**Joint Operational Programme "BLACK SEA 2007 – 2013"**
**Black Sea Earthquake Safety Net(work) - ESNET Project**
**Turkey Country Assessment Report**
**İstanbul, June 2012**

## 1. Introduction

Black Sea **E**arthquake **S**afety **Net**(work), ESNET Project is structured with the objective of contributing to the prevention of natural disasters generated by earthquakes in Black Sea basin, by developing a joint monitoring and intervention concept. The Project is funded by **EU** and started to be implemented by 2nd March 2012 under the cross border partnership of **Turkey**, International Blue Crescent Relief and Development Foundation - **IBC**, **Romania** National Institute of Research and Development for Earth Physics – **NIEP**, Geophysical Institute of **Bulgarian** Academy of Sciences – **BAS**, and Geology and Seismology Institute of **Moldavian** Academy of Sciences – **IGS**.

**"ESNET Project Turkey Country Assessment Report"**, is developed within the context of **Joint Operational Programme "BLACKSEA 2007-2013",** Black Sea Earthquake Safety Net(work) – **ESNET** Project and aims to be used in designing the common concept/approach for dealing with earthquakes at regional level, thus ensuring the cross-border character of the objective by giving technical and characteristic information at National and Regional basis regarding Project Location İstanbul Province, Marmara and Black Sea Region, Turkey.

The development of this report is realized by the academic and technical involvement of **Boğazici University, Kandilli Observatory and Earthquake Research Institute, KOERI** National Earthquake Monitoring Observation Center **(NEOC – UDIM)** and **Department of Earthquake Engineering** including the operative involvement of ESNET Project **IPA** Leader Implementing Partner International Blue Crescent Relief and Development Foundation Project Management, **IBC** in **June,2012.**

It is highly acknowledged the academic and technical supports that provided within the development of this report by the **Boğaziçi University Kandilli Observatory and Earthquake Research Institute KOERI** Director **Mustafa ERDİK Ph.D., Professor**, Deputy Director **Nurcan Meral ÖZEL, Ph.D., Assoc.Professor**, Faculty Member **Eren UÇKAN, Ph.D.Asst.Professor**, Research Associates **Can ZÜLFİKAR Ph.D.**, **Hakan ALÇIK Ph.D., Kandilli Observatory and Earthquake Research Institute National Earthquake Observation Center (NEMC)** Director **Doğan KALAFAT, Ph.D.**, Deputy Director **Kıvanç KEKOVALI, Ph.D., Kandilli Observatory and Earthquake Research Institute Earthquake Preparedness Education Unit (DPEU) Seyhun PÜSKÜLCÜ, M.Sc.,** Boğazici University, Kandilli Observatory and Earthquake Research Institute **Department of Earthquake Engineering Project Assistant Özge ZÜLFİKAR Msc.**

IBC is thankful to ESNET Project National Authority **Republic of Turkey Ministry for EU Affairs** and Contracting Authority **Turkish Republic Prime Ministry Undersecretariat of Treasury Central Finance and Contracting Unit – CFCU** and also all the Worldwide Donors since the establishment of IBC supporting IBC Projects in the field of emergency response and enabling IBC to gain wide experience in the related fields.

## 2. Seismicity

### 2.1. Seismicity Introduction

Tectonic evolution of Turkey has been dominated by the collision of the African and Arabian plates with the Eurasian plate along Hellenic arc to the west and the Bitlis-Zagros suture zone to the east. This collisional and contractional zone is being accompanied by the tectonic escape of most of the Anatolian plate to the west by major strike-slip faulting on the right-lateral North Anatolian Fault Zone and left lateral East Anatolian Fault Zone which meet at Karlıova forming an east-pointing cusp (Dewey et al. 1986; Şengör 1979; Şengör et al. 1985).

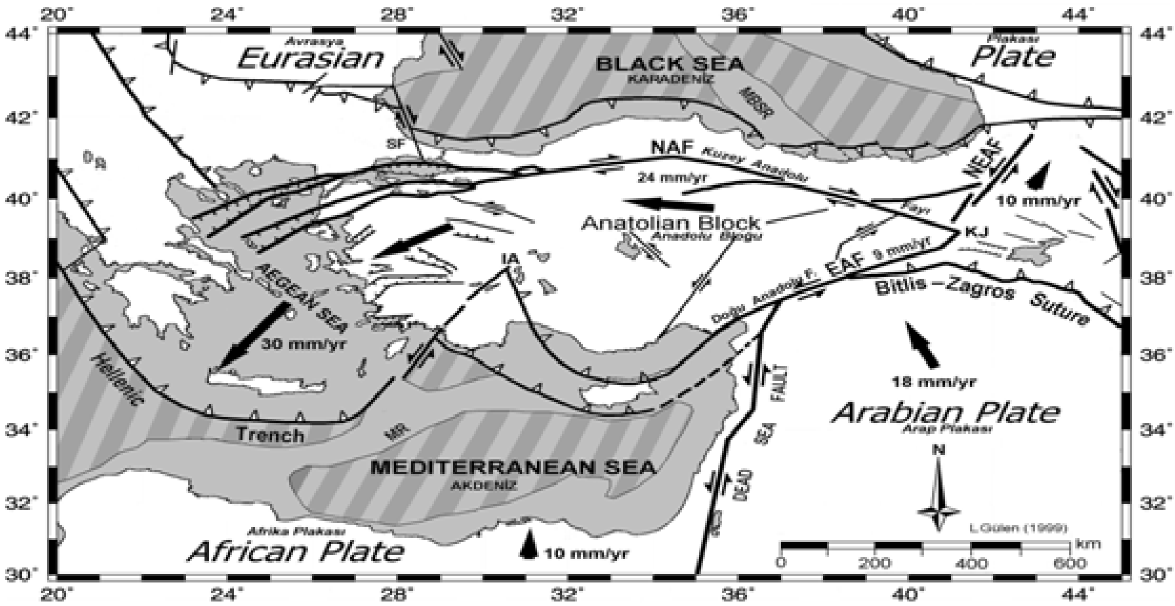


**Figure 1 :** Simplified tectonic map of Turkey modified after Gülen (1999). The North Anatolian Fault Zone (NAF), East Anatolian Fault Zone (EAF),Bitlis Zagros Suture are the most important tectonic structures of Turkey.

The slip along the NAFZ is approximately 2 cm/yr while the slip along the EAFZ is 1 cm/yr. This indicates that the escaping Anatolian block is rotating counter-clockwise. This rate of westward slip does not account entirely for the strain induced by the 3.0 cm/yr convergence of the Arabian plate with respect to Eurasia (Dewey et al. 1986; Reilinger et al. 1997). Interplay between dynamic effects of the relative motions of adjoining plates thus controls large-scale crustal deformation and the associated earthquake activity in Turkey.

The other well-known seismically-active fault system is the EAFZ, which is an active left-lateral strike slip fault forming the boundary between the Anatolian Block to the northwest and the Arabian - African plates to the southeast. The EAFZ runs in the NE-SW direction and is approximately 650 km long and 1-30 km wide. It connects the NAFZ to the Dead Sea - Read Sea Fault System and extends its southwestern terminus to the immediate east of Cyprus. The Kozan, Savrun, Goksu and Surgu faults are considered to be the southwestern extension of the EAFZ. Major earthquakes on the EAFZ are 1905 Malatya (M = 6.8), 1971

Bingöl (M = 5.9). Bitlis Convergene zone in southeastern Turkey has also produced lots of destructive earthquakes. Historical data suggest that this area was very active during the past 2000 years. During the century 1975 Lice (M = 6.6) event occurred.

The Cyprean Arc encompasses a wide and complex zone of oceanic subduction along which the African Plate subducts under the Turkish (Anatolian) Block. The region accounts for both shallow and deep-focus earthquake activity. Numerous earthquakes in the region have focal depths exceeding 100km. The EAFZ and the Hellenic and Cyprean arcs represent the boundary between the African and Anatolian plates in the Eastern Mediterranean region (Mc Kenzie 1972; Ben- Avraham et al. 1988).

Western Turkey and its surrounding area is also a seismically very active part of the country. The Turkish plate moves westward from Karitova junction. Interaction of this motion and the subduction of the Mediterranean lithosphere beneath the Turkish plate cause a N-S extension and E-W shortening in western Turkey. As the region is under extension in NNE-SSW direction. Aegean grahcn system consists of several grabcns and horsts bounded by oblique E-W trending normal faults. This direction coincides with directions of T axis obtained from focal plane solutions of some well-known earthquakes that occurred in this century. From north to west, these grabens are called below:

Edremit Bay, Bakırçay-Simav, Gediz- Küçük Menderes, Büyük Menderes, Gökova Bay. Seismic activity of this area is mainly associated with these systems. Fault plane Solutions of destructive earthquakes show dominantly normal faulting such as 1969 Alasehir (M = 6.9), Gediz (M = 7.3) events etc.

Seismic hazard for the Turkish megacity İstanbul is extremely high; the western continuation of the North Anatolian Fault Zone (NAFZ) which accommodate 25 mm/yr of rigth lateral motion runs in close vicinity through the Marmara Sea. Istanbul and its surroundings are the settlements, which were damaged by many earthquakes along the history. Historic records for past 2000 years (Ambrayses, 2002) reveals a statistical recurrence of one destructive earthquake hitting İstanbul each century.

### 2.2. Country and Project Area Seismicity

Turkey is one of the most seismically active countries in the continents of the world, because the country is located at the junction of the main tectonic plates namely, African, Arabian and Eurasian.

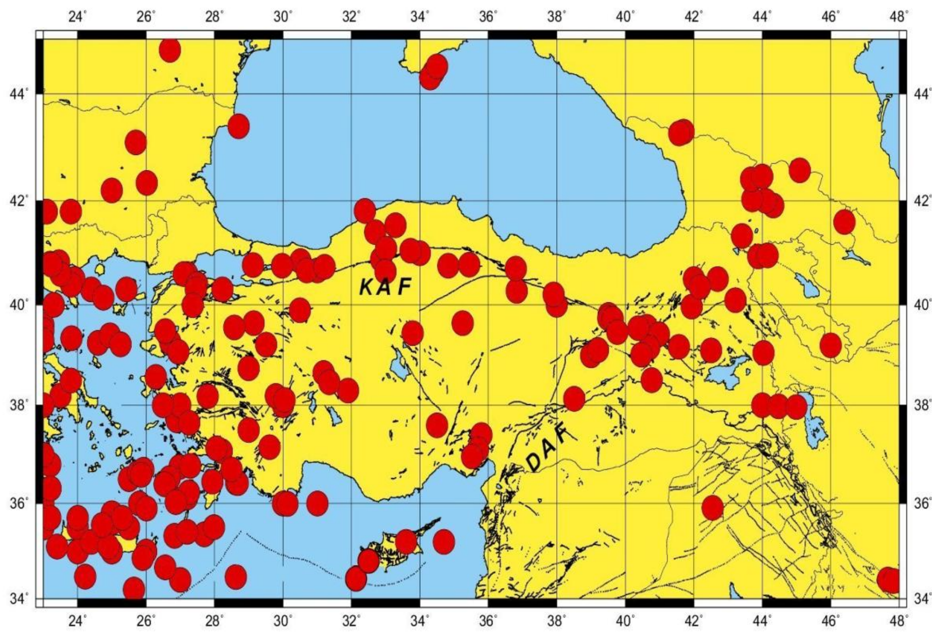


**Figure 2 :** Seimic activity of Turkey and its surrounding area 1900-2010; M>6.0

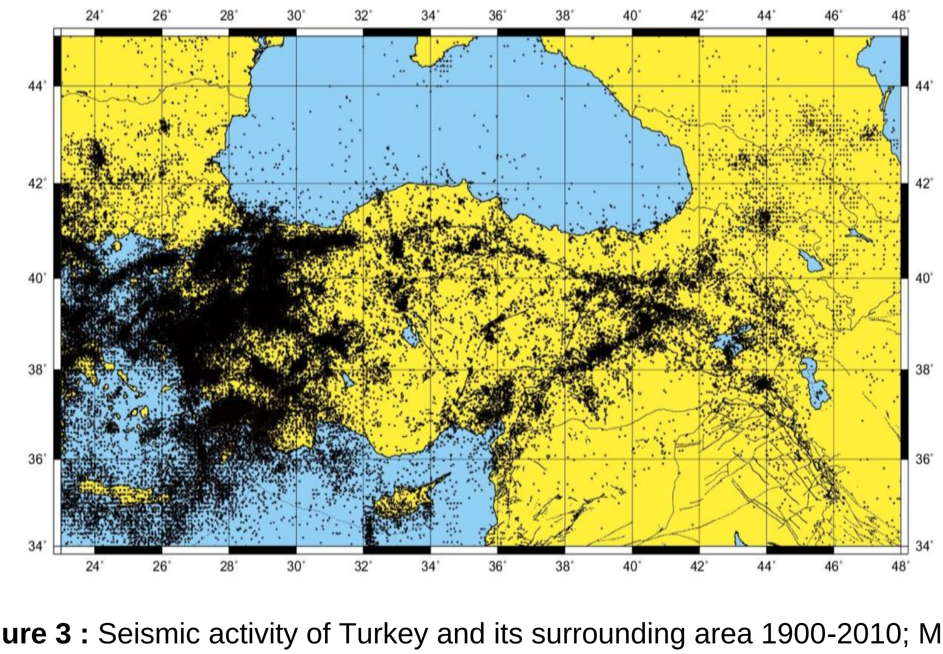

**Figure 3 :** Seismic activity of Turkey and its surrounding area 1900-2010; M>2.5

Seismicity in the Marmara region is the result of tectonic movements along two possible westward extensions of the NAFZ beyond the Mudurnu Valley where the influence of the Aegean extensional tectonic regime has been recognized (Barka et al. 1988). At this point it divides into two strands. The northern strand called Izmit-Sapanca fault extends from Sapanca Lake through the northern part of the Armutlu Peninsula Toward inside the Marmara Sea. Here, it makes some steps forming troughs like a kind of pull-apart basin; it appears again on the land near Murefte, continuing along the Saros Bay and then enters the Aegean Sea. The southern branch called Iznik-Mekece fault runs from Geyve through Mekece and passing south of Iznik Lake to Gemlik Bay. It goes into the Marmara Sea, appearing near the Bandırma Bay and cutting the Kapıdağ Peninsula continues in the Biga Peninsula and then enters the Agean Sea. The number of earthquakes identified in this region for the historical period is around 600. Thirty-eight of them are estimated to be relatively large shocks of magnitude Ms > 7.0 (Ambraseys et al.1991). For the instrumental period (after 1900), earthquake activity in the Marmara Sea region shows typical swarm-type activities.

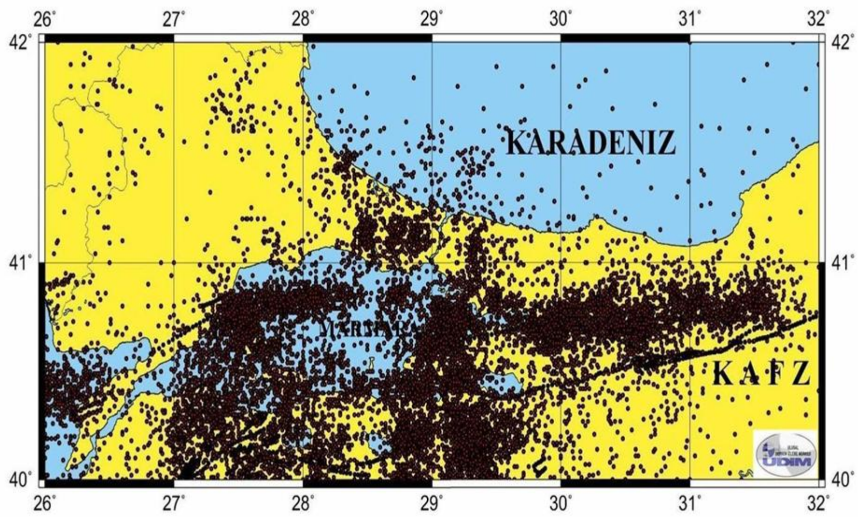


**Figure 4 :** Seismic activity of the Marmara Region between 1900-2010 (M>2.5)

Between 1939 and 1967 the fault zone had a remarkable earthquake activity during which six westward migrating large earthquakes created a 900 km lung continuous surface rupture along the fault zone from Erzincan to the western end of Mudurnu Valley, such as 1939 Erzincan (M = 7.9), 1942 Erbaa-Niksar (M = 7.3), 1943 Tosya-Ilgaz (M = 7.3), 1944 Bolu-Gerede (M = 7.3), 1957 Abant (M = 7.1), 1967 Mudurnu Valley (M = 7.1). The last destructive earthquake on the NAFZ is 1999 İzmit (Mw = 7.4). On August 17, 1999, a major earthquake occurred in the Marmara region, western Turkey, with a magnitude Mw = 7.4 at 40° 70' N, 29° 98' E and 17 km depth .

