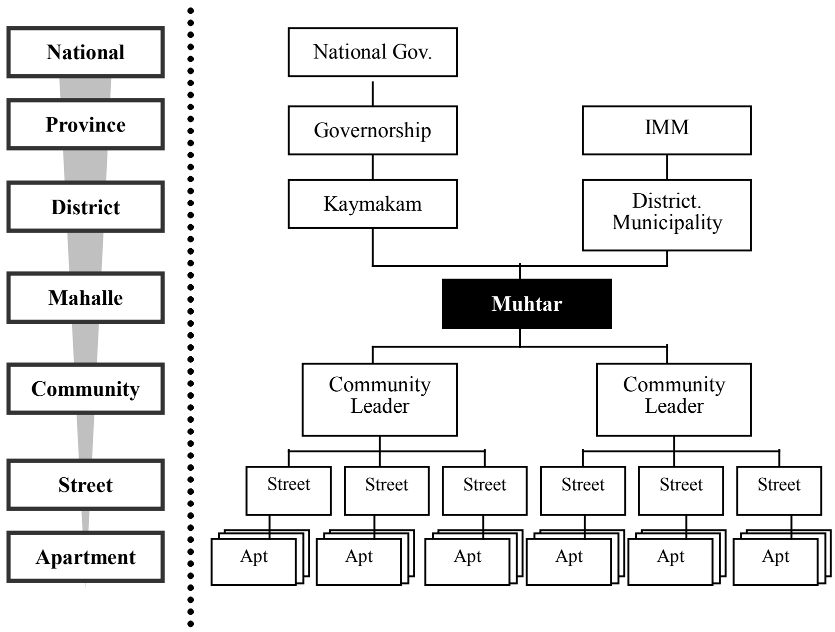
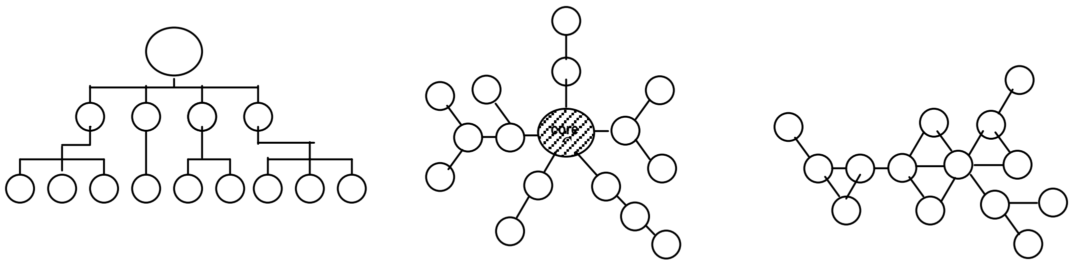


Figure 5.1.2 Institutionalizing Muhtars, or Elected Mahalle Leaders, as Network Centre Hubs

Self-reliant social organizations based on human networks in the local area are a key driving force. It is ideal in terms of sustainability that these organizations work steadily and include disaster management aspects in improving social welfare or the local living conditions. .

Institutionalizing community-based self-reliant organizations includes three types of communities: namely, umbrella, core and network. In the umbrella organizations, a vertical chain of command is strengthened and a strong representative organization coordinates all the organizations below it. While in the network organizations, there is no hierarchy but each organization is inter-related with one another. The core organizations lie in between the other two. The core organization acts as a hub for combining all of the organizations. The type of the community organization depends on the style of the existing organizations, and the intervention of the district municipality of the area, but the important issue is how to inter-link the community activities effectively among community based organizations and public authorities.



Umbrella Hub Network

Figure 5.1.3 Different Local Organizations Styles

It is important to include university professors and professionals (such as chamber of engineers, attorneys, etc.) for advice. It is recommended that district municipalities institutionalize a system that provides such professionals to community-based activities upon request.

The following activities are recommended for this purpose:

Activity 3.1: Identify smaller units within mahalles, such as neighborhoods or streets.

Activity 3.2: Enhance activities at the neighborhood level within each mahalle.

Activity 3.3: Identify different stakeholders in the community, and strengthen the network between them.

Activity 3.4: Define role sharing and specify the responsibilities of each stakeholder.

Activity 3.5: Enhance professional input for community building and planning.

Chapter 6. Earthquake Analysis

6.1. Scenario Earthquake

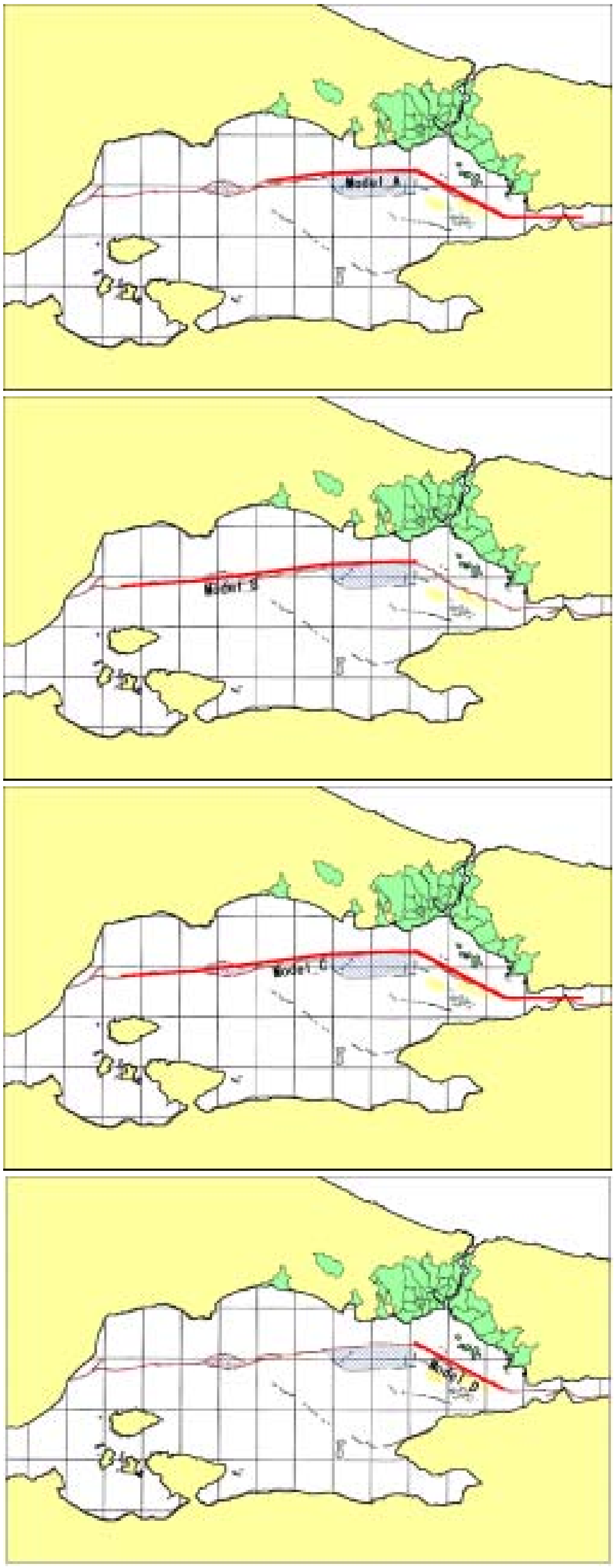
Based on discussions with institutesand researchers relevant to this investigation and the recent increase of research work on the North Anatolian Fault (NAF), the earthquake scenarios were developed so as to reflect appropriate damage estimations for disaster prevention planning.

Four earthquake scenario models were determined as shown inFigure 6.1.1.

Model A: This model considers an approximately 120 km long section from just west of the 1999 Izmit Earthquake fault to Silivli. This model is the most probable of the four earthquake scenarios because the seismic activity is progressing to the west. The moment magnitude (Mw) is estimated to be 7.5.

Model B: This model considers an approximately 110 km-long section from the eastern end of the 1912 Murefte-Sarkoy Earthquake fault to Bakılköy. The moment magnitude is estimated to be 7.4.

Model C: This model presumes a simultaneous rupture of the entire 170 km section of the NAF in the Marmara Sea. The moment magnitude is estimated to be 7.7. If a rupture of the maximum length of the faults is assumed, this is the worst case within reason. Model D: This model considers the continuous fault found in the northern area of the Marmara Sea that follows the base of the northern steep slope of the Çinarcık Basin. A normal fault model was developed, following the northern slope of the Çinarcık Basin. This model was developed with reference to many recent research efforts. The moment magnitude (Mw) is estimated to be 6.9.



Model A

Model B

Model C

Model D

Figure 6.1.1 Scenario Earthquakes

6.2. Ground Motion

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. A compiled ground classification map is shown in Figure 6.2.1.

Based on the fault model, peak acceleration, peak velocity and acceleration response spectrum are calculated with selected empirical attenuation formulae that can explain the observed data during the August 17, 1999 Izmit Earthquake.

Subsurface amplification was evaluated with an amplification factor for each site class. It was classified by average S wave velocity over the upper 30m (AVS30) of surface soil. 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.

The PGA distribution maps are shown in Figure 6.2.2 toFigure 6.2.5. Refer to the main report for PGV and Sa distribution maps.

a. Model A

In this scenario, acceleration exceeds over 400 gals in the seashore of the European side and Adalar. The valley following north from Haliç also suffers acceleration in excess of 400 gals. Acceleration from Eminönü to Büyükçekmece ranges between 300 and 400 gals. In the majority of areas of the New City, Çatalca, and Silivri the acceleration ranges between 200 and 300 gals. The Asian side suffers almost entirely less than 300 gals except in the seaside area.

b. Model B

The PGA distribution of the European side is similar to Model A. However, in this scenario, the majority of the Asian side area suffers less than 200 gals except in Adalar, Kadıköy, and Üsküdar.

c. Model C

The seaside area of Bakırköy and part of Adalar experience more than 500 gals. Accelerations of over 400 gals are estimated in Tuzla, from Fatih to Avcılar, and in the valley extending to the north from Haliç. The area with 400 to 500 gals is a little wider to the north, compared to Model A. Every grid experiences the largest PGA values in this model, compared to values among the four scenario earthquakes.

d. Model D

Parts of Adalar and Bakırköy experience accelerations of more than 400 gals. Bakırköy and a part of Tuzla suffer 300 to 400 gals. Areas from Eminönü to Avcılar, and the Asian seashore experience 200 to 300 gals of acceleration.

