EARTHQUAKE RISK REDUCTION STUDIES at GENERAL DIRECTORATE OF DISASTER AFFAIRS

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INTRODUCTION

General Directorate of Disaster Affairs (GDDA) is the responsible authority for assessing hazard and risk of earthquake, landslide, rock-fall and avalanche and the implementation of loss reduction countermeasures. Preventing and reducing the results of natural disasters are one of the main duty GDDA in Turkey. It has departments of earthqauke research, emergency and transportation, disaster investigation and damage assessment, planning and loan management, temporary housing, prefabricated housing production and construction, and disaster fund management and supplies. The Turkish Red Crescent Society and The General Directorate of Civil Defense as well as the local administrators and city governors play major roles in rescue and relief operations. The finance for disaster restoration works are mainly met by the National Budget.

The duties and responsibilities of General Directorate of Disaster Affairs are shortly as follows:

- to make emergency relief organizations and coordination in the event of disaster
- to take necessary measures to establish temporary shelters for disaster victims
- to execute and organize disaster relief
- to coordinate and cooperate with related ministries
- to determine disaster prone areas and take necessary counter measures
- to prepare land use map, projects and various plans;
- to research on reduction of earthquake risk; to study earthquakes and their results; to prepare Earthquake related documents and maps; to determine the criteria and regulations for earthquake resistant structures.
- to develop seismic recording and strong motion network; to maintain these networks

Turkey is located in the Alp-Himalaya earthquake belt that extends from Azor islands to Southeast Asia. The North Anatolian Fault Zone (NAFZ), Aegean Graben System (AGS), East Anatolian Fault (EAF) and Southeast Anatolian Thrust (SAT) are the most important faults in Turkey and also they are quite active faults. The North Anatolian Fault Zone extends East-West direction at the Northern part of Turkey and accepted as a dextral strike slip fault the relative motions between the Anatolian block and Eurasian plate. Figure 1 shows both distribution of the earthquake epicenters equal or greater than magnitude M ≥ 4 for a period 1881-2003 and active fault lines (Saroglu et al., 1992). Epicenters are concentrated on the NAFZ, EAF, AGS and SAT.

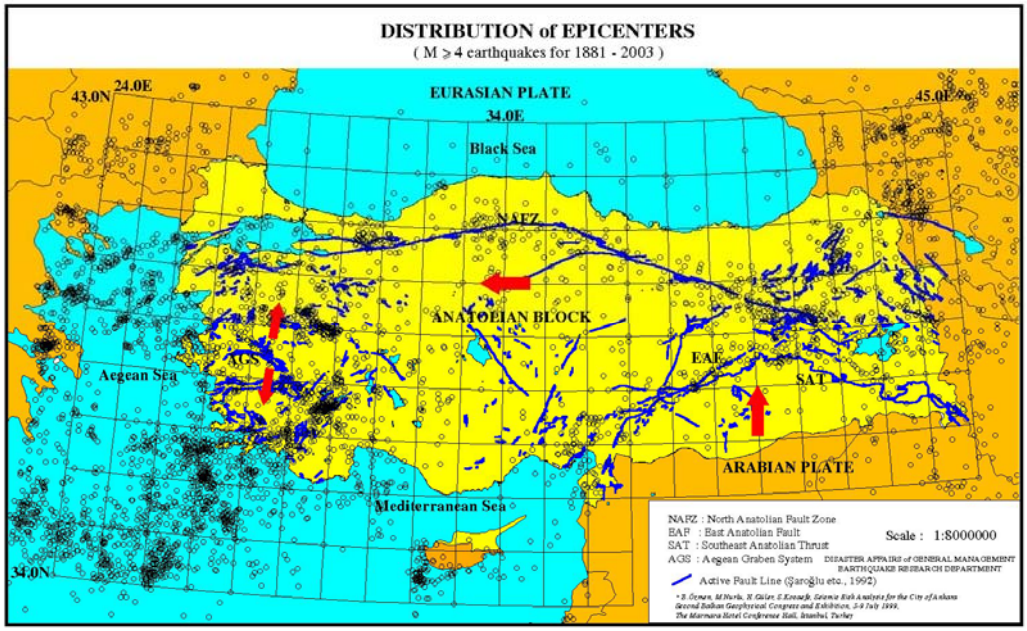

Figure 1 : Epicentral location for the earthquakes occurred during 1881 – 2003

The correlation between epicenters and locations of tectonic elements is fairly good. An outstanding feature of earthquake occurrences in Turkey is that the focal depths are shallow except for the ones in the Mediterranean Sea, so that usually considerable damage has been accompanied with the earthquakes when the magnitude is larger than, about 5.5.

Figure 2 shows the destructive earthquakes that occurred in Turkey within the years (1900 – 2003). Between 1900 and 2003 years there were 148 earthquake disasters that killed 100,000 people, injured 71,790, and damaged 611,157 buildings. This has accounted for the %78 of the total number of buildings damaged by natural

disasters in the 20th century alone. The amount of losses caused by earthquake disasters has therefore totalled to approximately US$ 19 billion. Actually an earthquake of magnitude class 7 occurred there almost every 3 or 4 years and has caused a great amount of damage.

