社会開発調査部報告書

No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
ISTANBUL METROPOLITAN MUNICIPALITY (IMM)

THE STUDY ON A DISASTER PREVENTION / MITIGATION BASIC PLAN IN ISTANBUL INCLUDING SEISMIC MICROZONATION IN THE REPUBLIC OF TURKEY

VOLUME III
GIS MAPS FOR DISASTER PREVENTION AND MITIGATION

PACIFIC CONSULTANTS INTERNATIONAL
OYO CORPORATION

SSF
JR
02-174

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
ISTANBUL METROPOLITAN MUNICIPALITY (IMM)

THE STUDY ON A DISASTER PREVENTION / MITIGATION BASIC PLAN IN ISTANBUL INCLUDING SEISMIC MICROZONATION IN THE REPUBLIC OF TURKEY

VOLUME III
GIS MAPS FOR DISASTER PREVENTION AND MITIGATION

DECEMBER 2002

PACIFIC CONSULTANTS INTERNATIONAL
OYO CORPORATION

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

川上隆朗

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,

N. Ikenishi

Noboru IKENISHI

Team Leader,

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

Implementation Organizations

Turkish Side

Administrative Consulting Committee

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

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.

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

Japanese Side

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

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

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)

An Outline of the Seismic Microzonation Maps

Introduction

Based on a number of map data collected through the project, JICA Study Team developed a GIS data base to support an analysis work for seismic microzoning.
Through the GIS-technique, the collected basic data maps were fully processed and analysed to understand spatial distribution of both socio-economical and physical constraints of the study area against potential seismic disaster. Results of those data analysis were displayed in forms of maps and tables.
This 'GIS Maps' compiles a number of selected outputs out of the results of this study. The existing urban condition, topographical and geological background of the study area and the results of seismic damage analysis according to the earthquake scenario were visually compiled.
These Seismic Microzoning Maps were prepared as an additional material to supplement the main report of this study. These will contribute to those who are concerned with research and planning works of urban environment or solution of urban land use problems of Istanbul area.

Outline of the Microzonation Maps

Input Data Items

In order to develop the GIS data base for this study, many kinds of both graphical and statistical data/information have been collected with cooperation of relevant agencies. All collected map data were digitised and filed in the computer after necessary modification, adjustment and updating. A total of sets of original map data were stored into the Microzoning Maps, which are demonstrated in this map atlas.

Data Processing by GIS

Data processing by GIS consists of three hierarchical stages, namely, primary, secondary and tertiary process, according to the degree of the spatial data manipulation.

The primary data analyses:

Simple overlay analyses of basic maps were conducted to identify spatial distribution patterns and characteristics in relation with regional factors. Cross tabulation in terms of area, length, density, average and/or frequency calculation were made to identify specific geographic features by district or census survey unit in this stage. Statistical data such as population and building were compiled into the corresponding statistical maps. Results of the primary data analysis may not only show existing urban conditions of Istanbul, but also bear planning indicators for seismic disaster management.

The secondary data analyses:

In this stage, seismic disaster related data were combined and analysed to understand spatial distribution of damage potential and constraints of the study area. For the model building, a number of evaluation criteria affecting seismic disaster such as conditions of natural/environmental constraints, and urban infrastructures were selected from the urban seismic disaster analyses point of view. The results of this data processing are the basis for the next data analysis.

The tertiary data analysis:

Simulation analyses for potential earthquake in the study area were conducted according to the earthquake scenario as the tertiary data analysis. Comprehensive damage analysis for buildings and human casualty of the study area was the most important results of this study. Details of damage analysis were explained in the main report.

GIS system for this study

For the development and operation of GIS of this study, study team applied ARC/INFO 8.2 and Arc View 3.2 software as a GIS. These are the most standard GIS software package in the world. Appropriate PC systems were used for data processing and compilation of output mapping. Large size inkjet plotter and A3 size colour printer were used for final map production. A0 size digitizer and scanner were used for digitisation. Functions on 'local database development' were fully employed for this study.

Contents of GIS Maps

A. Existing Conditions

A-1 Study Area
A-2 Mahalle Boundary
A-3 Elevation
A-4 Slope
A-5 Geological Map : IMM, 1:5.000
A-6 Epicentral Distribution of Historical Earthquakes
A-7 Epicentral Distribution of Earthquakes, 1905 - 2001
A-8 Damaged Building Ratio in İstanbul at 1999 Kocaeli Earthquake
A-9 Urban Expansion
A-10 Existing Landuse
A-11 Conservation Area (Designated by Conservation Board)
A-12 Population by Mahalle
A-13 Population Density by Mahalle
A-14 Number of Building by Mahalle
A-15 Building Density by Mahalle
A-16 Building Ratio Distribution by Structure Frame Structure: RC
A-17 Building Ratio Distribution by Structure Masonry Structure: Briquette, Brick
A-18 Building Ratio Distribution by Construction Year : 1949 and Before
A-19 Building Ratio Distribution by Construction Year : 1950 - 1959
A-20 Building Ratio Distribution by Construction Year : 1960 - 1969
A-21 Building Ratio Distribution by Construction Year : 1970 - 1979
A-22 Building Ratio Distribution by Construction Year : 1980 - 1989
A-23 Building Ratio Distribution by Construction Year : 1990 and After
A-24 Building Ratio Distribution by Story : 1 - 3 Stories
A-25 Building Ratio Distribution by Story : 4 - 7 Stories
A-26 Building Ratio Distribution by Story : 8 - 15 Stories
A-27 Building Ratio Distribution by Story : 16 and Over Stories
A-28 Number of Primary and High School by District
A-29 Location of Fire Brigade
A-30 Medical Facility: Number of Hospital and Policlinic by District
A-31 Number of Governmental Facilities by District and Location of Municipality and Kaymakamlık
A-32 Number of Security Facilities by District and Location of District Police (İlçe Emniyet)
A-33 Active Parks by Mahalle (Area >= 25000m2)
A-34 Active Parks by Mahalle (500 <= Area < 25000 m2)
A-35 Water Supply Pipelines Network
A-36 Sewage Pipelines Network
A-37 Natural Gas Pipelines Network
A-38 High Voltage Electricity Line Network
A-39 Telecom Fiber Optic Lines Network
A-40 Existing Road Network by Road Function
A-41 Road Length (m/ha)
A-42 Bridge Location
A-43 Number of Hazardous Facility by Mahalle : LPG and Oil Stations
A-44 Number of Hazardous Facility by Mahalle : Factories

B. Earthquake Analysis

B-1 Location Map of Existing Ground Survey
B-2 Location Map of Geological Survey
B-3 Ground Classification Map
B-4 Distribution of Acceleration at Bedrock: Model A
B-5 Distribution of Velocity at Bedrock: Model A
B-6 Distribution of Peak Ground Acceleration: Model A
B-7 Distribution of Peak Ground Velocity: Model A
B-8 Distribution of Acceleration Response Spectrum (0.2 sec): Model A
B-9 Distribution of Acceleration Response Spectrum (1.0 sec): Model A
B-10 Distribution of Acceleration at Bedrock: Model C
B-11 Distribution of Velocity at Bedrock: Model C
B-12 Distribution of Peak Ground Acceleration: Model C
B-13 Distribution of Peak Ground Velocity: Model C
B-14 Distribution of Acceleration Response Spectrum (0.2 sec): Model C
B-15 Distribution of Acceleration Response Spectrum (1.0 sec): Model C
B-16 Distribution of Liquefaction Potential: Model A
B-17 Distribution of Liquefaction Potential: Model C
B-18 Risk for Slope Stability: Model A
B-19 Risk for Slope Stability: Model C

C. Seismic Damage Analysis

C-1 Number of Heavily Damaged Building: Model A
C-2 Ratio of Heavily Damaged Building: Model A
C-3 Seismic Intensity: Model A
C-4 Number of Heavily Damaged Building: Model C
C-5 Ratio of Heavily Damaged Building: Model C
C-6 Seismic Intensity: Model C
C-7 Number of Dead People: Model A
C-8 Number of Dead People: Model C
C-9 Fire Outbreak Possibility: Model C
C-10 Distribution of Water Pipe Damage: Model C
C-11 Distribution of Sewage Pipe Damage: Model C
C-12 Distribution of Natural Gas Pipe Damage: Model C
C-13 Distribution of Natural Gas Service Box Damage: Model C
C-14 Electricity Cable Damage length (km): Model C
C-15 Distribution of Telecommunication Fiber Optic Cable
C-16 Damage Possibility of Bridge

D. Urban Vulnerability Analysis and Evaluation

D-1 Vulnerability Evaluation: Emergency Operation Issue Population in Heavily Damaged Building
D-2 Vulnerability Evaluation: Emergency Operation Issue Total Refugee
D-3 Vulnerability Evaluation: Emergency Operation Issue Total Removal Debris
D-4 Medical Facility: Number of Bed per 100 Heavily Injured People in Model C
D-5 Land Availability for Urban Structure Improvement
D-6 Vulnerability of Building Structure: All Factors
D-7 Vulnerability Issues on Building and Urban Structure for Earthquake Disaster
D-8 Proposed Measures to Improve Building/Urban Structure
D-9 Isolation Risk Caused by Road Blockage
D-10 Facilities for Primary, Secondary and Tertiary Emergency Road Study
D-11 Bridge with High Damage Potential: Reinforcement Priority Based on Damage Possibility and Priority for Road Network
D-12 Proposed Emergency Road Network

Annex

List of All GIS Maps compiled in the Study

Explanation of GIS Maps

A. Existing Conditions

Base Map

A-1 Study Area
A-2 Mahalle Boundary

The study area consists of 27 districts of IMM and the built-up area of additional 3 districts (Büyükçekmece, Silivri and Çatalca). The following maps were used as base map.