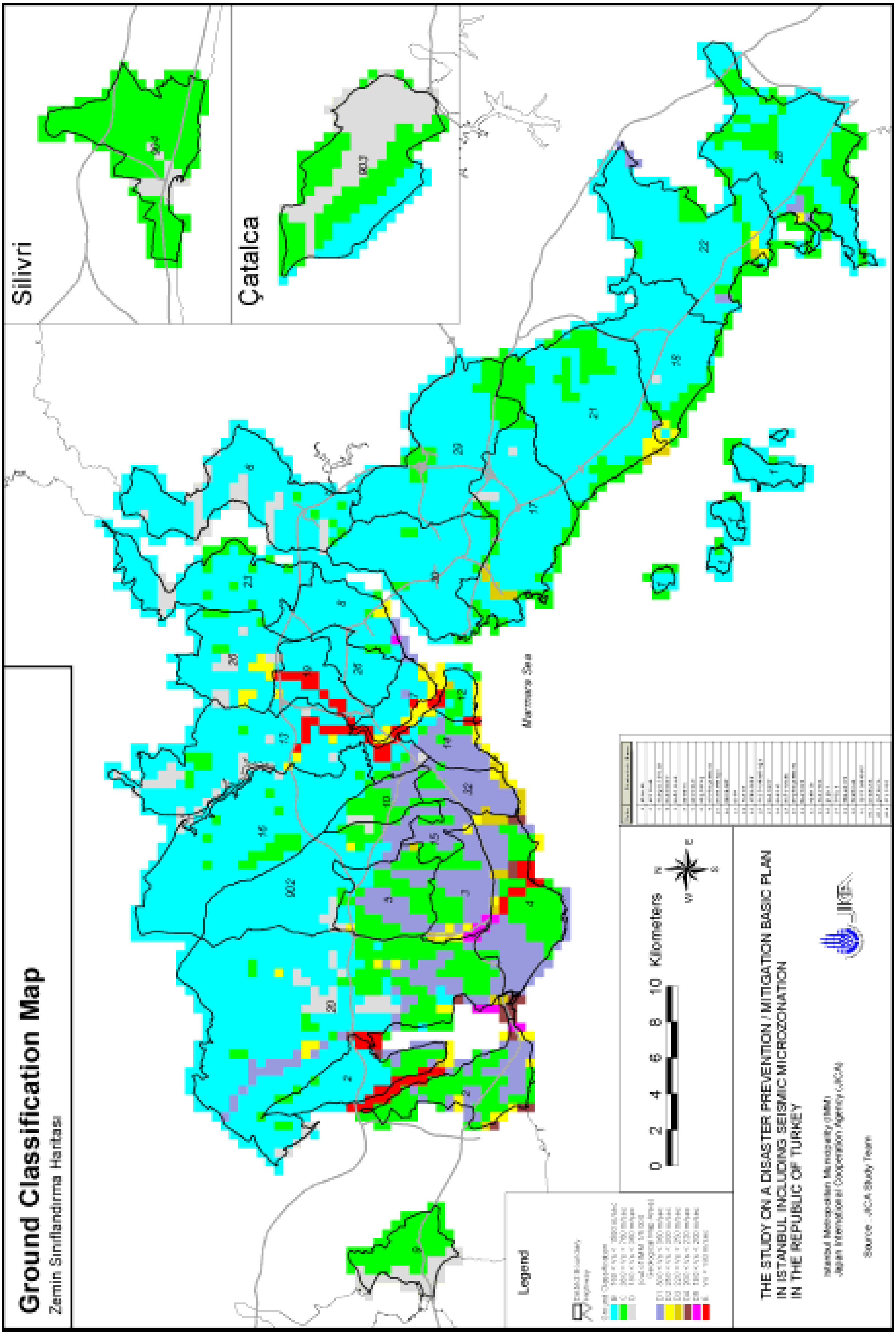


Figure 6.2.1 Ground Classification Map

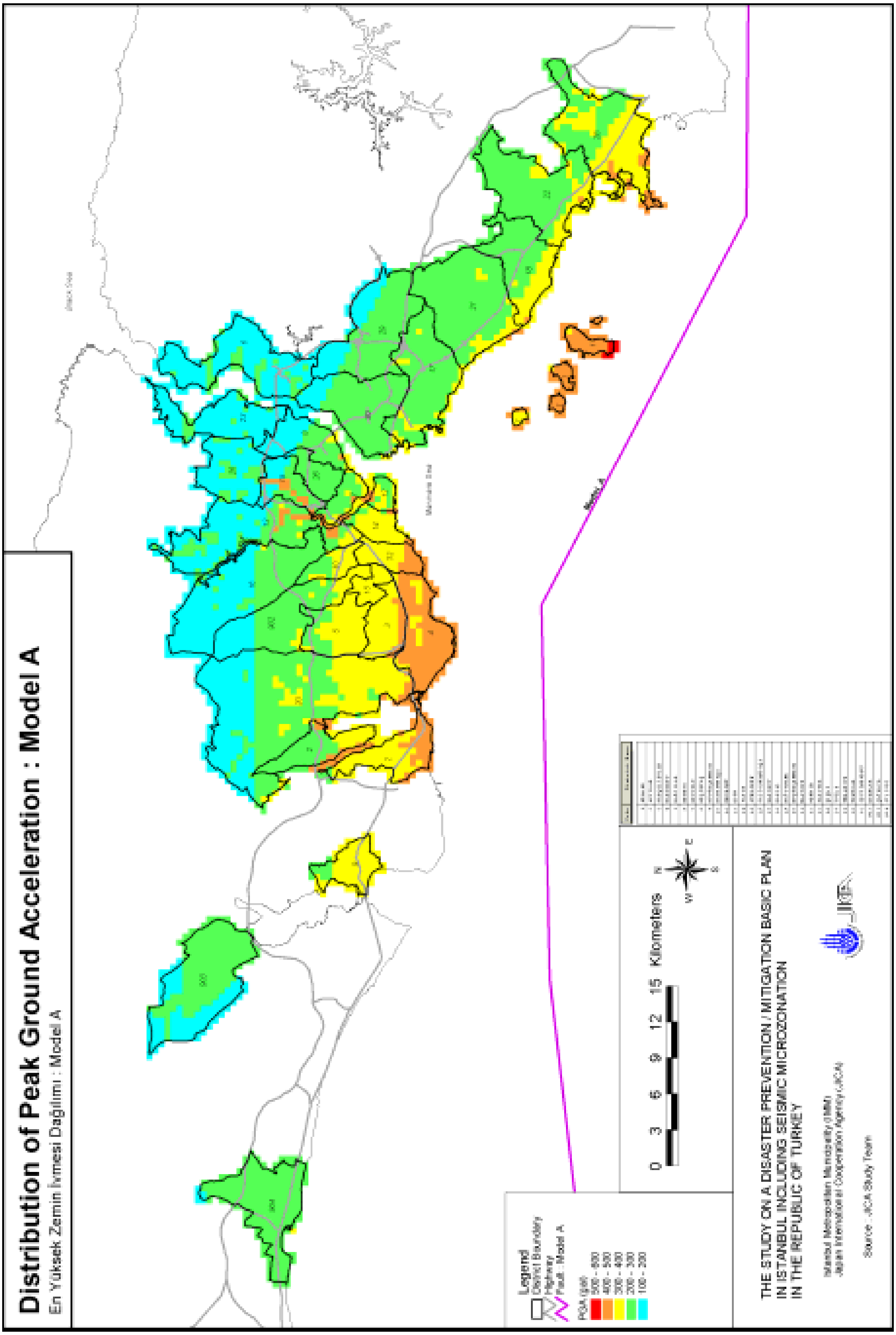


Figure 6.2.2 Distribution of Peak Ground Acceleration: Model A

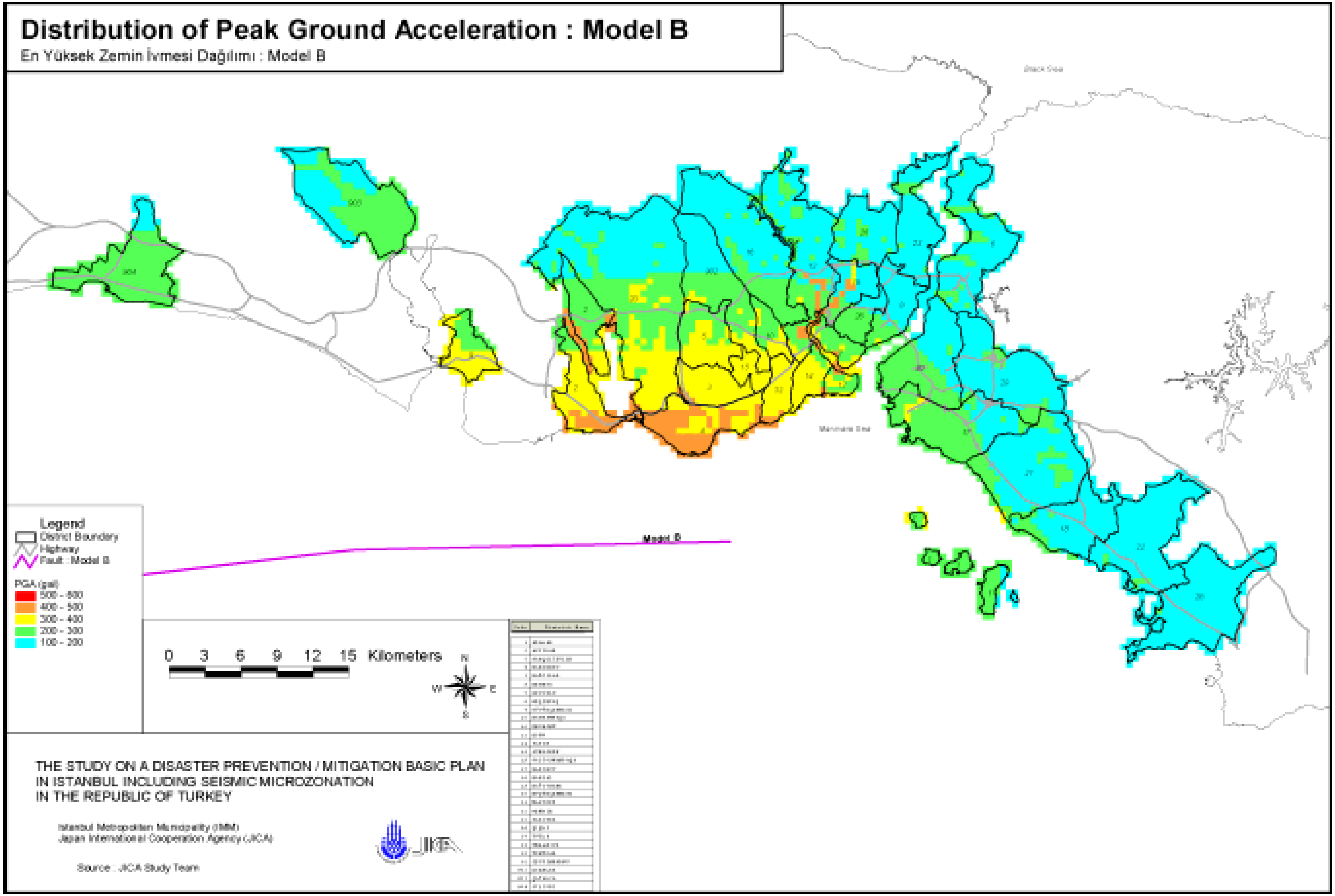


Figure 6.2.3 Distribution of Peak Ground Acceleration: Model B

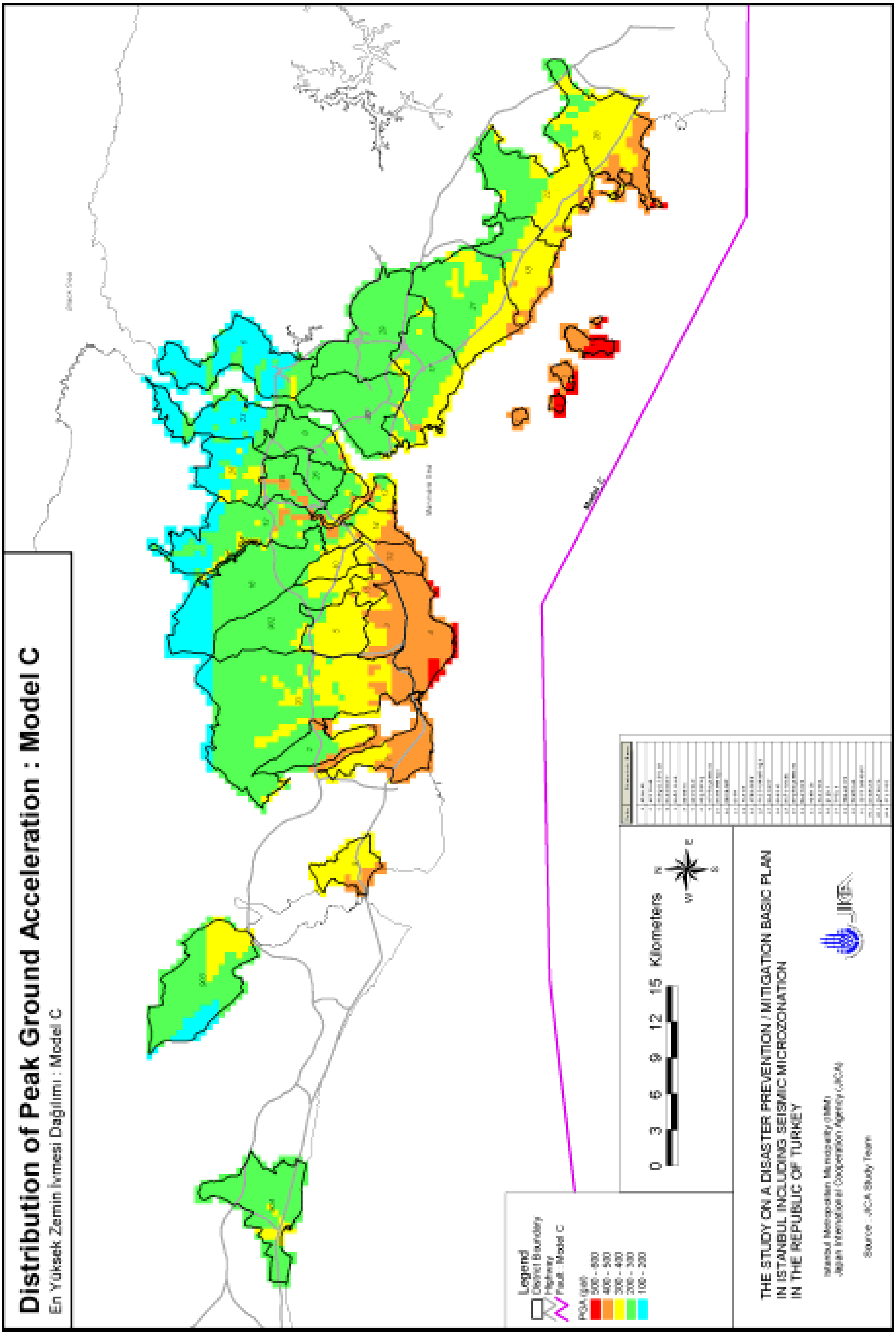


Figure 6.2.4 Distribution of Peak Ground Acceleration: Model C

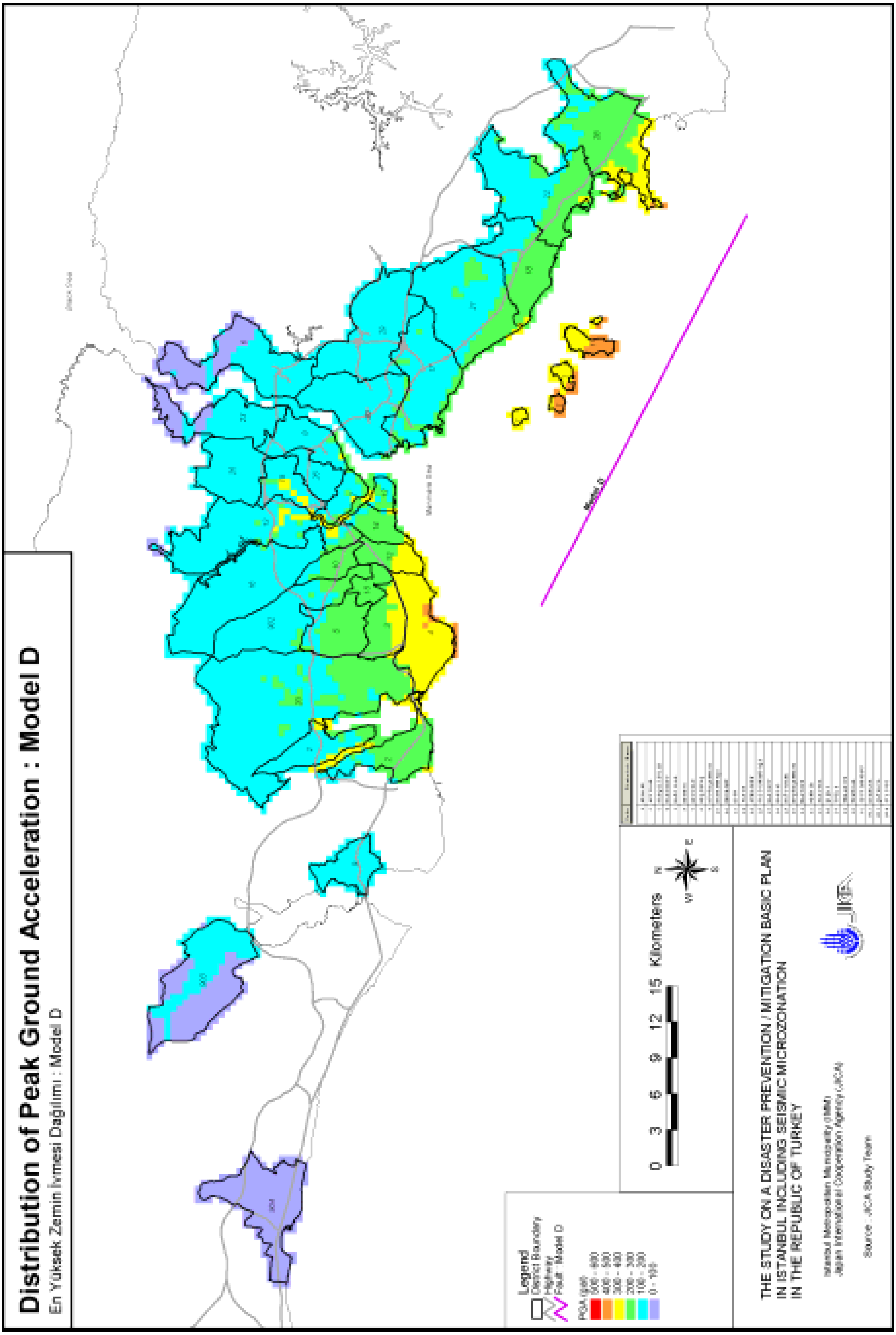


Figure 6.2.5 Distribution of Peak Ground Acceleration: Model D

6.3. Evaluation of Liquefaction Potential

6.3.1. General

The evaluation of the liquefaction potential is conducted according to the Method Grade 3 of "Manual for Zonation on Seismic Geotechnical Hazards" by TC4, ISSMFE (1993). 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. Man-made ground and Quaternary deposits are the focus of the evaluations. The 500 m grid system used in the earthquake analysis is modeled in this analysis as well. Figure 6.3.1 shows a flow chart of liquefaction potential analysis.

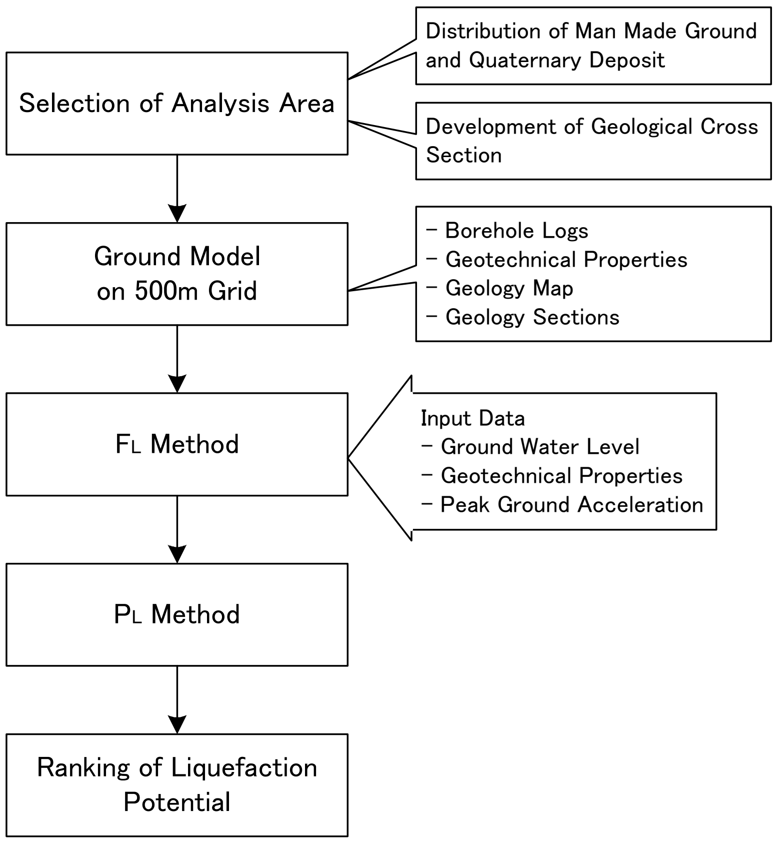


Figure 6.3.1 Flowchart of Liquefaction Analysis

6.3.2. Condition of the Analysis

(1) Analyzed Area

From the particle size distribution, Yd, Qal, Ksf, Cf, and Sbf are characterized as sandy soil or have sandy soil layers. However, 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. Tertiary deposits (Çf, Sbf) also have obviously higher N-values than man-made ground (Yd) and Quaternary deposits (Qal, Kşf). Therefore, the liquefaction potential study is conducted only in the areas where man-made ground (Yd) and Quaternary deposits (Qal, Kşf) are found.

(2) Setting up of the Soil Parameters

The soil parameters necessary for the study are the 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 using the following data:

- The boring logs are based on the boring conducted by the Study Team in the analyzed areas (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).

Table 6.3.1 lists the chosen parameters.

Table 6.3.1 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

The underground water level used in the calculation has been set as GL-1m. This takes intoconsideration the shallowest underground water level observed during boring work by the Study Team and in the observation holes.

(4) Modeling of the ground

Cross-sections of soil layers are prepared based on the seven (7) geological classes (Man-made Ground, Qal-Clay, Qal-Sand, Qal-Gravel, Ksf-Clay, Ksf-Sand, and Ksf-Gravel) covering the man-made Ground and Quaternary deposits. Then, three dimensional soil layer constitutions are estimated based on the cross-sections and configuration of the soil. Model columns of the soil layers are prepared, using 500 m grids (units for seismic motion calculation), and employing an average soil constitution in each grid. The liquefaction study is carried out (179 grids) in specific places where soil data is available. Models are set up covering soil layers from the ground surface down to 20 m of depth or less.

(5) The peak ground acceleration

The peak ground acceleration obtained from the result of the earthquake analysis is included in the calculation. The liquefaction studies are carried out for two earthquake scenario cases, Model C and Model A.

6.3.3. Liquefaction Potential

The results of the analysis for each grid are presented in the Supporting Report. These results are summarised in Table 6.3.2.

Figure 6.3.3shows the distribution of liquefaction potential in the case of Model C.

Table 6.3.2 Summary of the Liquefaction Analysis

Liquefaction Potential	Criterion	Explanation	No. of Grid	
			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 6.3.2 shows the liquefaction analysis results by districts. The ratio of the area examined in the liquefaction analysis for the liquefaction potential is 17%. Liquefaction analyses were not conducted in the Adaral, Büyükçekmece, Bayrampaşa, Saryer, Şişli, Esenler, Çatalca, and Silivri districts. The districts whose area was evaluated “Very High” (Model C) and was greater than 40 ha were Küçükçekmece, Eyüp, Avcilar and Beyoğlu.

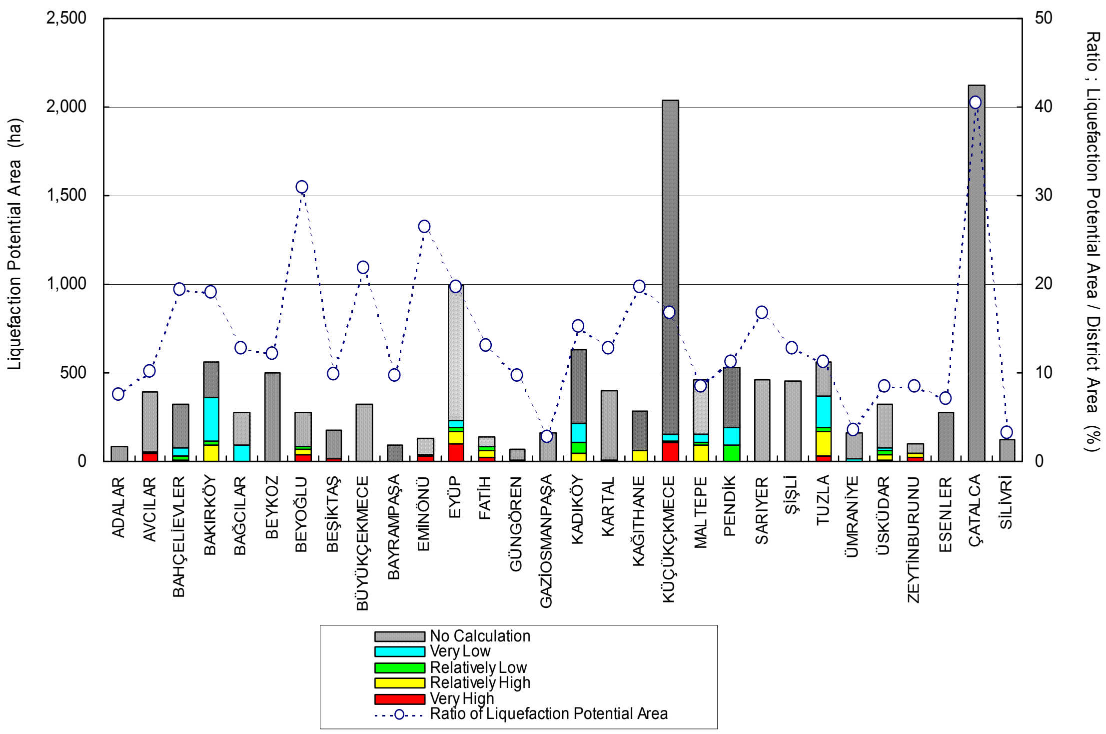


Figure 6.3.2 Liquefaction Analysis Results by Districts (Model C) and Ratio of Liquefaction Potential Area

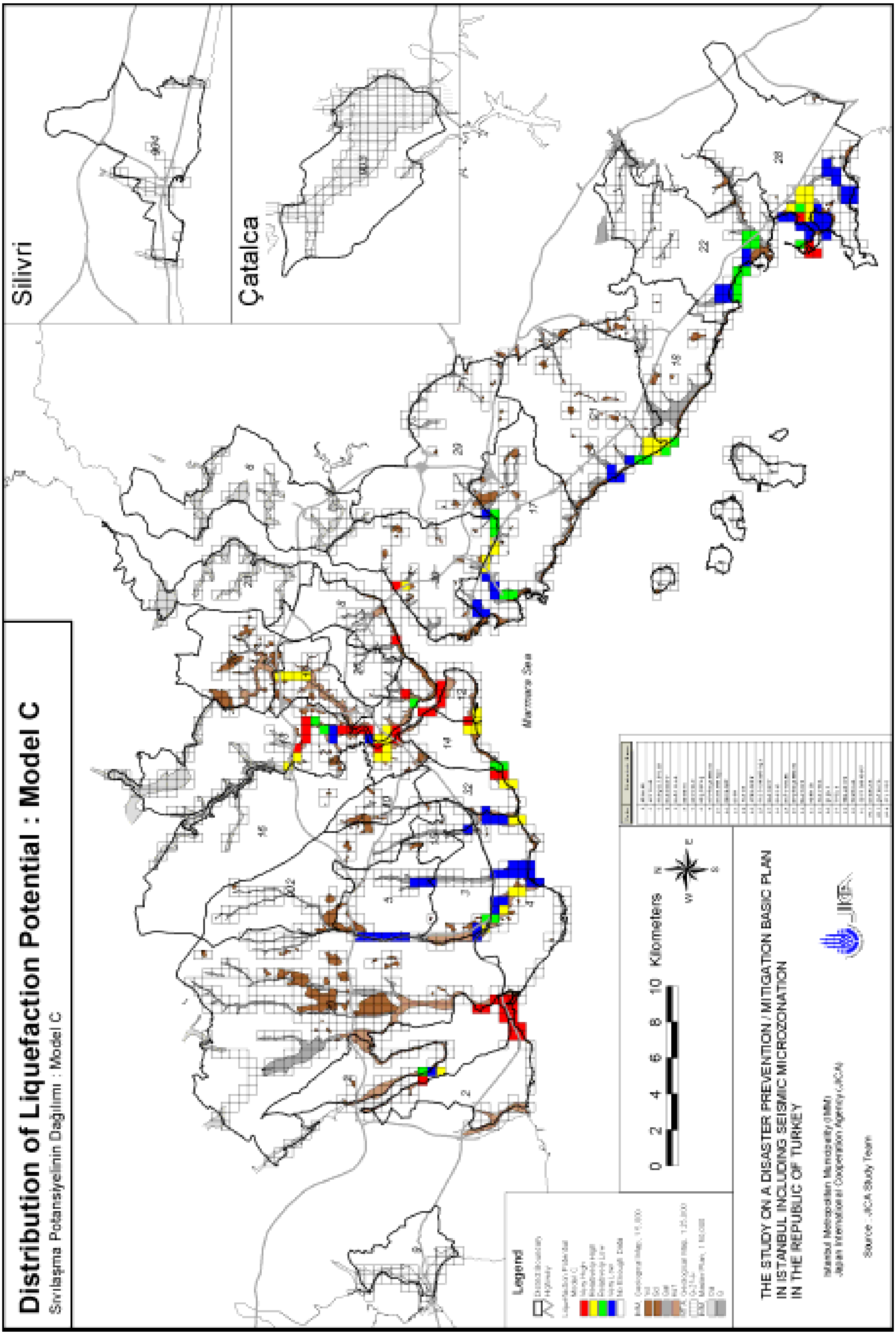


Figure 6.3.3 Distribution of Liquefaction Potential: Model C

6.4. Evaluation of Slope Stability

6.4.1. Method of Slope Stability Evaluation

(1) Present Topographic Condition and Slope Stability Condition

The types of major slope failure in the study area are classified as follows:

Area of Rock Formation

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.

Area of Tertiary Formation

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

Bilge Siyahi (1998) studied a procedure of slope stability for microzonation purposes. Safety factor *Fs* for slope stability is induced as

$$Fs = N_1 \tan\phi \qquad \text{(eq.6.4.1)}$$

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 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 value of ϕ can be determined or estimated.

The slope gradients for each of the 50-m grids covering the Study Area are calculated first. Then the slope stability of each point is judged, using Siyahi's equation (eq. 6.4.1) by taking the peak ground acceleration value and strength of soil into account. A score of $F_i = 0$ for a stable point ($Fs > 1.0$) or $F_i = 1$ for an unstable point ($Fs < 1.0$) is given.

a. Slope Stability Evaluation for 500m Grids

There are a total of one hundred 50 m grids in every 500 m grid and the stability score for a 500 m grid is determined as follows:

$$\text{Unstable Score}\,(\text{500m Grid}) = \sum_{i=1}^{100} \text{Score}\, F_i\,(\text{50m Grid})$$

$$F_i\,(\text{50m Grid}) = 1\,(\textit{unstable}) \quad \textit{or} \quad 0\,(\textit{stable})$$

If all of the 50 m grids are evaluated as unstable, then the 500 m grid is given a score of 100. If all of the 50 m grids are evaluated as stable, then the 500 m grid is given a score of zero. This score directly represents the percentage of 50 m grids in each 500 m grid judged as unstable. Finally, the results are represented by risk for each 500 m grid, as shown in Table 6.4.1.

Table 6.4.1 Evaluation of Risks on Slope Stability for 500m Grid

Unstable Score (500 m Grid)	Risk Evaluation for 500 m Grid
0	Very low
1-30	Low
31-60	High
61-100	Very high

(3) Parameters for Calculation

Slope gradient is determined using a 50 m grid base. Ground motions for scenario earthquake Model A and Model C are considered. Shear strength for each geological formation, which reflect slope failure characteristics, are estimated from existing references.

6.4.2. Slope Stability

(1) Slope Stability Risk

In Model A, "Very High Risk" grids exist in Adalar and Silivri. These correspond to steep cliffs and are not residential areas. "Low Risk" grids exist in Avcılar and Küçükçekmece, and Büyükçekmece. These correspond to residential areas. In Model C, "Very High Risk" grids extend to Avcılar and "High Risk" grids prevail in Büyükçekmece. These correspond to residential areas. "Low Risk" grids extend to Bahçelievler, Bakirköy, and Güngören, and these also correspond to residential areas.

(2) Slope Stability Condition for each District

Slope risks are examined at a more detailed level. An nstable score are summarized for each district.

The stability score for each district is determined as follows:

$$\text{Unstable Score}\left(\text{District}\right)=\frac{\text{Number of Unstable 50m grid}}{\text{Number of 50m grid in the District}}\times 100\ (\%)$$

This score directly represents the percentage of the area in each district judged as unstable. Unstable scores are summarized for each district. Results are shown in Figure 6.4.1. In the Büyükçekmece district, areas of “low risk” and “high risk” prevail. Unstable scores for Model A and Model C are about 3% and 7%, respectively. These areas are characterized by landslides. Unstable areas are concentrated in 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.