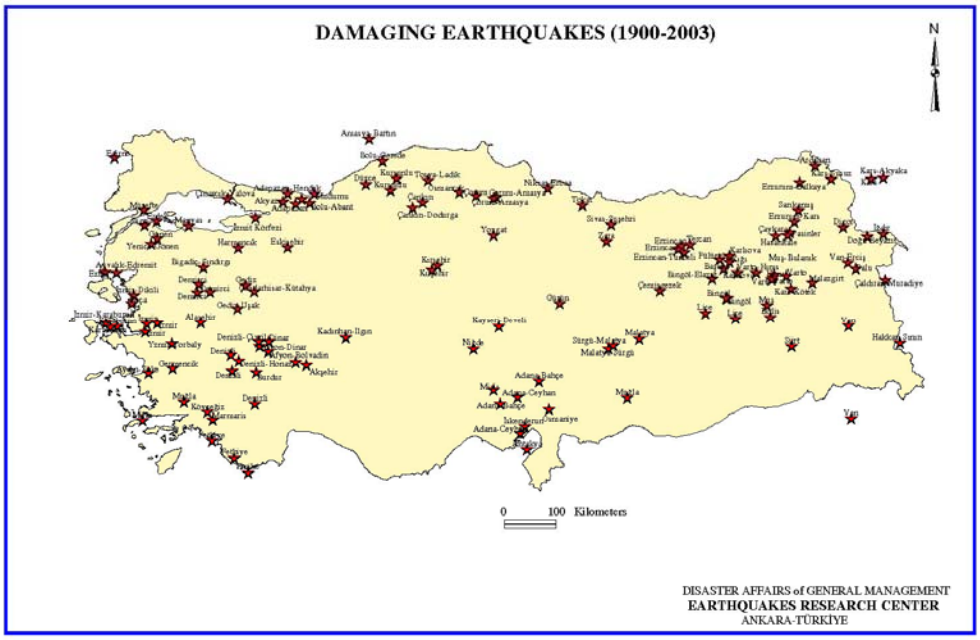

Figure 2 : Epicentral location for damaging earthquakes occurred during 1900 – 2003

Fig. 3 shows the epicenters of an historical earthquake with intensity larger than V (MSK) which occurred from BC 2100 to 1900 AD in Turkey and surrounding vicinity. The earthquake catalogue is prepared by Soysal et al (1981). The catalogue contains 1175 historical earthquakes which occurred in Turkey and the surrounding areas limited by the 22^0 - 45^0 E longitudes and 33^0 - 45^0 N latitudes.

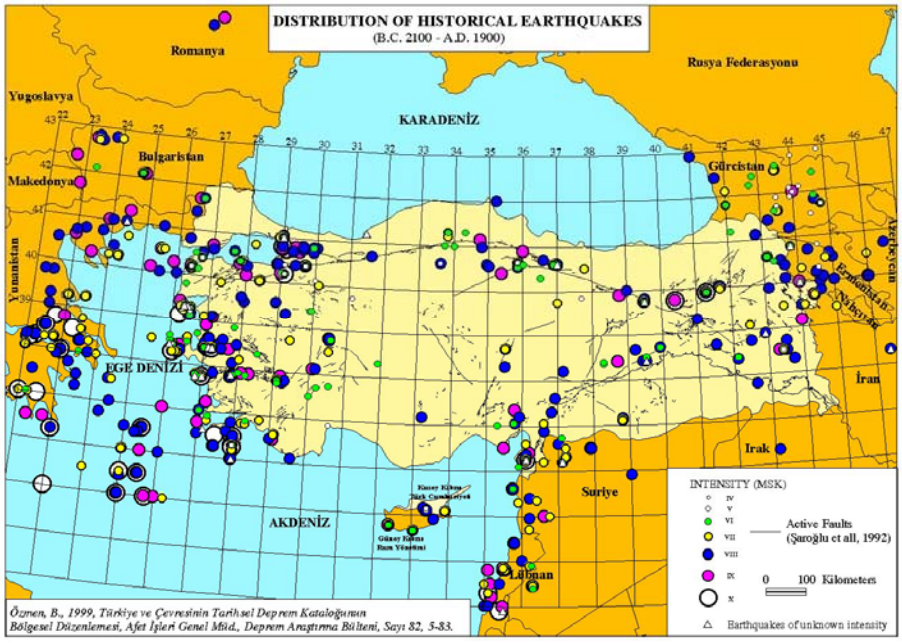

Figure 3 : Epicentral location for historical damaging earthquakes occurred during BC 2100 – AD 1900

Assuming a *Poisson* type model for earthquake occurrence in Turkey, there is a 63 percent annual probability for an intensity VII MSK scale earthquake or eight earthquakes with intensity V. Similarly, the probability for an intensity IX earthquake every 5 years is 63 percent. Figure-4 shows the annual frequency of earthquake occurrence in Turkey.

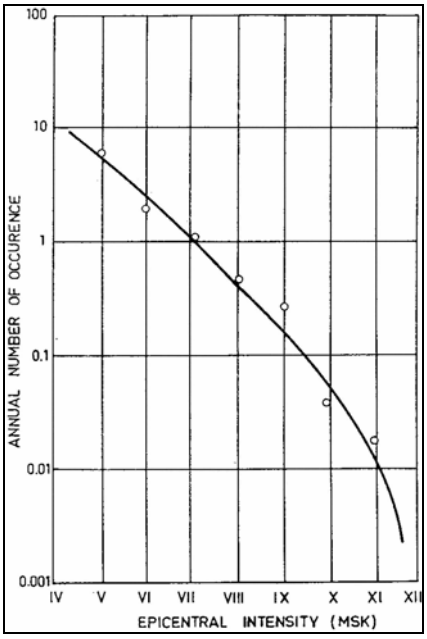

Figure 4 : The Annual frequency of earthquake occurrences in Turkey

The Ministry of Public Works and Settlement published An official Earthquake Hazard Zoning Map of Turkey was developed by GDDA in 1996. It based on expected a maximum acceleration value that has calculated with probabilistic method. It assumes that a normal construction, which has 50 years of economical life, may not be exposed larger than these expected maximum acceleration values with 90 percent probability. The whole country is divided into the 5 different hazard zones in the following manner (Özmen et al 1997) (Figure 5).