Data	Source	Scale	Covering Area	Year	Number of Sheet	Total Area (km^2)
Topographic Map	Directorate of Photogrammetry, IMM	1,5:000	IMM Except Adalar	1995 – 1997	472	2,754
Topographic Map	Directorate of Photogrammetry, IMM	1:1,000	Adalar	1987	69	25
			Bakırköy port	1995	1	0.37
			Same as 1:5,000		3,899	1,422
				1997	2,926	1,066
Topographic Map "İçmesuyu ve Atıksu Hatları, Barajlar, İçmesuyu ve Atıksu Havzaları	Directorate of Mapping Works, İSKİ	1:50,000	All the Study Area	2000	5	7,608

Administrative boundary dividing sub-district or smaller unit is usually employed for the data analysis unit for urban/regional planning. The concrete and most detailed unit in Istanbul is mahalle. The Study Team compiled the municipality and mahalle boundary. Base mahalle list was created from "Population Census, 2000" together with mahalle lists from district municipalities. There is apparent gap between two sources and the gap was confirmed through interviews with each district municipality. The municipality and mahalle code system is based on "Population Census, 2000" because the mahalle list of Population Census is the best mahalle list with code system. Some codes were changed to more than 900 and all the code-missing areas were given code more than 900. The code more than 900 means that it was given by the study team to stop relational database analysis error. The code less than 100 means the same code as "Population Census, 2000".

Topographic Condition

A-3 Elevation
A-4 Slope

Elevation data of the IMM's 1:1,000 digital map were processed to generate 50 m grid DTM data and 50m grid slope gradient data.
One of the most obvious features of the topography of Istanbul is the Bosphorus Strait, which separates Istanbul as part of both Asia and Europe. Both sides of the strait show steep mountainous topography while the other area of Istanbul is on relatively gentle hill topography. Another distinctive topographic feature is that no major plane is spread out in Istanbul.
Elevation of the Study Area varies from 0 to 500m and elevation of most of the urbanized area is less than 150m. Elevation of the valley is almost less than 50m and the river gradient is relatively low. The gradient of the ground surface is varies from 0 to approximately 100% and the gradient of most of the urbanized area is less than 10%.

Geology and Seismicity

A-5 Geological Map: IMM, 1:5.000
A-6 Epicentral Distribution of Historical Earthquakes
A-7 Epicentral Distribution of Earthquakes, 1905 - 2001
A-8 Damaged Building Ratio in İstanbul at 1999 Kocaeli Earthquake

The 1:50,000 scaled geological map of the Study Area was compiled by Prof. Dr. F.Y.Oktay and Dr. R.H.Eren in 1994. The Counterpart Agency later significantly improved this map by conducting supplemental geological surveys and by adding available borehole, geophysical exploration, and observation data. These maps were later reduced to a 1:5,000 scale in digital form.
The stratigraphic column of Istanbul has been divided into litho-stratigraphic units as follows (Oktay ve Eren, 1994), "Istanbul" group (the Paleozoic), "Gebze" group (Triassic), "Darıca" group (Upper Cretaceous-Lower Eocene), "Çatalca" group (Eocene), "Terkos" group (Oligocene), "Halkalı" group (Upper Miocene). Young sediments are not divided into litho-stratigraphic units, except "Kuşdili Formation, the Late Quaternary.

Land Use

A-9 Urban Expansion
A-10 Existing Landuse
A-11 Conservation Area (Designated by Conservation Board)

Urban settlements were started and growing to 100,000 populations the after establishment of Eastern Romanesque Empire by Constantine at the year 330. After the establishment of Ottoman Empire, measures to settle citizens increased population to 200,000 on the end of 15th century, 0.8 million at the end of 16th century. In 18th century, great fire out breaks and spread in City Wall Area changed the trends of population increase to decrease.
In 19th century, modernization of economy, industry, and socio-politics encouraged rapid expansion of urban areas, as around 3.5 times area of that of 15th century.
After the Second World War, industrialization accelerated explosive immigration trend to Istanbul. For the explosive population growth from one million to ten millions in the period, 83% of the existing urbanized area at 1994 was rapidly developed to cater and absorb the increasing housing demand with out proper urban development plan and appropriate growth control measures. In order to avoid the above uncontrollable situation, Greater Istanbul Municipality was introduced and established to manage and control urban development and to provide proper municipal services in Istanbul at 1984 by Law 3030.
Presently, identified archeological heritage, historical, and traditional works, and natural environmental resources are grouped into one of four categories of area conservation systems as follows:
-Area Conservation 1: Archeological Area (eastern top of the Istanbul Peninsula)
-Area Conservation 2: Historical Urban Area (inside the Walled City, Beyoğlu, and Eyüp, and towns in Adalar islands, etc.)
-Area Conservation 3: Historical Scenery Conservation Areas (along the Bosphorus Strait,
-Mixed area conservation of the above
In addition, the Istanbul Peninsula and the Chronological Walled City of Constantinople/Istanbul were registered as World Heritage sites by UNESCO in 1992.

Population

A-12 Population by Mahalle
A-13 Population Density by Mahalle

According to the Population Census of 2000 by the State Institute of Statistics of the Prime Ministry, the total population of Istanbul within its 27 districts and additional 3 districts (Büyükçekmece, Silivri and Çatalca) is 8,831,766 and its population density is 89 persons/hector.
Gaziosmanpaşa has the largest population counted at 667,809, and Kadiköy has the second largest population counted at 660,619. The district that has the smallest population is Çatalca, having 15,624. Within 27 districts in Istanbul, Adalar has the

Explanation of GIS Maps

smallest population.
Güngören has the largest population density counted at 378 persons/ha and Fatih follows counted at 377 person/ha. On the contrary, Adalar, Büyükçekmece, Çatalca, and Silivri each have a rather small population density counted at 16 persons/ha, 24 persons/ha, 3 persons/ha and, 12 persons/ha, respectively.

Building

A-14 Number of Building by Mahalle
A-15 Building Density by Mahalle
A-16 Building Ratio Distribution by Structure Frame Structure: RC
A-17 Building Ratio Distribution by Structure Masonry Structure: Briquette, Brick
A-18 Building Ratio Distribution by Construction Year: 1949 and Before
A-19 Building Ratio Distribution by Construction Year: 1950 - 1959
A-20 Building Ratio Distribution by Construction Year: 1960 - 1969
A-21 Building Ratio Distribution by Construction Year: 1970 - 1979
A-22 Building Ratio Distribution by Construction Year: 1980 - 1989
A-23 Building Ratio Distribution by Construction Year: 1990 and After
A-24 Building Ratio Distribution by Story: 1 - 3 Stories
A-25 Building Ratio Distribution by Story: 4 - 7 Stories
A-26 Building Ratio Distribution by Story: 8 - 15 Stories
A-27 Building Ratio Distribution by Story: 16 and Over Stories

Building data was provided from by the State Institute of Statistics of the Prime Ministry. The data consisted of 1) structure type, 2) construction year, and 3) number of stories of each building. The total number of buildings within the Study Area is counted at 724,609 buildings.
(1) Structure Types
The ratio of RC frame structures is 74.4% and of briquette/brick masonry is 21.7%; therefore, 96.1% of structures are made up of these two types. Newly developed areas in the last three decades that are mainly made up of RC structures are Avcilar, Bahçelievler, Bağcilar, Büyükçekmece, Gaziosmanpaşa, and Esenler, with 90% of its building stock made up of RC structures. On the contrary, the building stock in old towns such as Adalar, Beyoğlu, Eminönü and Fatih is more than 30% masonry structures. Most masonry structures are made of briquette and brick, and it is remarkable that in Eminönü, 19% of the bulding stock is comprised of stone masonry buildings.
(2) Building Construction Year Data
The original 2000 Building Census data was aggregated into 6 categories: 1) 1949 and before, 2) 1950-1959, 3) 1960-1969, 4) 1970-1979, 5) 1980-1989, and 6) 1990 and after. The number of buildings before 1969 was only 127,755 (17.9 % of the total number of buildings in the year 2000). Also, development rapidly increased after 1970, with the construction of mostly RC frame structures. It can be considered that this wave of construction contributed to the construction of rather low quality buildings, especially residential buildings.
(3) Number of Stories
The original 2000 Building Census data was aggregated into four (4) categories: 1) 1-3 stories, 2) 4-7 stories, 3) 8-15 stories, and 4) 16 stories and over.
Buildings with up to 4 stories account for 52.9% of the total number of buildings. By district, these buildings (1-4 stories) make up 70% of the buildings in the districts of Adalar, Beykoz, Eyüp, Sariyer, Tuzla, Ümraniye, Çatalca, and Silivri. These districts are mostly low-density areas with a population density of less than 100person/ha. On the contrary, Bahçelievler, Kadiköy, and Şişli have a rather large number of high-story buildings. 9.4% to 12.9% of the buildings in these districts were buildings with more than 16 stories.