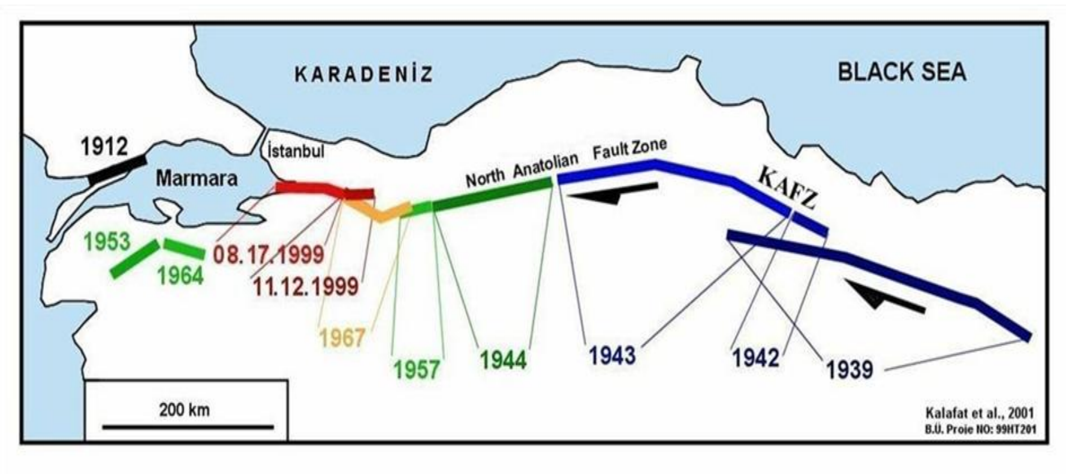


**Figure 5 :** The westward migration earthquakes since 1939 along the North Anatolian Fault Zone.

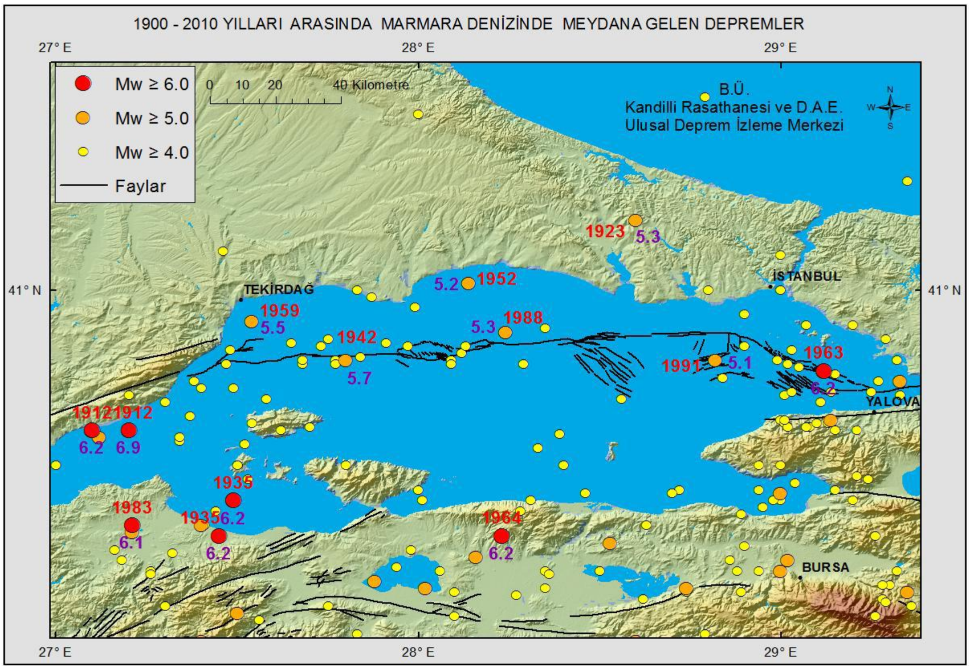


**Figure 6 :** The earthquake activity map of the Marmara Region (Mw>4.0;1900-2010)

Seismologists (Parsons et.al., 2000) have noted that the epicenters of strong earthquakes seemingly migrate from east to west along the NAFZ and they point out the possibility of another big earthquake hitting Istanbul where the western edge of the NAFZ is situated. New earthquake probability calculations for the Marmara Sea providing a forecast of 30 year Poisson probability of a M>7 earthquake affecting İstanbul is 41 % (Parsons, 2004).

### 2.2. Monitoring Network

Two institutions are currently operating seismic stations at national scale as Kandilli Observatory and Earthquake Research Institute **(KOERI)** and Republic of Turkey Prime Ministry Disaster and Emergency Management Presidency **(AFAD)** .However, many universities and municipalities have also invested in seismic instrumentation. These are intended for educational or very local studies do not have any objective related to national scale monitoring. The Earth Science Research Institute **(TUBITAK)** Marmara Research Center has developed both instrumental infrastructure and the know-how for operating temporary networks.

Two consecutive major earthquakes in 1999 in Marmara Region became the turning point in disaster management in Turkey. Pre-disaster measures came into the agenda of the government and country, together with these earthquakes. Turkey's Disaster Management System was mainly focused on the post-disaster period and there were no incentives or legislations to encourage risk analysis or risk reduction approaches before these earthquakes. Both the academic and the technical authorities agreed that the country’s strong need was, to develop pre-disaster precautions covering a revised legislation and administrative restructuring. By the Act 29/5/2009 dated and No.5902 Establishment of Disaster and Emergency Management Presidency; General Directorate of Turkey Emergency Management under Prime Ministry, General Directorate of Civil Defense under Ministry of Interior, General Directorate of Disaster Affairs under Ministry of Public Works and

Settlement were closed. Three core institutions have unified under single independent authority with the act adopted by the parliament and entered into force in June, 2009. The name of the new institution is Prime Ministry Disaster and Emergency Management Presidency.(DEMP). In order to take necessary measures for an effective emergency management and civil protection issues nationwide, the presidency conducts; pre-incident works such as preparedness, mitigation and risk management, during incident works such as response, post incident works such as recovery and reconstruction. By the new system in Central Government the only responsible organization is DEMP and affiliated to the Prime Ministry.

http://www.afad.gov.tr/Ingilizce_Site/index.html

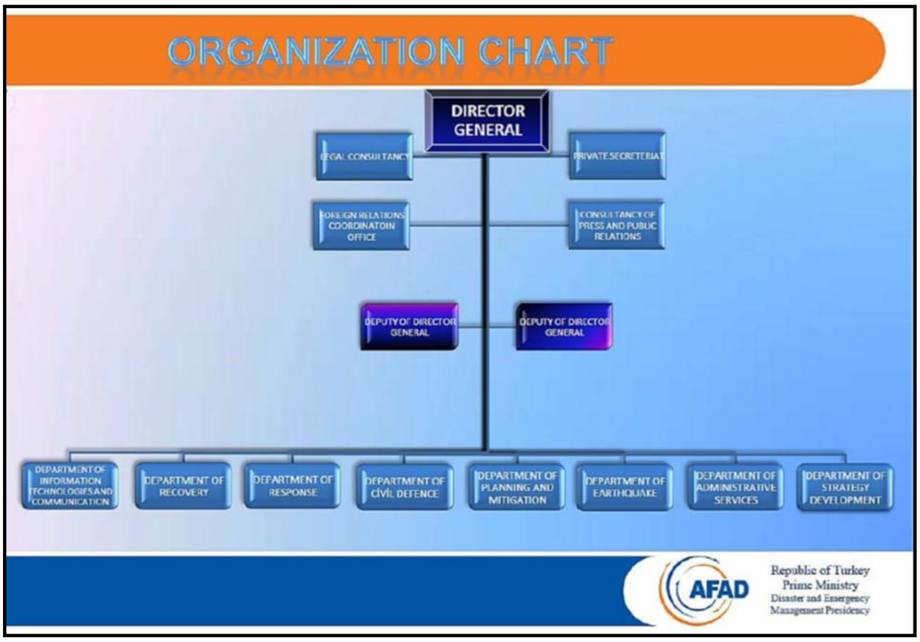


**Figure 7 :** The organization chart of Republic of Turkey Prime Ministry Disaster and Emergency Management Presidency

Kandilli Observatory and Earthquake Research Institute (KOERI) is serving as a trustful information centre for reduction of losses during natural disasters, to understand the earth and to protect life quality of citizens in nature for 140 years. It is one of the oldest and known scientific organizations in Turkey. In 1983, it turned to institute under Bogazici University, since then the renewal and expansion has been continuing. Kandilli Observatory and Earthquake Research Institute, The primary studies are earthquakes while research and application studies are continuing together with Master and PhD education in Astrophysics, Earthquake Engineering, Geodesy and Geophysics departments. KOERI is the first institution where observatory, education, research and application activities are collected under one organization. In addition to the departments listed above, the operational centers under KOERI are: National Earthquake Monitoring Centre (NEMC), Belbaşı Nuclear Monitoring Centre (NDC), İznik Earthquake Damage Reduction Centre, Meteorological and Astronomy Laboratories. National Earthquake Monitoring Center (KOERI-NEMC) currently is capable of acquisition of seismic data, analysis of this data and delivering the earthquake parameter results in a healthy, quick and real time manner in Turkey and surrounding areas.

The real time earthquake parameters are provided to all disaster related organizations. KOERI is disseminating earthquake parameters to the public and relevant seismological centers by fax and internet channels both at national and international level. http://www.koeri.boun.edu.tr/eng/topeng.htm

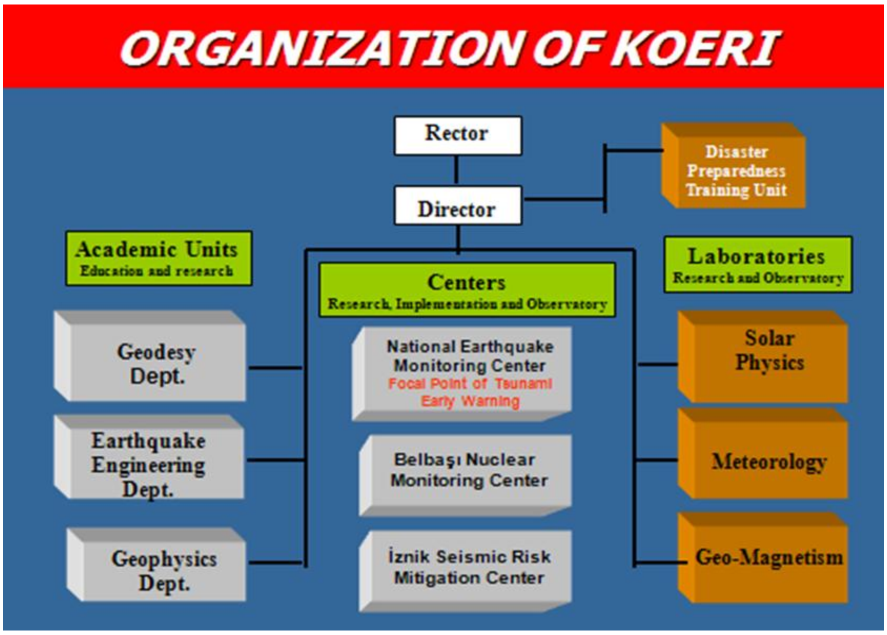


**Figure 8 :** The organization chart of KOERI

KOERI- NEMC has installed stations in every part of Turkey and developed Turkish Seismic Network continuously aiming to improve the location and magnitude determinations for all earthquakes M > 2.5 in a more efficient and accurate manner within internationally recognized residual standards at any location in Turkey. Earthquakes occurring in any part of Turkey are located and the magnitude is calculated from the continuous real time data received from this network within a short time during 7 days 24 hours.

KOERI-NEMC is using Earthworm software for temporary storage and event detection, and has its own data analysis software zSacWin for earthquake analysis and parametric data dissemination. SeisComp3 has also been installed at NEMC (National Earthquake Monitoring Center) and is currently operational. There are 192 real time stations at the moment with satellite or online communications (Figure 9).

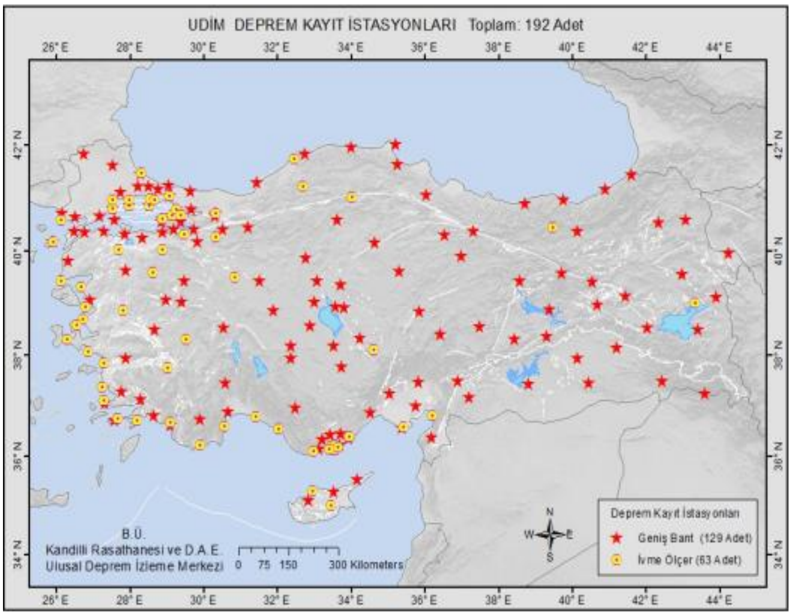


**Figure 9 :** The distribution of seismic stations of KOERI-NEMC (129 Broad-Band; 63 Strong-Motion)

Fully-equipped 5 Sea Bottom Observatories with 3 component BB sensors (360 sec.), 3C accelerometer, pressure difference measurement, hydrophone, temperature measurement, underwater lighting, flow meter, real time camera/light) were also installed in the Marmara Sea with the support of Türk Telekom (Fig 10).

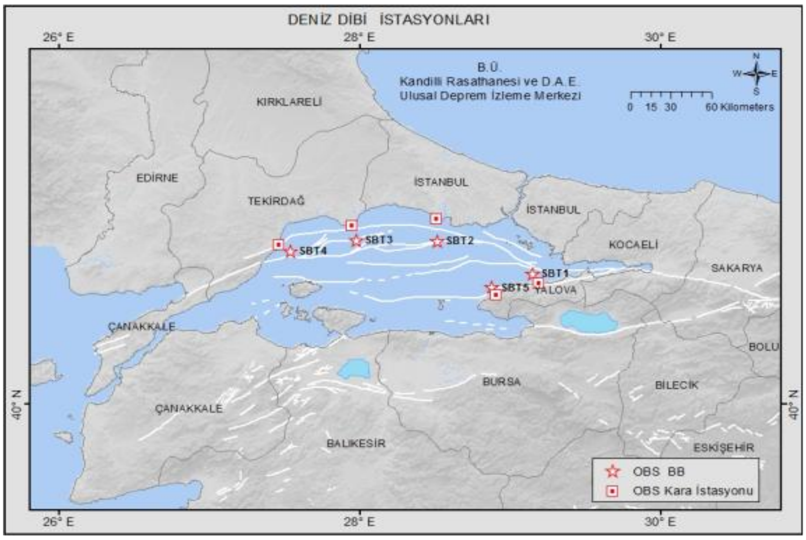


**Figure 10 :** The distribution of Ocean Bottom Seismometers (OBS) in the Marmara Region.

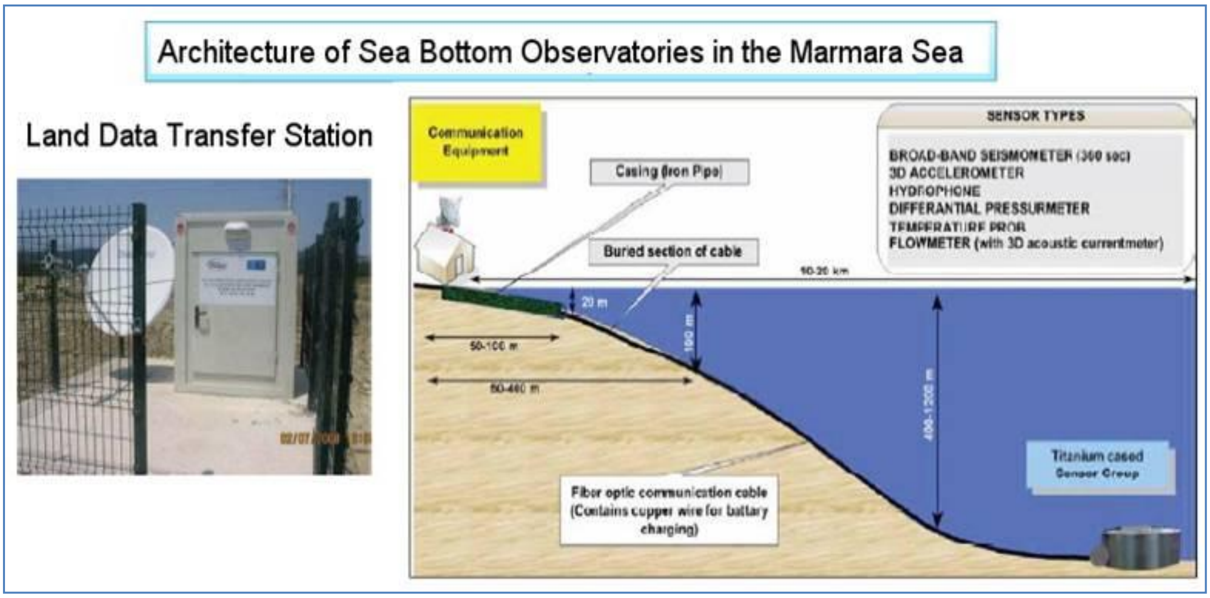


**Figure 11 :** Architecture Sea Bottom Observatories (OBS) in the Marmara Sea

Data are recorded at the center both in analog and digital forms obtained from all stations. The data are saved in the recording instrument as continuous and event files too. At the same time, the digital waveforms of the magnitudes larger than 4.5 are published immediately by internet channels for the relevant international seismological centers and the researchers. Thus, the earth scientists can obtain rapidly the data using ftp for their researches.

NEMC provides important earthquake data for preparing of earthquake risk and seismotectonic maps. Figure shows KOERI processing system. In the Institute it is used different 3 software, Earthworm-Seiscomp-3 and own software system Zsacwin. Earthworm is temporarily storage and format converted. These machines are acquisition systems. Broandband data are coming using satellite system.

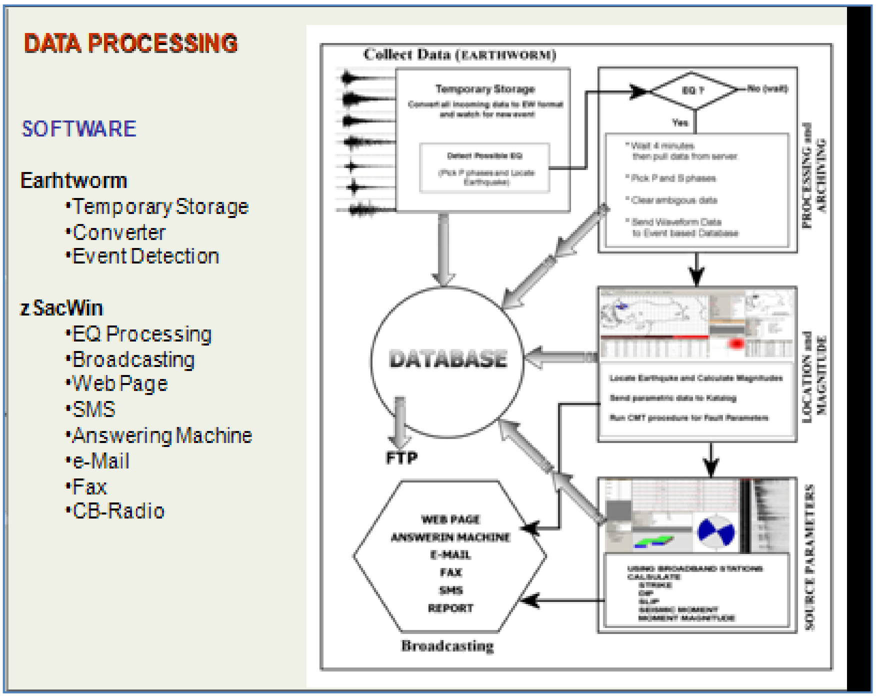


**Figure 12 :** Data processing chart of KOERI

Data processing was developed at KOERI-NEMC as zSacWin software. Earthquake location analysis and fault mechanism solutions are obtained using this programme. After that, disseminating earthquake information also to relevant agencies are made in the short time. A more detailed description of the seismic network and data acquisition system can also be found at wwwçkoeri.boun.edu.tr/UDİM. Seiscomp-3 software is used for quickly automatic earthqauke locations and real-time data exchange over internet.