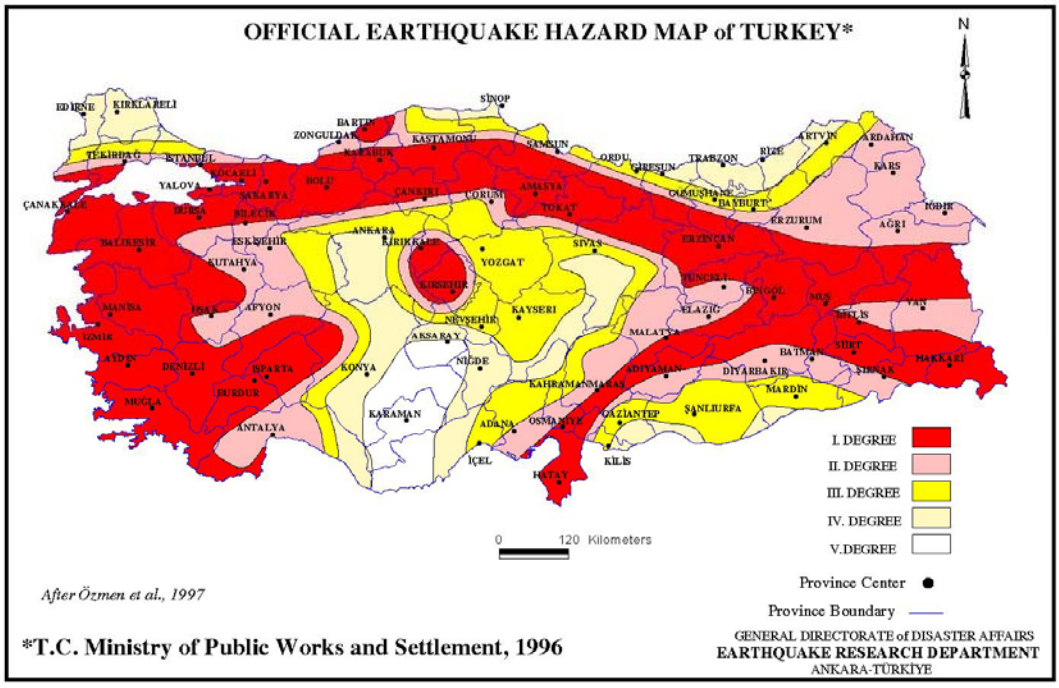

Figure 5 : The Official Earthquake Hazard Map of Turkey

Table 1: Distributions of Elements at Risk in Turkey

Earthquake Zone	Surface Area (%)	Population (%)	Industry (%)	Dams (%)
Zone 1 (pga >= 0.40 g)	42	45	51	46
Zone 2 (pga = 0.30 - 0.39 g)	24	26	25	23
Zone 3 (pga = 0.20 - 0.29 g)	18	14	11	14
Zone 4 (pga = 0.10 - 0.19 g)	12	13	11	11
Zone 5 (pga < 0.10 g)	4	2	2	6
TOTAL	**100**	**100**	**100**	**100**

The *pga* is the expected peak ground acceleration with 90 percent probability of non-exceedance during 50 years. g: gravity (981 cm/s).

Sixty six percent of the surface area of Turkey lies in Zone 1 and Zone 2 degrees of seismic risk, and the percentage of the population living in these risk areas is %71 (Table 1). In addition, most of the industrial sites and dams are also located in these seismically active areas.

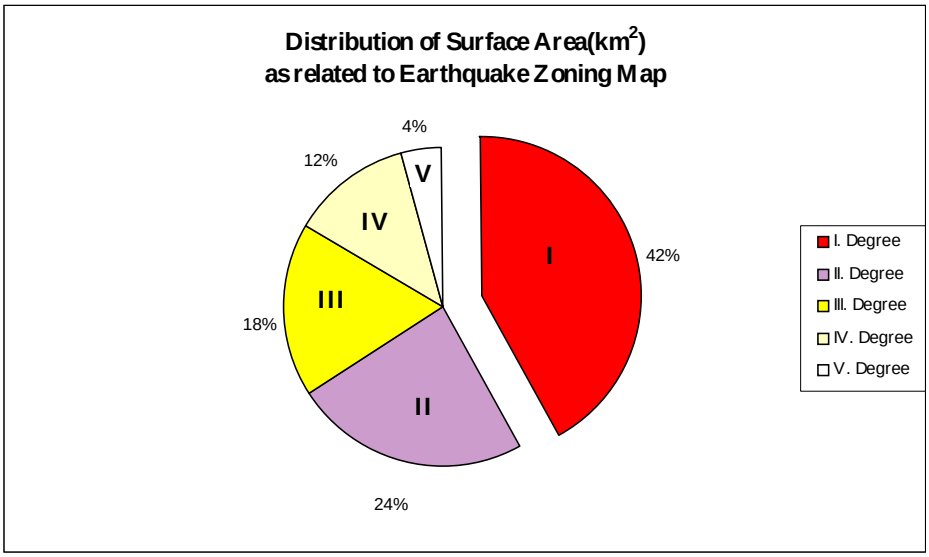

Figure 6: Distribution of surface area as related to earthquake zoning map

It is situated at I degree hazard zone % 43 of provinces center in the Turkey, at II degree hazard zone % 28 of provinces, at III degree hazard zone % 16 of provinces, at IV degree hazard zone % 11 of provinces and at V degree hazard zone % 3 of provinces (Table 2).