Public Facilities and Open Spaces

A-28 Number of Primary and High School by District
A-29 Location of Fire Brigade
A-30 Medical Facility: Number of Hospital and Policlinic by District
A-31 Number of Governmental Facilities by District and Location of Municipality and Kaymakamlık
A-32 Number of Security Facilities by District and Location of District Police (İlçe Emniyet)
A-33 Active Parks by Mahalle (Area >= 25000m2)
A-34 Active Parks by Mahalle (500 <= Area < 25000 m2)

(1) Educational Facilities
The current situation for the educational facilities was examined based on the data obtained from the provinces. The numbers of primary schools and high schools, population, and holding capacity per school in each district in the Study Area are examined.

	Public	Private	Total	Population	Population per school
Primary School	1208	177	1385		
High School	384	164	548		
Total			1,933	8,831,766	4,596

More than 100 schools, both primary and high schools, are located in Kadıköy, Üsküdar and Gaziosmanpaşa. Districts with less than 30 schools are Esenler, Eminönü and Adalar. An average of 64 schools are located in each district.
Population per school was calculated by dividing district's population by the total number of schools in the district. Çatalca, Büyükçekmece and Silivri are the districts with density of less than 1,000 persons per school. Districts with the density greater than 7,000 persons/school are Bağcılar, Güngören, Avcılar and Esenler. Over all the average for the Study Area is 4,569 persons/school.
The province anticipates using total of 280 schools in Istanbul as emergency shelters/temporary housings. Available floor areas of schools, populations, and population densities to clarify usability of the schools for the purpose are also examined in the Study.

(2) Fire Fighting Facilities
The fire fighting facilities is examined based on the data obtained from the IMM Fire Department. There is more than 1 fire fighting facility in most of the districts. Most of fire-fighting facilities are located close to the first-degree road designated by the IMM.

(3) Medical Facilities
The medical facilities are examined based on the data obtained from the provinces. More than 30 medical facilities, both hospitals and policlinics, are located in Gaziosmanpaşa, Üsküdar and Eyüp. Districts with less than or equal to 3 medical facilities are Kağıthane, Silivri, Adalar, Çatalca, and Tuzla(0 facility). In an average 16 facilities are located in each district.

Category	Hospital					Policlinic		Total
	Public	Private	SSK	University	Public Corporation	Public	Private	
Number	31	141	15	6	8	9	24	468

Current situation with regards to the numbers of beds is examined based on the data obtained from the Ministry of Health.
More than 2,000 beds in the medical institution are located in Bakırköy and Üsküdar. Districts with less than 100 beds are Ümraniye, Maltepe, Eyüp, Çatalca, Tuzla. In an average 648 beds are located in each district.
More than 2,000 beds per 100,000 people are available in Adalar and Bakırköy. Districts with less than 40 beds per 100,000 people are Esenler, Bağcılar, Eyüp, Maltepe, Ümraniye and Tuzla.

Number of total hospital and policlinic	Number of total bed	Population	Average Number of beds per 100,000 people
468	19,433	8,831,766	220

(4) Governmental Facilities
Current situation for the governmental facilities, ministerial, provincial, and municipal buildings, is examined based on the data obtained from the province.
More than 35 buildings of governmental facilities are located in Fatih, Kadıköy, and Beşiktaş. In an average 16 buildings are located in each district.

(5) Security Facilities
Current situation for the security facilities, district polices (İlçe emniyet), polices, gendarmes (Jandarma), and other relating facilities, is examined based on the data obtained from the province.

(6) Park
Distribution of parks and its area available for temporary evacuation are examined.

Lifelines

A-35 Water Supply Pipelines Network
A-36 Sewage Pipelines Network
A-37 Natural Gas Pipelines Network
A-38 High Voltage Electricity Line Network
A-39 Telecom Fiber Optic Lines Network

(1) Gas
The natural gas distribution service is provided by IGDAŞ. Their database is comprehensive and contains important and necessary information, such as pressure regulation valve locations, main pipe network, distribution pipe network, and other related attributes.
(2) Water and Sewage
Water supply service and sewage is provided by ISKI. ISKI is also managing their network database, which includes pipe type/diameter information, joint type information, etc.
(3) Electricity
Electricity service is separated into two parts. Electricity supply is operated by TEAŞ. This service is separate for the two sides of the city (TEAŞ European side and TEAŞ Anatolian Side), and electricity distribution is operated by BEDAŞ (European Side) and AKTAŞ (Anatolian Side). Each company had data in different formats or no digital format data was available and the Study Team digitized all received hard copy network information.
(4) Telecommunications
Turk Telecom provides telecommunication service. Their jurisdiction areas are separated into two parts: one is for the European side and the other is for the Anatolian side. Recently, the project to set up GIS network data for the fiber optic cable network has been started.

Roads and Bridges

A-40 Existing Road Network by Road Function
A-41 Road Length (m/ha)
A-42 Bridge Location

Road data were collected from topographical maps of scale 1/5,000. Total length is approximately 13,700 km. The road network is the most important infrastructure for transportation and also functions as a lifeline and communication system. The density of roads directly correlates to land usage. The density is rather high in residential areas and, also, that narrow streets are dense in these areas.

	Total length ratio	Ratio to area	Ratio to persons
Width of 2-6 m and functioning as a city street	64.7 %	89.5 m/ha	1.00 m/person
Width of 7-15 m and functioning as a secondary road of the principal network	29.9 %,	41.4 m/ha	0.46 m/person
Width of more than 16 m and functioning as principal roads for an extended area	3.5 %,	4.9 m/ha	0.05m/person

Bridge data was supplied by the relevant organizations, and the Study Team conducted its own inventory survey on the structural features.

Organization	Number of Bridge
17th Reg.Hwy.	336
1th Reg.Hwy.	49
IBB-construction Dept.	15
IBB-Infra. Coord. Dept.	30
IBB Maintenance Dept.	133
IBB Metro	20
TCDD Railway – Asian side	39
TCDD Railway - European side	37

Hazardous Facilities

A-43 Number of Hazardous Facility by Mahalle: LPG and Oil Stations
A-44 Number of Hazardous Facility by Mahalle: Factories

The Licensing Directorate of IMM compiled the list of the 882 registered hazardous facilities. These are categorized as 1) large LPG storage, 2) paint/polish products factories, 3) Chemical Warehouses, 4) fuel/LPG filling stations, 5) fuel filling stations.

Big LPG Storage	Factory of Paint/Polish Products	Warehouse of Chemical Products	Fuel/LPG Filling Facility	Fuel Filling Station	TOTAL
163	91	404	123	33	814

B. Earthquake Analysis

Ground Classification

B-1 Location Map of Existing Ground Survey
B-2 Location Map of Geological Survey
B-3 Ground Classification Map

The Counterpart Agency has their archive for existing soil investigation and geophysical survey reports. All boring logs, laboratory tests and survey results are collected and analyzed for the Study. Geological database is developed through the Study. All of the borehole logs are digitized and stored into this database system. Seismic refraction database is already developed by the Counterpart Agency. Furthermore, boring investigation and geophysical survey were undertaken during the Study.

	Number of Borehole	Total Length (m)
Existing data: European side	1063	2832.86
Existing data: Anatolia side	703	27780.45
JICA Study	48	10596.46
Total	1814	41209.77

	PS logging	Seismic Refraction	Microtremor	Microtremor horizontal array
Existing Data	0	907	263	0
JICA Study	39 locations, total length 2288 m	0	0	40
Total		907	263	

The Study Team and Counterpart Agency compiled geological cross sections in every 1 km interval, in north-south and east-west direction and finally total of 4,623 of 500m by 500m geological column models were generated. Average shear velocities for subsurface soil of 30m (AVS30) were defined based upon geological stratigraphy and results of PS logging work. Total of 10 types of ground classification were defined for every 500m by 500m grids covering all the study area.