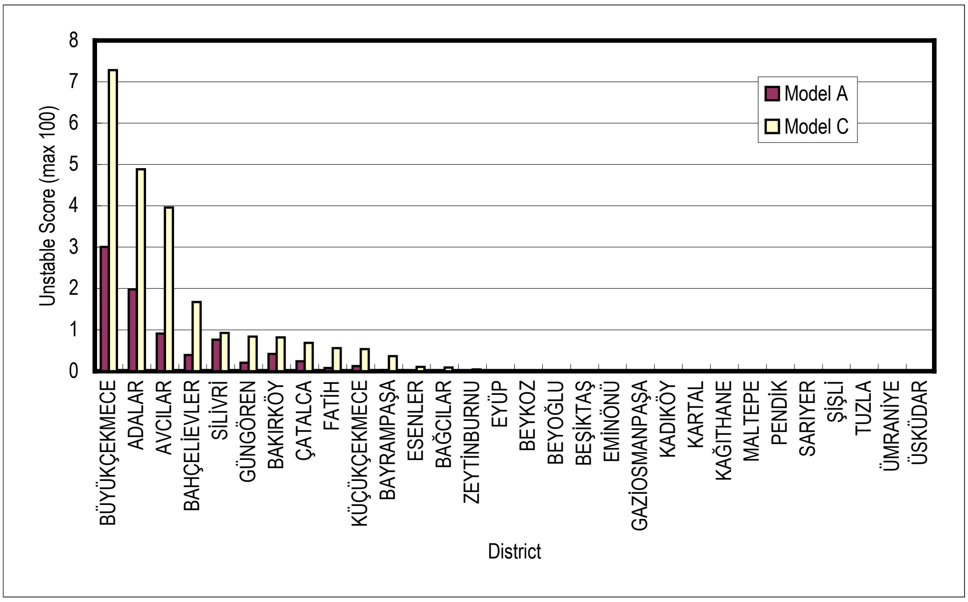


Figure 6.4.1 Unstable Score (Area Ratio) of Slope by District

Souce: The JICA Study Team

Chapter 7.
Estimation of Damages and Casualties

Chapter 7. Estimation of Damages and Casualties

In this study, earthquake damage estimations are conducted for Model A as the most probable case and Model C as the worst case scenarios.

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.

7.1. Buildings

The building inventory database for each mahalle is made from data complied by the Building Census 2000. The number of buildings in each mahalle is shown in Table 7.1.1 by class. To calculate the building damage by mahalle, the seismic motion for each mahalle is calculated from the seismic motion for the 500 m grid cell considering the building density distribution.

The definition of building damage is shown in Table 7.1.2. The "Heavily", "Moderately" and "Partially" damaged buildings are calculated for all types of buildings included in the Building Census 2000. "Heavily" damaged buildings imply that buildings are heavily damaged or collapse and that these buildings are unfit for living without repair or being entirely rebuilt because remaining roofs or walls may eventually collapse. "Moderately" damaged buildings are those that are able to be used for evacuation purposes just after the hazard, but need repair for permanent living. "Partly" damaged buildings are inhabitable, but it is desirable to repair these buildings because of damage to the structure and earthquake resistance has been compromised.

The cause of building damage is limited to the seismic vibration itself. Other causes of damage such as liquefaction, landslides, and fire are not included. This assumption will not affect the results because these phenomena will not be main causes for damage in the considered earthquake disaster in Istanbul.

Damages are calculated for each mahalle and building classification. A summary of the results are shown in Table 7.1.3. In this table, the result of a simulation for the Izmit earthquake is also included. As the building damage for some mahalles is not available, only the damage ratio is shown. The building damage analysis method is calibrated by the damage during the Izmit Earthquake and the Erzincan Earthquake and the simulated results meet the observed damage well. The damage for each mahalle is shown in Figure 7.1.1 and Figure 7.1.2.

The characteristics of damage for the two scenario earthquakes are as follows:

(1) Model A

The total number of heavily damaged buildings is estimated as 51,000. This is the 7.1% of total buildings in study area. The number of moderately or heavily damaged buildings that needs repair to become inhabitable is 114,000. 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. The heavy damage ratio of several mahalles along the coast reaches more than 30%. More than 200 buildings in several mahalles on the European side as well as some mahalle on the Asian Side will suffer heavily damaged buildings. 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 at 59,000. This is 8.2% of the total buildings in Study Area. The number of moderately or heavily damaged buildings that needs repair to become inhabitable is 128,000. The damage distribution is almost the same as as that of Model A. The heavy damage ratio of one mahalle along the coast of the European Side reaches more than 40%. More than 200 buildings in several mahalles on the European Side as well as some mahalles on the Asian side will suffer heavily damaged buildings. It should be noted that more than 400 buildings in Şilivri and Büyükçekmece are also heavily damaged.

Table 7.1.1 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%)

Table 7.1.2 Definition of Building Damage

Object	All buildings in 2000 Building Census	
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 structural damage For evacuation: Unusable, Danger For living: Unusable without repair or rebuild (Damage Grade 4 & 5 in EMS-98)
	Moderately	Moderate structure damag For evacuation: Usable For living: Necessary for repair (Damage Grade 3 in EMS-98)
	Partly	Partly structure damage For evacuation: Usable For living: Usable, repair is desirable (Damage Grade 2 in EMS-98)

Table 7.1.3 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%)		

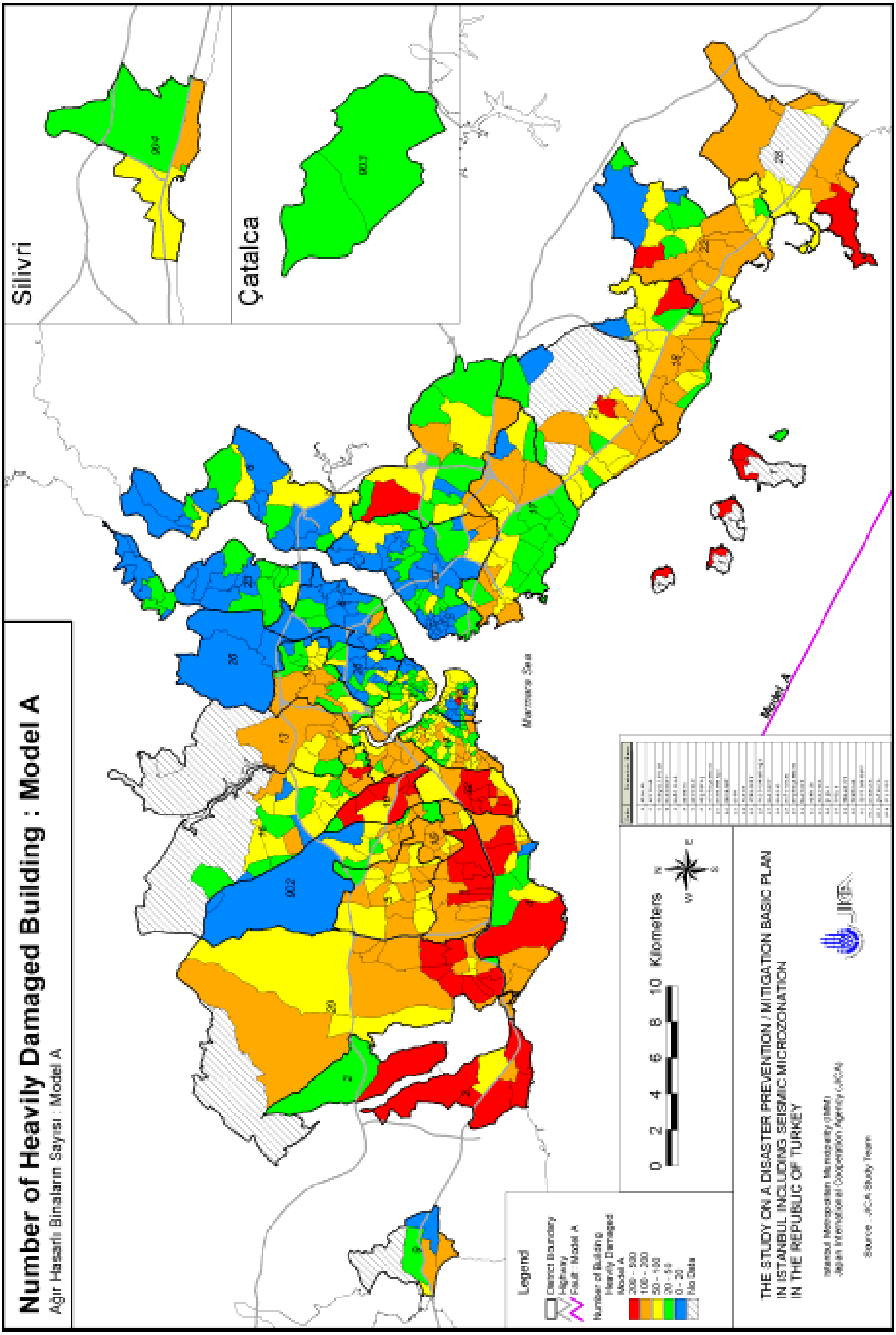


Figure 7.1.1 Number of Heavily Damaged Buildings: Model A

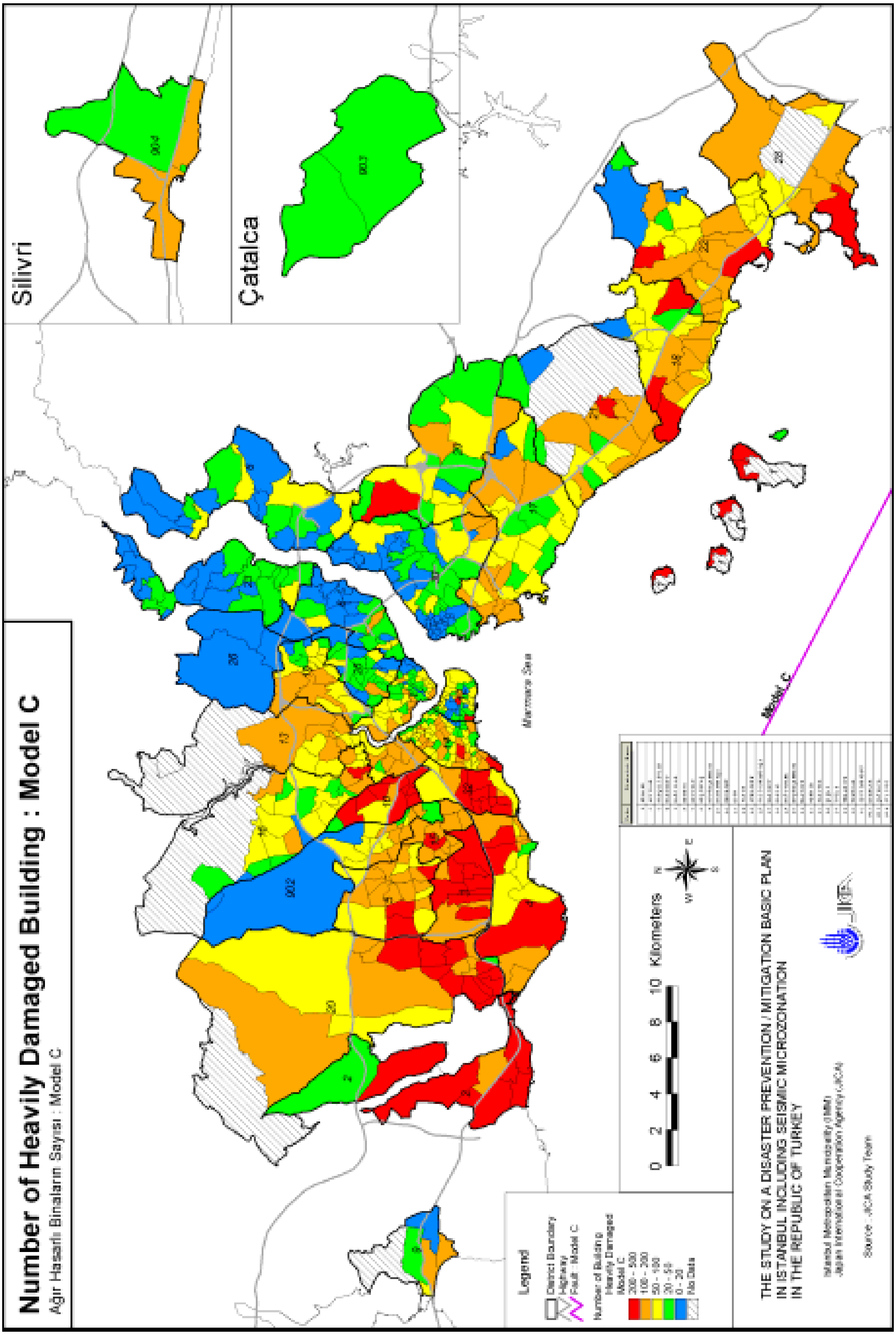


Figure 7.1.2 Number of Heavily Damaged Buildings: Model C

7.2. Human Casualties

Building collapse, as opposed to other factors such as fires, tsunamis, or landslides, will be the most notable cause of human casualties in a future earthquake considering the weakness of buildings in Istanbul. Therefore, in estimating the death toll, the relation between building damage and the death toll is studied based on the earthquake hazard in Turkey. The damage function for the cause of deaths and severely injured people is derived through this analysis. The death toll and the number of severely injured are evaluated based on empirical relationships and building damage distribution. This empirical damage function is drawn in great account from the damage caused by the Izmit Earthquake. Accordingly, the estimated damage is applicable for a nighttime event because the Izmit Earthquake occurred at around 3 AM.

The definition of human casualty damage is shown in Table 7.2.1. In this estimation, the event is assumed to occur at nighttime. The cause of death is mainly building collapse. In large-scale earthquakes, people can also die from disease in refugee camps; those people are not included in this assumption. Most fatalities are assumed to have occurred instantaneously, and the rest are assumed to occur in the few days following the earthquake.

Fatalities are calculated for each district. A summary of results are shown in Table 7.2.2. In this table, the result of a simulation of the Izmit Earthquake is also included. The human casualty analysis method is made from actual earthquake figures from the Izmit Earthquake and the Erzincan Earthquake, and the simulated results reasonably compare to the observed results.

The damages for each district are shown in Figure 7.2.1 and Figure 7.2.2. Characteristics of damages for the two scenario earthquakes are as follows:

(1) Model A

The death toll is estimated at 73,000, 0.8% of the total population in the Study Area. Severely injured people will number in 120,000. In Fatih, more than 6,000 people will die. Adalar shows the highest death ratio at 8.4%.

(2) Model C

The death toll is estimated at 87,000, 1.0% of the total population in the Study Area. Severely injured people will number in 135,000. In Bahçelievler, Fatih and Küçükçekmece, more than 6,000 people will die. Adalar shows the highest death ratio at9.3%.

Table 7.2.1 Definition of Casualty Damage

Time of event	Nighttime event is assummed	
Evaluation unit	Person	
Cause of damage	Mainly building collapse	
Definition of damage grade	Death	- Instant death under collapsed building - Suffocation under collapsed roofs or walls - Trapped in collapsed building and not rescued in sufficient time
	Severely Injured	- Bone fracture, rupture of internal organs, crush syndrome etc., all requiring hospitalization

Table 7.2.2 Summary of Casualty Damage

		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	

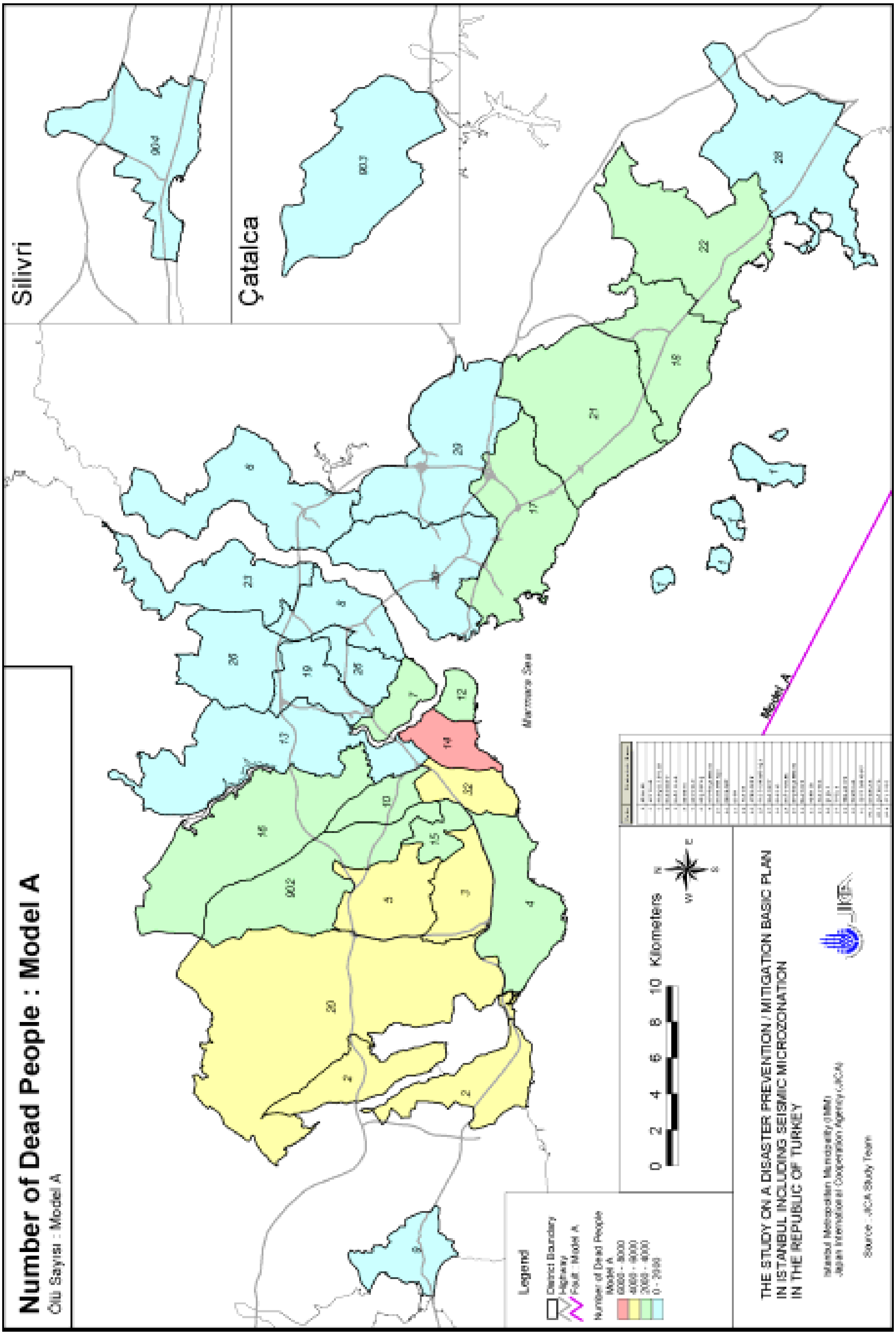


Figure 7.2.1 Number of Dead People (Model A)

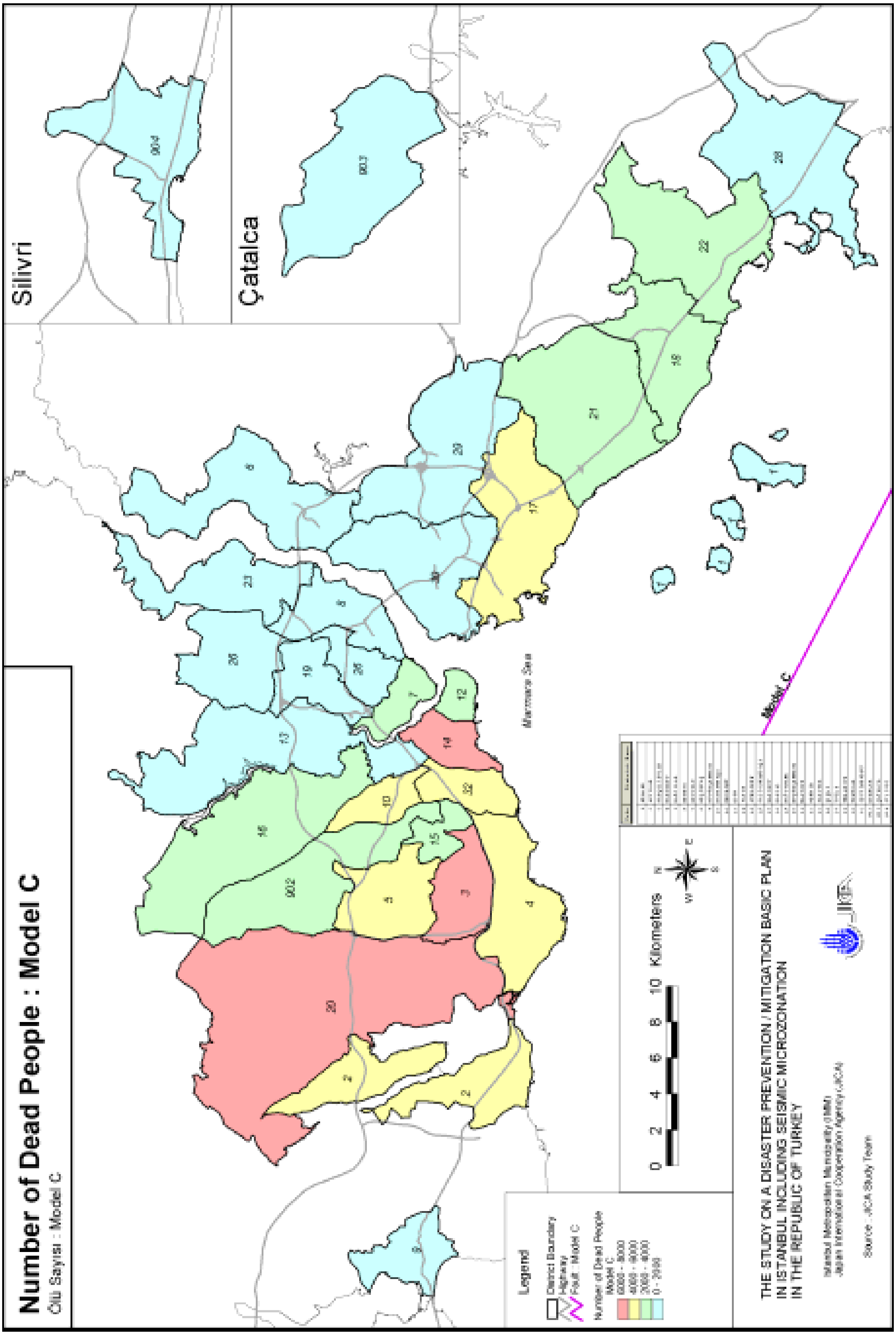


Figure 7.2.2 Number of Dead People (Model C)

Chapter 8.
Evaluation of Urban Vulnerability

Chapter 8. Evaluation of Urban Vulnerability

8.1. Buildings

The first step of the building survey was carried out in order to gain a quantifiable understanding of the earthquake resistance of the buildings in the study area. The investigated buildings are the following two (2) schools:

1) Üsküdar Ticaret Meslek Lisesi (S-1)

2) Hazerfen Ahmet Çelebi İlköğretim Okulu (S-2)

a) Üsküdar Ticaret Meslek Lisesi b) Hazerfen Ahmet Çelebi İlköğretım Okulu

Photo 8.1.1 An Exterior View of Buildings

The results assessed for each direction of each building, $I_{S,}$ are shown in Table 8.1.1.