**Figure 13 :** The basic earthquake information disseminated to relevant agencies, media, researchers using different communication facilities.

BOGAZICI UNIVERSITY
KANDILLI OBSERVATORY AND EARTHQUAKE RESEARCH INSTITUTE (KOERI)
NATIONAL EARTHQUAKE MONITORING CENTER (NEMC)
WAVEFORM DATA REQUEST SYSTEM

Click here to Return to the Continuous Data Request Section

Short Period . BB (Vertical) . BB(North-South) . BB (East-West)

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(Every file contains one hour SAC formatted data)

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| BNG.SHZ.KO | 753 | |
| BNN.SHZ.KO | 756 | |
| BNT.SHZ.KO | 756 | |
| BODT.BHE.KO | 304 | |
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**Figure 14 :** The waveform data from all stations are available since May of 2005 for researches

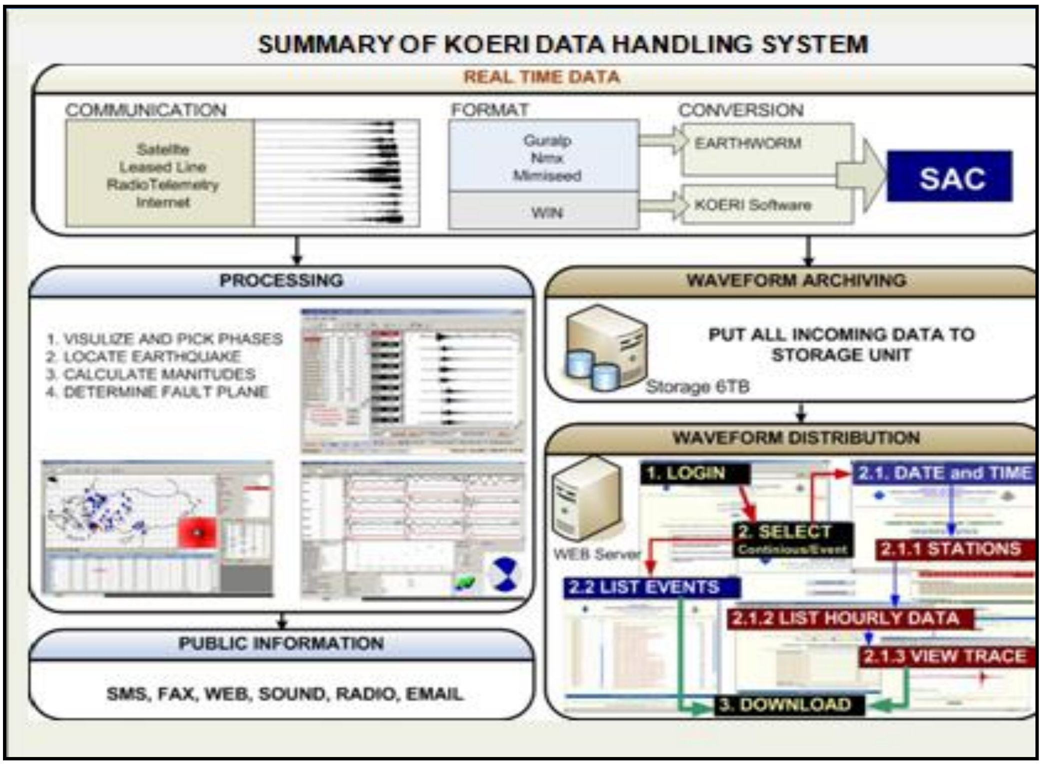



**Figure 15 :** Summary of KOERI data handling System

**Perspective/Plan for Seismic Observation and Reporting**

- The main purpose of National Earthquake Monitoring Center is to improve real time seismology capacity. The following NEMC strategic plans are listed as:
- To complete Optimum National Backbone Broad-Band Seismic Network.
- To eliminate seismic gap on the coasts with seismic network on the land.
- To improve the methods in automatic solution.
- To improve rapid automatic Moment Tensor Solution.
- To improve defining tectonic properties and active faults.
- To monitor rupture before and during the earthquake.
- To improve defining crust and velocity information and to provide high quality and reliable data.
- To improve defining the epicenter and magnitude of the earthquakes in more healthy manner.
- To improve the earthquake detection threshold.
- To improve the capacity of implementing automatic shake maps, loss maps
- To improve tsunami and earthquake early warning capacity.

In addition to monitor earthquake data, to detect temperature, pressure and underwater current flow.

- To do integration strong and weak motion networks.

For the future years, within the restructuring of KOERI it is proposed that the current BB weak motion and SMA strong motion network in the Marmara Region is planned to run from one center. It is also planned to improve real time observation capacity within a unique network and all earthquake parameters are planned to be sent to Turkey Disaster and Emergency Management Presidency. At the same time, the current active early warning system is planned to be installed in all parts of Turkey, the capacity improvement is still continuing.

- To improve international data exchange among the neighboring countries and international seismological centers.

Signing MOU agreements between Germany (GFZ), Netherlands (ORFEUS) and Greece (AUTH) real time data exchange is established. To accomplish real time data exchange between Bulgaria, Romania, Armenia, Georgia, Azerbaijan, Syria and Iraq in order to improve the quality of solutions.

After 1999 Kocaeli Earthquake Disaster Preparation Education Unit was built in order to reduce human and other losses. Within this scope education of educators is provided for government institutions such as Ministry of Education, Directorate of Civil Defense to improve earthquake consciousness.

- To provide quick and reliable information to the public.

In addition to the earthquake monitoring and analysis on land, it is mandatory to do scientific studies in the seas surrounding Turkey, Kandilli Observatory with the current technological capability and human resources can serve for this mission and if the infrastructure is supported, KOERI would like to install and run such centre. Our institute based on the qualifications above, announced the candidature to be the Regional Tsunami Watching Centre for North Eastern Atlantic, the Mediterranean and Connected Seas under the NEAMTWS group during the 4th IOC/ICG/NEAMTWS meeting 21-23 November 2007. During the Sixth Session of the Intergovernmental coordination group for the Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and connected Sea (IOC/ICG/NEAMTWS held on the 11-13 November 2009 the studies of Turkey has been supported. The studies for being a North East Atlantic, Mediterranean and Connected Seas (National/Regional Tsunami Centre (NTWC-RTWC) is planned to be completed by 2012. The Tsunami Early warning centre and damage reduction system is planned to be operational. Great effort has been spent for this purpose.

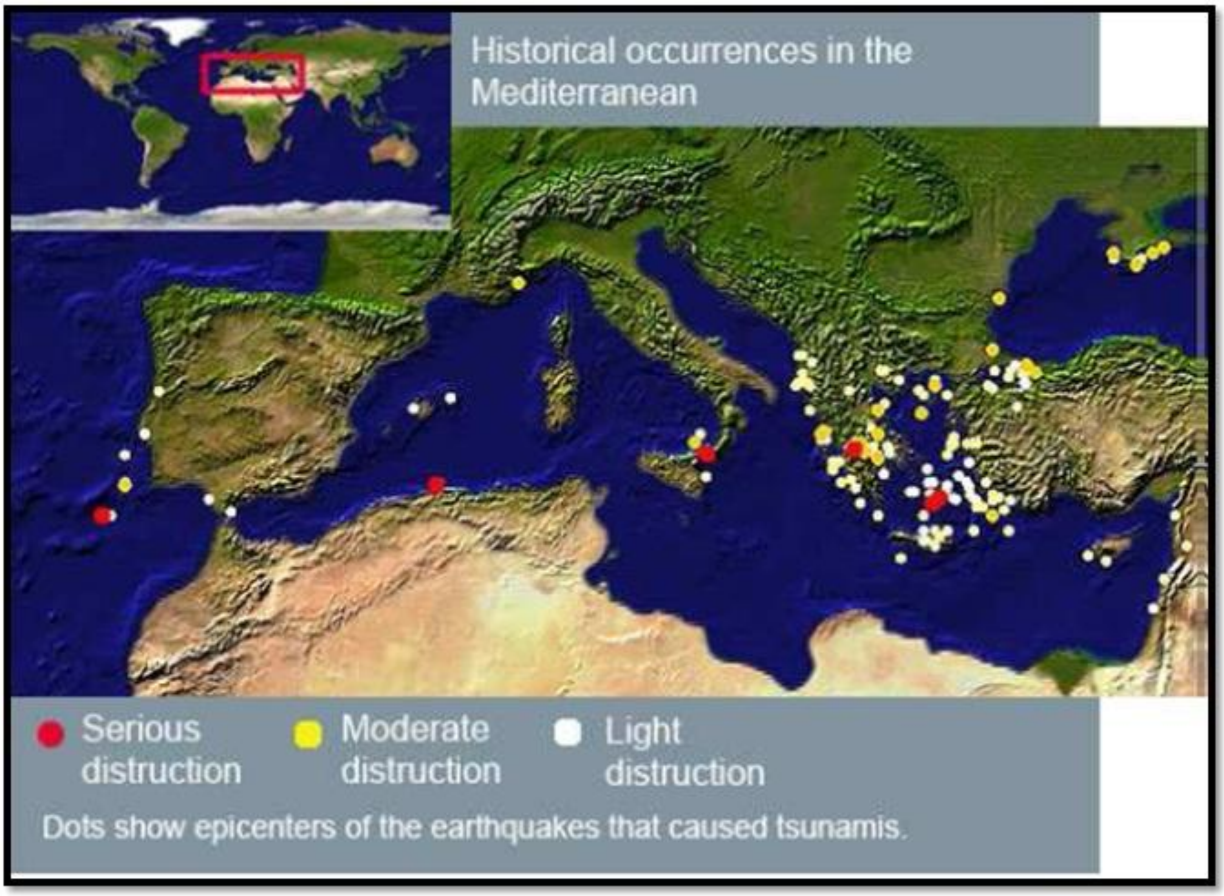



**Figure 16 :** Historical tsunamis for Turkey and its surrounding area


**Figure 17 :** Locations of the Sea Level Measurement Stations for Tsunamis

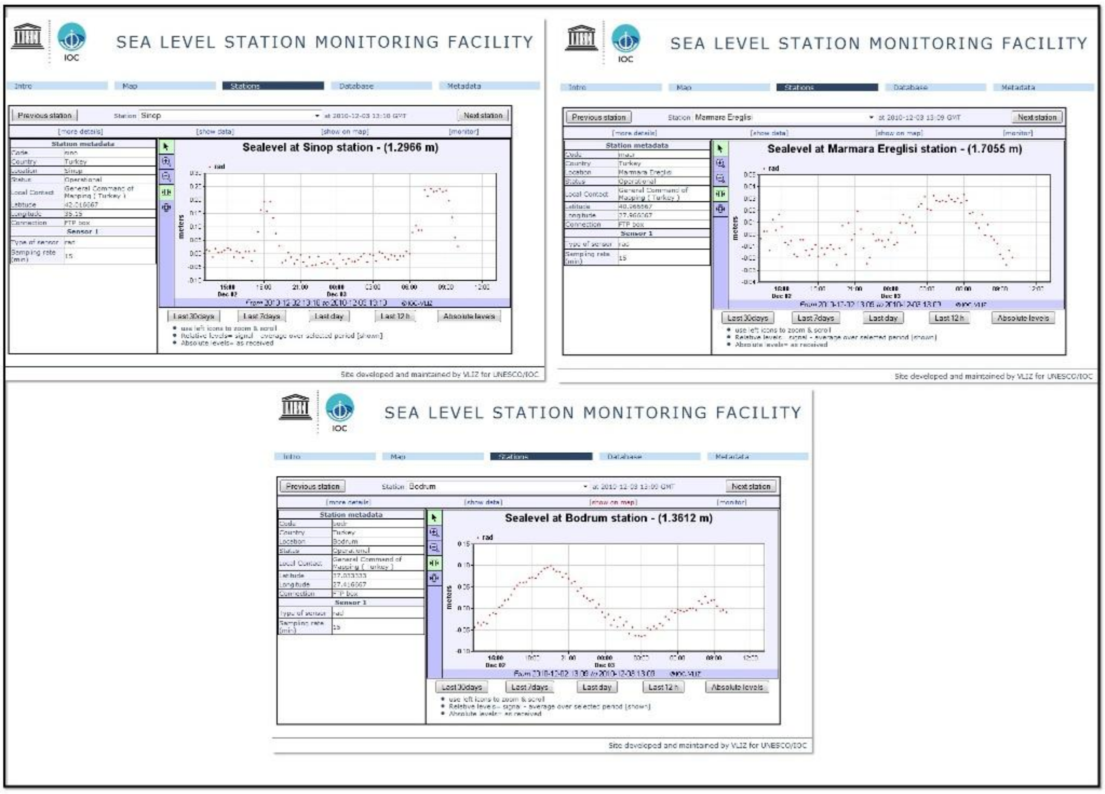



**Figure 18 :** Sea level station monitoring facility for Turkey

**Regional Tsunami Warning Centre (NTWC) in İstanbul, Turkey**

To address the needs of a Tsunami Warning System, KOERI has taken the lead to set up a Tsunami Warning Center, which is expected to act also as a regional center under the UNESCO IOC – ICG/NEAMTWS initiative. The project is fully supported by relevant national institutions and agencies. KOERI is responsible for the operation of the National Earthquake Monitoring Network for Turkey consisting 108 broadband and 22 short period seismometers. KOERI is also in the process of enhancing its observational capabilities with the deployment of 5 sea bottom observation systems in the Sea of Marmara, including broadband seismometers and differential pressure meters, pressure transducer, strong-motion sensor, hydrophone, temperature measurement device and flow meter. The deployment phase is finalized in December 2010 and the system is fully operational. The seismic component of the sea-bottom observation system will improve the spatial distribution of the existing seismic network, especially after the integration with the land-based stations. Existing seismological network is being improved especially in the coastal regions and bilateral agreements were concluded with several neighboring countries to exchange seismological data. A Protocol with the responsible national agency for sea level monitoring has been concluded and currently three tide-gauge stations are transmitting data to IOC Sea Level Station Monitoring Facility. In addition, KOERI is considering to set-up its own tide gauge network consisting of 10 stations. NAMI DANCE Tsunami Simulation - Visualization Code has been installed in KOERI and some of the tsunami scenarios have already been simulated. The near-future goal is to create a tsunami model database based on deterministic approaches (scenarios) and to derive tsunami hazard and risk maps for Turkey. KOERI is currently functioning as the de facto National Tsunami Warning Center and is expected to operate as the Regional Tsunami Watch Centre in 2012, providing coverage to Eastern Mediterranean, Aegean and Black Seas.

Specific role in TRIDEC KOERI is involved in WP 2 (End-User Requirements and Scenario Definition), WP 6 (Natural Crisis Management) and WP 8 (Dissemination and Exploitation). In WP 2, KOERI mainly contributes in the identification of the end-user requirement together with the definition of a set of mandatory and recommended standards for the Project.

NTWC-TR is integrated into the 24/7 operational National Earthquake Monitoring Center (NEMC) of KOERI comprising 129 BB and 61 strong motion sensors. Based on an agreement with the Disaster and Emergency Management Presidency (DEMP), data from 10 BB stations located in the Aegean and Mediterranean Coast is now transmitted in real time to KOERI. Real-time data transmission from 6 primary and 10 auxiliary stations from the

International Monitoring System will be in place in the very near future based on an agreement concluded with the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) in 2011. In an agreement with a major Turkish GSM company, KOERI is enlarging its strong-motion network to promote real-time seismology and to extend Earthquake Early Warning system countrywide. 25 accelerometers (included in the number given above) have been purchased and installed at Base Transceiver Station Sites in coastal regions within the scope of this initiative. Data from 3 tide gauge stations operated by General Command of Mapping (GCM) is being transmitted to KOERI via satellite connection and the aim is to integrate all tide-gauge stations operated by GCM into NTWC-TR.

A collaborative agreement has been signed with the European Commission - Joint Research Centre (ECJRC) and MOD1 Tsunami Scenario Database and TAT (Tsunami Analysis Tool) are received by KOERI and user training was provided. The database and the tool are linked to SeisComp3 and currently operational. In addition KOERI is continuing the work towards providing contributions to JRC in order to develop an improved database (MOD2), and also continuing work related to the development of its own scenario database using NAMI DANCE Tsunami Simulation and Visualization Software. Further improvement of the Tsunami Warning System at the NTWC-TR will be accomplished through KOERI's participation in the FP-7 Project TRIDEC focusing on new technologies for real-time intelligent earth information management to be used in Tsunami Early Warning Systems.

In cooperation with Turkish State Meteorological Service (TSMS), KOERI has its own GTS system now and connected to GTS via its own satellite hub. The system has been successfully utilized during the First Enlarged Communication Test Exercise (NEAMTWS/ECTE1), where KOERI acted as the message provider.

KOERI is providing guidance and assistance to a working group established within the DEMP on issues such as Communication and Tsunami Exercises, National Procedures and National Tsunami Response Plan. KOERI is also participating in NEAMTIC (North-Eastern Atlantic and Mediterranean Tsunami Information Centre) Project.

Finally, during the 8th Session of NEAMTWS in November 2011, KOERI has announced that NTWC-TR is operational as of January 2012 covering Eastern Mediterranean, Aegean, Marmara and Black Seas and KOERI is also ready to operate as an Interim Candidate Tsunami Watch Provider.