Site Class	Average S wave velocity over upper 30m
A	>1500m/sec
B	760 - 1500m/sec
C	360 - 760m/sec

Explanation of GIS Maps

D		180 - 360m/sec
	D1	300 - 360m/sec
	D2	250 - 300m/sec
	D3	220 - 250m/sec
	D4	200 - 220m/sec
	D5	180 - 200m/sec
E		<180m/sec

Seismic Motion

- B-4 *Distribution of Acceleration at Bedrock: Model A*
- B-5 *Distribution of Velocity at Bedrock: Model A*
- B-6 *Distribution of Peak Ground Acceleration: Model A*
- B-7 *Distribution of Peak Ground Velocity: Model A*
- B-8 *Distribution of Acceleration Response Spectrum (0.2 sec): Model A*
- B-9 *Distribution of Acceleration Response Spectrum (1.0 sec): Model A*
- B-10 *Distribution of Acceleration at Bedrock: Model C*
- B-11 *Distribution of Velocity at Bedrock: Model C*
- B-12 *Distribution of Peak Ground Acceleration: Model C*
- B-13 *Distribution of Peak Ground Velocity: Model C*
- B-14 *Distribution of Acceleration Response Spectrum (0.2 sec): Model C*
- B-15 *Distribution of Acceleration Response Spectrum (1.0 sec): Model C*

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. 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.

	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

Based on the fault model, peak acceleration, peak velocity, and acceleration response spectrum were calculated with a selected empirical attenuation formula. Subsurface amplification was evaluated by an amplification factor for each site class (AVS30). 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.

(1) Peak Ground Acceleration (PGA)

a. Model A

Acceleration exceeds over 400 gals on the seashore of the European side and in Adalar.
The valley following north from Haliç also experiences accelerations of over 400 gals.
Acceleration in Eminönü to Büyükçekmece ranges from 300 to 400 gals.
In the majority of areas of the New City, Çatalca, and Silivri, acceleration ranges from 200 to 300 gals.
The Asian side suffers less than 300 gals, except for the seaside areas.

b. Model B

The PGA distribution of the European side is similar to Model A.
The majority of the Asian side area experiences accelerations of less than 200 gals, except Adalar, Kadıköy, and Üsküdar.

c. Model C

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

d. Model D

A part of Adalar and Bakırköy experience accelerations of over 400gals.
Bakırköy and part of Tuzla experience accelerations of 300 to 400 gals.
Accelerations of 200 to 300 gals are experienced from Eminönü to Avcılar and on the Asian seashore.

(2) Peak Ground Velocity (PGV)

a. Model A

Grid classes D4, D5, and E on the European side experience velocities of over 80 kine.
Grid classes D1, D2, and D3 in Fatih, Bayrampaşa, Bağcılar, Avcılar, and the southern districts on the European side experience velocities of 60 to 80 kine.
The class C grid on the Asian seashore experience velocities of 40 to 60 kine.

b. Model B

The PGV distribution on the European side of Model B is somewhat similar to Model A. The majority of the Asian side, except the seaside from Maltepe to Tuzla and along the valley, experience velocities of less than 40 kine.

c. Model C

The area that experiences velocities of 40 kine is wider than that of Model A on the Asian side.
Every grid experiences the largest PGV among the three scenario earthquakes.

(3) Acceleration Response Spectrum (Sa, h=5%)

The 5% damped Sa values for the period of 0.1 to 2.0 seconds were calculated.

a. Model A

0.2 sec: Sa values of 500 to 1000 gals are experienced from Eminönü to Büyükçekmece on the European side and on the seaside of the Asian side. Other areas experience 200 to 500 gals.
1.0 sec: Grid classes D and E at the seaside of Bakırköy experience over 500 gal. Eminönü to Büyükçekmece and the Asian seashore experience 200 to 500 gals.

b. Model B

The Sa distribution of the European side for Model B is similar to that for Model A. Almost the entire area on the Asian side experiences accelerations of 200 to 500 gals at 0.2 sec, and less than 200 gals at 1.0 sec.

c. Model C

0.2 sec: The Sa distribution for Model C is very similar to that of Model A.
1.0 sec: Almost all of Bakırköy experiences accelerations of over 500 gals, and the area with 200 to 500 gals is wider than that of Model A.

d. Model D

0.2 sec: The Sa distribution of Model D on the European side is similar to Model A. The majority of the Asian side experiences accelerations of 200 to 500 gals, except for the seaside.
1.0 sec: A part of Bakılköy experiences accelerations of over 500 gals. Bahçelievler and the southern district of the European side and seashore of the Asian side experience 200 to 500 gals. The majority of the study areas suffer less than 200 gals.

Seismic Hazards

- B-16 *Distribution of Liquefaction Potential: Model A*
- B-17 *Distribution of Liquefaction Potential: Model C*
- B-18 *Risk for Slope Stability: Model A*
- B-19 *Risk for Slope Stability: Model C*

(1) Evaluation of Liquefaction

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 districts in the area evaluated as having "very high" (Model C) liquefaction potential areas , wider than 40 ha.

(2) 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

Explanation of GIS Maps

evaluated for each district. In the Büyükçekmece, Adalar, and Avcılar districts, 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.

C. Seismic Damage Analysis

Damage to Buildings and Number of Dead People

C-1 Number of Heavily Damaged Building: Model A
C-2 Ratio of Heavily Damaged Building: Model A
C-3 Seismic Intensity: Model A
C-4 Number of Heavily Damaged Building: Model C
C-5 Ratio of Heavily Damaged Building: Model C
C-6 Seismic Intensity: Model C
C-7 Number of Dead People: Model A
C-8 Number of Dead People: Model C

The building inventory database was obtained from the compilation of data from the 2000 Building Census for each mahalle. Building types are classified for damage estimation purpose. Each type is defined as a combination of "Structure", "Floor Number" and "Construction Year". The damage vulnerability function will be given for each of building type.

Structure	Floor Number	Construction Year -1959	1960 - 1969	1970 -	Total
RC Frame with Brick Wall	1 - 3F	7,120 (1.0%)	13,757 (1.9%)	200,950 (27.7%)	221,827 (30.6%)
	4 - 7F	6,280 (0.9%)	15,449 (2.1%)	280,231 (38.7%)	301,961 (41.7%)
	8F -	481 (0.1%)	886 (0.1%)	18,468 (2.5%)	19,835 (2.7%)
Wood Frame	1 - 2F	4,755 (0.7%)	697 (0.1%)	1,583 (0.2%)	7,035 (1.0%)
	3F -	3,611 (0.5%)	222 (0.0%)	358 (0.0%)	4,191 (0.6%)
RC Shear Wall	1 - 3F	1 (0.0%)	0 (0.0%)	13 (0.0%)	13 (0.0%)
	4 - 7F	0 (0.0%)	0 (0.0%)	200 (0.0%)	200 (0.0%)
	8F -	0 (0.0%)	0 (0.0%)	564 (0.1%)	564 (0.1%)
Masonry	1 - 2F	25,967 (3.6%)	24,881 (3.4%)	83,215 (11.5%)	134,063 (18.5%)
	3F -	16,952 (2.3%)	8,208 (1.1%)	8,877 (1.2%)	34,037 (4.7%)
Prefabricated		20 (0.0%)	12 (0.0%)	864 (0.1%)	896 (0.1%)
		65,188 (9.0%)	64,113 (8.8%)	595,322 (82.2%)	724,623 (100.0%)

Building damages are calculated based on scenario earthquakes Model A and Model C. In these estimations, every type of building included in the building census for the year 2000 is included.
The damage vulnerability functions are defined for each of building type. Buildings are calculated as "heavily," "moderately," or "partly" damaged. "Heavily" damaged buildings are buildings that are severely damaged or have collapsed, and these buildings are unfit to occupy until they are repaired or rebuilt. "Moderately" damaged buildings are buildings that are able to used for evacuation purposes just after the hazard, but they need to be repaired before occupied permanently. "Partly" damaged buildings can be used for living, but it is desirable they be repaired because the structure is partly damaged and its earthquake-resistance has been compromised. The cause of damage is limited to the seismic vibration itself. Damage due to other causes, as liquefaction, landslide, and fire, are not included. This assumption will not affect the result because these phenomena are not main causes of earthquake disasters.

		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	

Seismic intensity is evaluated based on building damage. In either Model, intensities VII to X are estimated. A large area of the European side is estimated to experience intensity X.

Intensity	Definition
XI:	Heavily Damage Ratio > 55%
X:	55% > Heavily Damage Ratio > 15%
IX:	15% > Heavily Damage Ratio .AND. Heavily + Moderately Ratio > 15%
VIII:	15% > Heavily + Moderately Ratio .AND. Heavily + Moderately + Partly Ratio >15%
- VII:	15% > Heavily + Moderately + Partly Ratio

The 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.

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

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

Fire Outbreak

C-9 Fire Outbreak Possibility: Model C

The fire potential of building dwellings is strongly affected by the local situation, namely, the fuel used for the cooking stove, the structure of the kitchen, the heating system, etc. Therefore, it is necessary to statistically analyze fire outbreaks during past earthquakes and develop a vulnerability function for the local area, but this type of data is not available in Istanbul. Therefore, the potential of fire outbreaks from facilities where flammable liquids or gas materials are handled is estimated based on Japanese experience. Consequently, the results show only a relative possibility of fire occurrence.