Table 2: Province, District and Sub-District city center number as related to earthquakes zoning map

Earthquake zone	Province number	Percent (%)	District number	Percent (%)	SubDistrict Number	Percent (%)
I	34	43	406	48	335	49
II	22	28	176	21	152	22
III	13	16	130	15	98	14
IV	9	11	116	14	78	12
V	2	3	19	2	15	2
Total	**80**		**847**		**678**	

NATIONAL TELEMETRIC EARTHQUAKE OBSERVATION STATIONS (TURKNET)

The first step in the mitigation efforts is to determine the earthquake source, earthquake parameters and the seismic activity. For this main pupose, in 1989 TURKNET (National Telemetric Earthquake Observation Network) has been established by Seismology Division of the Earthquake Research Department, the General Directorate of Disaster Affairs. For the first step, seismic telemetred systems of 13 stations are being installed on the North Anatolian Fault Zone, from İzmit to Sivas provinces. Now the number of stations has become twenty-four around the country (Figure 7). Data evaluation has been carried on in Ankara data processing center. The seismic activity determined by seismology division every day, updated and given in the WEB page of the earthquake research department. The origin time, epicentral coordinates, magnitude and depth of every earthquake is given in the address of **http://sismo.deprem.gov.tr** besides, any earthquake occurred anywhere in Turkey is reported to the press or other instutions via fax, telephone or our web page. After a strong earthquake people of the seismology division work twenty-four hours continuously. All information obtained in the center are open for all the universities and releated institutions.

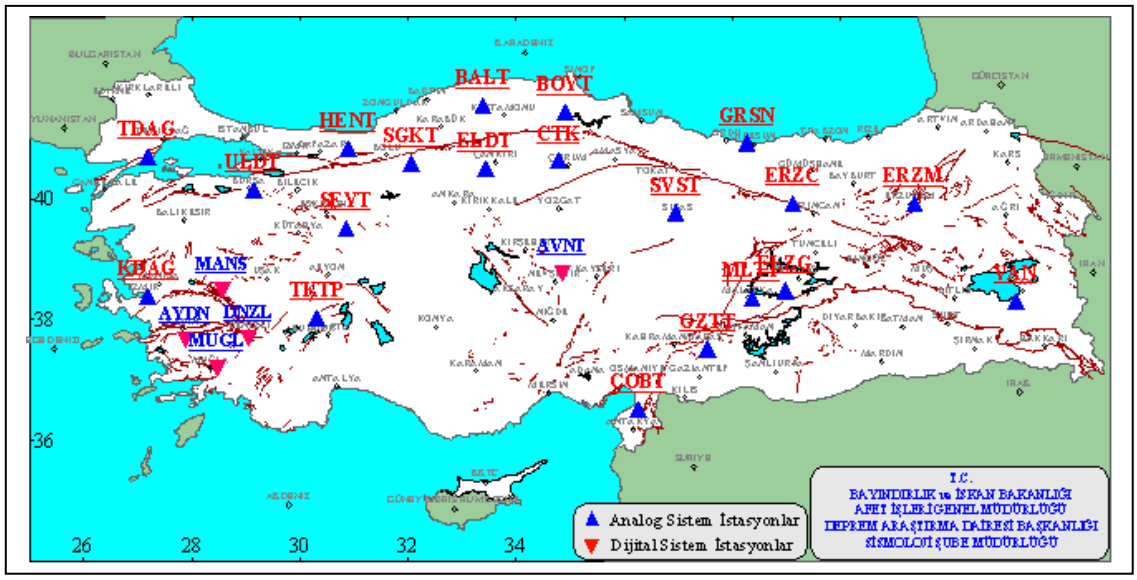

Figure 7 : National Telemetric Earthquake Observation Stations (TURKNET)

MICROEARTHQUAKE STUDIES AROUND SAKARYA-BOLU REGION

In the frame of Turkish and German joint project on earthquake prediction, in the western part of the North Anatolian fault zone, around Izmit-Bolu area, a multidisciplinary earthquake research studies have been carried on since 1984. In the frame of this project between 1985-1996, seismological studies carried out by using magnetic tape recording systems (MLR) and data processing systems.

In November 1996, more developed fifteen digital telemetric micro earthquake stations have been installed instead of MLR recording systems and a data processing centre (SABONET) has been established in Sakarya at the Directorate of Public Works and Settlement (Figure 8). The telemetric earthquake stations, related equipments and software used for data processing centre prepared by the Nanometrics Company in Canada. The earthquake data from the stations are transmitted to the data processing centre directly or via transmitters.