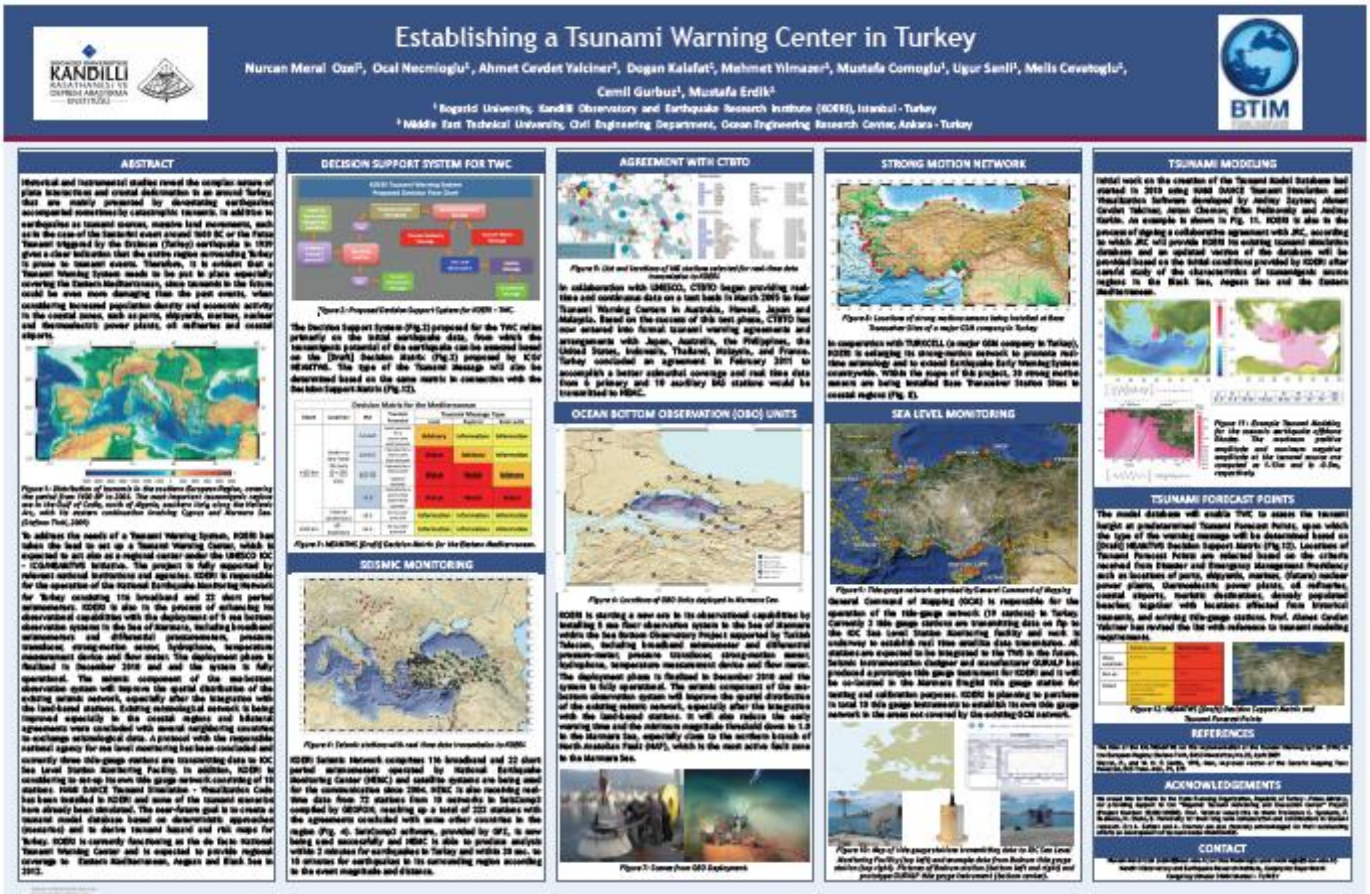



**Figure 19 :** Tsunami Warning Center in Turkey - BTIM

## 3. Seismic Hazard

### 3.1 Definitions and Methods

The natural events such as earthquakes, hurricanes, tornados and floods are capable of causing deaths, injuries and property damage. These events are called as natural hazards and hazard associated with earthquakes are referred as seismic hazard. The potentially destructive effects of earthquakes such as ground shaking, liquefaction and landslides are included in Seismic Hazard and the prediction of the severity and likelihood of occurrence of these effects at a particular site are studied in Seismic Hazard analysis.

Turkey is one of the most vulnerable countries in the world to natubral disasters due to its location within the active earthquake zones (Figure 20). It is estimated that 81 percent of the population of Turkey lives in the areas at risk from at least two hazards, such as earthquakes, floods or landslides. These areas also generate an estimated 83 percent of the country's GDP1. Earthquakes have the largest impact on people's lives and cause significant economic damage as the country lies on the 1,400-kilometer long Northern Anatolian fault, which slips at a rate of 24 millimeters per year. Between 1992 and 2004, Turkey experienced 130 earthquakes of 5.0 and above on the Richter scale. In total these caused over 80,000 causalities and heavy damage to about 450,000 buildings. The most devastating recent earthquake was in 1999 in the Marmara region which killed about 17,000 people, made 200,000 people homeless and resulted in the estimated fiscal cost of up to $2.2 billion.

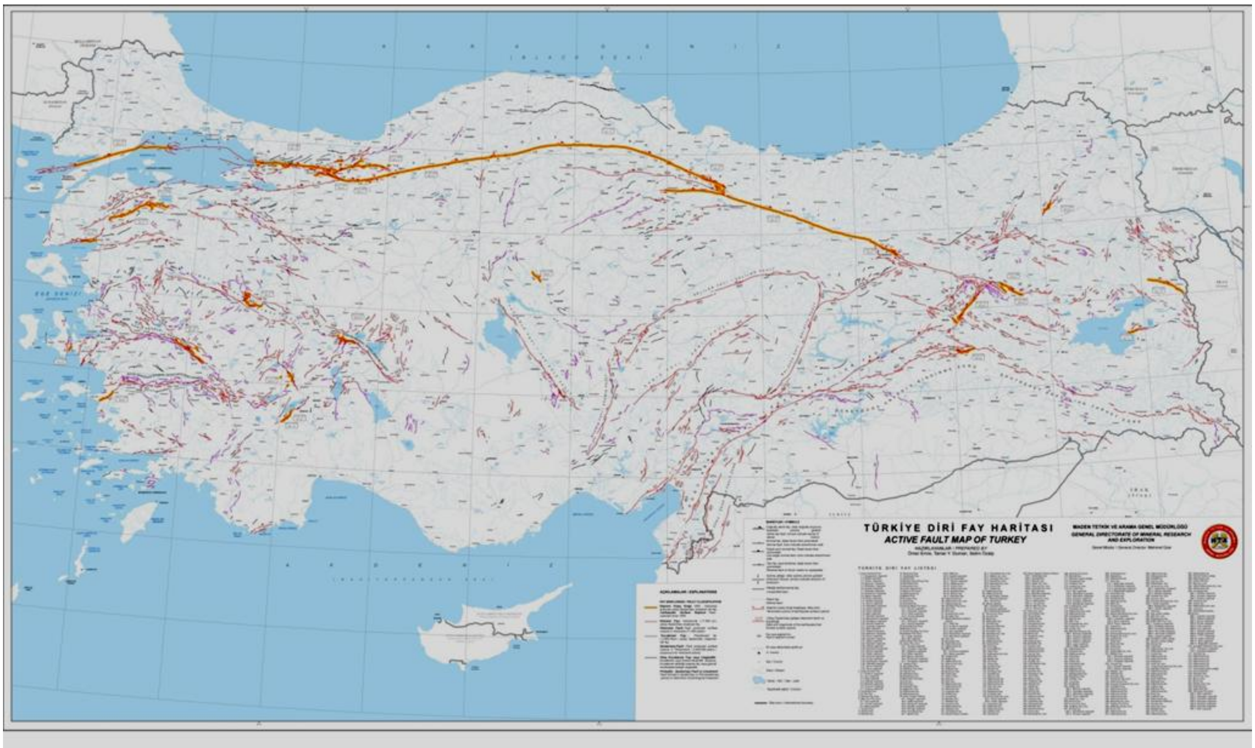



**Figure 20 :** Actual Active Fault Map of Turkey (2012, MTA).

There are two main methods to assess the Seismic Hazard. These are Deterministic Seismic Hazard Assessment (DSHA) and Probabilistic Seismic Hazard Assessment (PSHA). The main requirement for any seismic hazard assessment is a seismicity model of the region which includes the models with the occurrence of different size earthquakes in time and space. In general seismicity models combine 3-components which are earthquake catalogues, seismic source zones and recurrence relations.

Earthquake Catalogues give the information on the origin time, location (epicentral coordinates and focal depth) and magnitude. Although instrumental records are available for the several tens of years only, the reports on historical seismicity are available for several hundreds of years. The seismic source zones give information on observed seismicity and tectonics. Once the earthquake catalogue for the region is compiled and the source zones have been determined, the seismicity model can be developed by a recurrence relation which is obtained from the number of earthquakes in different magnitudes from the earthquake catalogue. The recurrence relation gives information on the annual rate of exceedance of earthquakes with different magnitudes. Once the seismicity model is developed, a decision on the methodology whether DSHA or PSHA will be applied is given. Both methodologies have some similarities, advantages, disadvantages and uncertainties. The more information on DSHA and PSHA can be found in the related references.

### 3.1.1. Deterministic Seismic Hazard Assessment (DSHA)

In general, deterministic analyses use discrete, single-values events or models to arrive at scenario-like descriptions of seismic hazard. Three basic elements are required to carry out the assessment: an earthquake source, a controlling earthquake of a specified size and a means of estimating the resulting ground motions. Deterministic seismic hazard assessment involves four basic steps (Figure 2). The first step involves the identification of the seismic sources capable of generating future earthquakes that could cause significant seismic hazard at the site. The controlling earthquake is selected, usually termed the Maximum Credible Earthquake, which is defined as the largest earthquake that can be reasonably expected to occur within each source zone (Krinitzsky, 2002). The magnitude of this earthquake can be determined on the basis of geological evidence through the use of empirical equations to relate magnitude to fault rupture dimensions. The scenario earthquakes are placed at the closest location within each source with respect to the site. Once the scenario earthquake magnitude and distance for each source zone have been defined, the ground motions at the site can be estimated using a ground-motion prediction equation. These equations provide estimates of ground motion (peak acceleration, peak velocity, response spectrum ordinates) for an earthquake of a given magnitude at different distances by means of a curve fitted to observed data (Crowley, 2005).

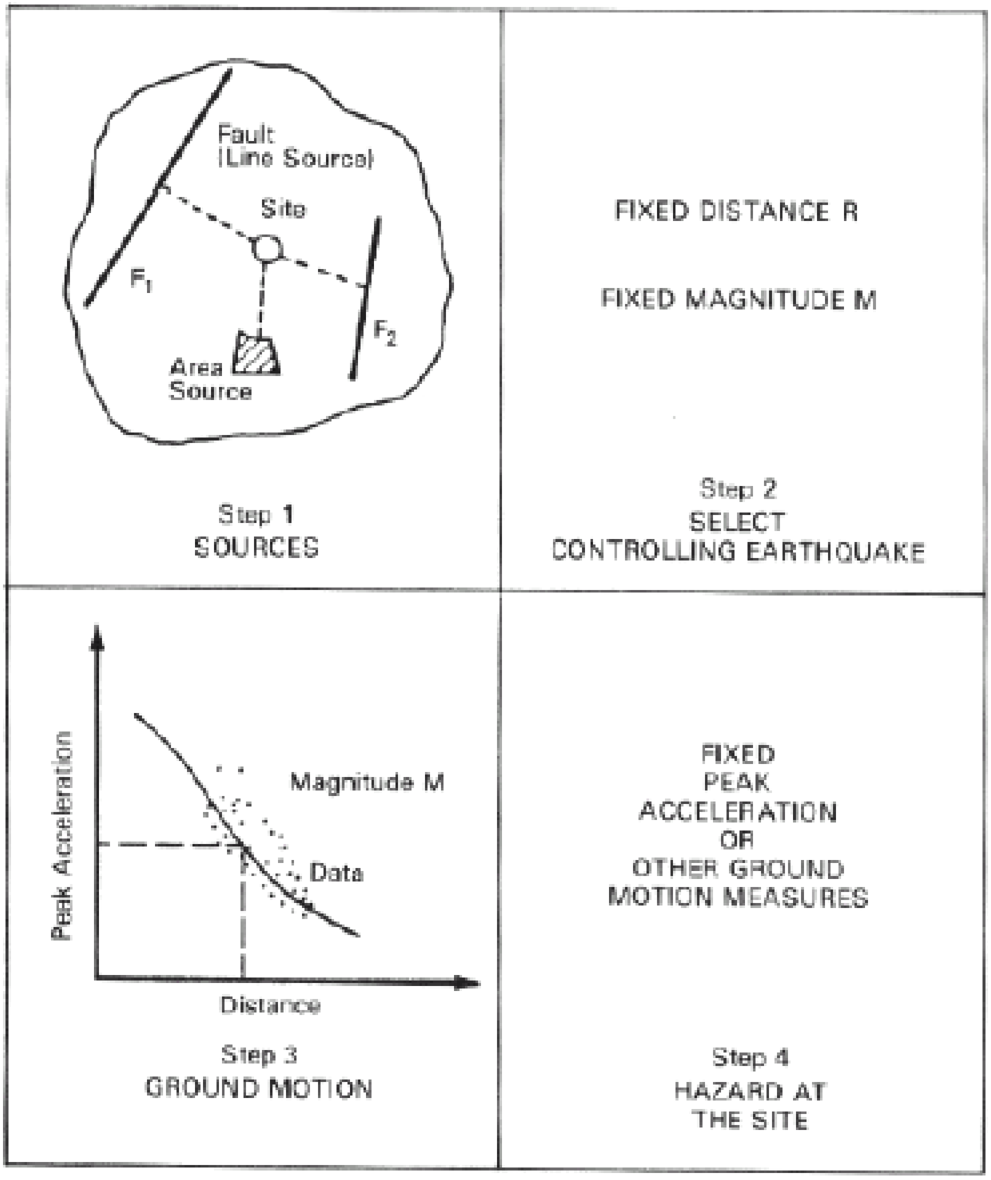



**Figure 21 :** The four-step process to a typical DSHA (after Reiter, 1990)

### 3.1.2. Conventional Probabilistic Seismic Hazard Assessment (PSHA)

In DSHA, it was shown how a few isolated M-D-ε triplets (magnitude, distance and number of logarithmic standard deviations) are considered in a deterministic seismic hazard assessment for a single site. In a probabilistic seismic hazard assessment, the fundamental difference is that all possible M-D- ε triplets are considered in the calculation of hazard (see e.g. Cornell, 1968; Reiter, 1990; Kramer, 1995). A PSHA comprises four basic stages (Figure 22). The first step involves the identification and characterization of the earthquake sources in much the same way as has been described for a DSHA. The main difference, however, is that a probability distribution of potential rupture locations within each source is defined. The second step of a PSHA involves the description of the temporal distribution of earthquake recurrence through the use of a recurrence relationship. These relationships specify the average rate at which an earthquake of some magnitude will be exceeded. The next step in the PSHA process is the definition of the ground motions at a site; this is carried out in a similar fashion to deterministic seismic hazard assessment whereby ground motion prediction equations are used. However, with PSHA a range of earthquakes is considered and so a family of ground-motion prediction curves is required for each magnitude. The fourth step lies in determining the hazard at a particular site through the integration of the effects of all earthquakes of different sizes, occurring at different locations in different source zones at different probabilities of occurrence. A hazard curve is produced which shows the probability of exceeding different levels of ground motion at the site during a specified period of time (Crowley, 2005).

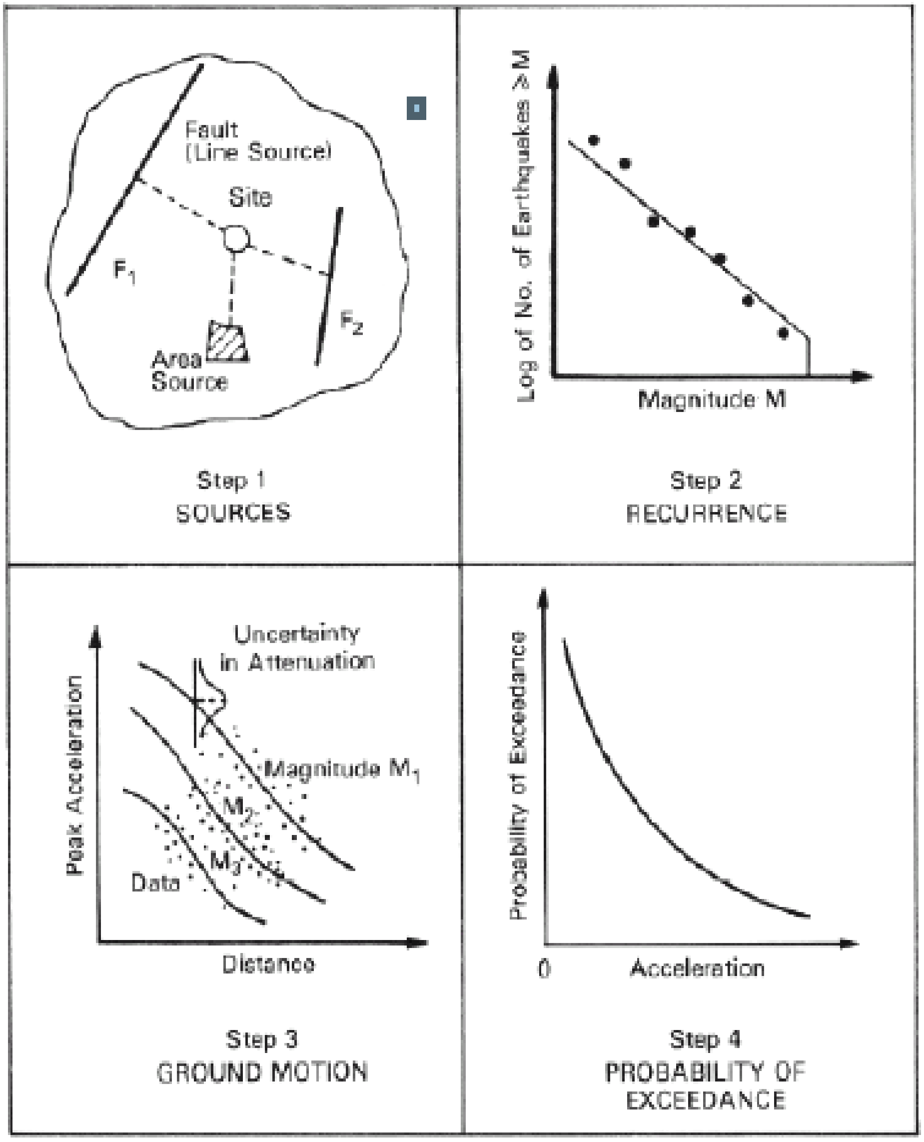



**Figure 22 :** The four-step process to a typical PSHA (after Reiter, 1990)

### 3.2 Results and Interpretation

For the earthquake hazard, the probabilistic earthquake hazard maps developed by KOERI for the Ministry of Transportation in connection with the preparation earthquake resistant design code for the construction of railways, seaports and airports ('Kıyı ve Liman Yapıları, Demiryolları, Hava Meydanları İnşaatlarına İlişkin Deprem Teknik Yönetmeliği-Ek A' of the Republic of Turkey Official Gazette dated 18 August 2007 and numbered 26617). These state of the art hazard maps provide the ground motion parameters that are associated with average return periods of 72, 475 and 2475 years (or 50%, 10% and 2% probabilities of exceedance in 50 years), (Figure 23, Figure 24).