Damage to Lifelines

C-10 Distribution of Water Pipe Damage: Model C
C-11 Distribution of Sewage Pipe Damage: Model C
C-12 Distribution of Natural Gas Pipe Damage: Model C
C-13 Distribution of Natural Gas Service Box Damage: Model C
C-14 Electricity Cable Damage length (km): Model C
C-15 Distribution of Telecommunication Fiber Optic Cable

Lifeline facilities are to be classified into two major categories, nodes and links. Nodes include facilities such as substations and purification plants. Links include facilities such as pipes or cables for supply and distribution purposes. A statistical approach for damage estimation of links, i.e., distribution pipes and lines, is applied in this study. Damages to node facilities are not estimated in this study, because such structures are different with respect to purpose and location and a statistical approach is not applicable for the analysis. Separate detailed surveys are required for the damage estimation of node facilities.

Water Pipeline Damage

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

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

Explanation of GIS Maps

Sewage Pipeline Damage

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

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

Gas Pipeline and Service Box Damage

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

	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%)

Electricity Cable Damage

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

	Cable Length (km)			Damaged Cable Length (km)		
	Under-ground	Over-head	Total	Underground	Overhead	Total
Model A	14,500	18,50	33,00	280 (1.9%)	540 (2.9%)	820 (2.5%)
Model C		0	0	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.

Damage to Bridges

C-16 Damage Possibility of Bridge

Purpose is to point out specific bridges that should be noticed in order to mitigate malfunction. This is so called "First screening". Considering that, the falling-off of the girder can give the most serious effect to the road system. Therefore, a methodology that is proposed by Kubo/Katayama is selected because that methodology is very effective for evaluate the bridges on the viewpoint of falling-off of the girder.

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

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

Damage to Public Facilities

C-17 Damages to 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.

D. Urban Vulnerability Analysis and Evaluation

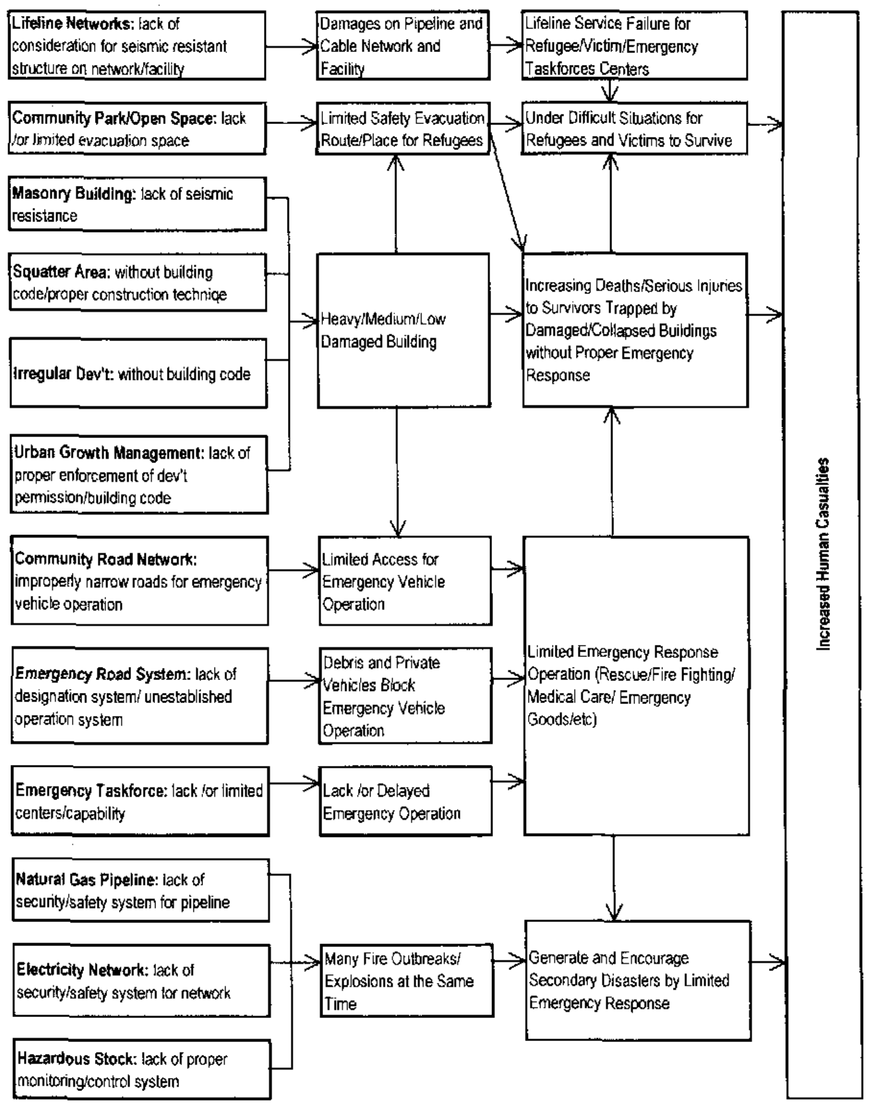
Urban Vulnerability and Proposed Measures for Improvement

- *D-1 Vulnerability Evaluation: Emergency Operation Issue Population in Heavily Damaged Building*
- *D-2 Vulnerability Evaluation: Emergency Operation Issue Total Refugee*
- *D-3 Vulnerability Evaluation: Emergency Operation Issue Total Removal Debris*
- *D-4 Medical Facility: Number of Bed per 100 Heavily Injured People in Model C*
- *D-5 Land Availability for Urban Structure Improvement*
- *D-6 Vulnerability of Building Structure: All Factors*
- *D-7 Vulnerability Issues on Building and Urban Structure for Earthquake Disaster*
- *D-8 Proposed Measures to Improve Building/Urban Structure*

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

Explanation of GIS Maps



- 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

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 are prepared:

- Recommendation to Strengthen Urban Structures: Urban Redevelopment
- Recommendation to Strength Urban Structures: Improvement of Urban Structures
- Recommendation to Reorganize Land-Use Plan and Zoning
- Recommendation to Promote Seismic Resistant Buildings

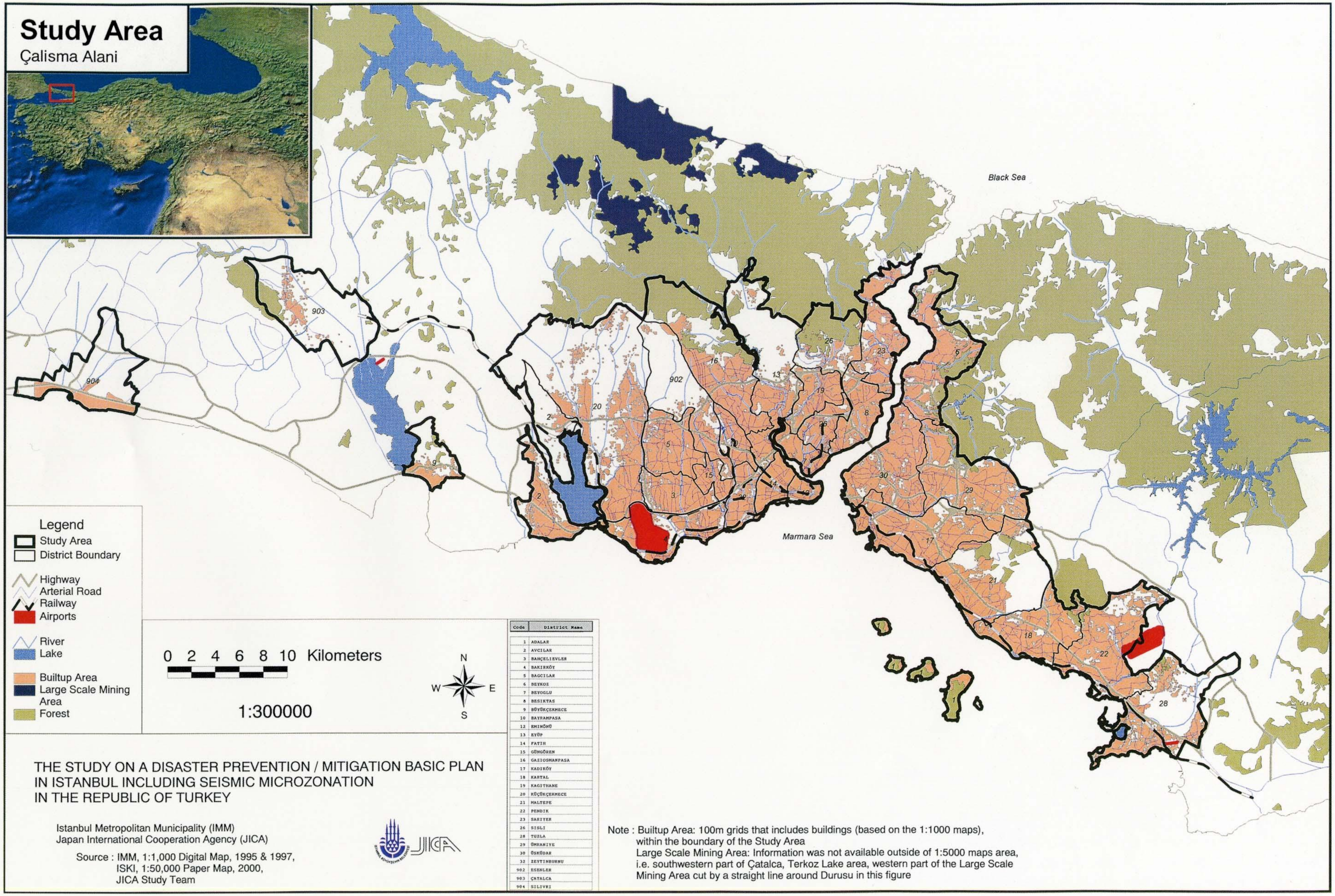
Isolation Risk, Proposed Measures for Bridge and Road Improvement