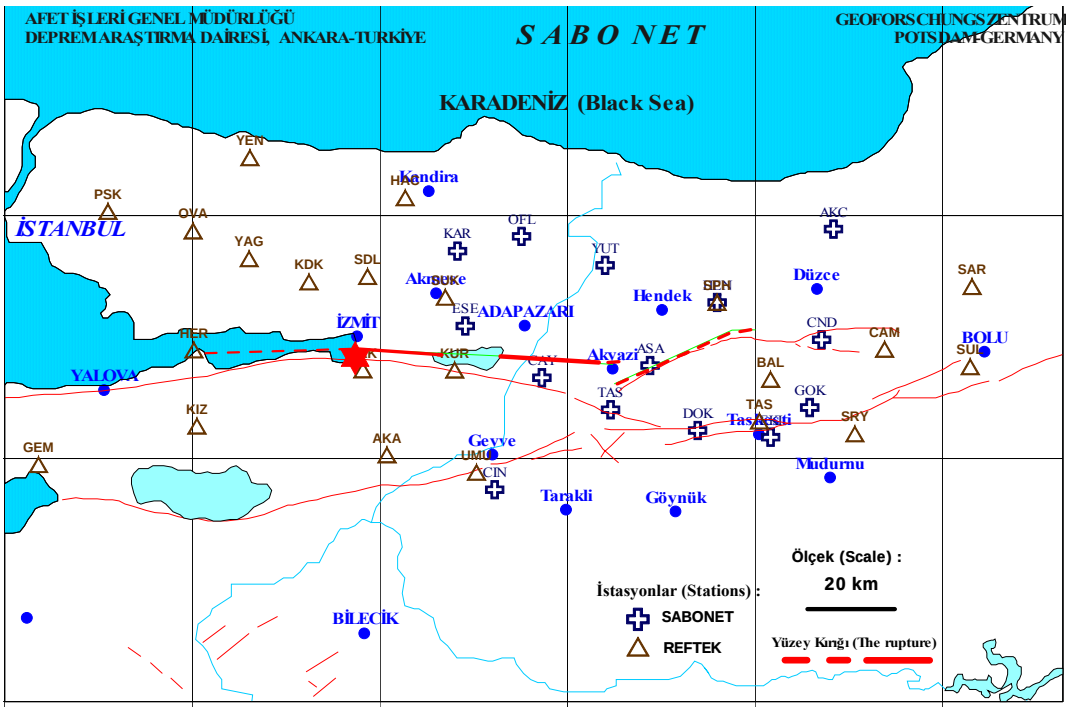

Figure 8 : SABONET Regional Seismic Observation Network

TURKEY STRONG GROUND MOTION NETWORK PROJECT

The Project of Establishing a Strong Ground Motion Network of Turkey has been started in 1973. The aim is to measure the ground accelerations that occurs during earthquakes. These acceleration data give important engineering information

for designing earthquake resistant structures. The acceleration data can also be used to develop attenuation relations for ground acceleration with distance and the strong ground motion recorded at a station can be used to estimate the damages it may cause in any inhabited places at various distances. During the realization of the Project, 120 acceleration recorders have been bought in total of which 67 are analog and 53 are digital instruments (Figure 9). Of these 120 instruments, 110 are deployed in the field, the rest are in the laboratory for repair, maintenace and to be deployed in the epicentral area for recording the ground strong motion of aftershocks in case a large earthquake. The principle used in the selection of the sites where the instruments are installed is that the network should be able to record the earthquakes which might occur on the active fault zones of Turkey. In the Eastern and Southeastern parts of Turkey digital instruments from which data can be retrieved by telephone lines are preferred since access to these sites for data retrieval and return by technicians take considerably time. Acceleration recordings are stored in a database and being updated right after any value is recorded. These data could be reached via internet from the followig web page: http://angora.deprem.gov.tr

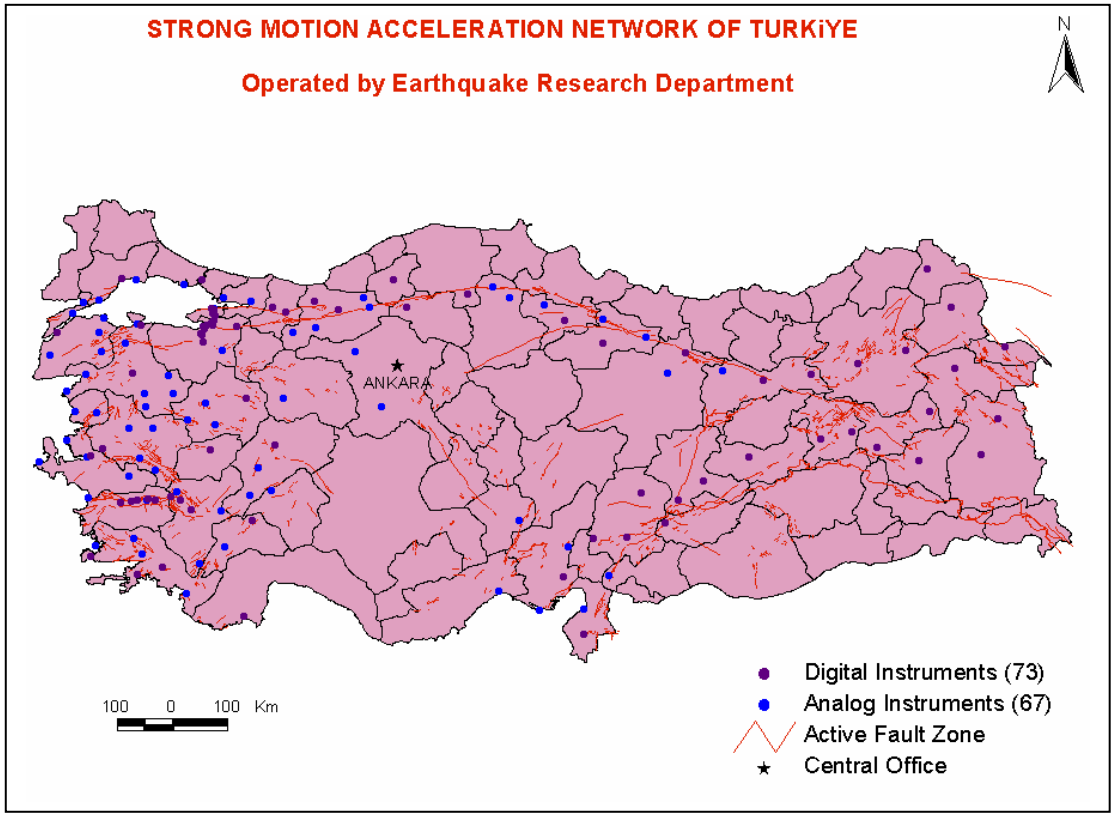

Figure 9 : Strong Motion Acceleration Network of Turkey

Besides in order to develop national strong ground motion network 20 digital acceleration recorders are obtained. 14 of them are distributed between Bursa-Yalova and remaining 6 of them will be established between Aydın-Denizli.