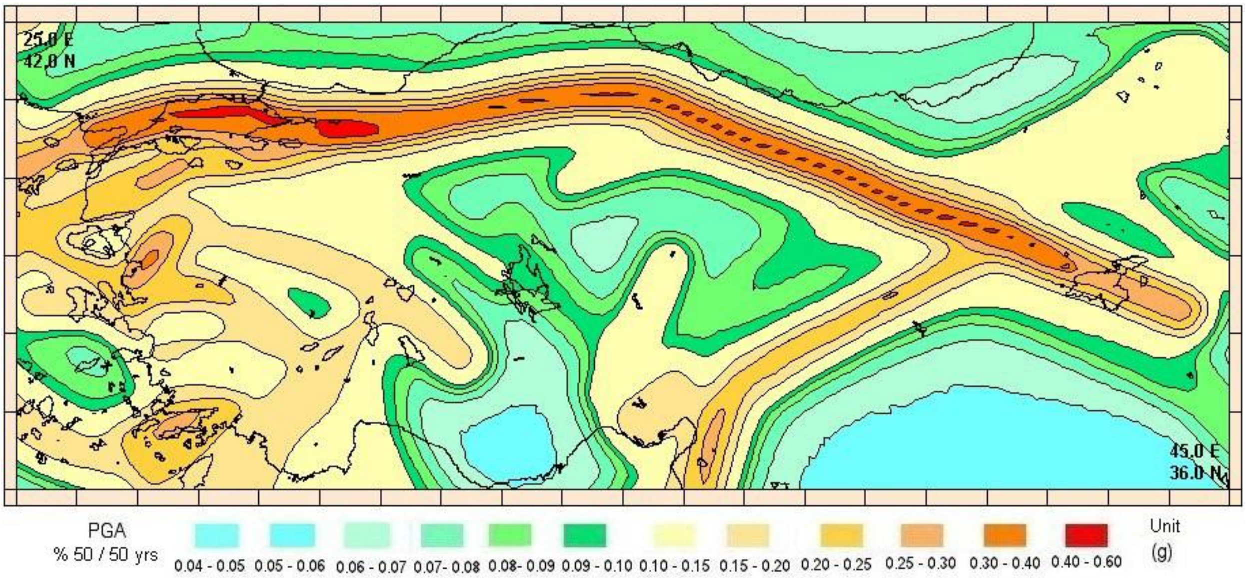



**Figure 23 :** Peak Ground Acceleration (PGA) for 50% probability of exceedence in 50 years.

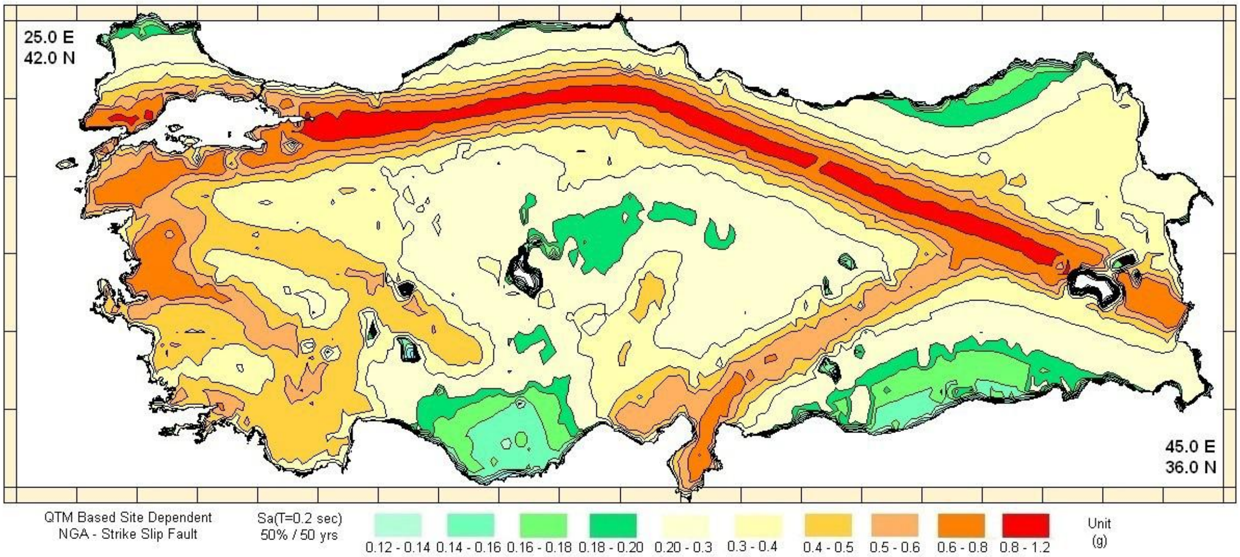



**Figure 24:** Site Dependent Spectral Acceleration at T=0.2 sec for 50% probability of exceedence in 50 years.

### 3.3 Seismic Codes

Many seismic source zonation maps are available for Turkey (Figure 25). Recently, the seismic source zonation model of Turkey was developed within the context of a project conducted for the Ministry of Transportation Turkey, aiming the preparation of an earthquake resistant design code for the construction of railways, seaports and airports (DLH, 2007). In order to account for the spatially more diffuse moderate size seismicity around the faults, widths of at least several kilometers were assigned to the zones even if the associated faults were well expressed on the surface.

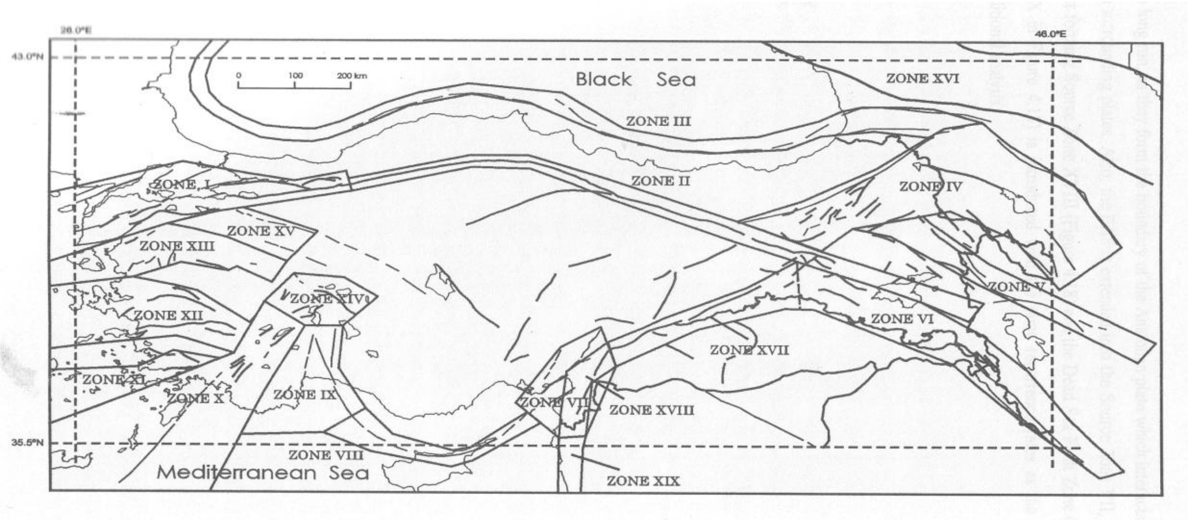



**Figure 25 :** Seismic source zonation model proposed by Onur, (1997).

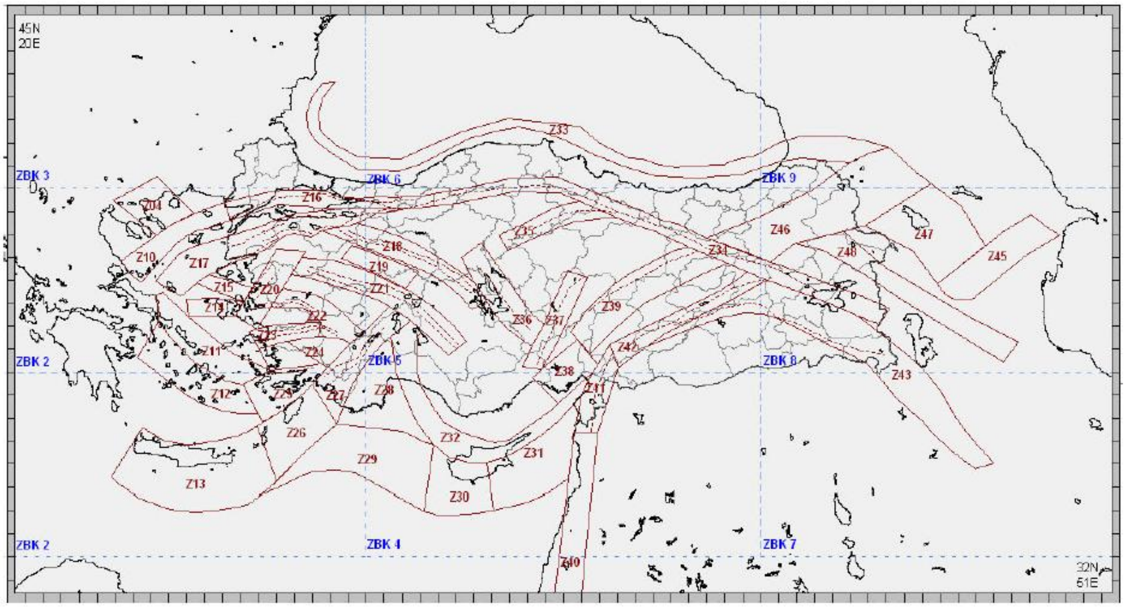



**Figure 26 :** Seismic Source Zonation Model of Turkey (within the context of DLH, 2007-Demircioğlu, 2010)

## 4. Seismic Risk

### 4.1 Definition Ways/Methods to Decrease Seismic Risk

The seismic risk can be computed as a compendium of seismic hazard, physical and social elements exposed to risk and their respective vulnerabilities and fragilities. Earthquake hazard assessment gives the probability that a certain parameter of ground motion such as MMI, PGA, spectral acceleration, or in more general case, of the seismic process that will be surpassed within a lifetime period. The population, structures, utilities, systems and socio-economic activities constitute the ‘Element at Risk’ in urban areas. The probabilistic earthquake hazard maps developed by KOERI can be used for the assessment of risks since the interest would be in the mitigation of near–term risks and the inherent difficulties in the extrapolation of exposure and vulnerability data for long return periods. Besides, for the estimation of earthquake losses in the Euro-Mediterranean region ELER (Earthquake Loss Estimation Routine) was developed by the EU FP6 project entitled 'Network of Research Infrastructures for European Seismology, NERIES'. Moreover, ELER methodology and software has recent been used for the assessment of earthquake risks in the Istanbul Province.

### 4.2.1 Site Effects Evaluation

After an earthquake, it is aimed to transfer the ground motion parameters estimated for bedrock level, to the surface by available soil classification maps and $V_s$30 parameters. The effect of local site conditions is important in the distribution of pga-pgv parameters and intensity. For Turkey, it will be appropriate to use QTM map (Figure 27) prepared by General Directorate Mineral Research and Exploration (MTA) and topographical slope based $V_s$30 map for Euro-Med region by Wald and Allen (2007) (Figure 28). QTM map of Turkey was obtained by classifying 1:100.000 scaled surface geology maps of MTA in terms of QTM after digitizing. In QTM map, Q-Quaternary class (sedimantary) shear wave velocity is represented by $V_s$-333 m/sec, T-Tertiary class (soft rock) shear wave velocity is represented by $V_s$-406 m/sec and M-Mesozoic class (hard rock) shear wave velocity is represented by $V_s$-589 m/sec. The relationship between topographical slope, local soil classes (from class B to class E) developed by NEHRP and Vs30 parameter is given in Table 1. Besides, in order to obtain site amplification factors based on NEHRP (National Earthquake Hazard Reduction Program) site classes (Table 2), it is used mean shear wave velocities-Vs30 and then applied to the frequency and amplitude dependent amplification factors determined by Borcherdt (1994) based on these velocities (Shake Map Manual, 2006). Borcherdt 1994 amplification factors that are used in the estimation of maximum ground acceleration and maximum ground velocity, are given in Table 3.

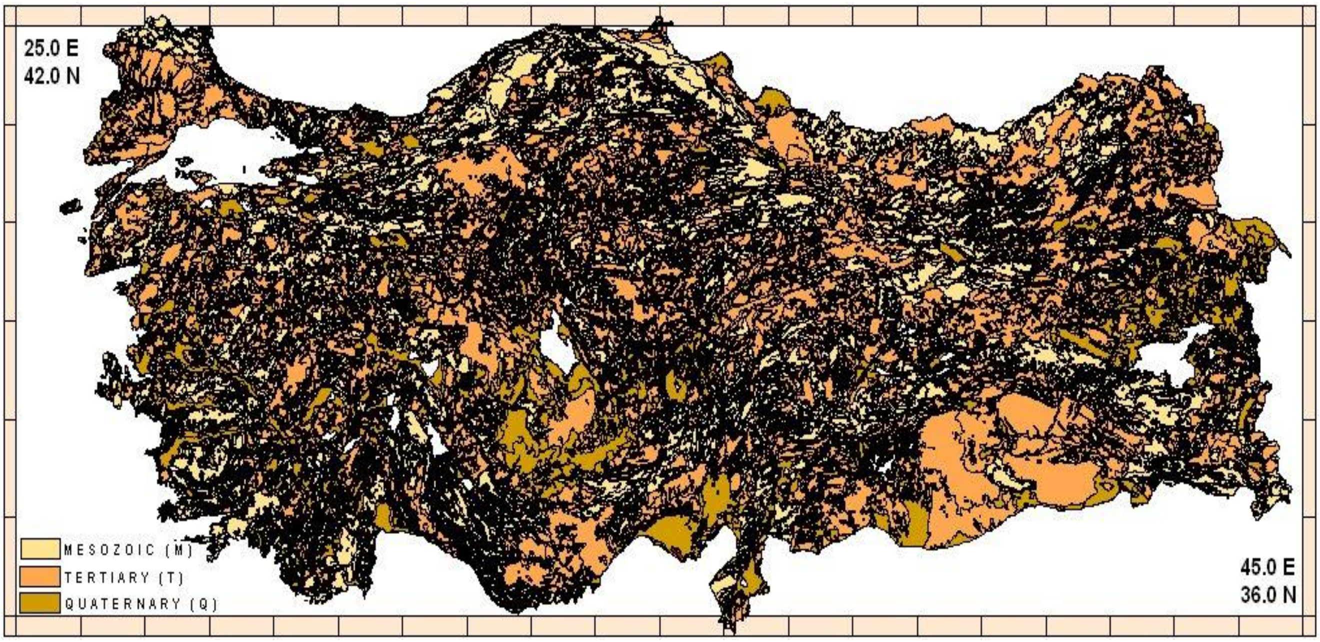



**Figure 27:** . Regional QTM Map of Turkey (MTA)

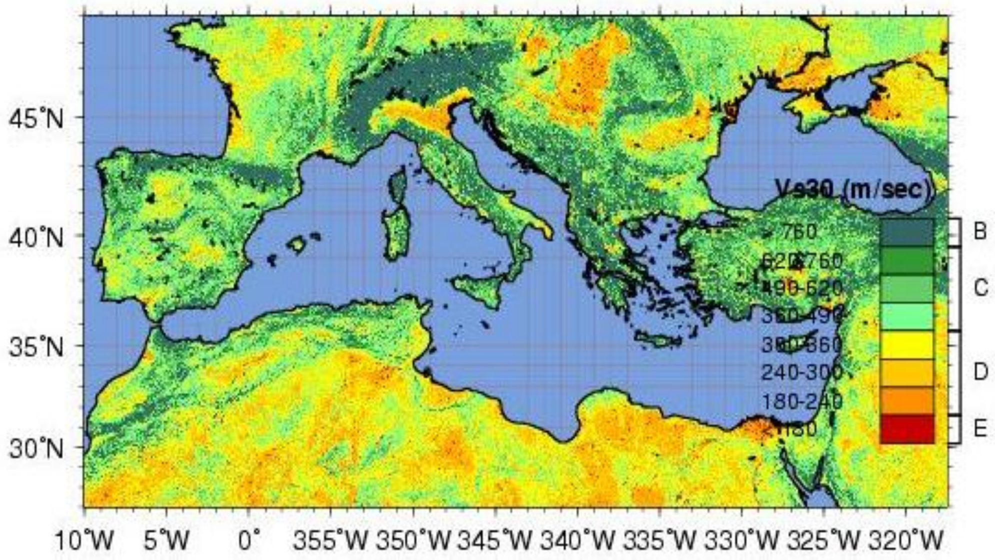



**Figure 28 :** Topographical Slope Based Vs30 Map Developed for South Europe and Mediterranean Regions (Wald and Allen, 2007).

**Table 1**. Change in Topographical Slopes with Respect to NEHRP Soil Classification and Vs30 parameters.

| Class | $V_s^{30}$ range (m/s) | Slope range (m/m) – (active tectonic) | Slope range (m/m) – (stable continent) |
|---|---|---|---|
| E | <180 | <1.0E-4 | <2.0E-5 |
| D | 180–240 | 1.0E-4–2.2E-3 | 2.0E-5–2.0E-3 |
| | 240–300 | 2.2E-3–6.3E-3 | 2.0E-3–4.0E-3 |
| | 300–360 | 6.3E-3–0.018 | 4.0E-3–7.2E-3 |
| C | 360–490 | 0.018–0.050 | 7.2E-3–0.013 |
| | 490–620 | 0.050–0.10 | 0.013–0.018 |
| | 620–760 | 0.10–0.138 | 0.018–0.025 |
| B | >760 | >0.138 | >0.025 |

**Table 2**. Soil profile type classification for seismic amplification (FEMA, 1994).

Soil profile type classification for seismic amplification (FEMA, 1994).

| Soil Type | General Description | Avg. Shear Wave Velocity (feet/s) | Avg. Shear Wave Velocity (m/s) | Avg. Blow Counts | Avg. Shear Strength (lbs/sq.ft.) |
|---|---|---|---|---|---|
| A | Hard Rock | > 5,000 | > 1,500 | | |
| B | Rock | 2,500 - 5,000 | 760 - 1,500 | | |
| C | Hard and/or stiff/very stiff soils; most gravels | 1,200 - 2,500 | 360 - 760 | > 50 | 2,000 |
| D | Sands, silts and/or stiff/very stiff clays, some gravels | 600 - 1,200 | 180 - 360 | 15 - 50 | 1,000 - 2,000 |
| E | Small to moderate thickness (10 to 50 feet) soft to medium stiff clay, Plasticity Index > 20, water content > 40 percent | < 600 | < 180 | < 15 | < 1,000 |
| $E_2$ | Large thickness (50 to 120 feet) soft to medium stiff clay Plasticity Index > 20, water content > 40 percent | < 600 | < 180 | < 15 | < 1000 |
| $F_1$ | Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. | By definition the F classification requires that a site dependent evaluation of the engineering parameters be conducted, as they do not fall into any of the other soil classifications. | | | |
| $F_2$ | Peats and/or highly organic clays greater than 10 feet thick | | | | |
| $F_3$ | Very high plasticity clays greater than 25 feet thick with Plasticity Index > 75 | | | | |
| $F_4$ | Very thick soft/medium stiff clays greater than 120 feet thick | | | | |

**Table 3.** Site Amplification Factors (ShakeMap Manual 2006, Borcherdt 1994)

| Class | Vel | Short-Period (PGA) | | | | Mid-Period (PGV) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 150 | 250 | 350 | | 150 | 250 | 350 |
| B | 686 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| BC | 724 | 0.98 | 0.99 | 0.99 | 1.00 | 0.97 | 0.97 | 0.97 | 0.98 |
| C | 464 | 1.15 | 1.10 | 1.04 | 0.98 | 1.29 | 1.26 | 1.23 | 1.19 |
| CD | 372 | 1.24 | 1.17 | 1.06 | 0.97 | 1.49 | 1.44 | 1.38 | 1.32 |
| D | 301 | 1.33 | 1.23 | 1.09 | 0.96 | 1.71 | 1.64 | 1.55 | 1.45 |
| DE | 298 | 1.34 | 1.23 | 1.09 | 0.96 | 1.72 | 1.65 | 1.56 | 1.46 |
| E | 163 | 1.65 | 1.43 | 1.15 | 0.93 | 2.55 | 2.37 | 2.14 | 1.91 |

### 4.2.2 Vulnerability Studies

#### 4.2.2.1. Building vulnerability

The population, structures, utilities, systems and socio-economic activities constitute the ‘Element at Risk’ in urban areas. Vulnerability is defined as the degree of loss to a given element at risk or a set of such, resulting from the occurrence of a hazard. Vulnerability functions (or fragility curves) of an element at risk represent the probability that its response to earthquake excitation exceeds its various performance limit states based on physical and socio-economic considerations. For a population of buildings exposed to earthquake hazard, the vulnerability relationships relate the probability of exceedence of multiple damage limit states to given measures of the ground motion severity.