D-9 Isolation Risk Caused by Road Blockage
D-10 Facilities for Primary, Secondary and Tertiary Emergency Road Study
D-11 Bridge with High Damage Potential: Reinforcement Priority Based on Damage Possibility and Priority for Road Network
D-12 Proposed Emergency Road Network

Estimation of probable road blockage due to collapsed buildings are discussed based on an estimate on probable damages to the buildings. The term of "road blockage" in this report is defined as a case where a passage wider than three meters cannot be secured to allow the smallest vehicles to go through after the buildings, etc. are collapsed.

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 prioritized earthquake-resistant reinforcement efforts for bridges and on future road construction plans, is suggested. Here, the influence of bridge damages and results of importance evaluation on roads and bridges in view of earthquake prevention.

A. Existing Conditions

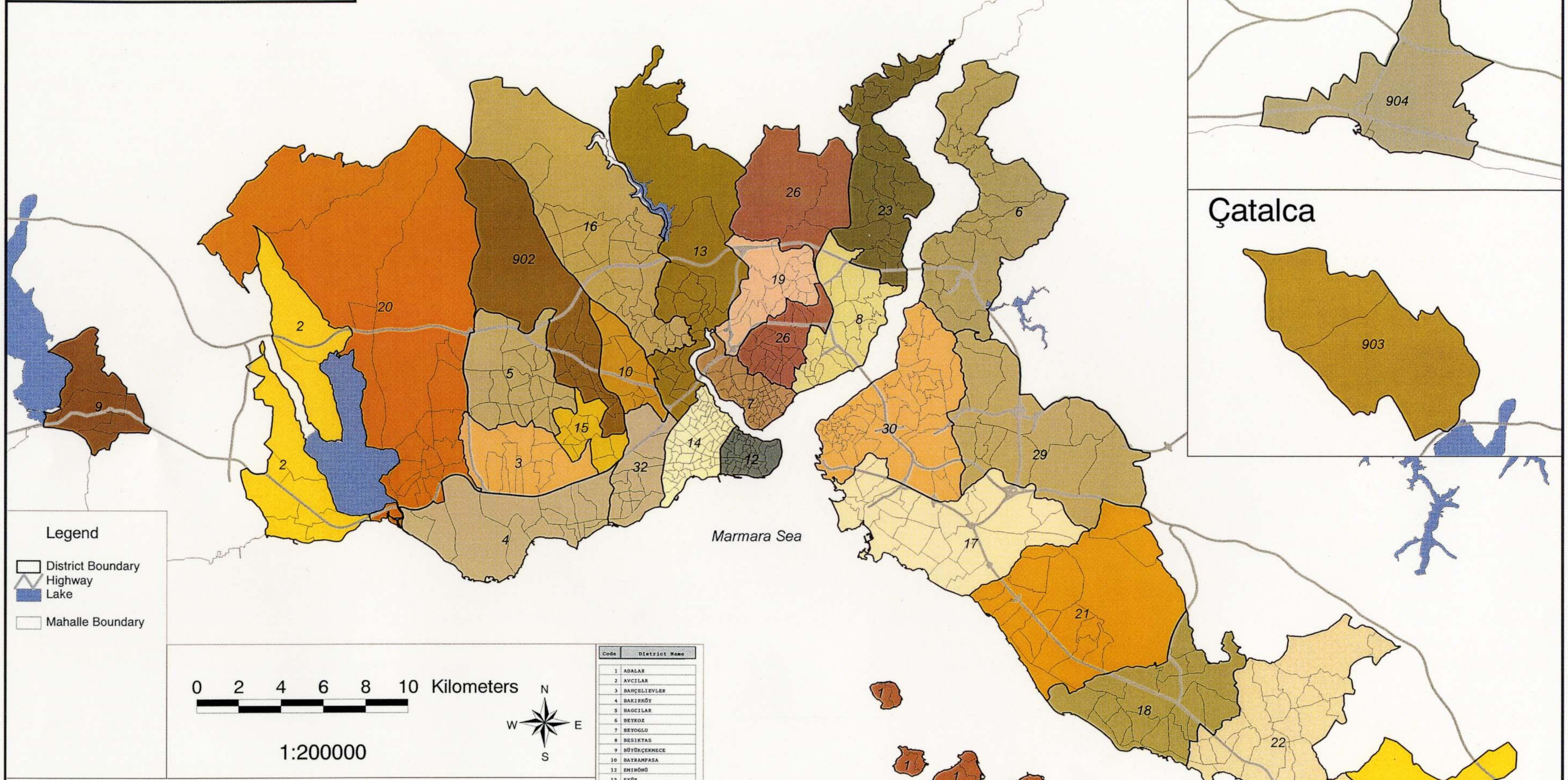


Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELIEVLER
4	BAKIRKÖY
5	BAGCILAR
6	BEYKOZ
7	BEYOGLU
8	BESIKTAS
9	BÜYÜKÇEKMECE
10	BAYRAMPASA
12	EMINÖNÜ
13	EYÜP
14	FATIH
15	GÜNGÖREN
16	GAZIOSMANPASA
17	KADIKÖY
18	KARTAL
19	KAGITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDIK
23	SARIYER
26	SISLI
28	TUZLA
29	ÜMRANIYE
30	ÜSKÜDAR
32	ZEYTINBURNU
902	ESENLER
903	ÇATALCA
904	SILIVRI