The first strong ground motion record of a relatively large earthquake was taken on 19th July 1976 from Denizli. All the earthquakes of Turkey having large magnitudes which had occurred since August 1976 have been recorded by our network. Following the recording of the strong ground motion of the earthquake, it is processed, digitized and put into a format and submitted to the use of all the interested national and international researchers through a web page on the Internet.

Using the peak acceleration record value, the magnitude of the earthquake and the epicentral distance to the recording point, attenuation relations of acceleration with the distance and magnitude has been calculated for Turkey. Previously, attenuation relations developed with records taken at different places of the world had been used in Turkey. The use of an attenuation relation developed from the records of Turkish earthquakes is an important progress. The attenuation relation developed from Turkish records is as given below. The PGA, The Peak Ground Acceleration, depends on Magnitude (M) and Distance (R), (in kilometers).

$$\mathrm{LogPGA} = 0.65M - 0.9\mathrm{LogR} - 0.44$$

Earthquake Disaster Prevention Research Center (Turkish – Japanese Joint Project)

A Joint project was started in April 1993 as a five-year program between the Governments of the Republic of Turkey and Japan. Support has been made by the Japan International Cooperation Agency (JICA), an extra-departmental organization of the Ministry of Foreign Affairs, Japan. The objectives of the project are to study systematically, develop and improve technologies and techniques for earthquake disaster prevention and mitigation through joint research activities in the Earthquake Disaster Prevention Research Center.

The targets of the project

a) To determine the earthquakes parameters and making a pre-estimation about the human loss and damage just after the earthquake,
b) To provide a reliable data transmission between local stations, the regional and main centers by using a computer network,

c) To evaluate the results and transmit them to administrative organizations in approximately with in 20 minutes.

The project service area is located in the central part of the North Anatolian Fault Zone and covers Samsun, Sinop, Kastamonu, Çankırı, Çorum, Yozgat, Amasya, Tokat and Ordu provinces (Figure 10). The earthquake observation system consists of a main center in Ankara, a regional center in Samsun and local stations in Amasya, Çankırı, Çorum, Kastamonu, Samsun, Vezirköprü, Tokat, Niksar and Yozgat.

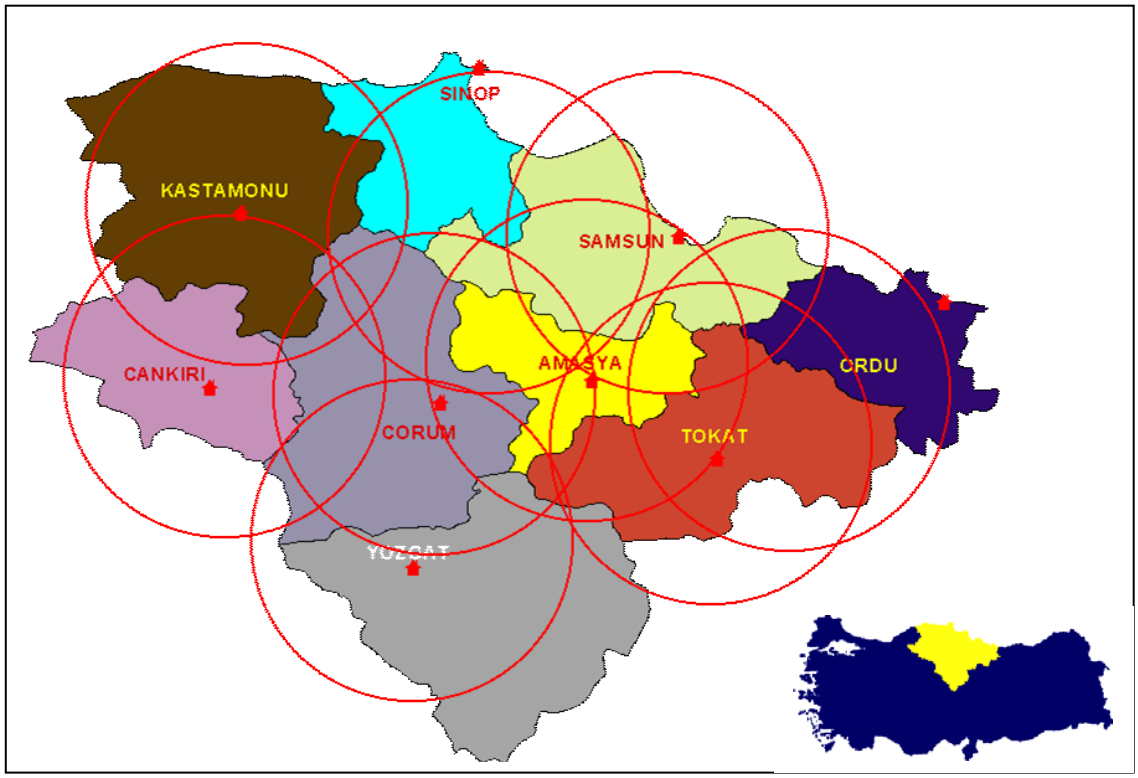

Figure 10: The project servis area of Turkısh – Japanese Joint Project

DETERMINATION OF NATURAL HAZARD AND RISK

The main aim of the project is to reveal natural hazard and risk of some provinces in Turkey by using recent technologies like Geographic Information System (GIS) and Remote Sensing (RS). The outputs of this study are multi-hazard map(earthquake, landslide, snow avalanche, rockfall). Those maps are prepared for decision makers and governorate in order to assist them during upgrading of Emergency Aid Plans of the city and its countries.