Under the JRA-3 component of the EU FP-6 NERIES Project, a methodology and software (ELER - **E**arthquake **L**oss **E**stimation **R**outine) for the rapid estimation of earthquake shaking and losses in the Euro-Mediterranean region has been developed (Figure 29).

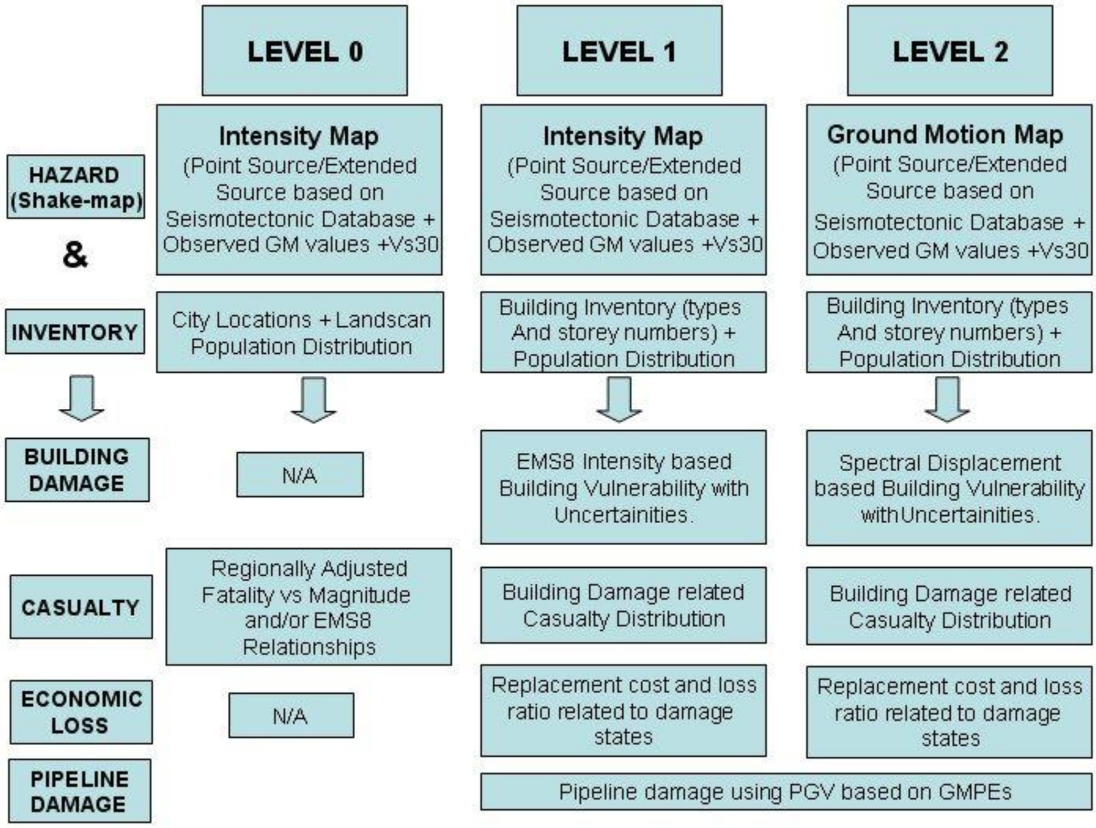



**Figure 29 :** Flow chart for multi-level analysis methodology of ELER

Level 1 module calculates number of damaged buildings and associated casualty. The intensity based empirical vulnerability relationship is employed to find number of damaged buildings. The casualty estimation is done through number of damaged buildings throughout regional building inventory data bases.

Level 2 module also calculates number of damaged buildings and associated casualty. The spectral acceleration-displacement-based vulnerability assessment methodology is utilized for the building damage estimation. The casualty estimation is done through number of damaged buildings using HAZUS99 (FEMA, 1999) and HAZUS-MH (FEMA, 2003) methodologies.

For the physical vulnerability of the building stock in Turkey, it will be referred from the PhD Thesis of Demircioğlu (2010), in this study she has utilized Turkish data based empirical vulnerability relationships calibrated the EMS98 Macroseismic scale through the use of fuzzy set theory (Giovinazzi and Lagomarsino, 2005). Demircioğlu (2010) has used the synthetically updated results of the building inventory dataset compiled by GRM Inc. from data obtained from Turkish Statistical Institute (TurkStat), Department of Housing and Urban Development, Department of Earthquake Risk Management and Urban Development. The total number of building with respect to main construction types, number of stories and construction date for the whole country indicated in Table 4.

**Table 4.** Distribution of the Buildings Classification

| Construction Type | | Number of Stories | | Construction Date | |
|---|---|---|---|---|---|
| R/C | 3,837,576 | Low Rise | 6,647,014 | Pre-1979 | 3,167,482 |
| Masonry | 2,977,263 | Mid Rise | 763,143 | Post-1979 | 4,345,890 |

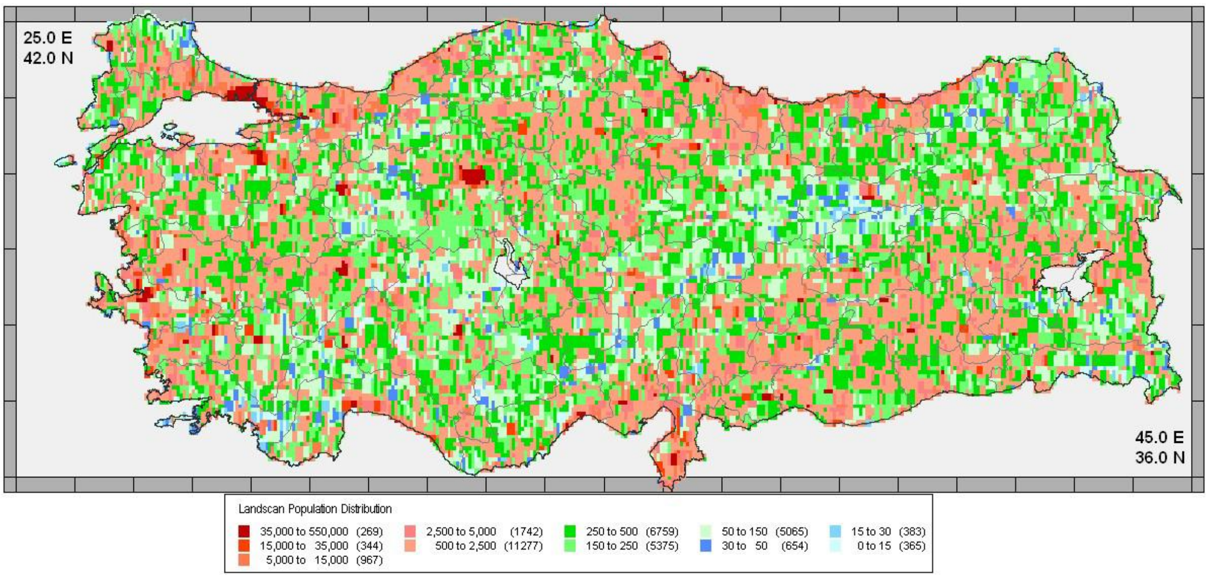



**Figure 30 :** Distribution of Population in Turkey on the basis of Landscan Data.

The people emigrating from rural areas increased the need for housing and other infrastructural facilities. There are about 1,200,000 buildings in Istanbul as of 2006.

The 17 August 1999, Mw=7.4 Kocaeli earthquake killed 18,000 people, destroyed 17,000 buildings, and caused $25 billion in damage. Approximately 1000 people in the İstanbul were killed and damage of buildings was rather serious, though the epicenter of the 1999 earthquake on NAFZ was more than 110 km away.

JICA study (2002) in coordination with İstanbul Metropolitan Municipality (IMM) estimate that a major earthquake of Mw=7.4 near to İstanbul might cost more then 50,000 lives and cause economic losses of more than $ 60-70 billions. Although expected number of injuries requiring hospitalization will be around 150,000; 30% of hospitals (in total of 635) are located in risky areas of southwest part of the city.

#### 4.2.2.2 Vulnerability Studies

##### 4.2.2.2.1. Education

In Turkey it is increasingly accepted that all type of disasters and especially earthquakes are the result of natural and social processes. The essential necessity of merging of the disaster safety concept in all forms of daily life is an obvious condition to achieve the goal of disaster reduction.

Educational, Study Programs and Education Policies in Turkey the disaster preparedness programs have reevaluated and redesigned with the impact of 1999 Marmara İstanbul and Gölcük Earthquakes in Northwestern of Turkey. More attention were accorded, and support were provided to efforts targeting schoolchildren and youth with the aim of making communities more aware of the threat of earthquake and of the need and possibility to become better prepared before earthquake and its strikes. With this understanding National Academic Institutions and educational establishments concerned with disaster risk reduction are giving to education is based on evidence that education contributes towards the knowledge and skills essential for disaster preparedness.

The Disaster Preparedness Education Unit (DPEU) at Bogazici University's Kandilli Observatory and Earthquake Research Institute (KOERI) was initially established a year after the 1999 Kocaeli earthquake, as the "Disaster Preparedness Education Project" (DPEP), a five-year program funded by the United States Agency for International Development's Office of Foreign Disaster Assistance (USAID-OFDA).

The goal of the project is to contribute to the efforts to prepare Istanbul for the likelihood of a damaging earthquake. It seeks to improve public disaster awareness, local preparedness, and first response organization and skills in order to decrease the loss of life and property in the event of such an earthquake.

In pursuit of this aim, four main education programs were established:

- Basic Disaster Awareness
- Non-Structural Mitigation
- Structural Awareness for Earthquakes
- Community Disaster Volunteer and Public Disaster Preparedness Program

In this context, the project created educational presentations, handbooks, CDs, and knowledge cards, including the Handbook for Disaster Preparedness in Schools, the Handbook for Disaster Preparedness in Hospitals, and publications on disaster preparedness for the disabled and on the conservation of museum works in disasters.

These programs reach diverse sectors of society and disseminate disaster preparedness protocols developed with the Ministry of National Education, the Ministry of the Interior Civil Defense Directorate, the Ministry of Health, the Turkish Red Crescent and the American Red Cross, local administrations, and assorted civil society organizations.

It is very important for community-directed earthquake education programs to be ongoing and sustainable. For this reason, Disaster Preparedness Education Unit (DPEU) was founded on 19 October 2004 to bring together the existing education programs created under DPEU with new and developing projects, and provide them with an institutional identity.

DPEU's education programs, which are developed with the participation of BU-KOERI faculty members, community experts, and practitioners, have been adopted by existing public institutions, civil society organizations, volunteers in assorted initiative groups, and educators responsible for disaster preparedness, in order to ensure their standardization, continuity, and long-term development.

DPEU accommodates the EARTHQUAKE PARK, where training courses, supported with an earthquake simulator.

DPEU aims to develop, supervise and evaluate training programs on disaster risk management; to prepare and disseminate training materials such as booklets, forms, presentations, videos and CD's; create a pool of trainers within KOERI; provide training programs at the national level in cooperation with other agencies if necessary; organize national and international seminars, workshop and public activities; coordinate training activities at EARTHQUAKE PARK and undertake collaborative works with scientific centers.

In 2011", DPEU has provided EARTHQUAKEPARK ABCD Disaster Awareness Training Program and up to now 4087 students and 226 accompanying teachers from 122 schools participated to the training activities.

In 2010 and 2011 in cooperation with the Natural Disaster Insurances Foundation, KOERI has also provided training in the districts along the main fault lines using the Mobile Earthquake Simulation and Training Truck.

**Development of an Education Subject throughout ESNET Project**

In the scope of ESNET Project, it is planned to give a few hour or day long lecture or seminars about the subjects mentioned above by the researchers and academic staff involved in this study. The presentation of the results obtained by the studies, organization and scope of the project, are especially substantial in terms of instructing. The education program will include the lectures about sections above and besides, if it is possible to give practical information, field tours including station observations that will be organized by Kandilli Observatory and Earthquake Research Institute Department of Earthquake Engineering Lecturers and Academicians.

#### 4.2.2.2.2. Infrastructure Vulnerability (Pipelines)

Pipeline systems consist of buried pipes and above ground support systems. In this section vulnerabilities of buried pipelines will be considered. Secondary support units such as buildings, mechanical and electrical systems and components will not be included.

**Fragilities** of buried pipes are based on some empirical expressions which are expressed as functions of some ground hazard parameters. These expressions are critical parts of loss estimation procedures and are given for material (ductile or brittle, continuous or segmented) and pipe diameter (large or small) for different ground hazard parameters (Peak Ground velocity PGV, Peak Ground Strain PGS or Peak Ground Displacement PGD).

The critical ground hazard parameters are given as;

1) **Wave Propagation (WP) hazard** : This type of hazard is a measure of transient ground strain and thus the fragilities of buried pipes, assumes PGV as the independent ground hazard parameter. As such permenant deformations do not occur. Damages rates are low but effective areas are very large.
   Generally factors affecting the fragility curves are classified according to the material type as ductile or brittle, and in some cases as the diameter and depth. Each country will provide the pipe inventories as defined above as well as the routes. Available codes such as ALA 2002, HAZUS 2000 and other empirical expressions will be used to estimate the damage rates per unit lengths of pipeline segments.

2) **Permanent ground deformations (PGD) .** This type of ground damage occurs when there is ground failure due to liquefaction induced lateral spreading, land slides or other effects. They are effective in much smaller areas but with higher damage rates as compared to WP. PGD values are generally calculated either from aerial photos or field measurements or through some empirical relations. Because of limited amount of observations these data may not be available. Therefore the scope of this project will be limited by the first item (1), only. However potential critical zones of PGD will be indicated on the GIS maps.

The education program for pipeline vulnerability will involve the basic criteria regarding the fragilities of buried pipes, the concept of repair rates for pipes, effects of pipe types such as segmented or buried, pipe diameter, burial depth, and finally ground hazards as described in the items above.

### 4.2.3. Rapid Response System and Shake Maps

Istanbul faces a significant earthquake hazard and risk as illustrated by the recently developed earthquake risk scenario for Istanbul. The tectonic setting showing the location of the Main Marmara Fault and EMS98 intensity distribution that would result from a moment magnitude Mw = 7.5 scenario earthquake is provided in (Figure 31). To assist in the reduction of losses in a disastrous earthquake in Istanbul a dense strong motion network is established. One hundred (100) strong motion recorders are stationed in dense settlements in the Metropolitan area of Istanbul in dialup mode for Rapid Response information generation (Figure 32). Ten (10) stations are sited at locations as close as possible to the Great Marmara Fault in on-line data transmission mode to enable Earthquake Early Warning. All together this network and its functions are called Istanbul Earthquake Rapid Response and Early Warning System (IERREWS http://www.koeri.boun.edu.tr/depmuh_index_eng.aspx ). The system is designed and operated by Bogazici University with the logistical support of the Governorate of Istanbul, First Army Headquarters and Istanbul Metropolitan Municipality. The construction of the system is realized by the GeoSig Inc. (www.geosig.com) and Poyry Energy (formerly Electrowatt-Ekono) (www.poyry.com) consortium. Communications are provided by AVEA GSM service provider (Erdik et al., 2003).

IERREWS consists of the following components:

- Monitoring system composed of various sensors,
- Communication link (off-line for the Rapid Response and on-line for the Early Warning) that transmits data from the sensors to computers,
- Data processing facilities that converts data to information, and
- System that issues and communicates the rapid response information and early warning.
- The Rapid Response part of the IERREWS has the objective of providing:
- Reliable information for accurate, effective characterization of the shaking and damage by other rapid post-earthquake maps (Shake, Damage and Casualty maps) for rapid response;
- Recorded motion for post-earthquake performance analysis of structures;
- Empirical basis for long-term improvements in seismic microzonation, seismic provisions of building codes and construction guidelines;
- Seismological data to improve the understanding of earthquake generation at the source and seismic wave propagation.