Table 8.1.1 Assessed Results for Each Direction of Each Building, I_S

a) Üsküdar Ticaret Meslek Lisesi (S-1)

		Index of Basic capacity E_O	Index of Irregularity in Plan S_D	Aged Deteriora-tion T	Seismic Index of Structure I_S
Ridge Direction	5 th story	2.068	0.540	0.800	0.893
	4 th story	1.004	0.540	0.800	0.434
	3 rd story	0.734	0.540	0.800	0.317
	2 nd story	0.645	0.540	0.800	0.279
	1 st story	0.606	0.540	0.800	0.262
Span Direction	5 th story	2.569	0.540	0.800	1.110
	4 th story	1.235	0.540	0.800	0.534
	3 rd story	0.895	0.540	0.800	0.387
	2 nd story	0.771	0.540	0.800	0.333
	1 st story	0.718	0.540	0.800	0.310

b) Hazerfen Ahmet Çelebi İlköğretım Okulu (S-2)

		Index of Basic Capacity E_O	Index of Irregularity in Plan S_D	Aged Deteriora-tion T	Seismic Index of Structure I_S
Ridge Direction	4 th story	1.683	0.600	0.800	0.808
	3 rd story	0.822	0.600	0.800	0.395
	2 nd story	0.632	0.600	0.800	0.303
	1 st story	0.556	0.600	0.800	0.267
Span Direction	4 th story	1.861	0.600	0.800	0.893
	3 rd story	0.909	0.600	0.800	0.436
	2 nd story	0.697	0.600	0.800	0.334
	1 st story	0.613	0.600	0.800	0.294

The *Seismic Index of Structure value, $I_{S,}$* shown in Table 8.1.1 represents the resistivity of the building. This index should be compared to the *Required Seismic Index, I_{SO}* , and then safety against an assumed earthquake can be assessed. The *Required Seismic Index, $I_{SO,}$* for a public facility in Japan is 1.32.

A similar method was applied in the damage investigation of the 1992 Erzincan Earthquake, and the relation between the result value of I_S and the actual damage ratio was compared as shown in Figure 8.1.1.

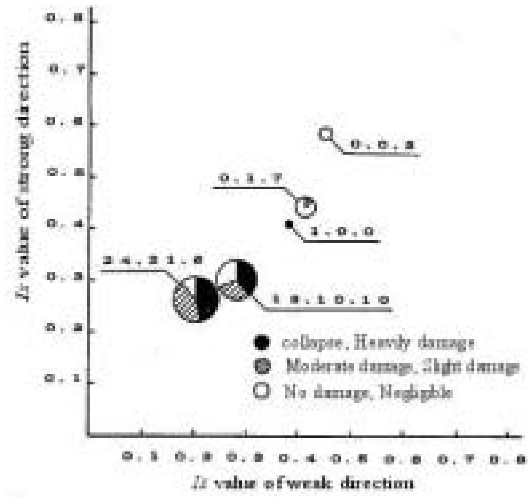


Figure 8.1.1 Relation between the I_S and Actual Damage Ratio (1992 Erzincan Earthquake)

- The buildings which have the value of I_S = 0.4 to 0.5 may sustain slight damage under the condition of the 1992 Erzincan Earthquake.
- Half of the buildings which have the value of I_S approximately 0.2 may reach the point of collapse or be heavily damaged under conditions similar to those of the 1992 Erzincan Earthquake.

The lowest I_S values for the first stories of each of the investigated buildings are 0.262 for Üsküdar Ticaret Meslek Lisesi and 0.267 for Hazerfen Ahmet Çelebi İlköğretim Okulu. Therefore, it is possible that these buildings may collapse or be heavily damaged under the conditions similar to those of the 1992 Erzincan Earthquake. It is then easily presumed that most school buildings have similar earthquake resistance problems because the design of the school buildings investigated are based on government school building design standards.

Additionally, there are some remarkable points that show why these buildings do not have sufficient earthquake resistance (details are contained in the main report).

Having derived a description of the earthquake resistance of the buildings, it can be said that most public facilities in Istanbul lack sufficient earthquake resistance, and it will be very difficult to improve the earthquake resistance of these buildings to be able to adequately respond to the motion assumed in the earthquake scenarios used in this study and, therefore, also difficult to prevent their collapse.

It is recommended that a detailed investigation of each and every public facility be carried out. If the results of these buildings are poor, it is advised that these buildings be demolished and reconstructed.

However, there may be an alternative policy where the maximum effort is carried out under limited resources. In the main report some important examples of Istanbul engineering efforts are reviewed, and some important examples of Japanese engineering are introduced.

8.2. Major Public Facilitities

Many major public facilities have critical roles in the event of an earthquake, serving as offices of disaster management, evacuation shelters, and medical facilities, for example. Earthquake damage to public facilities will impact physical, social, and economical aspects of human lives. Therefore, it is important to have earthquake resistant public facilities. In this section, damage estimations for the following public facilities are given:

1) Educational facilities: primary and high schools

2) Medical facilities: hospitals, and clinics

3) Fire fighting facilities: fire fighting station

4) Security facilities: district police (ilçe emniyet), police, and gendarme (jandarma)

5) Governmental facilities: ministry, provincial and municipal

In general, building structures of public facilities are different from regular buildings. Hence, the fragility function for the damage estimation must be set specifically for public facilities. However, sufficient current data was unavailable and it was not possible to determine the fragility function for public facilities. Therefore, the damage estimation for public facilities is conducted using the measure of damage estimation for all buildings as discussed in the previous chapter.

Consequently, for further analysis it is necessary to remember that the damage estimation for major public facilities was determined with all building functions in mind. The drawbacks of such an approximation are stated below.

1) The fragility functions for all buildings include not only buildings whose structures are similar to those of the public facilities, but also other buildings. Thus, the resulting damage estimation does not entirely represent public facilities, which often have unique structures.

2) Public facilities are generally made stronger than regular buildings. Therefore, the predicted damages may be overestimated.

Also, some public buildings that were being seismically retrofit were not considered in this damage estimation.

Under these circumstances, the damage estimation conducted was that for the major public facilities in the entire Study Area as a whole. However, the damage estimation for the public facilities of each individual district was not estimated. Significant damages to major public buildings were identified through comparison with the damage to all of the buildings stated in the previous chapter.

8.2.1. Facilities Data

The parameters of the data used for the earthquake scenario study is shown in Table 8.2.1 below. The detailed data is cited in the Supporting Report.

Table 8.2.1 Data and Parameters

Data		Unit	Structure	Story	Construct-ion 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 ( ) indicates when the data was provided to the Study Team.

8.2.2. Characteristics of the Facilities

Data on public facilities, such as building structure type, number of stories, year of construction, and earthquake intensity, are summarised in Figure 8.2.1.

8.2.3. Results of the Damage Estimation

The damage rate of the major public facilities is similar to that of all buildings, with the exception of fire fighting facilities. The damage rate of fire fighting facilities is lower than that of all the other buildings. This may be possible because the buildings are built using reinforced concrete and have heights lower than or equal to 3 stories. However, fire fighter stations are inherently weak structures against earthquakes because the first floor of the building, a garage, has only three (3) walls made of brick and the rest of the building is usually open to the street.

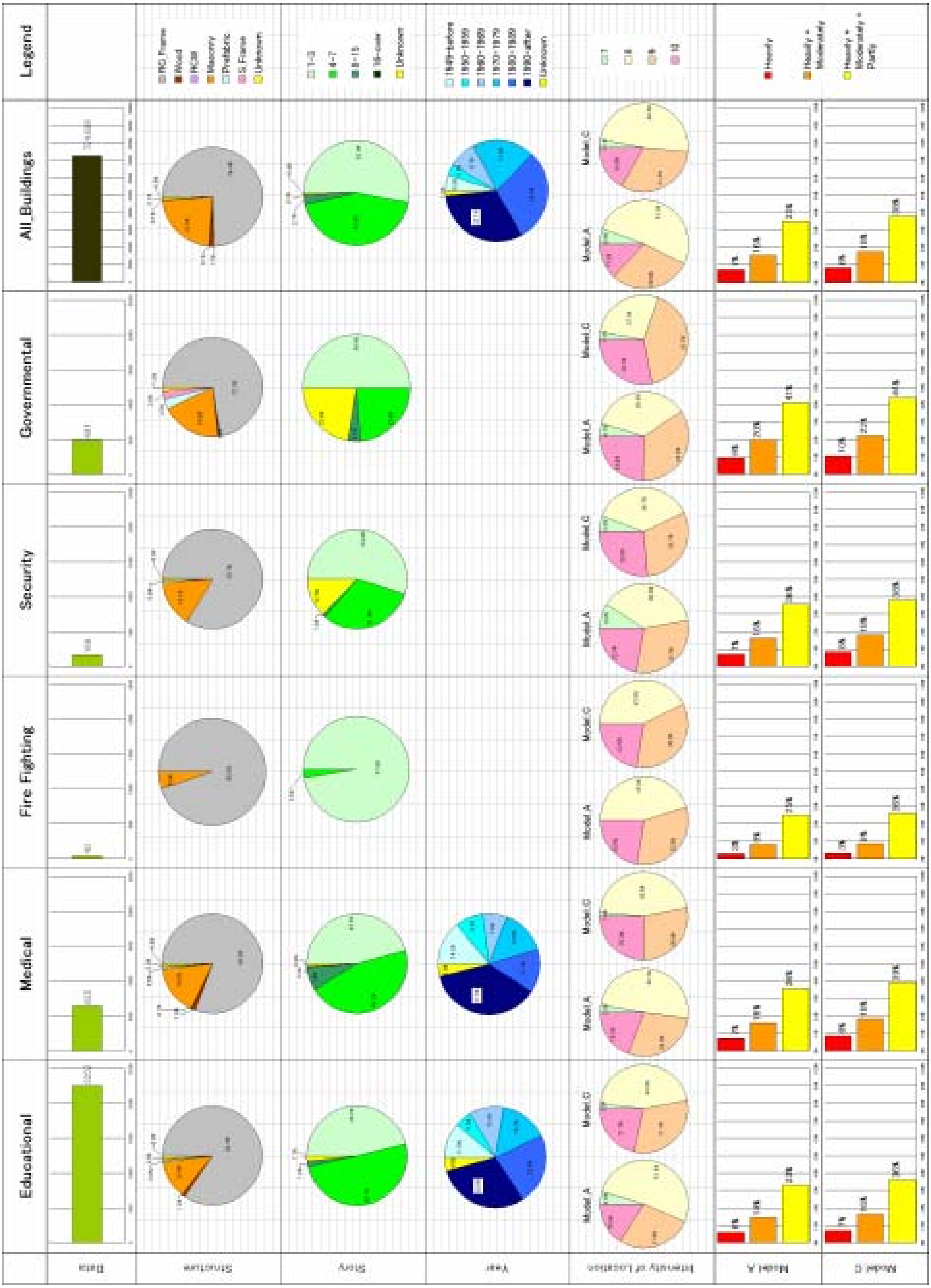


Figure 8.2.1 Characteristics of Public Facilities and Results of the Damage Estimation

8.3. Fire

During an earthquake, many fires will break out from many facilities and buildings. The possibility of fire from dwellings is strongly affected by the local situation, namely the fuel used for cooking, the structure of kitchens, the heating system during winter, etc. Therefore, it is necessary to statistically analyse fire outbreaks during past earthquakes and asses the vulnerability function for the local area. However, this type of data is not available in Istanbul. Therefore, the possibility of fire outbreaks from facilities where inflammable liquids or gases materials are handled is estimated in this study. Facilities include paint/polish products factories, chemical product warehouses, storage facilities, LPG filling stations, and fuel filling stations. The distribution of the vulnerability rating for each mahalle is shown in Figure 8.3.2 and Figure 8.3.3.

If there are many wooden buildings in the area and if the space between buildings is not wide enough, fire will spread to from one building to another. There are many wooden buildings in the city of Japan; therefore, the incidence of fire spreading in the city is well studied by Japanese researchers. Figure 8.3.1 shows the results of the numerical simulation about the relation between the "burned area ratio" and the "wooden building coverage area ratio" by the Ministry of Construction (1982). The definition is as follows:

$$\text{Burnt Area Ratio} = \frac{\text{Burnt Floor Area}}{\text{Total Area}}$$

$$\text{Wooden Building Coverage Area Ratio} = \frac{\text{Wooden Building Coverage Area}}{\text{Total Area}}$$

From this figure, it is concluded that fire will not spread if the wooden building coverage area ratio is less than 30%. The wooden building coverage area ratio of all the mahalles is less than 10%. This means no fire spreading is estimated in the Study Area.

In conclusion, there should be little possibility of a great fire because most of the buildings are constructed with concrete and bricks. However, it should be kept in mind that many fires occur immediately after an earthquake and fire-fighting teams are delayed from reaching the fires because of roads blocked by debris.

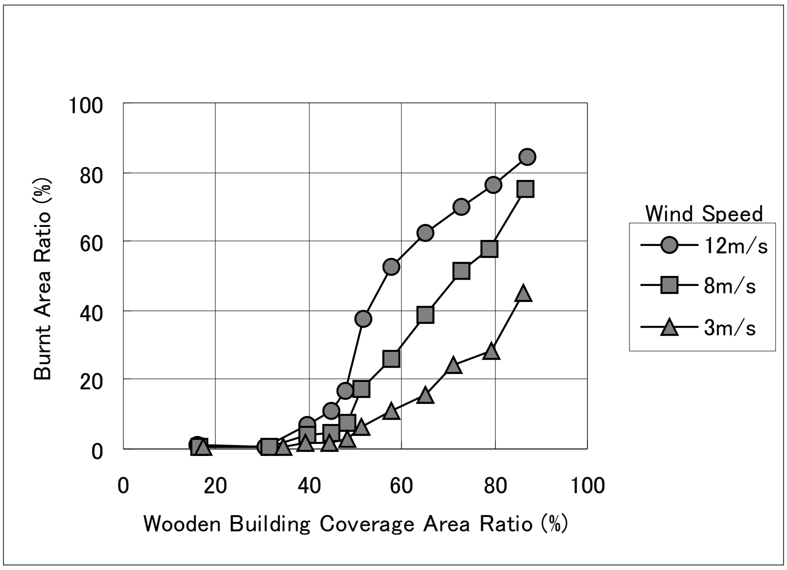


Figure 8.3.1 The Relation between Burned Area Ratio and Wooden Building Coverage Area Ratio

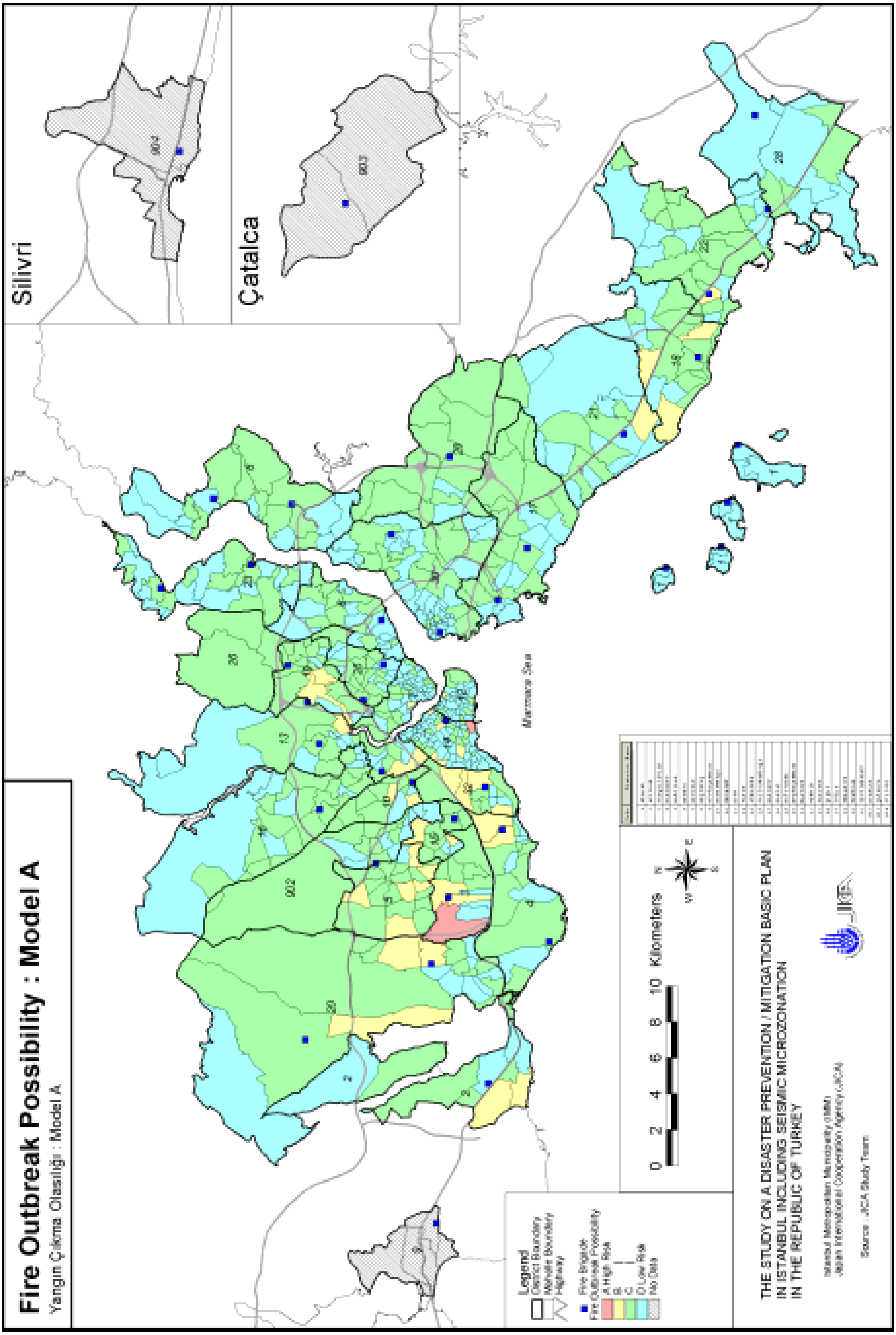


Figure 8.3.2 Fire Outbreak Possibility from Hazardous Facilities : Model A

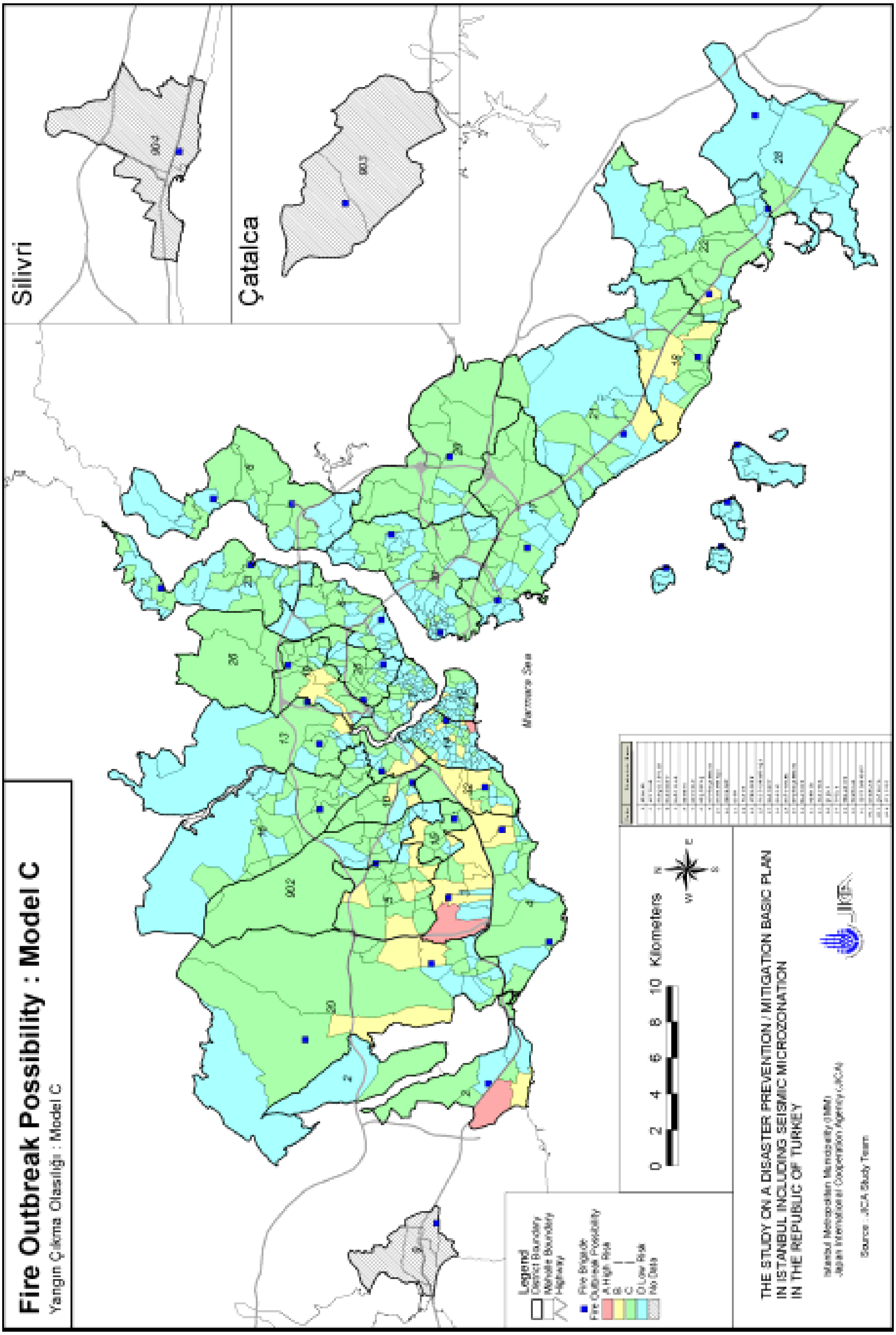


Figure 8.3.3 Fire Outbreak Possibility from Hazardous Facilities : Model C

8.4. Lifelines

Lifeline facilities are 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 the damage estimation of links (i.e., distribution pipes and lines) is applied in this study. Damages to the 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 the node facilities.