Geographic Information System (GIS) and Remote Sensing (RS) techniques are used during this project aiming to create a disaster information network.

These works are being carried out:

- To determine hazard and risk level of provinces
- to prepare regulations and data which are based on disaster emergency plans
- to guide city planners to prepare regional land use plans
- and to provide necessary information to decision makers

By all these studies, natural hazard maps are prepared. In addition, disaster scenarios are carried out to be able to assess probable damages beforehand.

One of such studies has already been completed and published for Kastamonu province. GDDA plans to enhance that kind of projects for all around the country. Determination of natural hazard and risk of provinces are underway for Bartın, Karabük and Zonguldak provinces.

I want to give a very short information about earthquake division of the report of natural hazard and risk assessment of Kastamonu province

As known, one of the most important fault zone of Turkey is North Anatolian Fault Zone. A certain part of this zone lies at southern of Kastamonu province. In the past years, 21 destructive earthquakes have been recorded between BC 2100 and AD 2003.

Intensity values of a 7.5 magnitude probable earthquake that may occur on North Anatolian Fault Zone have been calculated deterministically and earthquake hazard maps have been prepared for investigation area(Figue 11).

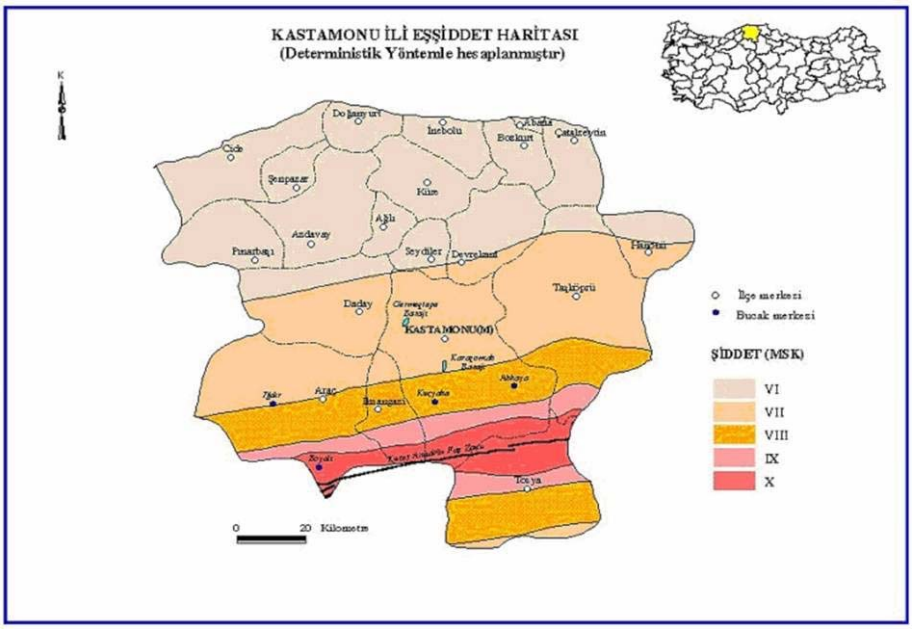

Figure 11: Iso-intensity map for Kastamonu province

The studies indicate that probability of occurrence of 7.5 magnitude earthquake in source area within 100 years is 86%.

Besides, microtremor measurements have also been carried out for city center. It has been seen by 88 measurement points that maximum amplitudes of young (Quaternary) deposits are 2-2.5 times higher than older deposits are. By means of these studies and geological investigations, lithology has also been included to the calculation as a factor. Then a new iso-intensity map of Kastamonu city center has been produced in according to soil condition.. As a conclusion, a probable 7.5 magnitude earthquake which may occur on North Anatolian Fault Zone results in VIII (MSK) as maximum intensity value (Figure 12).