A-1 Study Area

Mahalle Boundary

Mahalle Sinirlari

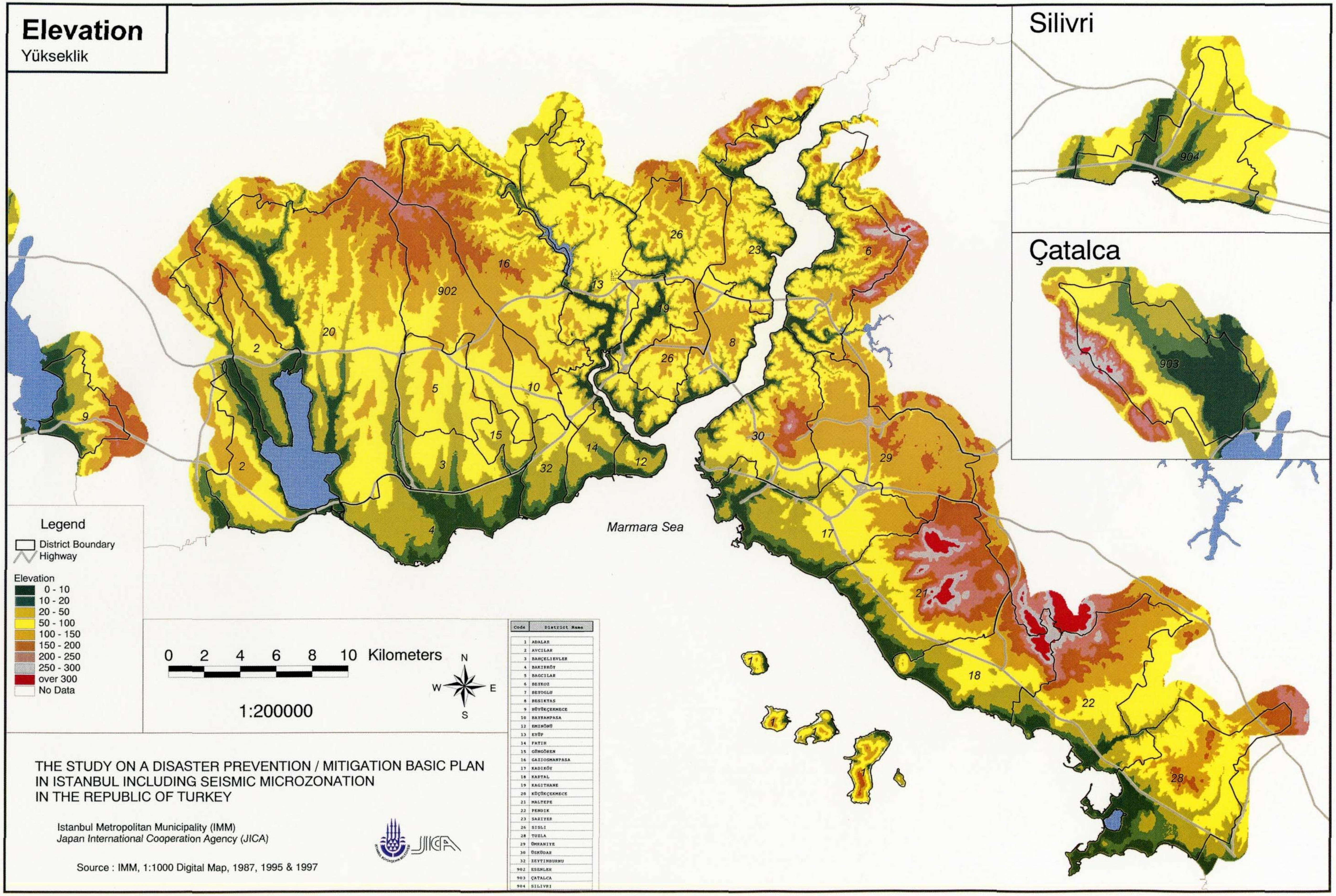


Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELIEVLER
4	BAKIRKÖY
5	BAGCILAR
6	BEYKOZ
7	BEYOGLU
8	BESIKTAS
9	BÜYÜKÇEKMECE
10	BAYRAMPASA
12	EMINÖNÜ
13	EYÜP
14	FATIH
15	GÜNGÖREN
16	GAZIOSMANPASA
17	KADIKÖY
18	KARTAL
19	KAGITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDIK
23	SARIYER
26	SISLI
28	TUZLA
29	ÜMRANIYE
30	ÜSKÜDAR
32	ZEYTINBURNU
902	ESENLER
903	ÇATALCA
904	SILIVRI

THE STUDY ON A DISASTER PREVENTION / MITIGATION BASIC PLAN
IN ISTANBUL INCLUDING SEISMIC MICROZONATION
IN THE REPUBLIC OF TURKEY

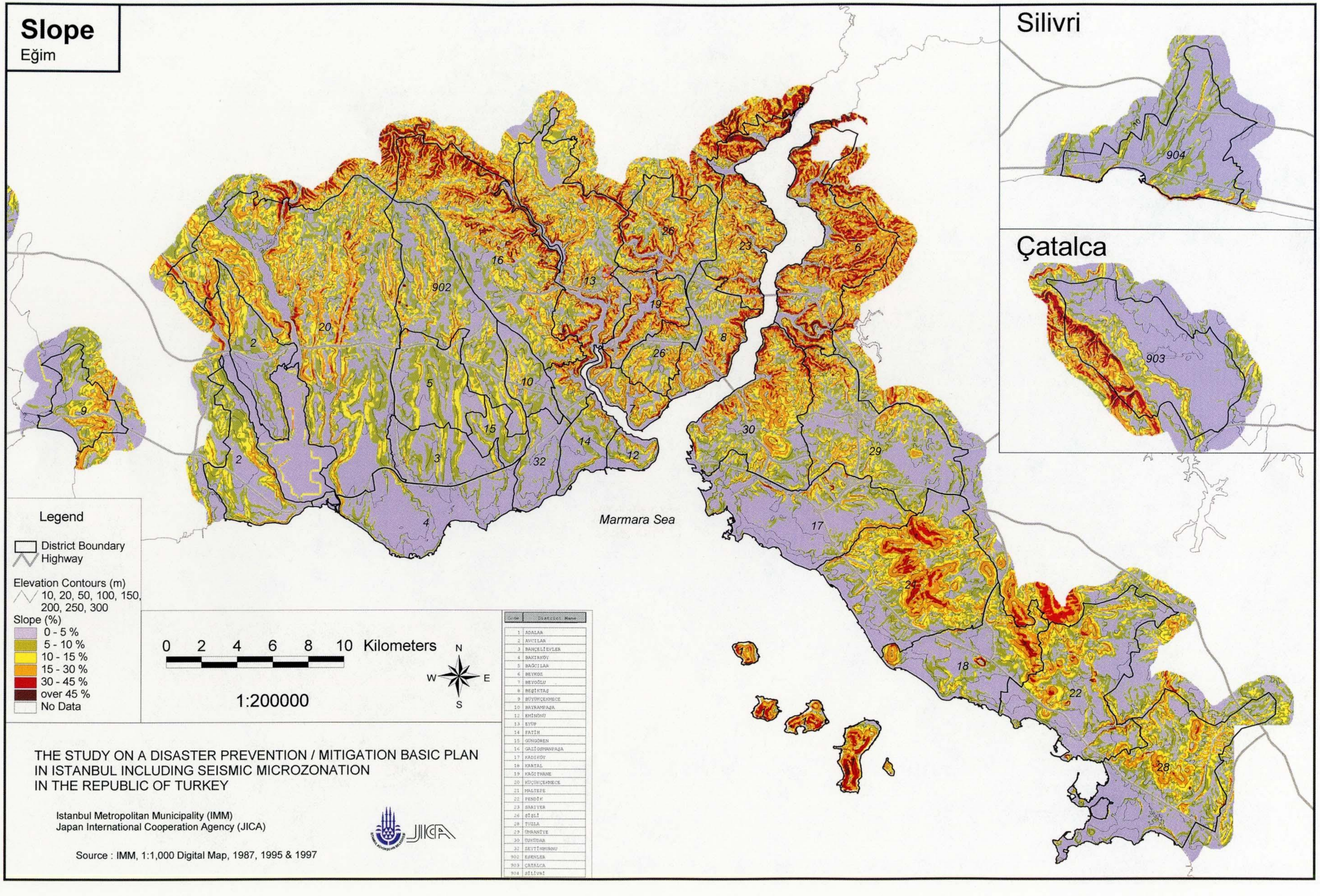
Istanbul Metropolitan Municipality (IMM)
Japan International Cooperation Agency (JICA)

Source : JICA Study Team based on description from municipalities



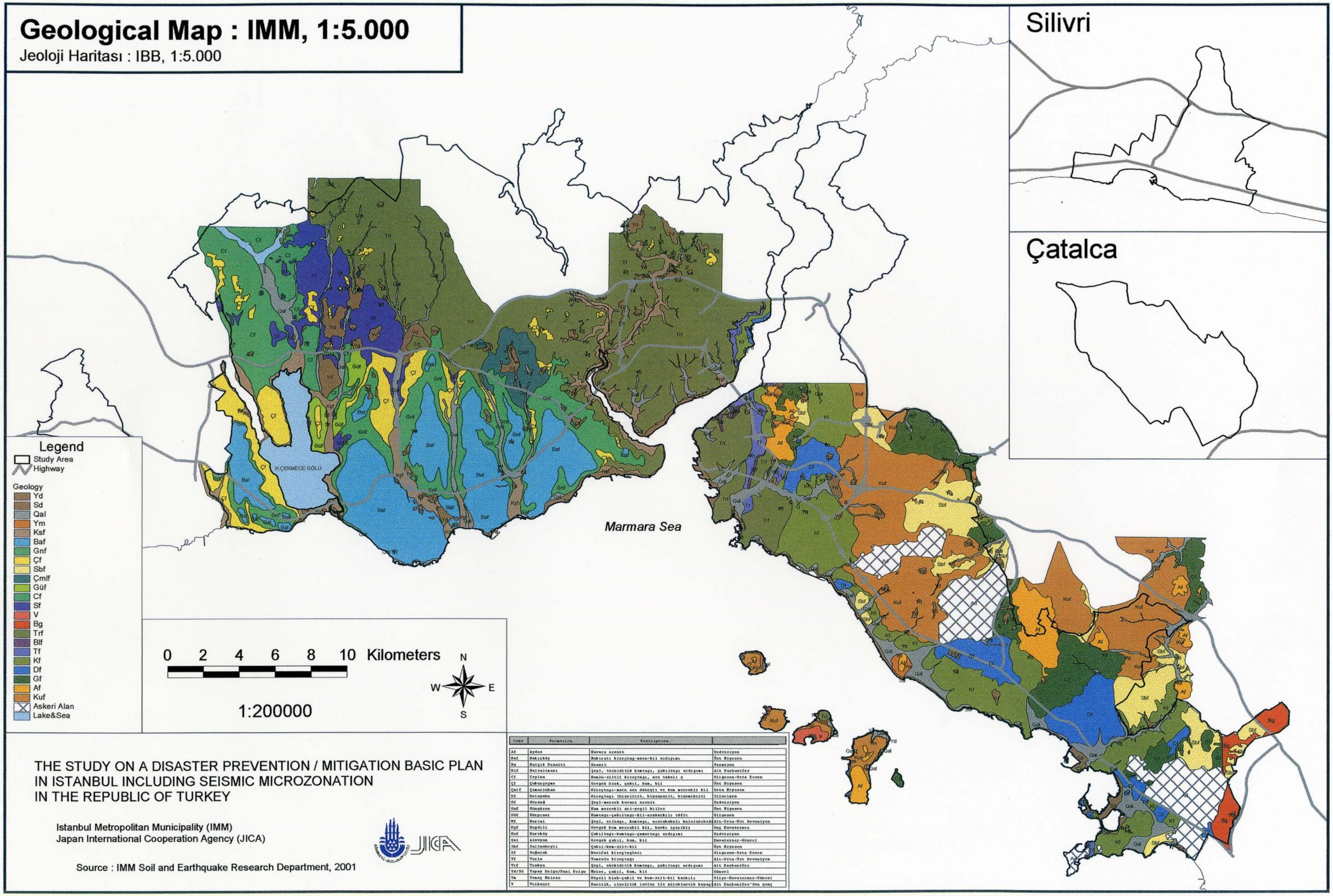
Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELIEVLER
4	BAKIRKÖY
5	BAGCILAR
6	BEYKOZ
7	BEYOGLU
8	BESIKTAS
9	BÜYÜKÇEKMECE
10	BAYRAMPASA
12	EMINÖNÜ
13	EYÜP
14	FATIH
15	GÜNGÖREN
16	GAZIOSMANPASA
17	KADIKÖY
18	KARTAL
19	KAGITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDIK
23	SARIYER
26	SISLI
28	TUZLA
29	ÜMRANIYE
30	ÜSKÜDAR
32	ZEYTINBURNU
902	ESENLER
903	ÇATALCA
904	SILIVRI