The additional three (3) districts, Silivri, Çatalca, and Büyükçekmece, are not included in the lifeline damage estimation because enough information was not available or the districts were not serviced.

(1) Water Supply Pipeline

Several researchers have proposed the correlations between pipeline damage and seismic parameters such as peak ground acceleration (PGA) or peak ground velocity (PGV). Based on these works, PGV is selected as the seismic parameter to evaluate the damage of pipes in this Study. From the considerations based on the damage by 1999 Izmit Earthquake, the damage function by the Japan Waterworks Association (1998) is selected for damage estimation in this analysis.

The damage estimation definition is shown in Table 8.4.1. The damage in each 500 m grid is calculated. A summary of results are shown in Table 8.4.2. The damage distribution for Model C is shown in Figure 8.4.1. Refer to the main report for Model A.

1,400 and 1,600 damage points are estimated for Model A and Model C, respectively. The damage is concentrated on the European side. The highest damage ratio is found in Fatih and Güngören.

Table 8.4.1 Definition of Water Pipeline Damage Estimation

Object	Distribution, Service Pipes
Type of Damage	Break of pipes or joints Pull out of joints
Amount of Damage	Number of damage points

Table 8.4.2 Summary of Water Pipeline Damage

	Pipe Length (km)	No. of Damage Points
Model A	7,568	1,400
Model C		1,600

(2) Sewage Pipeline

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

The damage estimation definition is shown in Table 8.4.3. The damage in each 500 m grid cell is calculated. A summary of results is shown in Table 8.4.4. The damage distribution for Model C is shown in Figure 8.4.2. Please refer to the main report for the damage distribution for Model A.

1,200 and 1,300 damage points are estimated for Model A and Model C, respectively. These numbers do not include the damage in several districts where there was not enough information available.

Table 8.4.3 Definition of Sewage Pipeline Damage Estimation

Object	All Pipes
Type of Damage	Break of pipes or joints Pull out of joints
Amount of Damage	Number of damage points

Table 8.4.4 Summary of Water Pipeline Damage

	Pipe Length (km)	No. of Damage Points
Model A	6,174	1,200
Model C		1,300

(3) Gas Pipeline and Service Box

The damage function developed by Disaster Prevention Council of the Tokyo Metropolitan Area (1997) was selected for the damage estimation of gas pipelines in this analysis, with consideration given to the damage caused by the Izmit Earthquake.

The 2000 Building Census has information on natural gas installations. About 186,000 buildings (= 25.6%) in total have a natural gas system installed. It was found that the gas service box is usually installed on the ground floor of the buildings or on the outer wall. If the building were to collapse, the gas box would be damaged. Even if the buried gas pipeline was not damaged, gas would leak from the service box, which could cause an explosion. In this study, it was assumed that all of the service boxes in heavily damaged buildings and half of them in the moderately damaged buildings would be damaged.

The damage estimation definition is shown in Table 8.4.5. The damage in each 500 m grid cell was calculated. A summary of results is shown in Table 8.4.6. The damage distribution for Model C is shown in Figure 8.4.3 and Figure 8.4.4. Refer to the main report for the damage distribution for Model A.

The damage estimate for the gas pipeline is low because the gas pipeline in Istanbul was recently developed. IGDAŞ used polyethylene pipes, which are highly flexible and have a high earthquake-resistance, in accordance with past earthquake damage experience. However, the damage to the service boxes amounts to more than 25,000 boxes because of the poor building structure.

Table 8.4.5 Definition of Gas Pipeline and Service Box Damage Estimation

Object	Distribution, Service Pipes	Service Box
Type 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

Table 8.4.6 Summary of Gas Pipeline and Service Box Damage

	Pipe Length (km)	No. of Damage Points	No. of Service Boxes	Total Damaged Boxes
Model A	4,670	11	185,000	25,000 (14%)
Model C		13		29,000 (16%)

(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, was available. The length of cable in each 500m grid cell is estimated based on the building distribution map on a 1/1,000 scale.

Based on the observed damage in Turkey and the existing damage functions, a new damage function for overhead cables was proposed and used for the damage analysis. For underground cable damage, the damage function of HAZUS99 was used based on the damage in the Erzincan Earthquake. High voltage transmission lines are presumed to have no damage based on past earthquake experience.

The damage estimation definition is shown in Table 8.4.7. The damage in each 500m grid cell is calculated. A summary of results is shown in Table 8.4.8. The damage distribution for Model C is shown in Figure 8.4.5. Refer to the main report for the damage distribution for Model A.

About 800 and 1,100km of damage areas 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.

Table 8.4.7 Definition of Electricity Cable Damage

Object	Distribution line (low and middle voltage)
Type of Damage	Cables Cut
Amount of Damage	Length of cables to be replaced

Table 8.4.8 Summary of Electricity Cable Damage

	Cable Length (km)			Damaged Cable Length (km)		
	Underground	Overhead	Total	Underground	Overhead	Total
Model A	14,500	18,500	33,000	280 (1.9%)	540 (2.9%)	820 (2.5%)
Model C				360 (2.5%)	710 (3.8%)	1080 (3.3%)

Note: Only total length information is available for cables on the Asian side. The length of overhead and underground cable is estimated by the mean overhead/underground ratio of cable on the European side.

(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 to fiber optic cable quantitatively. Nonetheless, it can be pointed out that fiber optic cable is more vulnerable to damage if the earthquake motion is larger or if liquefaction will occur.

Figure 8.4.6 shows the location of fiber optic cable with PGA distribution for Model C and the liquefaction potential area. The relatively vulnerable section can be recognised from this map.