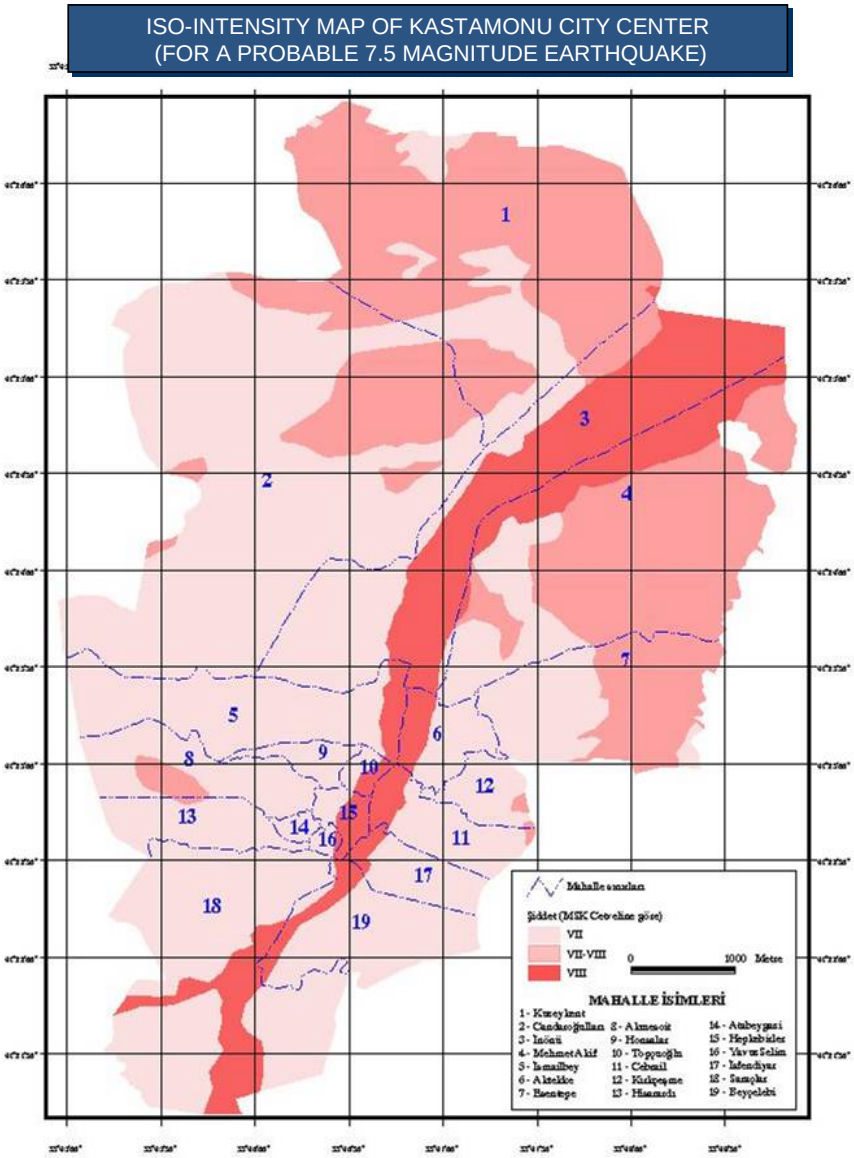

Figure 12: Iso-intensity map of Kastamonu city center

By taking these values into consideration, as a result of the earthquake scenario for Kastamonu city center casualties and damages were determined as follows with adding result of secondary disasters (landslides, rockfall):

Death : 82
Total casualties: 206
Minor injuries: 155
Heavy injuries (needs hospital): 51
People will be homeless: 3660
Heavy damages for buildings: 316
Medium level damages: 566
Light level damages: 629

Besides, in earthquake scenario, lifelines of social community, which are dams, power lines, roads, bridges, communication facilities, engineering structures were examined and some information about their possible damages during an earthquake was given.

Microzonation Studies for Mitigation of Disaster Risk;

The main goal of the project supported by the Government of Switzerland is to develop land use management for reducing earthquake risk in Turkey. The project is intended to demonstrate the use of seismological, geological and geotechnical data in terms of state of the art microzonation. In this framework, microzonation maps will be prepared for pilot areas in Sakarya and Kocaeli provinces. The outcomes of these studies are planned to use land use management in Turkey and to prepare a guide for seismic microzonation. The cost of project is undertaken by Swiss Development and Cooperation Agency. The project will be implemented by World Institute for Disaster Risk Management, USA, General Directory of Disaster Affairs, a number of national universities, the municipalities concerned and participants in project activities.

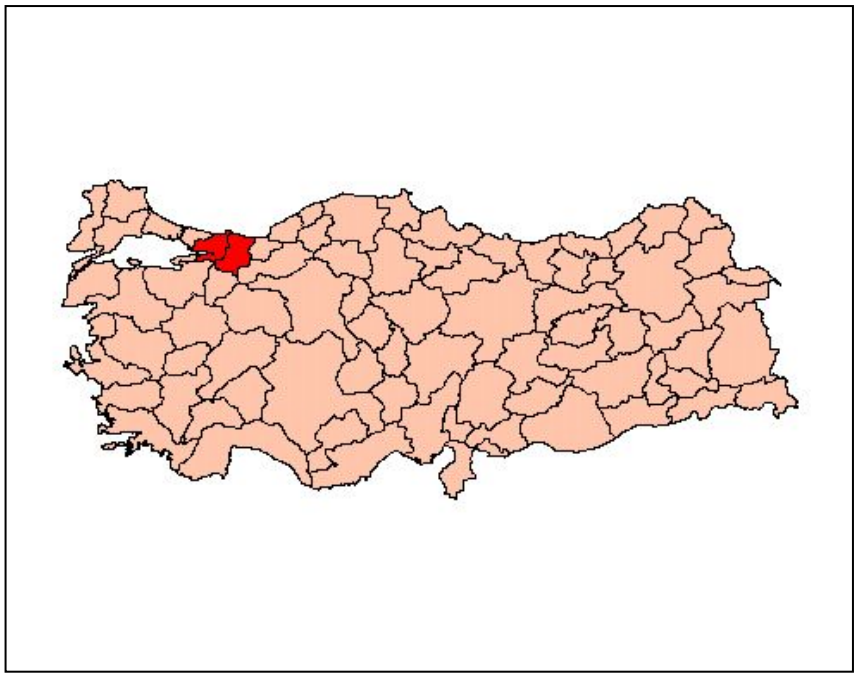

Figure 13: Investigate area of DRM project