A-3 Elevation



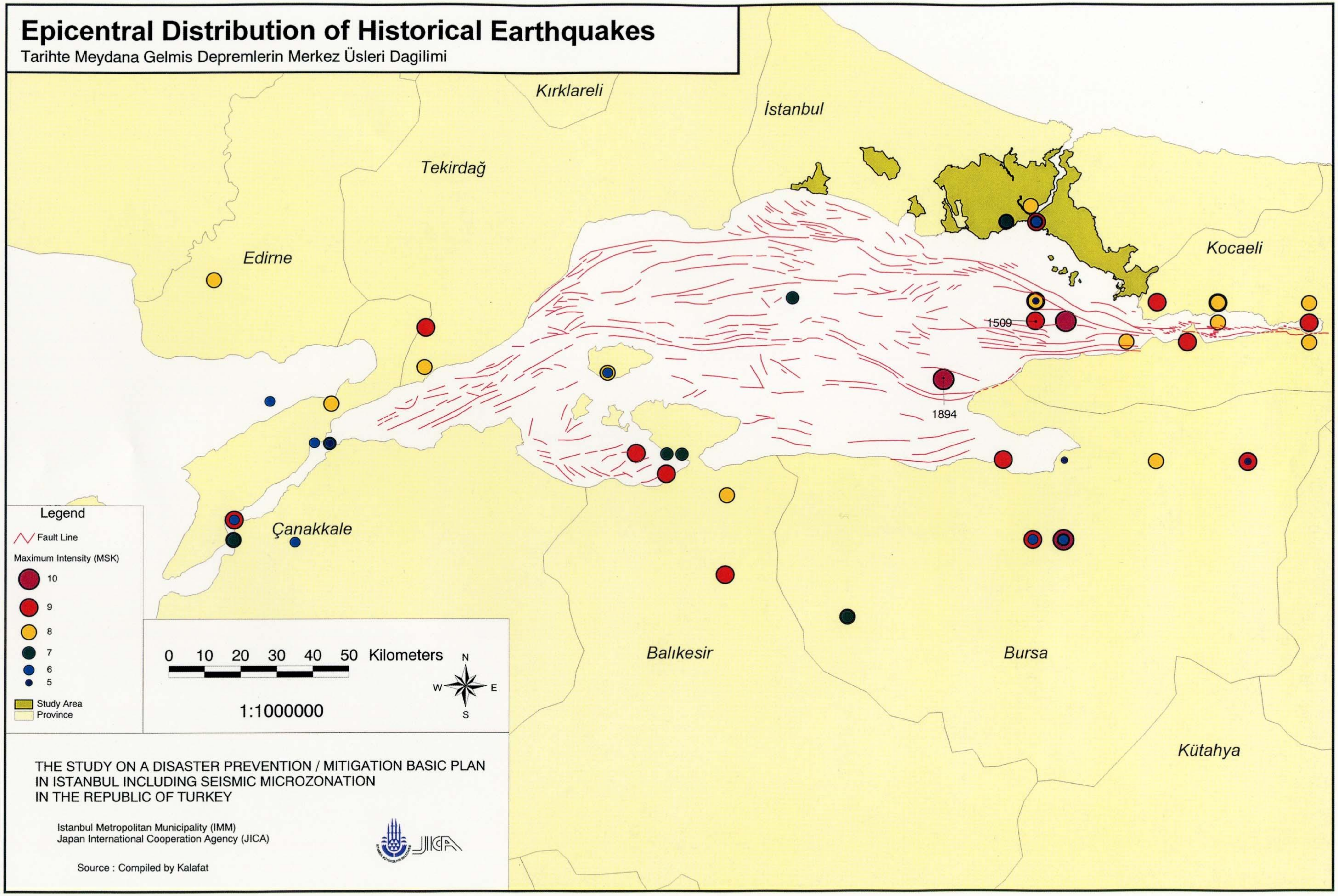
Code	District Name
1	ADALAR
2	AVCILAR
3	BAHÇELİEVLER
4	BAKIRKÖY
5	BAĞCILAR
6	BEYKOZ
7	BEYOĞLU
8	BEŞİKTAŞ
9	BÜYÜKÇEKMECE
10	BAYRAMPAŞA
12	EMİNÖNÜ
13	EYÜP
14	FATİH
15	GÜNGÖREN
16	GAZİOSMANPAŞA
17	KADIKÖY
18	KARTAL
19	KAĞITHANE
20	KÜÇÜKÇEKMECE
21	MALTEPE
22	PENDİK
23	SARIYER
26	ŞİŞLİ
28	TUZLA
29	ÜMRANİYE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

A-4 Slope



Code	Formation	Description	
Af	Aydos	Kuvars arenit	Ordvisiyen
Baf	Bakırköy	Maktralı kireçtaş-marn-kil ardıgımı	Üst Miyosen
Bg	Balçık Graniti	Granit	Permiyen
Blf	Baltalimanı	Şeyl, türbiditik kumtaşı, çakıltaşı ardıgımı	Alt Karbonifer
Cf	Ceylan	Kumlu-siltli kireçtaşı, ara tabalı ç	Oligosen-Orta Eosen
Çf	Çukurçeşme	Gevşek blok, çakıl, kum, kil	Üst Miyosen
Çmlf	Çamurluhan	Kireçtaşı-marn ara düzeyli ve kum mercekli kil	Orta Miyosen
Df	Dolayoba	Kireçtaşı (biyolitit, biyosparit, biyomikrit)	Siluriyen
Gf	Gözdağ	Şeyl-mercek kuvars arenit	Ordvisiyen
Gnf	Güngören	Kum mercekli gri-yeşil killer	Üst Miyosen
Güf	Gürpınar	Kumtaşı-çakıltaşı-kil-arakatkılı tüfit	Oligosen
Kf	Kartal	Şeyl, siltaşı, kumtaşı, aratabakalı kalsitürbidi	Alt-Orta-Üst Devoniyen
Kşf	Kuşdili	Gevşek kum mercekli kil, kavkı içerikli	Geç Kuvaterner
Kuf	Kurtköy	Çakıltaşı-kumtaşı-çamurtaşı ardıgımı	Ordvisiyen
Qal	Alüvyon	Gevşek çakıl, kum, kil	Kuvaterner-Güncel
Sbf	Sultanbeyli	Çakıl-kum-silt-kil	Üst Miyosen
Sf	Soğucak	Resifal kireçtaşları	Oligosen-Orta Eosen
Tf	Tuzla	Yumrulu kireçtaşı	Alt-Orta-Üst Devoniyen
Trf	Trakya	Şeyl, türbiditik kumtaşı, çakıltaşı ardıgımı	Alt Karbonifer
Yd/Sd	Yapay Dolgu/Suni Dolgu	Moloz, çakıl, kum, kil	Güncel
Ym	Yamaç Molozu	Köşeli blok-çakıl ve kum-silt-kil katkılı	Pliyo-Kuvaterner-Güncel
V	Volkanit	Dasitik, riyolitik lavlar ile piroklastik kayaçl	Alt Karbonifer'den genç

A-5 Geological Map : IMM, 1:5.000



A-6 Epicentral Distribution of Historical Earthquakes