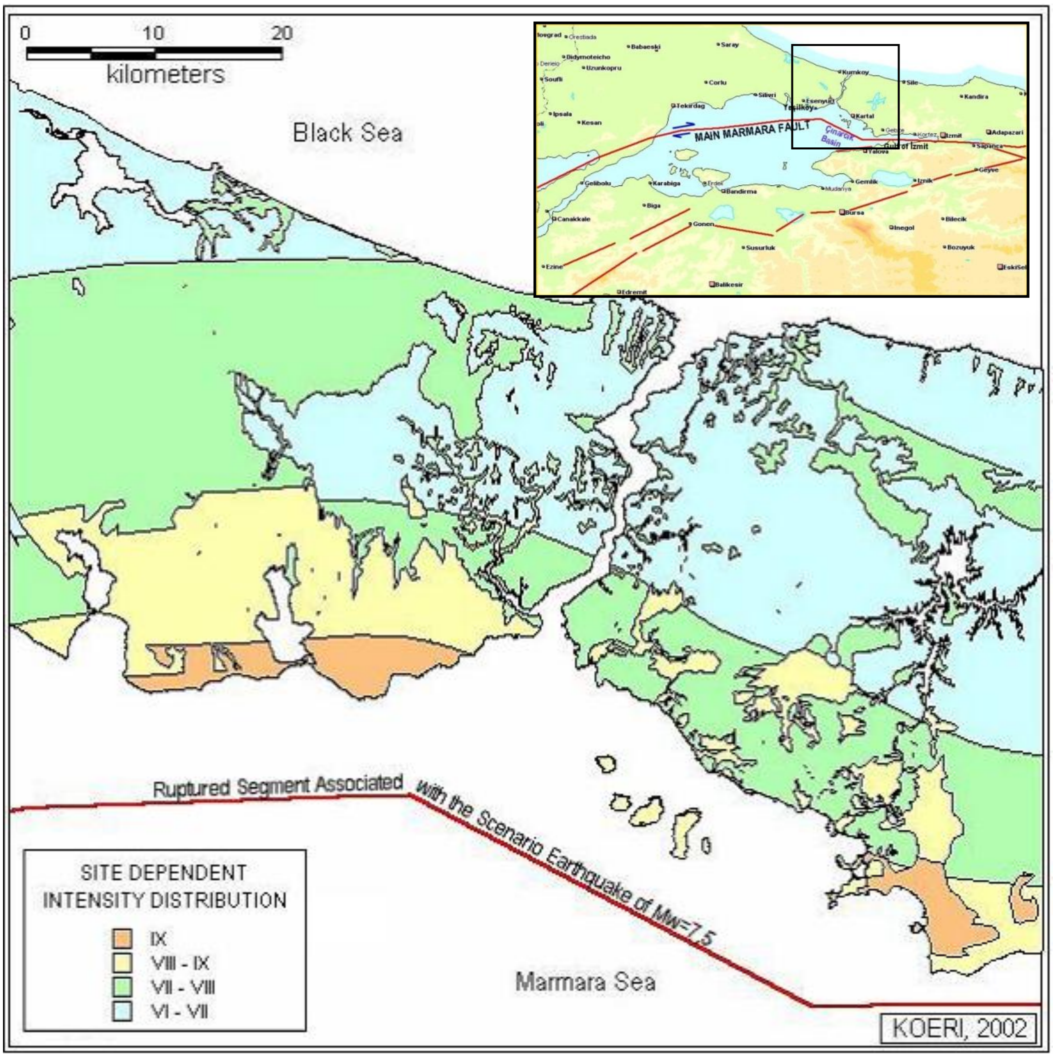



**Figure 31 :** Intensity distribution as a result of the scenario earthquake (KOERI, 2002). Inlet hows the main Marmara fault and the Marmara Region.

The Rapid Response System satisfies the COSMOS (The Consortium of Organizations for Strong-Motion Observation Systems) Urban Strong-Motion Reference Station Guidelines (www.cosmos-eq.org) for the location of instruments, instrument specifications and housing specifications. The relative instrument spacing is about 2–3 km which corresponds to about 3 wavelengths in firm ground conditions and more than 10 wavelengths for soft soils for horizontally propagating 1 s shear waves. Strong-motion instruments are generally located at grade level in small and medium-sized buildings, such that the motion recorded corresponds to that on the ground in the surrounding area. Site geology at stations has been characterized in general terms. Certain stations have borehole data. New borehole surveys for other stations are being planned. For communication of data from the rapid response stations to the data processing center and for instrument monitoring a reliable and redundant GSM communication system (backed up by dedicated landlines and a microwave system) is used, on the basis of a protocol agreement with the AVEA GSM Service provider. In normal times the rapid response stations are be interrogated (for health monitoring and instrument monitoring) on regular basis. After triggered by an earthquake, each station will process the streaming three-channel strong motion data to yield the spectral accelerations at specific periods, 12 Hz filtered peak ground acceleration and peak ground velocity and will send these parameters in the form of SMS messages at every 20 s directly to the main data center through the GSM communication system.

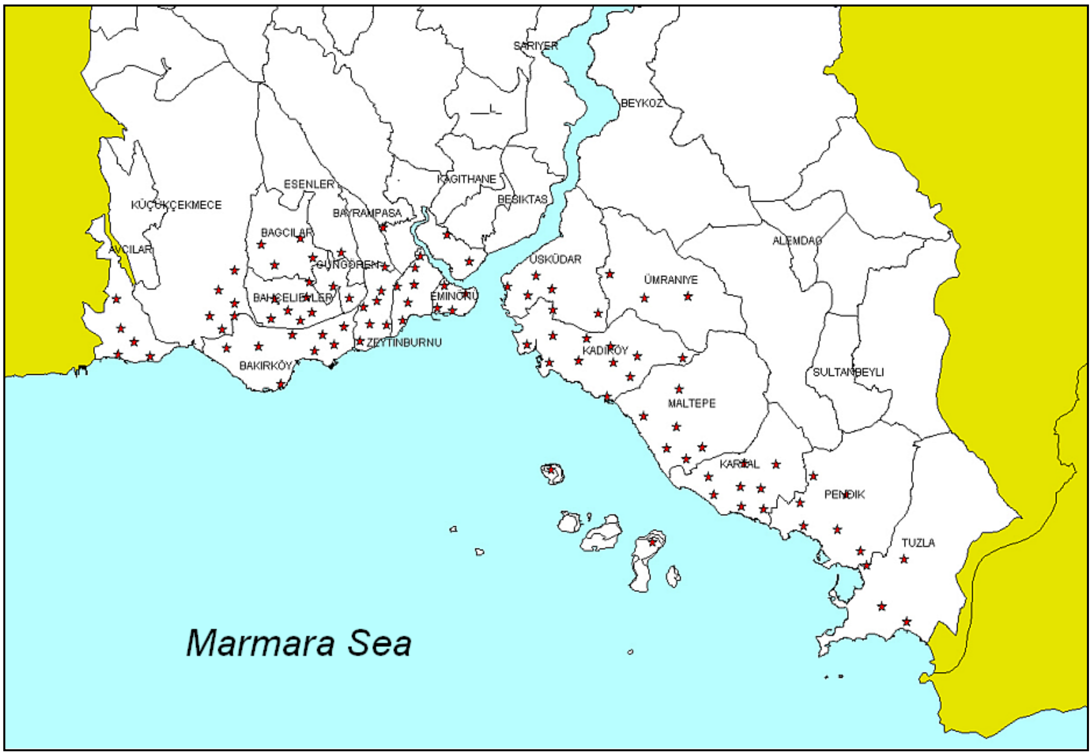



**Figure 32** : Location of RR stations (Erdik et ., 2003)

The main data processing center is located at the Department of Earthquake Engineering, Kandilli Observatory and Earthquake Research Institute of Bogazici University (KOERI-BU) (Figure 33). A secondary center located at the Seismological Laboratory of the same Institute serves as a redundant secondary center that can function in case of failure in the main center (Figure 34). Shake, damage and casualty distribution maps will be automatically generated at the data centers after the earthquake and communicated to the end users within 5 min. Full-recorded waveforms at each station can be retrieved using GSM and GPRS modems subsequent to an earthquake.

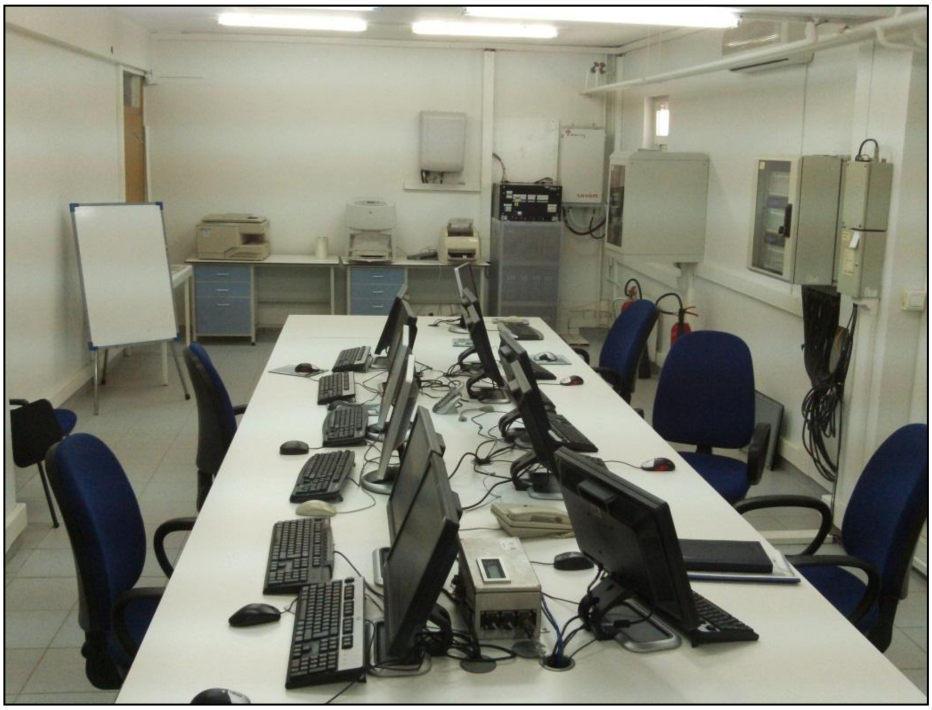


**Figure 33:** Main center in KOERI

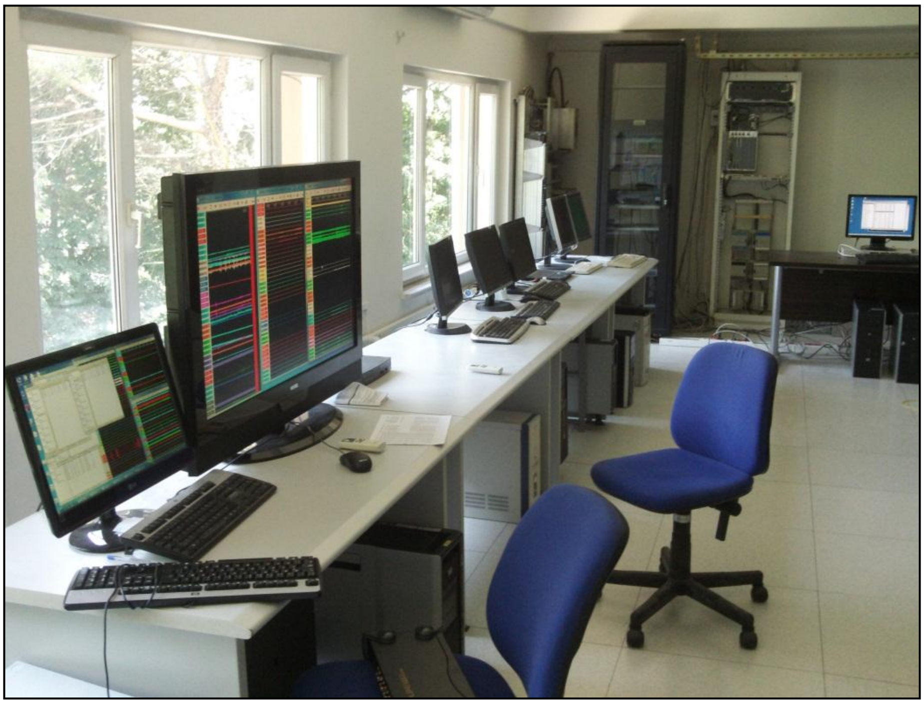


**Figure 34 :** Secondary Center in KOERI

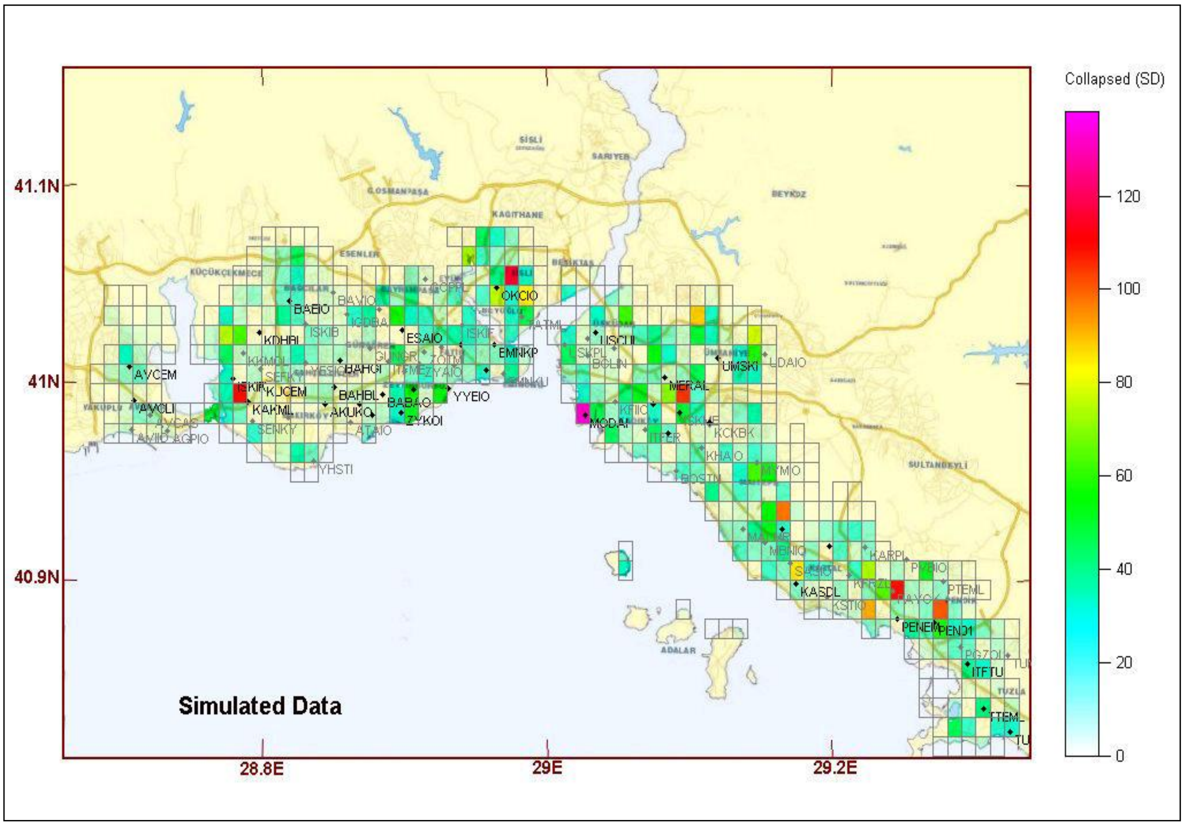
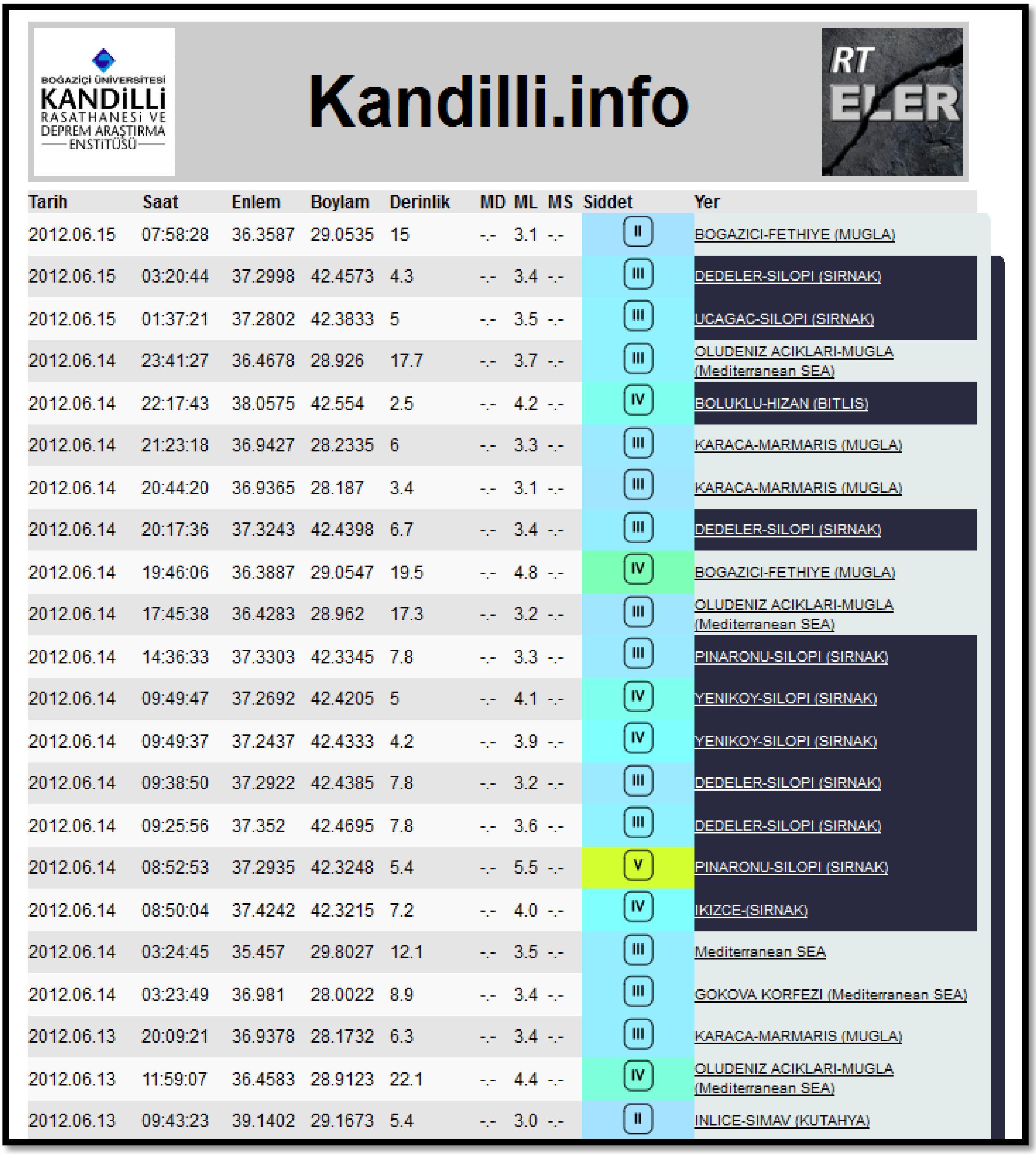



**Figure. 35 :** Example of building damage map that results from a randomly simulated strong motion data.

For the generation of Rapid Response information two methodologies based on spectral displacements and instrumental intensities are used. These methodologies are coded into specific computer programs (ELER) similar to HAZUS. Both of the methodologies essentially rely on the building inventory database, fragility curves and the methodology developments in the Istanbul Earthquake Risk Assessment Study conducted by the Department of Earthquake Engineering of Bogazici University. For the computation of input ground motion parameters, spectral displacements obtained from the SMS messages sent from stations will are interpolated to determine the spectral displacement values at the center of each geo-cell using two-dimensional splines. The earthquake demand at the center of each geocell is computed using these spectral displacements. The instrumental intensity at each the center of each geo-cell is computed as a function of short-period spectral acceleration. Using the response spectra and the instrumental intensities the building damage and the casualties are computed separately by using the spectral displacement based and intensity based fragility curves. The computations are conducted at the centers of a 0.01◦ × 0.01◦ grid system comprised of geo-cells (1120 m × 830 m) size. The building inventories (in 24 groups) for each geocell together with their spectral displacement and intensity based fragility curves are incorporated in the software. The casualties are estimated on the basis of the number of collapsed buildings and degree of damage. Example of building damage map thatresults from a randomly simulated strong motion data is provided in (Figure 35). For transmission of the Rapid Response information to the concerned agencies (Istanbul Governorate, Istanbul Municipality and First Army Headquarters) digital radio modem and GPRS communication systems are used (Figure 36).