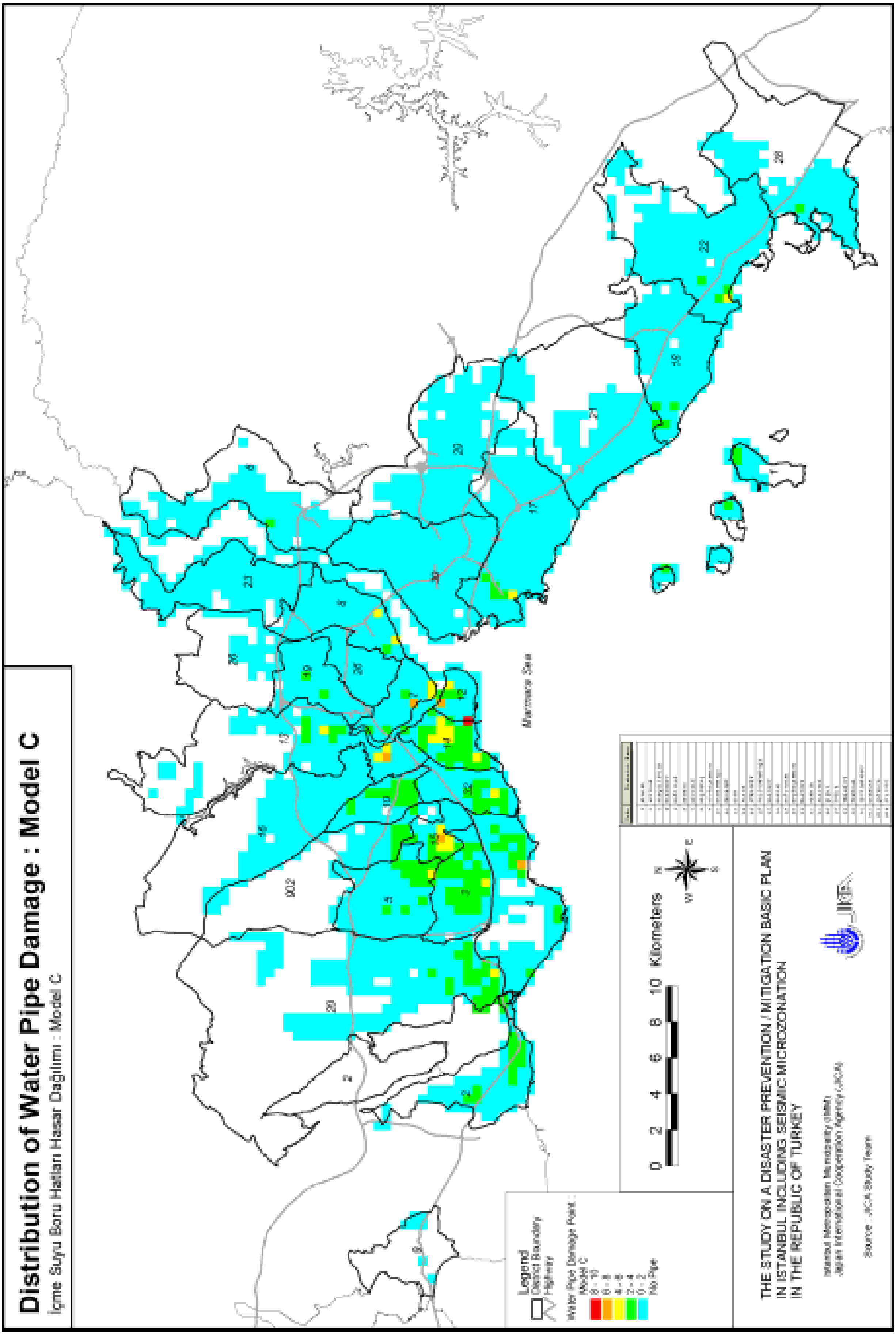


Figure 8.4.1 Distribution of Water Pipeline Damage: Model C

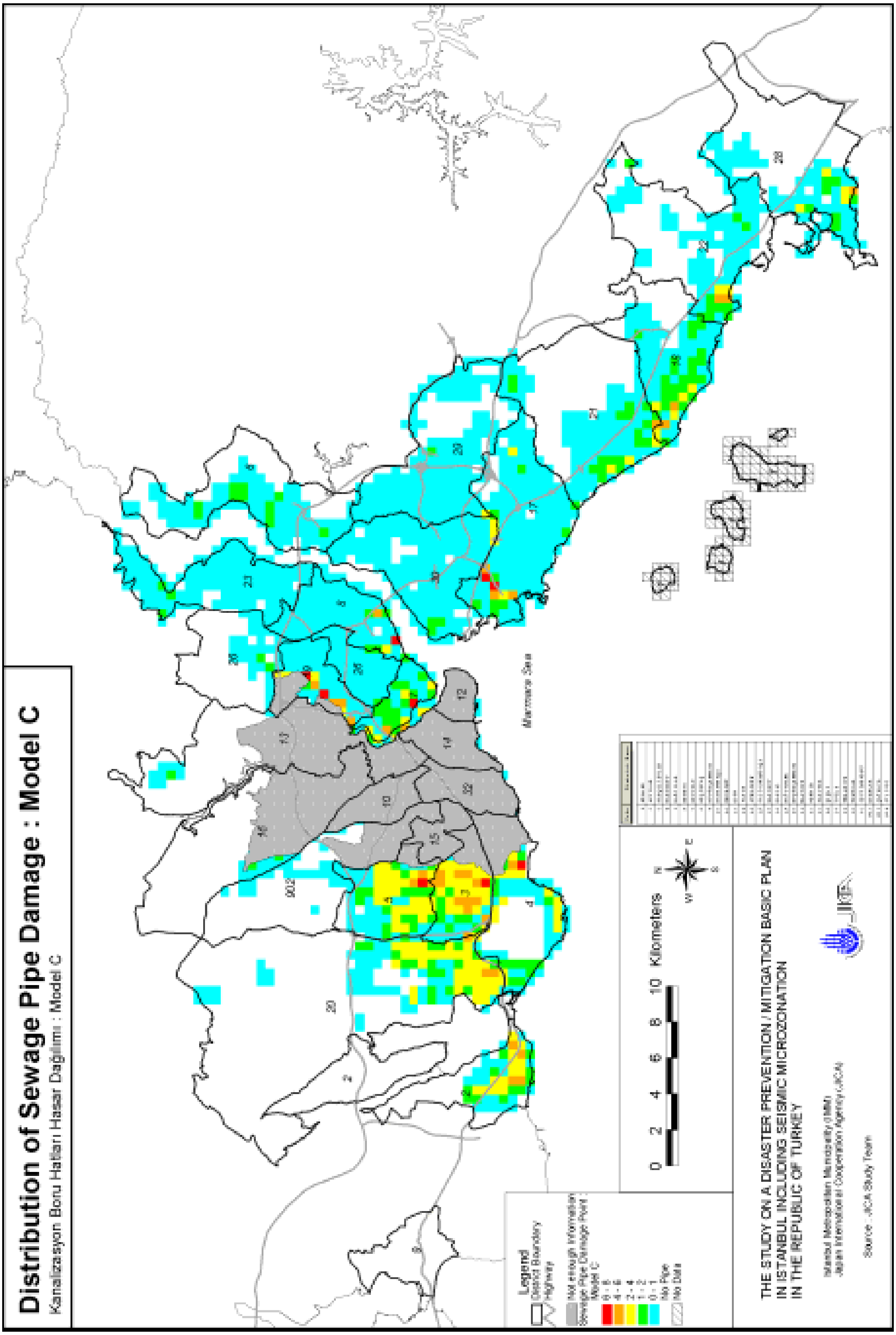


Figure 8.4.2 Distribution of Sewage Pipeline Damage: Model C

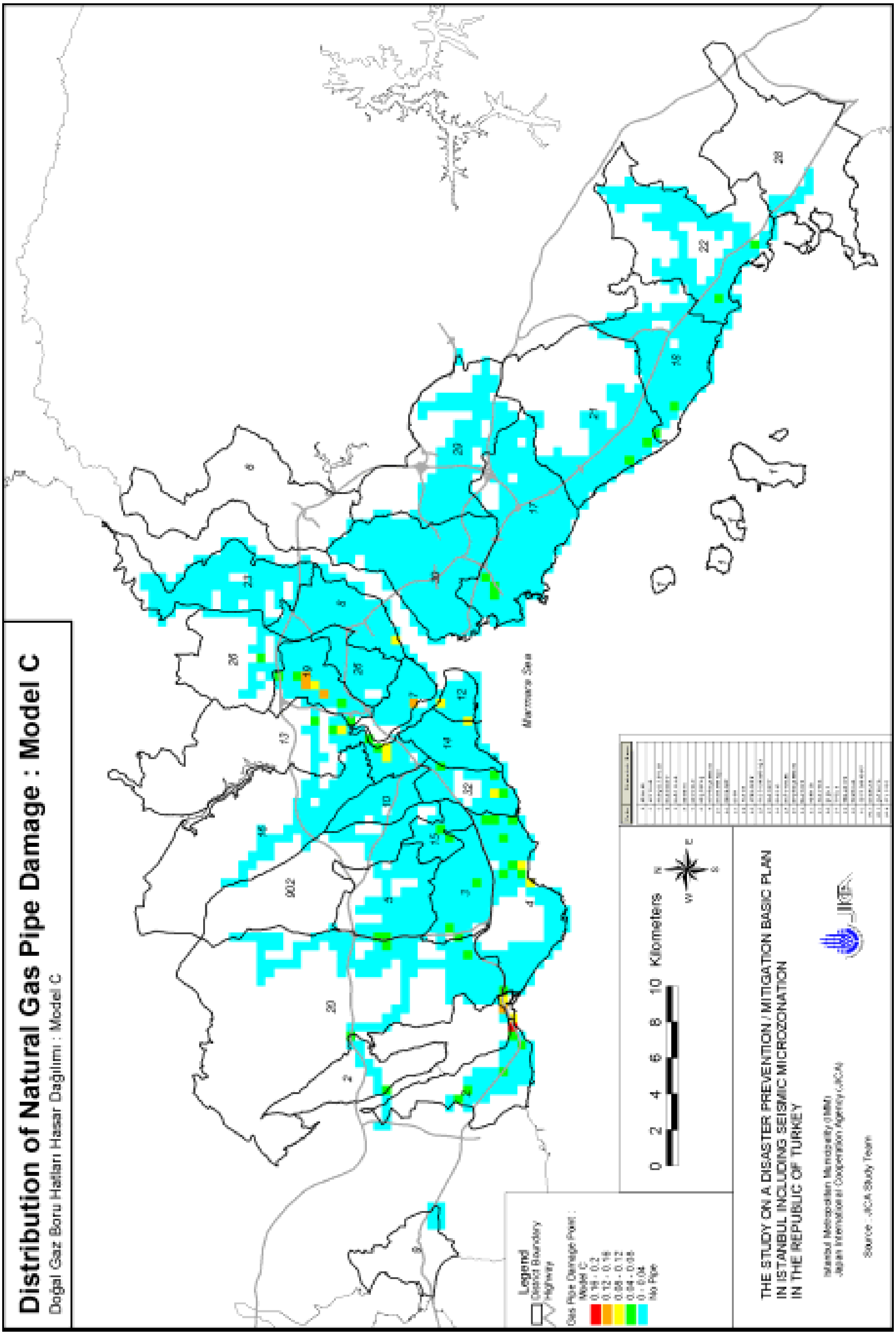


Figure 8.4.3 Distribution of Natural Gas Pipeline Damage: Model C

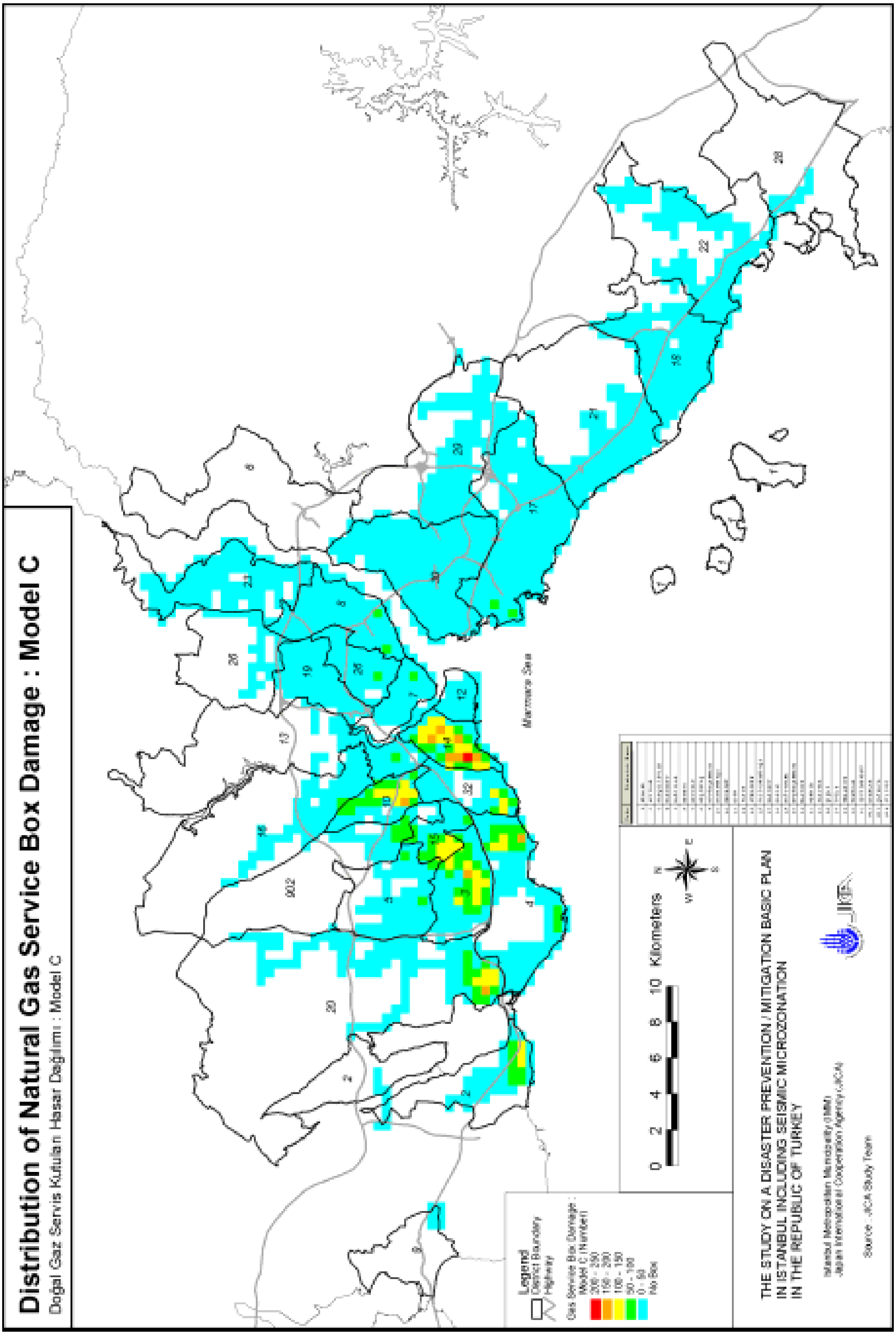


Figure 8.4.4 Distribution of Natural Gas Service Box Damage: Model C

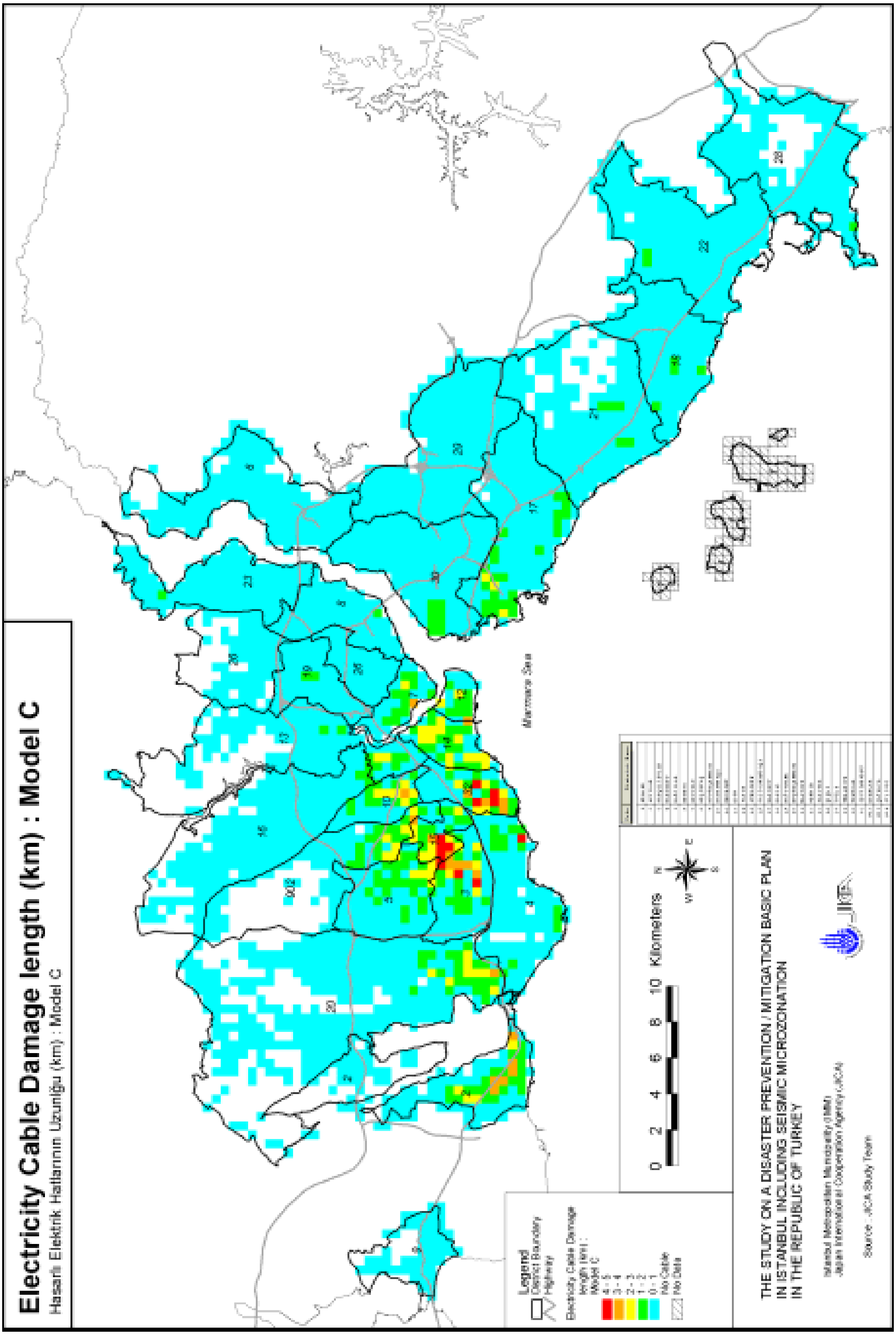


Figure 8.4.5 Electricity Cable Damage Length (km): Model C

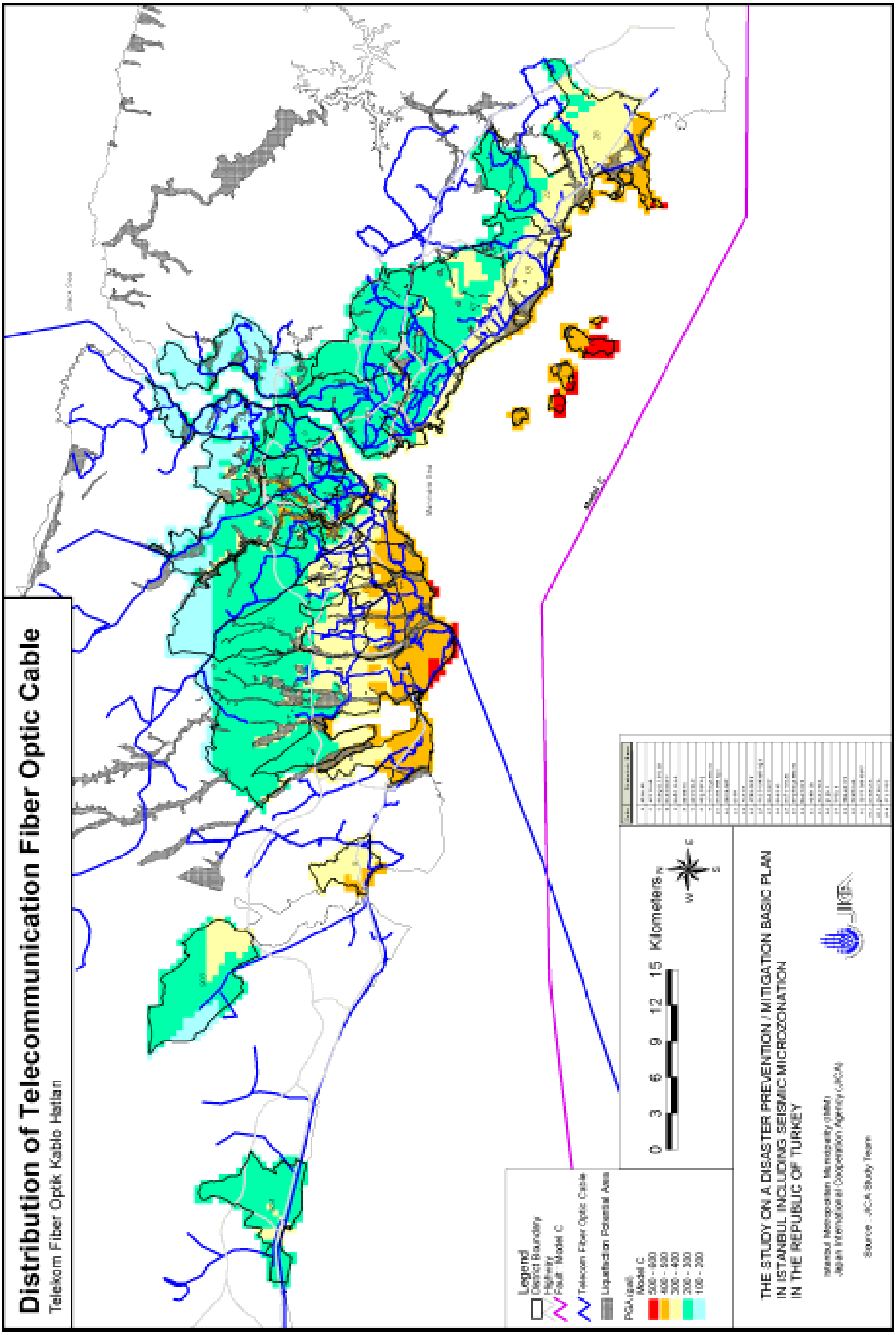


Figure 8.4.6 Distribution of Telecommunication Fiber Optic Cable

8.5. Bridge

In order to obtain a basic understanding of the earthquake resistance of the bridges, a methodology that is proposed by Kubo/Katayama (hereafter Katayama's method) was carried out. In this method the value of y_i is given as a *Predictors of damage degrees*.

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 to 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 8.5.1. 21 samples of Moderate probability and four (4) samples of *Large proberbility of falling-off* were identified. A lot of samples were centered on the degree of 10.

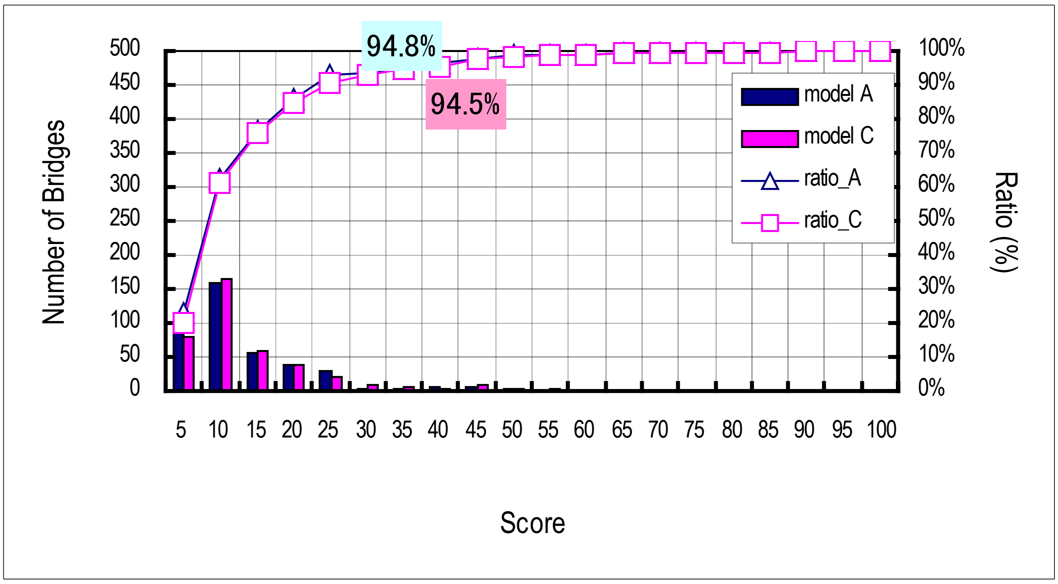


Figure 8.5.1 Distribution of *Predictors of damage degrees*

The list of the bridges that were evaluated as class (A) or (B) is shown in Table 8.5.1.

The two samples that do not belong to either class (A) or (B) are shown in Table 8.5.2. These two bridges are found in the following condition;

- Height of the pier is more than 10 m
- Peak Ground Acceleration of the site is more than 300gal

The bridges shown in Table 8.5.1 and Table 8.5.2 need a detailed investigation done as the next step and reasonable earthquake resistant strengthening should be made if necessary.

Regarding earthquake resistance, the condition of bridges is not as serious when compared to the condition of buildings.

However, the use of bridges is in high demand during emergency periods and during the recovery period of an earthquake. Considering this point, “Basic point”, “Countermeasure on designing” and “Urgent countermeasure” are recommended in the main report.

Table 8.5.1 The Bridges that were Evaluated as Class (A) or (B)

BRIDGE No.	SOURCE	Ground type				Probability of Liquifaction			Girder Type: 1 Span		Girder Type: 2 or more span				Type of Bearing			Max. Height of Abut./Pier			Min. Bridge Seat Width		JMA seismic intensity scale										Foundation Type		Material of Abut./Pier		REMARKS	JMA seismic intensity scale		PGA (gal)		Predictors of damage degrees		Class of damage degree	
		Stiff	Medium	Soft	Very Soft	Nothing	Fear	Having	Arch or Rigid Frame	Simple Beam	Simple Beam	Single Continuous Girder	more than one Continuous Girder	Combination Of Continuous & Simple	with Specific Device	Bearing (with clear design concept)	exist two bearing that can move axial derection	less than 5 m	5 to 10 m	more than 10m	Wide	Narrow	5	5.5	6	6.5	7	5	5.5	6	6.5	7	Spread	Pile	Masonry	Reinforced Concrete		Model A	Model C	Model A	Model C	Model A	Model C	Model A	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	402	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	40	40	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
UA61T	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 8.5.2 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

8.6. Roads and Traffic

8.6.1. Importance Evaluation on Road Network

Taking into account earthquake disasters, the evaluation of the importance of road networks was based on considering the importance of the total road network as well as on the effect of damaged bridges. Based on the results of the evaluation, a comprehensive evaluation and investigation, focusing on the prioritised earthquake-resistant reinforcement efforts for bridges and on future road construction plans, is suggested. Figure 8.6.1 shows a flow chart of the investigation related to the evaluation of the importance of the road network.

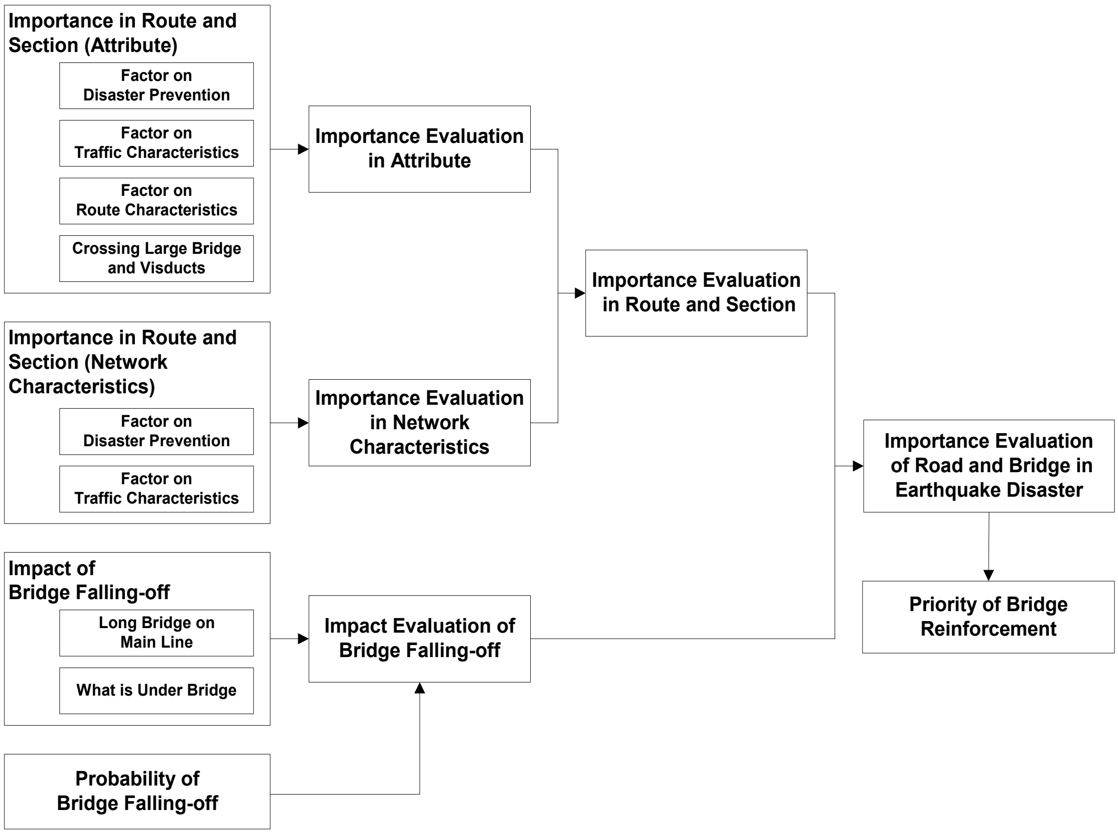


Figure 8.6.1 Flow chart for evaluating the importance of road network

(1) Importance Evaluation of Routes and Sections Along Network

The importance of the total road network was evaluated based on the importance of related attributes and network characteristics. The importance attributes was evaluated on the sum of the evaluation of individual attributes, such as traffic and roadside area characteristics, using arbitrarily applied evaluation grades and weights. The importance of road network characteristics was evaluated based on the importance of road functions assuming an earthquake disaster. The importance was characterised for three stages. The result pointed out roads in order of importance as the following: 1) loop roads, 2) major radial roads connecting loop roads, and 3) main urban roads. Loop roads and major radial roads were evaluated as particularly important.

(2) Influence of Bridge Disasters

The earthquake-resistant evaluation of 480 bridges was carried out applying the Katayama method. The evaluation found a need for the earthquake-resistant reinforcement of 24 bridges. In addition, two bridges, each having a span of 10 m or longer and subjected to 300 gals or larger surface acceleration, were selected as requiring counteraction to an earthquake. The effect of bridge damage was evaluated for 26 identified bridges based on the further impact of an earthquake, such as a bridge breaking and/or significant deformation appearing on the lower structure of the bridge.

(3) Results of Importance Evaluation on Roads and Bridges in view of Earthquake Prevention

The priority ranking of earthquake-resistant measures for bridges was established based on the importance evaluation of road blocks and effects due to bridge damages. The result is given in Figure 8.6.2. The priority ranking of earthquake-resistant measures for bridges gives a higher rank to road blocks having a stronger importance and to bridges with a greater importance. Earthquake-resistant measures for bridges should be made systematically following the established priority ranking.

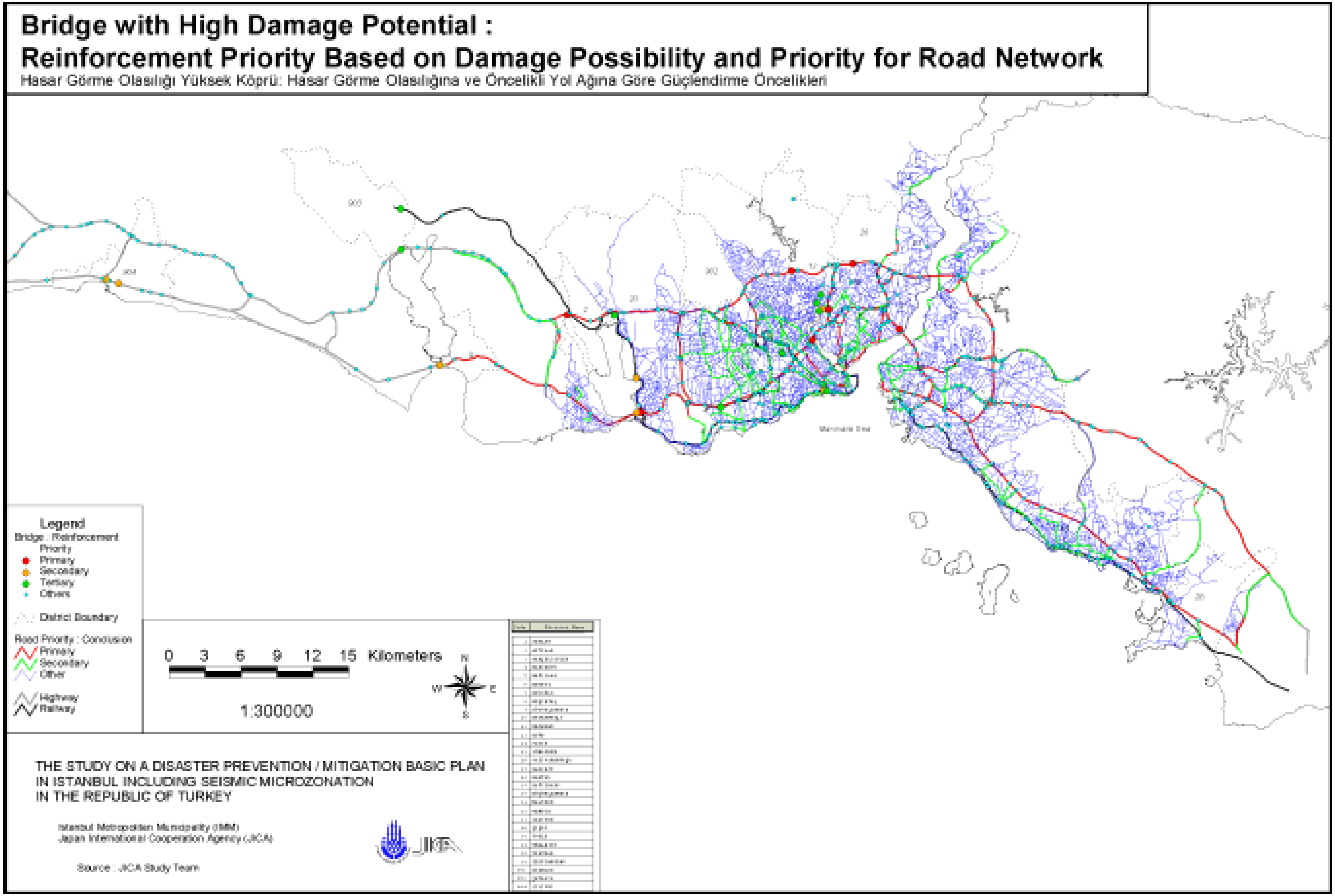


Figure 8.6.2 Bridge with High Damage Potential: Reinforcement Prioritisation Based on Damage Potential and Prioritisation of Road Network

8.6.2. Road Blockage Forecast due to Building Collapse

The blockage of roads caused by collapsed buildings was estimated and evaluated based on the results of assumed building damage derived from a Model C earthquake. The terms “road blockage” or "road blocks" refer to the situation in which a road width of 3 m (which would allow for the smallest of vehicles to drive through the road) cannot be secured due to debris from a buildings collapse.

The estimation of road blockage was carried out for three cases: 1) roads 2 to 6 m in width; 2) roads 7 to 15 m in width; and 3) roads 16 m or greater in width. Using the estimation, the evaluation found four stages where areas would be expected to be isolated due to road blockages.

Figure 8.6.3 shows the segment areas expected to be isolated by road blocks. According to the estimation, many isolated segment areas will be located in the southern part of the city on the European side. These isolated segment areas could significantly hamper evacuation and rescue activities, the removal of collapsed buildings, and the transportation of relief goods. Accordingly, in those segment areas highly expected to become isolated, necessary improvements should be made, such as the construction of additional roads and the use of roadside lands to reduce the possibility of isolation.

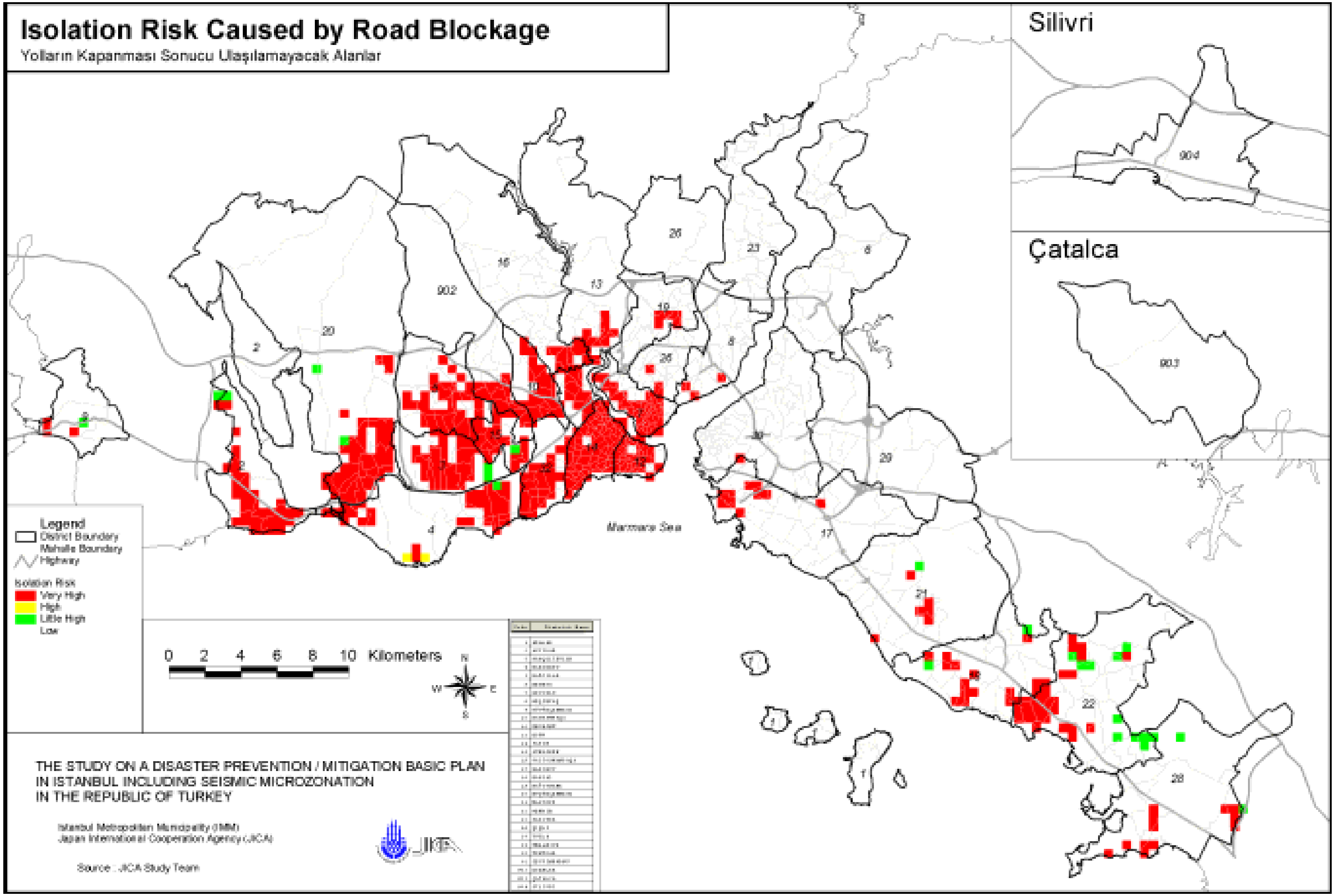


Figure 8.6.3 Istanbul Risk Caused by Road Blockage

8.6.3. Ideal Road Maintenance Considering Earthquake Disaster Prevention

The development and maintenance of roads should take into account the future of occurrence of an earthquake disaster, based on the results of the road network importance evaluation and on the estimation of road blockage caused by building collapse. This can be summarised as follows:

(1) Road Network Composition

a. Road Systems and Networks

Highway (E5) handles urban traffic and would require a substitute route plan to separate the national main traffic from urban traffic.

Some 1st Degree Roads specified by IMM have narrow widths and would require a plan to secure sufficient width or to construct substitute routes.

A seaside temporary storage site may be prepared to transport the waste through a sea route or to treat the waste.

b. Road Widths

To avoid road blocks, it is necessary to secure roads with surplus width. Improvements including the use of roadside land are required for very narrow roads (2m to 6m in width).

In addition to road construction and urban area preparation, the construction of public parking lots (such as large underground parking areas) is required.

(2) Cooperation with Sea Traffic During Earthquake Disaster

It is important to establish a cooperative link between road traffic and sea traffic to reduce traffic jams, assure material distribution and waste transportation, and facilitate other activities during earthquake disasters.

To do this, it is necessary to systematically strengthen and construct port and harbor facilities that can perform material transportation, and to further construct roads connecting the port to the harbor.

8.7. Port and Harbor

Istanbul faces the Bosphorus Strait and the Marmara Sea and has many large and small ports and harbors. In particular, Haydarpasa Port, Istabul-Taksim, Eminonu, and Moda are some of the major ports and harbors of Istanbul. They have relatively large port and harbor facilities. It is preferable that these large port and harbor facilities have their earthquake resistance be evaluated. Efforts to strengthen and reinforce their earthquake-resistant capability and efforts to establish and strengthen ports and harbors as disaster prevention bases should also be carried out.

8.7.1. Role of Port in Emergency

Port and harbor facilities are expected to have various functions during an emergency, including the storage of relief goods, the transportation of material to the disaster sites, the treatment and transportation of disaster waste, and the preparation of refugee areas.

(1) Establishing and Strengthening the Earthquake-Resistance of Port and Harbor Facilities

In addition to the important functions ports and harbors perform under normal conditions, it is also important to establish the earthquake-resistance of the ports and facilities' physical property. This requires that one take into account the importance of the functions ports and harbors provide after an earthquake and the degree of difficulty of reconstruction works.

(2) Strengthening the Functions of Ports and Harbors as Disaster Prevention Bases

It is important to strengthen the functions of ports and harbors as bases of transportation efforts, such as those of transporting relief goods and those dealing with the reconstruction and recovery of disaster areas, by making full use of the space and characteristics of ports and harbors.

(3) Establishing a Cooperative System among Port and Harbor Facilities

Strengthening the system of cooperative links between port and harbor facilities is necessary so that, during an emergency, individual port and harbor facilities perform their roles to the scale and the functions of each respective facility.

8.7.2. Strengthening the Earthquake Resistance of Harbor Facilities

Taking into account the importance and function of ports, wharfs, and harbors as disaster prevention bases, it is necessary to strengthen their earthquake-resistance. The increase in earthquake resistance of port and harbor facilities requires not only the improvement in the earthquake-resistance of individual wharfs, ports, and harbors but also the improvement of their earthquake resistance as a whole.

8.7.3. Importance of Strengthening Harbor Disaster Prevention Bases

The identification of the space and characteristics of a port and harbor to strengthen the port and harbor's function as a disaster-prevention base is extremely effective. The following measures are expected:

(1) Maintenance of Disaster Prevention Base

Based on the arrangement of existing port and harbor facilities, it is preferable that each disaster-prevention base provide a storage facility for relief goods, a communication and information facility, a temporary storage facility for disaster waste, etc. during an earthquake disaster.

(2) Maintenance of Green Tracts of Land for Shelter Use

Taking into consideration the current arrangement of facilities, traffic routes, and open space, it is preferable to develop green tracts of land for use in the provision of shelter areas.

(3) Importance of Disaster Prevention of Harbors Space

It is important to secure the harbor as a safe space that fully utilises water and open areas (green tracts of land) to allow satisfactory support of recovery activities and to prevent a secondary disaster from occurring at port and harbor facilities.

Chapter 9.
Preparedness Measures to Strengthen Vulnerable Urban and Building Structure

Chapter 9. Preparedness Measures to Strengthen Vulnerable Urban and Building Structure

9.1. Proposed Preparedness Measures to Strengthen Vulnerable Urban and Building Structure

In Istanbul Metropolitan Area, ten times of rapid urban expansion after Second World War were shared by illegal and irregular urban developments, which are categorized to weak building and urban structure for earthquake disasters. On the study, the proposed 7 categories strategic measures as follows to strength building and urban structures are formulated on the comprehensive vulnerability analysis and compilation of improvement issues. For the future implementation, the proposed areas of 7 categories of improvement and strengthen measure by mahalle of statistical, analytical and planning unit are proposed to revise on the formulated district disaster prevention and management plans based on detaile analysis.

9.1.1. Vulnerability and Improvement Issues on Urban Earthquake Disaster

(1) Mechanism of Urban Earthquake Disaster

Disaster damages in megalopolis are not only generated from human casualties by direct building damages on deteriorated and vulnerable building structures but also secondary disaster damages of vulnerable urban structures as follows,

- Luck of safety evacuation space and routes
- Excessive land utilization
- Disturbed emergency vehicle access by narrow road and debris

In the metropolitan area, old town areas developed before 19th century were almost designated for archeological and historical urban conservation area, in where building and urban renewal are strictly controlled. The strict control in the areas generate issues to keep safety and life of citizens based on dense and rigid traditional urban land use and alleyway system and defenseless building structure for earthquake disasters. On the other hand, illegal and irregular urban developments are almost sharing newly expanded urban areas after 1950. In those areas, building code and seismic resistant code were not applied and also, planning and design standards of road and public facilities are also not adapted on developments. The both of building and urban structure vulnerabilities are crucial issues for the future safety on foreseeable earthquake disaster.

(2) Method of Vulnerability Analysis

Urban earthquake disaster vulnerability was assessed from the building and urban structure vulnerability analysis based on the available statistical data. Improvement issues and locations are identified and compiled on the results of building and urban structure vulnerability.

The analytical work to identify issues and vulnerability are shown on the work flow chart as follows. On the study, the result of building damage estimation on the microzonation is not only incorporated on the building vulnerability analysis but also, on urban structure vulnerability analysis based on the following reasons.

- Vulnerable urban structure cause and increase human casualties, which are originated by building damage
- Mahalles, which are categorized low ratio of heavy and moderate building damage, are excluded on the urban structure vulnerability analysis

The issues to strengthen and improve the identified vulnerabilities are compiled to 4 categories as follows,

- Issuable mahalles to introduce strategic improvement measures for both vulnerable conditions of building and urban structures,
- Issuable mahalles to introduce strategic improvement measures for vulnerable building structure,
- Issuable mahalles to introduce strategic improvement measures for vulnerable urban structure, and
- Other mahalles without serious issues and vulnerability on building and urban structure

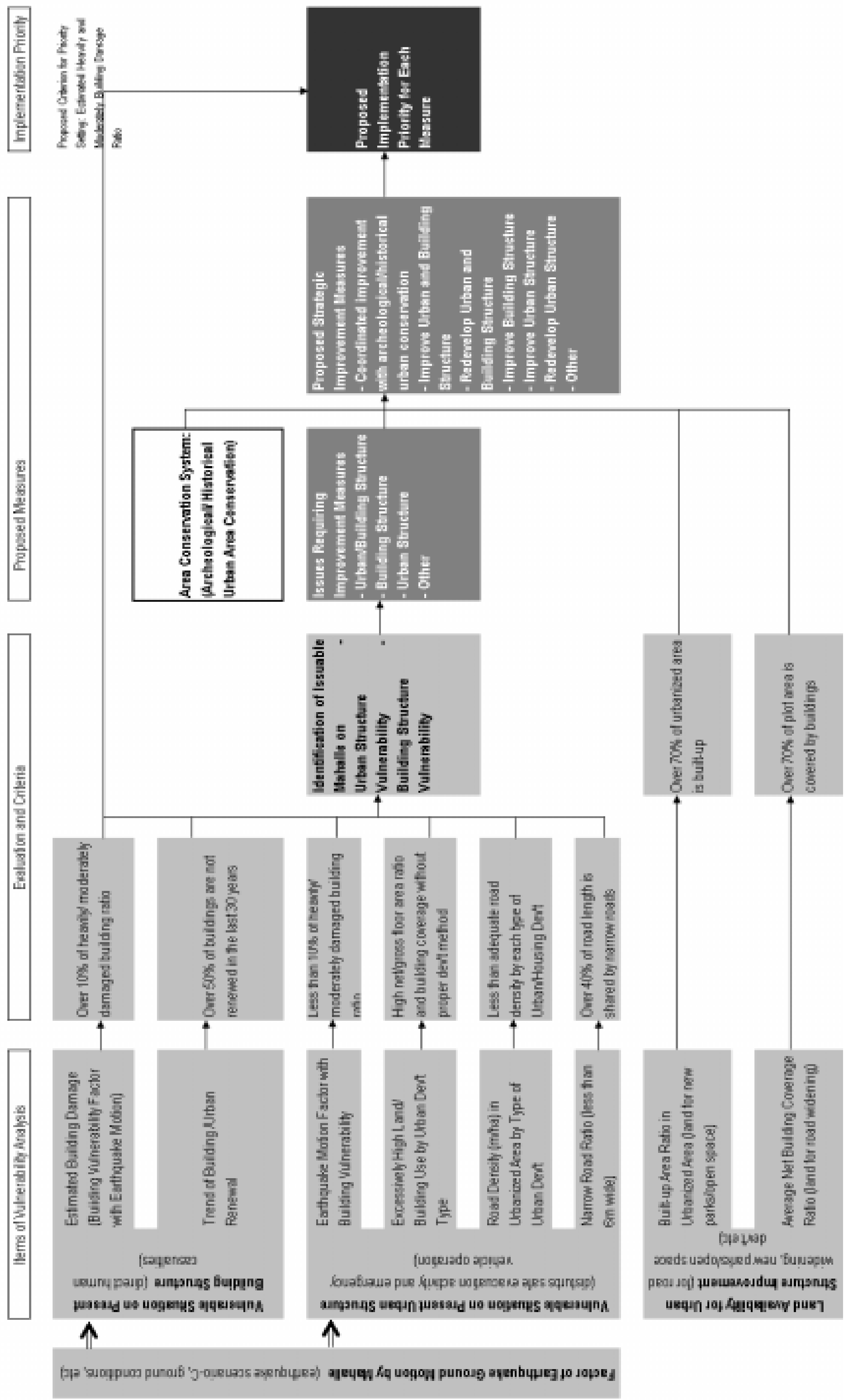


Figure 9.1.1 Work Flow Chart of Vulnerability Analysis

9.1.2. Proposed Strategic Improvement Measures for Vulnerable Building and Urban Structure

For consideration of improvement measures for urban structure vulnerability, land availability for road widening of emergency/evacuation/narrow roads, new parks/open spaces for evacuation area etc. are the indispensable key factor to select proper improvement measures for issuable mahalles on urban structure. Urban redevelopment measure will be required for the mahalle, in where land is not available for urban structure improvement. Land availability in each mahalle is assessed from built-up area ratio and average building coverage ratio.

On the other hand, designated archeological and historical urban conservation areas will require other measures to strengthen one of most vulnerable building and urban structure, which should be well coordinated with conservation of national heritages, than the measures for the newly expanded urban area.

Preliminary simple seismic resistant structure diagnosis for privately owned buildings is proposed to evaluate and categorize the existing conditions of building structural, which are enough seismic resistance, required reinforcement, and required reconstruction, to input to the plan formulation of improvement measures. Also for to enhance activities of building reinforcement and reconstruction for the assessed buildings, incentive measures for reinforcement and reconstruction are proposed as follows,

- Newly set-up discounted earthquake insurance rate for improved enough seismic resistant building,
- Reduction / or exemption of new building registration tax for reconstructed seismic resistant building,
- Reduction of real estate tax for seismic resistant building, and
- To provide soft lone (low interest/long repayment period) for reinforcement and reconstruction of assessed building.

Fund system to improve building structure and redevelopment, which is planned by IMM, is proposed to apply for the above reinforcement and reconstruction of the assessed buildings. However, huge amount of funding source will be required for low rate of turnover funds based on the proposed long-term repayment system.

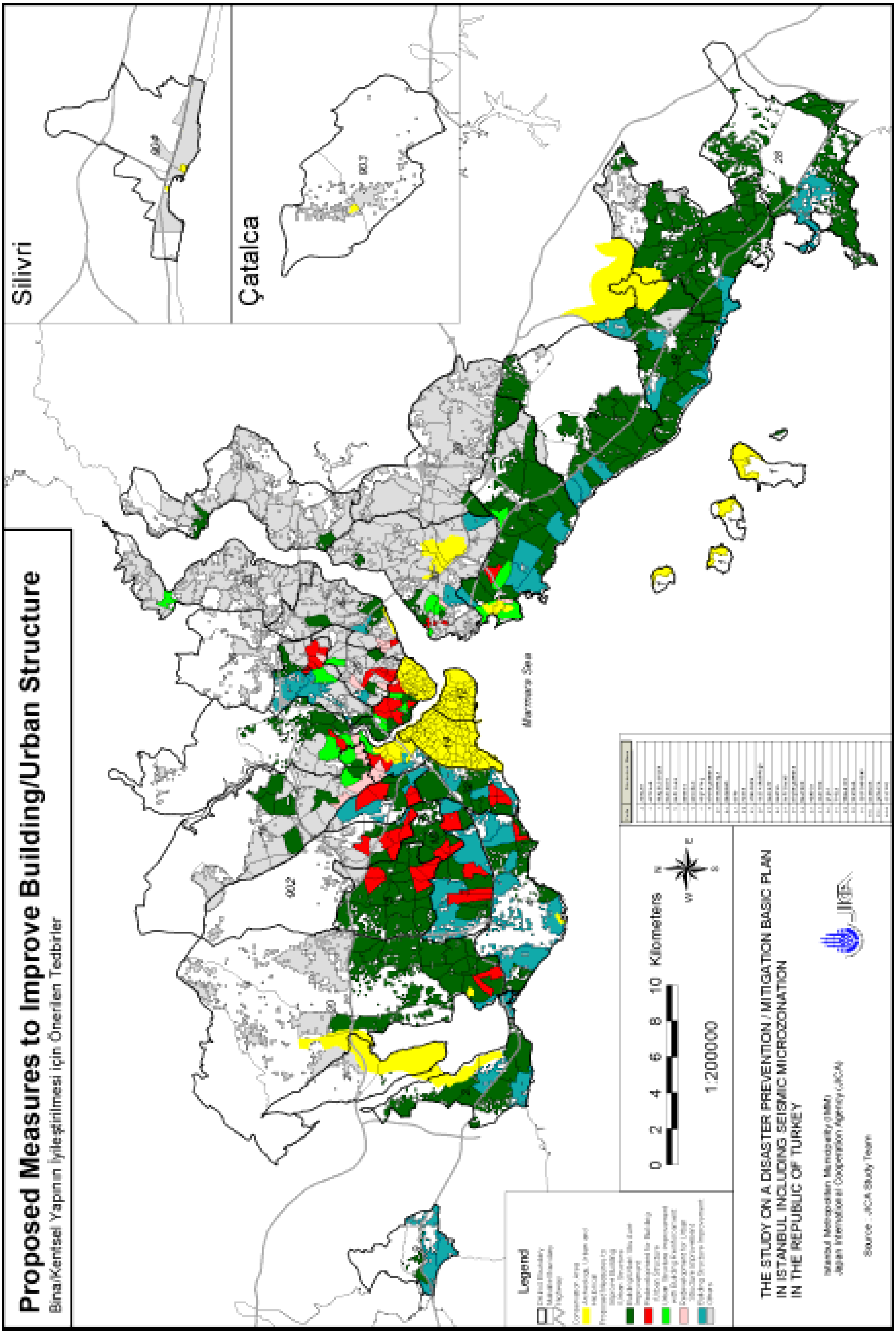


Figure 9.1.2 Proposed Measures to Improve Building/Urban Structure

1) **Proposed Measure to Improve Building/Urban Structure-1:** Urban Redevelopment

The proposed areas are categorized serious issuable mahalles without land for urban structure improvement as follows,

Seriously vulnerable building structure

- Heavy and moderate building damage ratio is over 30% /or
- Building renewal in the past 30 years is delayed.

Seriously vulnerable urban structure

- Narrow road ratio is more than 80% of total road length /or
- Land utilization condition is excessively high /or
- Existing parks/open space is less than 50% of area demand for community evacuation/gathering space.

Rigid urban development: lack of land for urban improvement

- Built-up area ratio is more than 90% of mahalle area /or
- Average building coverage ratio is over 80%

IMM and each district municipality should cooperate to formulate and implement the following urban redevelopment plan for the identified mahalle and surroundings based on the results of preliminary simple seismic resistant building diagnosis.

- Road widening/improvement plan for emergency road, evacuation road and narrow road under the coordination with district disaster prevention and management plan,
- District evacuation plan with parks/open space development program,
- Improvement plan of other resources for disaster management, and
- Building redevelopment program by horizontal/vertical land readjustment.
- Implementation program to coordinate all urban redevelopment projects with the proposed funding system for building improvement and redevelopment.

2) **Proposed Measure to Improve Building/Urban Structure -2:** Coordinated building and urban structure improvement

The issuable vulnerability condition for the area is the same of 1). However, mahalles is not fully and rigidly developed yet and land is available for urban structure improvement.

IMM and each district should cooperate to formulate and implement the following improvement plans for the identified mahalles and surroundings based on the results of preliminary simple seismic resistant building diagnosis.

- Road widening/improvement plan for emergency road, evacuation road and narrow road under the coordination with district disaster prevention and management plan,
- District evacuation plan with parks/open space development program,
- Improvement plan of other resources for disaster management, and
- Building reinforcement/reconstruction plan by building block bases with the proposed funding system for building improvement and redevelopment
- Implementation program to coordinate all improvement projects.

3) **Proposed Measure to Improve Urban Structure -1:** road, park and other improvement with urban redevelopment method

The proposed areas has serious issuable vulnerability mainly on urban structure as follows,

Vulnerable building structure

- Heavy and moderate building damage ratio is 10% to 30% /or
- Building renewal in the past 30 years is not so delayed.

Seriously vulnerable urban structure

- Narrow road ratio is more than 80% of total road length /or
- Land utilization condition is excessively high /or
- Existing parks/open space is less than 50% of area demand for community evacuation/gathering space.

Rigid urban development: lack of land for urban improvement

- Built-up area ratio is more than 90% of mahalle area /or
- Average building coverage ratio is over 80%

IMM and each district should cooperate to formulate and implement the following urban structure improvement plans based on the results of preliminary seismic resistant diagnosis.

- Road widening/improvement plan with redevelopment plan/program along road for emergency road, evacuation road and narrow road under the coordination with district disaster prevention and management plan,
- District evacuation plan with parks/open space redevelopment plan/program,
- Improvement plan of other resources for disaster management, and
- Building reconstruction and reinforcement program for the assessed building blocks.

4) **Proposed Measure to Improve Urban Structure-2:** Road, park and other resources improvement

The proposed mahalles has the same issuable vulnerability of 3). However, mahalles is not fully and rigidly developed yet and land is available for urban structure improvement.

IMM and each district should cooperate to formulate and implement the following urban structure improvement plans based on the results of preliminary seismic resistant diagnosis.

- Road widening/improvement plan for emergency road, evacuation road and narrow road under the coordination with district disaster prevention and management plan,
- District evacuation plan with parks/open space development program, and
- Improvement plan of other resources for disaster management.

5) **Proposed Measure to Improve Building Structure:** Reinforcement and reconstruction

The proposed mahalles has issuable vulnerability on building structure as 1).

IMM and district should cooperate to formulate and implement the following building reinforcement and reconstruction plans for the assessed weak building structure.

- Review of the proposed building structure improvement area by the results of preliminary seismic resistant building diagnosis,
- Formulation of reinforcement and reconstruction plan and program for each building blocks with financial program,
- Based on the district disaster prevention and management plan, urban structure vulnerability should be carefully analyzed in detail and formulate/ implement urban structure improvement plan under the coordination with building improvement program.

6) Proposed Measures for Historical Urban Conservation Area:

Based on the vulnerability analysis, the designated historical urban conservation areas are assessed to be one of most issuable area on the both of building and urban structure vulnerability. Conservation of archeological and historical heritages is not only important issue but also, to keep life and safety of residents and citizens in the area is also important issue for the central and local governments.

The following conservation system is proposed to balance and harmonize conservation and safety of citizens for the area.

- Strict Conservation for Registered Heritage of archeological, historical, and traditional monuments, buildings and heritages,
- Historical Scenery Conservation Zone for Buffer of Heritage Conservation: height and façade control for the surroundings building block of the above heritage
- Historical Scenery Conservation for Selected Alleyway and Street Network: height and façade control along the selected alleyway and streets
- Historical Climate Conservation for the Designated Conservation Areas: height and color control

Ministry of culture, their regional conservation committees and IMM should carefully identify and designate the above point/line/area in Historical Peninsular and the part of Beyoglu, Eyüp etc. Joint committee, which is composed from regional conservation committee, IMM and district, is proposed to formulate the balanced conservation and improvement plans for the designated conservation areas. The following improvement measures for the identified issuable vulnerability are proposed to coordinate with the balanced conservation plan.

- To insert safety evacuation road for narrow alleyway area to keep life of citizens (except the selected alley and street for conservation),
- To introduce, widen /or improve proper emergency road to link with disaster management center, emergency response centers and emergency good centers in the areas (except the selected alley and street for conservation),
- To create and provide safety evacuation place for residents and citizens (except the selected building block for conservation),

- To provide incentive measures for building reconstruction and reinforcement to the assessed weak structure except the building within historical scenery conservation
- To provide incentive measures and financial assistance for reinforcement and reconstruction of weak structure buildings within historical scenery conservation

7) Proposed Measures to Promote Seismic Resistant Building:

The proposed areas has certain issues on building vulnerability, which is 10% to 30% of heavy and moderate building damage ratio, except the proposed areas for the above.

Each district and IMM should jointly review the proposed areas on district disaster prevention and management plan formulation study by the results of preliminary seismic resistant building structure. Formulation of building reinforcement and reconstruction plans and programs is proposed for the identified areas with incentive programs.

9.1.3. Review of Emergency Road Network and Proposed Preparedness Measures

Emergency road network system is expected to keep road transport functions for proper emergency vehicle operation for collection and exchange disaster information, emergency response activities, emergency goods supply, and rehabilitation works. For to maintain the emergency road function, 1st, 2nd and 3rd emergency road network should link an identified disaster management center, emergency response center and emergency goods centers. The required measures to maintain the functions are not only designation and preparedness measures before event but also, maintenance and debris removal, access control of private traffic and smooth emergency vehicle traffic on the emergency road. On the other hand, huge length of categorized road networks of regional, metropolitan and district arterial roads are currently designated for emergency road in the metropolitan area. However, sign-boards of emergency roads are only set on the designated road sections at the present. But also, road widening and improvement plans and quantitative road maintenance programs are not formulated to organize proper network yet. The disaster management center of province is already organizing the committee to re-organize and review the previous emergency road network system of hierarchical road function to JICA proposals as follows,

- 1st emergency road network should link all levels of disaster management centers to collect and exchange disaster information,
- 2nd emergency road network should link all the identified emergency response centers, and

- 3rd emergency road network should link emergency goods storage and circulation centers

The related centers and facilities for hierarchical emergency road networks are identified as follows by the provincial disaster management centers,

Table 9.1.1 Identified Centers Linked by 3 Levels of Emergency Road Network

	Identified Centers by Provincial Crisis Management Center	No. Center
Centers for Primary Emergency Road	Crisis Management Centers of Province/Department	4
	IMM Disaster Management Center	1
	District Crisis Management Center	30
	Related Government Offices	60
	Airport	4
	Ports	5
	Total facilities	104
Centers 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 Centers for Machinery	2
	Gathering Area for District Machinery	13
	Piers	44
	Heliport (helipad)	200
	Tent Village	486
	Total facilities	244
Centers for Tertiary Emergency Road	Loading Heavy Machinery	5
	Centers for Unloading and Loading Vehicle Equipment	3
	Center for Unloading and Loading Supply Materials	4
	Centers for Vehicle Unloading and Loading: Truck Terminal	9
	Centers for Unloading and Loading : Sea and Land Transport	6
	Logistic Support and Coordination Centers	2
	Total facilities	29
G. Total		377

Source: Database was provided by the provincial crisis management center. The identified centers were selected and categorized by JICA Study Team

The proposed 3 levels of emergency road networks are selected from regional, urban and district main road and wider road. However, selected and proposed emergency roads are composed from 371km (45%) of emergency road of wider than 15m width, 137km (17%) of 12m to 15m width sections, 278km (34%) of 7 to 11m, 31km(4%) of 2m to 6m width road sections.

Road widening projects are proposed to implement from narrow road sections less than 15m width and including reinforcement of the assessed weak structural bridges by proper seismic resistant diagnosis.

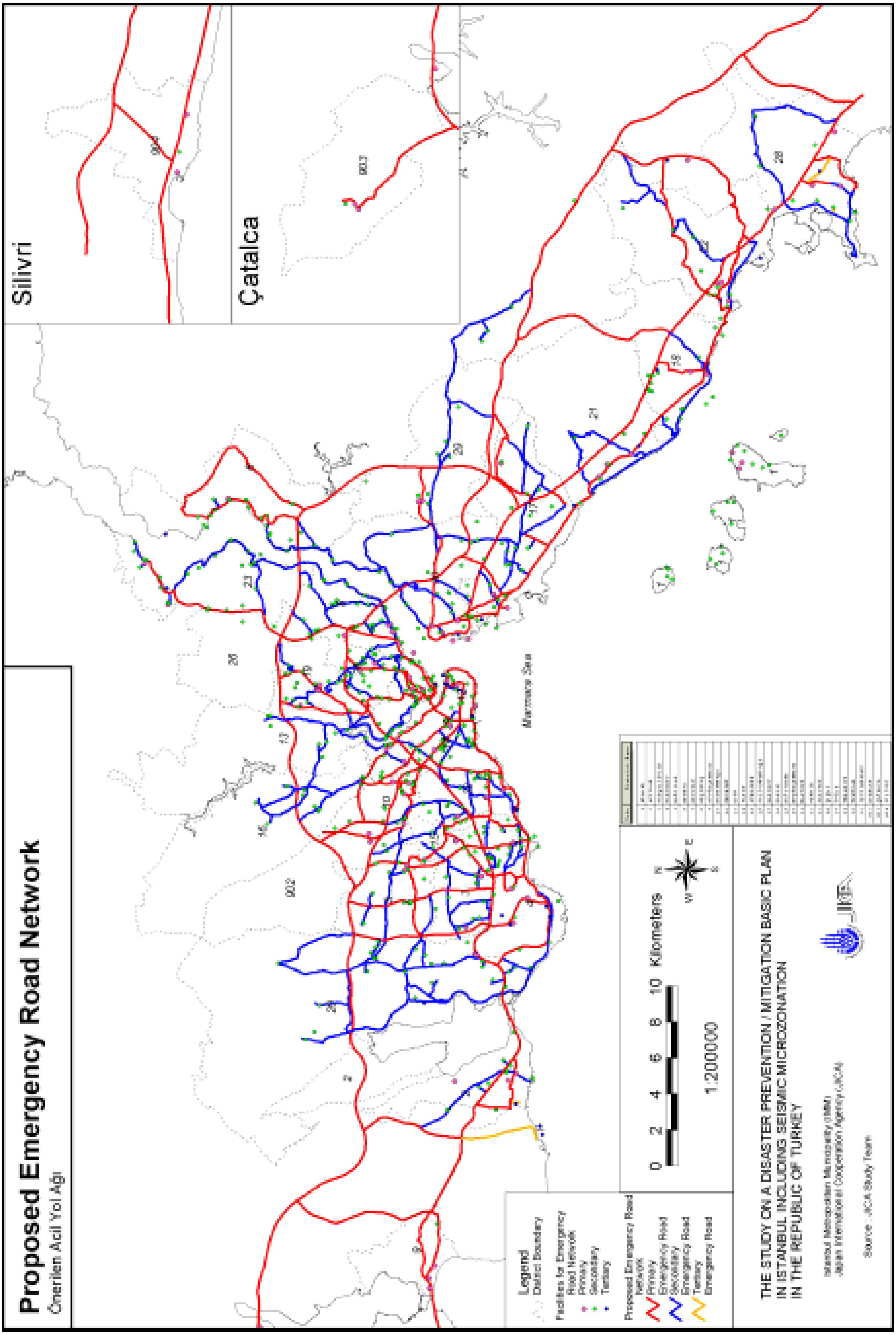


Figure 9.1.3 Proposed Emergency Road Network

9.1.4. Proposed Emergency Evacuation System and Preparedness Measures

Emergency evacuation system is expected to reduce human casualties of survived victims from secondary disasters and aftershocks. However, emergency evacuation system is not introduced and established in Istanbul Metropolitan Area yet. On the other hand, tent village, which provide temporary living space for refugees just after earthquake event, has been designated and established with lifeline preparation. Huge number of small scale fire-outbreaks and explosions will be generated by the estimated huge number of building damages as following mechanism,

- The estimated around 29,000 damaged service boxes and pipes of natural gas supply in the damaged buildings will cause fire-outbreaks and explosions
- Also, electric power lines in damaged buildings will be cut and cause short-circuits and fires
- Secondary disasters of fire-outbreaks and explosion will generate and encourage human casualties, who are survived victims in and outside damaged buildings

Proposed measures for emergency evacuation system:

1) Staged Evacuation System

   - Community evacuation and gathering place: to provide safety gathering and evacuation place for each neighborhood community
   - Evacuation route: to provide safety and smooth evacuation routes to regional evacuation place
   - Regional evacuation place: to provide more safety evacuation place in each regional evacuation zone, which is less than 3km distance and around 6sqkm, from secondary disaster and aftershocks
   - Tent village: to provide temporary living space for victims of housing damage just after event

2) Proposed joint study for IMM and each district:

   - Formulation of district emergency evacuation plan, which include the following proposed facilities, and review of the present plan of tent village
   - Formulation and execution of implementation plans and programs of required preparedness measures

3) Proposed Measures of Community Evacuation and Gathering Place for Provincial Crisis Management Center / IMM / District

- To provide 0.5m^2 net evacuation space (1.5m^2 gross) for each residents and citizens in neighborhood unit
- Selection and designation of the existing parks, open space and school (only seismic resistant structure building) for the space in each neighborhood unit
- Park/open space development or to strengthen school facilities for neighborhood unit, in which the required area of park / open space is not available
- To prepare storage of emergency response goods, water and foods for self community disaster task forces

4) Proposed Measures of Regional Evacuation Place for Provincial Crisis Management Center / IMM

- Set up regional evacuation zone (6km^2 and maximum 3km distance)
- Selection and designation of major parks and open space for each regional evacuation zone
- Development of major park and open space for lack of park/open space within regional evacuation zone or
- To make agreement to provide regional evacuation place between the adjacent districts
- To prepare emergency reservoir (or storage) of potable water and storage of emergency foods for the estimated refugees
- To prepare proper lifeline network for the estimated refugees

5) Proposed Review Point of Designated 486 Tent Villages by Provincial Crisis Management Center / IMM / District

- Designated parks and open space for regional evacuation place could be transferred and used to tent village
- Designated small tent villages should be reviewed from the condition of safety
- Development of major park and open space for lack of tent villages within district or
- To make agreement to provide tent village between the adjacent districts

- To prepare proper lifeline network for the estimated refugees

6) Proposed Measure of Emergency Evacuation Route for Provincial Crisis Management Center/IMM

  - To select and designate evacuation route (wider than 20m width road or 10m width pedestrian) for the area more than 3km distance evacuation for regional evacuation place and
  - To select and designate evacuation route (same of the above) for the identified hazardous area with the registered hazardous facilities and the estimated high building damage
  - To improve safety condition of designated route (widening, provide buffer etc.)

9.1.5. Proposed Measures for Master Plan and Land Use Zoning System

Review of the present master plan and land use zoning system from disaster prevention and mitigation for Istanbul are proposed as follows,

- **New Land Use Zoning Category of Natural Hazard Area**: the identified areas of unstable slope and liquefaction areas are proposed to designate for the area.

  For the area, the following control, guideline and measures are proposed to apply to control inappropriate land use and development.
  - guide and introduce proper land use (parks/open space)
  - guideline/code for seismic resistance and liquefaction
  - improvement of port/road/bridge in the area

- **Improvement and Establishment of Registration/Monitoring System for Hazardous Facility**:

- **Review of Urban Development Direction of Master Plan**: the coastal areas of Marmara Sea are not proposed for urban expansion area especially on the side of European in the future.

- **Proposed Administrative Area for Urban Development and Growth Control**: All of urbanized and rural areas within the area of law 3030 are proposed to be the administrative area of IMM for to establish harmonized municipal management system of urban development/growth control and proper municipal services in the metropolitan area under the master plan.

9.2. Framework to Review Emergency Response and Rehabilitation Works

Emergency response plans of 9 taskforces and 64 emergency response agencies of the members of Provincial Crisis Management center are qualitative without quantitative target and frameworks except water and sewage (ISKI).

Based on the results of microzoning Study of Scenario Earthquake C, frameworks for each emergency response activities are shown for the indicative figure to improve capability and provable organizational structure and task distribution.

9.2.1. Framework for Debris Removal Response from Emergency Road

For maintaining of emergency road network for proper response activities, debris removal from designated emergency road is indispensable issues for taskforce teams within 3 days. The proposed 818km of emergency roads are sharing 6% of the total road length within the metropolitan area. The estimated 2.6 million tons of debris on the proposed emergency roads share around 2% of the estimated total debris of 140million tons of damaged buildings.

The required capability of debris removal to open 1 lane on each direction from emergency roads will require 11,000 heavy goods vehicle and more than 2,000 shovels and bulldozers with proper taskforce team. Distribution of the framework is shared 33% in European Marmara Sea side, 20% in European Inland and Asian Marmara Sea side.

The followings are the issues to review and improve capability of debris removals in the metropolitan area,

- Check and up-grade capability of each debris removal taskforces
- Measures to keep the required taskforce teams with required heavy good vehicles and machinery for each district
- Review of heavy goods gathering points and garage functions
- Coordination of temporary disposal sites with emergency evacuation places.

9.2.2. Framework for Rescue Operation

Missing persons the required rescue operation is not only generated by 710,000 residents in heavily damaged building but also, a part of 910,000 residents in moderately damaged buildings and some disaster weak of 1,940,000 residents in partially damaged buildings. The major part of 223,000 estimated death and heavily injuries will be the minimum demands of rescue operation in heavily damaged building, which will require rescue taskforce teams with specialized technology and machinery. However, part of missing resident in moderately damaged building could be rescued by specialized taskforce team or self-community taskforces based on the damaged condition. However, missing disaster weak in partially damaged buildings could be almost rescued by self-community disaster taskforces.

The specialized taskforce teams would be limited within survival times of missing persons under damaged building. Self- Community Disaster Taskforce System is proposed to be indispensable measure to minimize and mitigate human casualties in the metropolitan area.

9.2.3. Framework for Emergency First Aids and Disaster Medical Care

The around 135,000 (1.5% of total pop) estimated heavily injuries and 3 times of slightly injuries would be counted for the total demand of first aid services on the site after earthquake event. The around 540,000 of 6% total population will be framework to organize first aid services and emergency stocks of medicine and equipment. The following measures are proposed to up-grade first aid services in the metropolitan area.

- to organize supporting teams for first aid services in each self-disaster taskforce
- to keep emergency stocks for first aid services in each neighborhood
- to provide paramedical and triage experts with equipment

The estimated heavily injuries could not be catered by the capacity of disaster medical services around 20,000beds, which is around 15% of heavily injuries. On the other hand, 18% of heavily/moderately and 21% of partially damaged buildings of the existing hospitals are not sufficient condition for the estimated disaster scenario. The following measures are proposed to up-grade disaster medical care services.

- To reinforce or reconstruct of assessed buildings by seismic resistant diagnosis
- To establish mixed transfer system for the demand of 135,000 heavy injuries (single helicopter transfer system will require more than 1,000 helicopters)
- To establish field hospital system and organization to increase capability of disaster medical care
- To prepare and establish inter-regional disaster medical care system with regional transfer system by sea and air

9.2.4. Framework for Fire Fighting

For 16 fire out-breaks from 814 registered hazardous facilities, the present 37 fire fighting station and Civil Defense for fire fighting taskforces of disaster in the metropolitan area will manage the estimated fire-outbreaks. And also, the estimated fire out-breaks will not spread based on the share of fire proofing building ratio (more than 85%). On the other hand, huge number of small scale fire out-breaks from damages of natural gas pipes/29,000 service boxes and electric power lines in damaged building could not be easily managed by the present fire fighting taskforces.

Improvement measures for fire fighting forces and mitigation measures for fire-outbreaks are proposed as follows,

- Training and equipment/machinery for chemical and high pressure gas hazard is proposed to the present Fire Fighting as Civil Defense
- Newly introduce and establish monitoring and valve control system for natural gas pipeline network and for pipes and service box damage within consumer's building (with building damage simulation model) is proposed to reduce spill of gas and secondary disaster.
- Same system of the above is also proposed for electric power cable network.

9.2.5. Framework for Emergency Potable Water and Foods

At the present, emergency stock system of potable water and food is not introduced and established yet in the metropolitan area. However, almost of goods circulation system and lifeline networks will be damaged and stopped after earthquake occurrence. Potable water and foods will not only available for victims in damaged building but also for almost of 8.8million citizens. The required potable water and foods for all citizens are estimated around 0.8million tons of potable water and 80million meals, which could not be supplied managed by limited capability of foods supply in the small cities on the surroundings and limited access to the metropolitan area. Systemized stock of emergency potable water and foods is proposed as follows,

1) Proposed measures to establish systemized stock for all citizens within 3 days survival period (up-to re-open emergency road) on each levels of IMM, district, community and family as follows,

- Provincial crisis management center to create major emergency potable water/foods storage center for each sides of European and Asian continents

- District crisis management center to create district emergency potable water /foods storage with circulation center functions
- Provincial/district crisis management centers and IMM to create appropriate scale of storage in community evacuation and regional evacuation places
- 3 days survival foods and water stock is proposed in each family

2) Proposed measures to establish systemized emergency foods/water/daily necessaries supply for victims and refugees in tent villages, regional evacuation areas and for families in malfunction area of lifeline

- Selection and designation of port/airport/track terminals/wholesale of foods for emergency goods circulation centers for each regional/national transport nodes of sea/air/land transport
- District emergency goods center should take the role to redistribute emergency goods from the above centers
- In emergency period, emergency goods, foods and water supply center with storage and cooking functions should be provided in each tent village and regional evacuation center

9.2.6. Framework for Tent Village

Building damage will generate homeless families and refugees, which are the demand of tent villages as follows,

All residents in heavy damaged building and half of residents in moderately damaged building and 10% of residents in partially damaged buildings are counter 1.3 million citizens, who require 333,000 tents with 833 to 1,170ha of tent village areas. The currently designated 486 tent villages with 1,000ha area are the middle of area demand. However, around 60% of designated areas are concentrated in the four districts of Kadıköy, Pendik, Büyükçekmece, Çatalca. In the other district, area demand of tent village for estimated refugees and victims could not success by the currently designated tent villages.

Tent village demands of residents in moderate damage buildings will be increase, when the government could not properly prvide assisstance to repair moderately damaged building based on the building damage inspection.

9.2.7. Framework for Temporary Housing Supply

Temporary housing will be provide to around 30% of residents in the heavy damaged buildings under the condition as follows,

- Damaged housing could not be used and repaired for living space
- Financial constraints to get other living space

The total demands of temporary housing are estimated around 52,000 units on 5.2km^2 land with lifelines for around 210,000 victims in the short term.

9.2.8. Framework for Cemetery

The estimated deaths by building damages are counted around 87,000, which will not only require 10 to 20ha of cemetery area preparation but also, coroner/autopsy, temporal store, cleaning, funeral service/burial, etc under the cooperation of related agencies.

9.2.9. Framework for Rehabilitation of Damaged Lifeline

The current emergency and rehabilitation plans are formulated and submitted except quantitative rehabilitation program to provincial crisis management center by each lifeline companies. The estimated lifeline damages on the micro-zoning study are as follows,

	Estimated damage		
Electric power cable	364km(overhead)	711km(buried)	1,075km(total)
LNG pipe	13 points	28,700 (damaged service box)	
Water supply pipe	1,580 points		
Sewage pipe	1,300 points		

Preparedness and emergency measures are proposed to each lifeline agencies as follows,

- Preparedness Measure: to procure and store proper volume of required materials and equipment for rehabilitation demand
- Preparedness Measure: newly establish monitoring and control system for electric power line/switch and LNG pipe line/valve to reduce and mitigate secondary
- Emergency Measure: provide temporary public telephone centers and potable water supply centers in regional evacuation place/tent village
- Rehabilitation Measures: to organize capable emergency and rehabilitation taskforce teams within minimized proper periods

9.2.10. Framework for Debris Removal

The estimated 140million ton debris of collapsed and damaged buildings is proposed to remove and dispose within 2 to 3 months for starting smooth urban reconstruction activities. The estimated debris will require 2,800 to 4,700 heavy machinery and 44,000 to 73,000 heavy goods vehicle with properly organized debris removal taskforce teams. Temporary debris gathering place will be required wide area in each district, in which gathering place should be coordinated with designated evacuation place/tent villages. Daily traffic demand to carry debris to final disposal site will be 220,000 to 365,000 trips, which will require the management for smooth traffic on emergency road and the improvement of the road to the candidate of vacant land of coal mining and quarry on European side.

Chapter 10.
Recommended Measures for Earthquake Disaster Mitigation

Chapter 10. Recommended Measures for Earthquake Disaster Mitigation

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 Izmit Earthquake. Already three (3) years have passed without any mitigation measures being carried out. The earthquake damage analysis of the study calculates 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 study results.

The necessary earthquake disaster mitigation measures, which are basically project-oriented, are laid out in short- and medium- to long-term perspectives. The short-term measures are to be implemented as soon as possible and the medium- to long-term measures are to be executed within five (5) to ten (10) years, or more. Short-term measures basically include retrofitting important facilities and infrastructures to secure their operational function in the event of an earthquake disaster. Medium- to long-term measures involve non-structural recommendations. Basic foci of 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 to have more open space areas in consideration of earthquake disaster preventive land-use of Istanbul. The arrangement of institutional systems for disaster management is also an important measure for a smooth and quick response to a large-scale earthquake disaster.

1) Short-Term Measures

The items listed below are to be implemented as short-term measures.

- Retrofitting of all hospitals
- Retrofitting of all school buildings
- Retrofitting of public facilities, such as City Hall and other government buildings
- Retrofitting of bridges
- Retrofitting of port facilities
- Retrofitting of all lifelines
- Construction of a disaster management centre
- Implementing a campaign to raise public awareness about disaster prevention

2) Medium- to Long-Term Measures

The items listed below are to be implemented as medium- to long-term measures.

- Formulation of a master plan for earthquake disaster prevention
- Formulation of an urban redevelopment plan aimed at establishing an earthquake resistant city
- Promotion of research for earthquake resistant buildings
- Establishment of a credit system for earthquake resistant housing
- Institutional system improvement for disaster management

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