**Figure 36 :** RR information transmission to three emergency response centers.

In Hazard module of ELER, for a given earthquake magnitude, epicenter information and if available actual station records of the event, spatially distributed intensity and ground motion parameters PGA, PGV, Sa, Sd were estimated through region specific ground motion prediction equations and gridded shear wave velocity information. By these input data, Shake maps are obtained as real time (http://www.kandilli.info/) (Figure 37, Figure 38) or scenario earthquakes.



Kandilli.info

BOĞAZİÇİ ÜNİVERSİTESİ KANDİLLİ RASATHANESİ VE DEPREM ARAŞTIRMA ENSTİTÜSÜ

RT ELER

| Tarih | Saat | Enlem | Boylam | Derinlik | MD | ML | MS | Siddet | Yer |
|---|---|---|---|---|---|---|---|---|---|
| 2012.06.15 | 07:58:28 | 36.3587 | 29.0535 | 15 | -.- | 3.1 | -.- | II | BOGAZICI-FETHIYE (MUGLA) |
| 2012.06.15 | 03:20:44 | 37.2998 | 42.4573 | 4.3 | -.- | 3.4 | -.- | III | DEDELER-SILOPI (SIRNAK) |
| 2012.06.15 | 01:37:21 | 37.2802 | 42.3833 | 5 | -.- | 3.5 | -.- | III | UCAGAC-SILOPI (SIRNAK) |
| 2012.06.14 | 23:41:27 | 36.4678 | 28.926 | 17.7 | -.- | 3.7 | -.- | III | OLUDENIZ ACIKLARI-MUGLA (Mediterranean SEA) |
| 2012.06.14 | 22:17:43 | 38.0575 | 42.554 | 2.5 | -.- | 4.2 | -.- | IV | BOLUKLU-HIZAN (BITLIS) |
| 2012.06.14 | 21:23:18 | 36.9427 | 28.2335 | 6 | -.- | 3.3 | -.- | III | KARACA-MARMARIS (MUGLA) |
| 2012.06.14 | 20:44:20 | 36.9365 | 28.187 | 3.4 | -.- | 3.1 | -.- | III | KARACA-MARMARIS (MUGLA) |
| 2012.06.14 | 20:17:36 | 37.3243 | 42.4398 | 6.7 | -.- | 3.4 | -.- | III | DEDELER-SILOPI (SIRNAK) |
| 2012.06.14 | 19:46:06 | 36.3887 | 29.0547 | 19.5 | -.- | 4.8 | -.- | IV | BOGAZICI-FETHIYE (MUGLA) |
| 2012.06.14 | 17:45:38 | 36.4283 | 28.962 | 17.3 | -.- | 3.2 | -.- | III | OLUDENIZ ACIKLARI-MUGLA (Mediterranean SEA) |
| 2012.06.14 | 14:36:33 | 37.3303 | 42.3345 | 7.8 | -.- | 3.3 | -.- | III | PINARONU-SILOPI (SIRNAK) |
| 2012.06.14 | 09:49:47 | 37.2692 | 42.4205 | 5 | -.- | 4.1 | -.- | IV | YENIKOY-SILOPI (SIRNAK) |
| 2012.06.14 | 09:49:37 | 37.2437 | 42.4333 | 4.2 | -.- | 3.9 | -.- | IV | YENIKOY-SILOPI (SIRNAK) |
| 2012.06.14 | 09:38:50 | 37.2922 | 42.4385 | 7.8 | -.- | 3.2 | -.- | III | DEDELER-SILOPI (SIRNAK) |
| 2012.06.14 | 09:25:56 | 37.352 | 42.4695 | 7.8 | -.- | 3.6 | -.- | III | DEDELER-SILOPI (SIRNAK) |
| 2012.06.14 | 08:52:53 | 37.2935 | 42.3248 | 5.4 | -.- | 5.5 | -.- | V | PINARONU-SILOPI (SIRNAK) |
| 2012.06.14 | 08:50:04 | 37.4242 | 42.3215 | 7.2 | -.- | 4.0 | -.- | IV | IKIZCE-(SIRNAK) |
| 2012.06.14 | 03:24:45 | 35.457 | 29.8027 | 12.1 | -.- | 3.5 | -.- | III | Mediterranean SEA |
| 2012.06.14 | 03:23:49 | 36.981 | 28.0022 | 8.9 | -.- | 3.4 | -.- | III | GOKOVA KORFEZI (Mediterranean SEA) |
| 2012.06.13 | 20:09:21 | 36.9378 | 28.1732 | 6.3 | -.- | 3.4 | -.- | III | KARACA-MARMARIS (MUGLA) |
| 2012.06.13 | 11:59:07 | 36.4583 | 28.9123 | 22.1 | -.- | 4.4 | -.- | IV | OLUDENIZ ACIKLARI-MUGLA (Mediterranean SEA) |
| 2012.06.13 | 09:43:23 | 39.1402 | 29.1673 | 5.4 | -.- | 3.0 | -.- | II | INLICE-SIMAV (KUTAHYA) |

**Figure 37 :** Real Time Earthquake Detection System by ELER

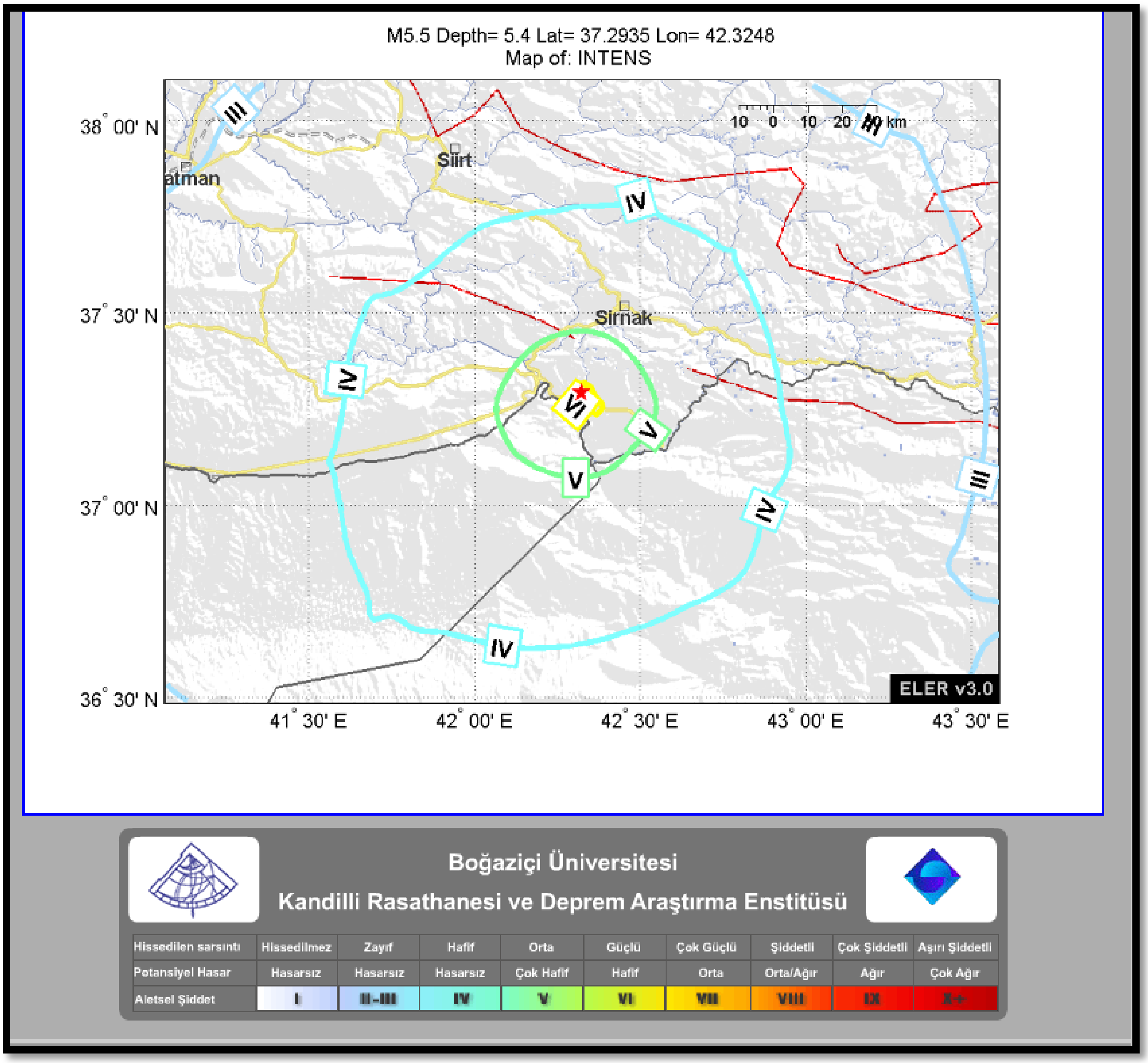



**Figure 38 :** Real Time Instrumental Intensity Assignment by ELER

### 4.2.4. Early Warning System (EWS)

The Early Warning part of the IERREWS ten strong motion stations were located as close as possible to the Great Marmara Fault in 'on-line' mode (Figure 39). Continuous telemetry of data between these stations and the main data center is realized with satellite connection (Alcik et al., 2009). Considering the complexity of fault rupture and the short fault distances involved, a simple and robust Early Warning algorithm, based on the exceedance of specified threshold time domain amplitude levels is implemented. The band-pass filtered accelerations and the cumulative absolute velocity (CAV time integral of the absolute acceleration) are compared with specified threshold levels. When any acceleration or CAV (on any channel) in a given station exceeds specific selectable threshold values it is considered a vote. Whenever we have 2 or 3 (selectable) station votes within selectable time interval, after the first vote, the first alarm is declared. The early warning information (consisting three alarm levels) will be communicated to the appropriate servo shut-down systems of the recipient facilities, which will automatically decide proper action based on the alarm level. Depending on the location of the earthquake (initiation of fault rupture) and the recipient facility the alarm time can be as high as about 8s (Erdik et al., 2003).

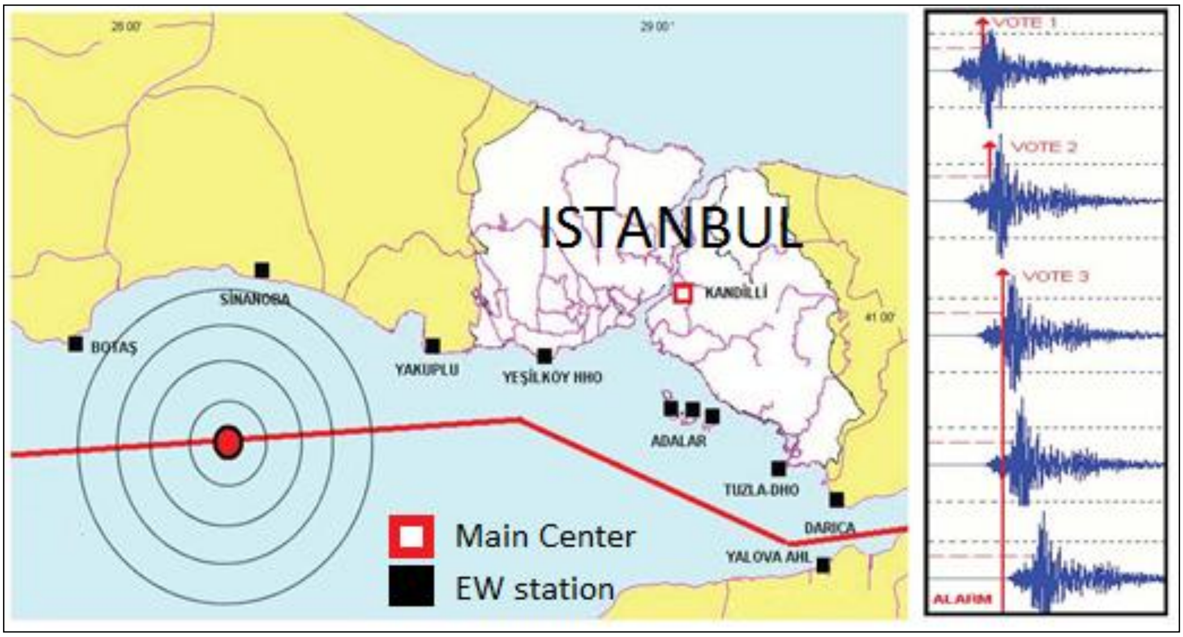



**Figure 39 :** Location of EW stations (Alcik et al., 2006)

### 5. Emergency Reactions in Turkey

The Disaster Management Hierarchy and Emergency Reaction System in Turkey up-dated and is covered by the Act 29/5/2009 dated and No.5902. Core emergency reaction institutions have unified under single independent authority with the act adopted by the parliament and entered into force in June, 2009.

#### 5.1. Main Institutions on Emergency Reaction and Intervention

#### 5.1.1. Prime Ministry Disaster and Emergency Management Presidency.(AFAD - DEMP)

- Main tasks and responsibilities of Prime Ministry Disaster and Emergency Management Presidency.(DEMP-AFAD);
- Ensure coordination between the prime minister's office, other ministries, and public, private and non-governmental institutions, and organizations at the central level.
- Arrange the coordination, flow of aid and information between central bodies and responders at the regional emergency management levels.
- Prepare and update response plans; provide financial assistance, information and training support for the central and regional-level emergency management units.
- Arrange manager training, professional training, and community training at the local level; produce and provide training materials; train the trainers.
- Conduct research and contribute to the development and upgrading of technical plans and construction regulations required for risk management.
- Pioneer activities in the development of risk profiles and plans for settlements; provide financial support for these projects.

### Commissions of DEMP - AFAD

### Disaster and Emergency High Commission

It is commissioned to approve reports, programmes and plans prepared for disaster and emergency situations. Disaster and Emergency High Commission consist of the Ministers of National Defense, Interior, Foreign Affairs, Finance, National Education, Health, Transportation, Energy and Natural Sources, Environment and Forest and Public Works and Settlement at the Chairmanship of Prime Minister or Deputy Prime Minister commissioned by the Prime Minister. Related Ministers, Foundation and Instution, Non-Govermental Organization members and other related experts might be invited to the Commission's meetings.

Commission meets at least twice in a year. Moreover, the Commission may meet on request of the Chairman of Commission. Secretariat of the Commission is conducted by the Presidency.

### Disaster and Emergency Coordination Commission

Disaster and Emergency Coordination Commission has been established in order to conduct coordination between foundation and institutions and Non Governmental Organizations, evaluate information, identify measures to be taken and ensure the application of this measures and to supervise in case of Disaster and Emergency Situations. At the Chairmanship of the Undersecretary of Prime Ministry; the Commission consist of the Undersecretaries of National Defense, Interior, Foreign Affairs, Finance, National Education, Health, Transportation, Energy and Natural Sources, Environment and Forest and Public Works and Settlement Ministries, Undersecretary of State Planning Organization, Director General of Disaster and Emergency Management Presidency, Head of Turkish Red Crescent Organization and Managers of other Ministries and Institutions commissioned by the Chairman of Commission according to type of Disaster and Emergency

Commission meets at least 4 times in a year. Also, the Commission may meet on request of the Chairman of Commission in case of necessity.

### Earthquake Advisory Committee

Earthquake Advisory Committee has been established for avoiding from earthquake, minimizing the effects of earthquake, suggesting about the actions which will be done after earthquake and determining priorities and policies related to earthquake researches. At the Chairmanship of the Director- General of Disaster and Emergency Management Presidency; the Committee consist of the representatives of Ministry of Public Works and Settlement, Directors of Bosporus University Kandilli Observatory and Earthquake Research Institute, Director of the Scientific and Technological Research Council of Turkey, Director General of Mineral Research and Exploration, Head of Turkish Red Crescent Society, five representatives who has works related to Earthquakes chosen by the Director- General of Disaster and Emergency Management Presidency between at least ten prelector recommended by the Council of Higher Education and three member chosen by the Director General of Disaster and Emergency Management Presidency between accredited NGO's.

Committee meets at least 4 times in a year. Moreover, Committee may meet on request of the Chairman of Committee in case of necessity. Secretariat of the Committee accomplishes by the Presidency.

Disaster Advisory Committees related to other disasters might be established by the Council of Ministers

### 5.1.2. National Earthquake Monitoring Center (NEMC) in KOERI

The most important goal of NEMC seismic network is to deliver the basic information for emergency response activities. In parallel to the task of emergency response, NEMC is the official source of information fort he public for questions concerning earthquake parameters as origin time, location, depth and magnitude.

NEMC provides important information to initiate the emergency operations in the destructive earthquake area. The primary goal of the NEMC is to determine the location, depth and magnitude of an earthquake with high reliable and fastest time to inform the governmental managements and officials. Following an earthquake felt by people, the most basic need of citizen is to be informed by official source. NEMC fulfill this crucial task of informing the public using different communication channels like, sms, fax, media, and webpage and telephone earthquake line.

KOERI is hosting the National Tsunami Warning Centre (NTWC) and is also Candidate Tsunami Watch Provider (CTWP) under the framework of UNESCO/ICG for the Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and Connected Seas (ICG/NEAMTWS). KOERI has undertaken and is currently involved in several EU-FP 6 and EU_FP 7 Projects including NERIES, SAFER, TRANSFER, LESSLOSS, SHARE and SERIES.

### 5.1.3. Turkish Red Crescent

Turkish Red Crescent Society is a humanitarian organization that provides relief to the vulnerable and those in need by mobilizing the power and resources of the community to protect human dignity anytime, anywhere, under any conditions and support the enhancement of the community’s capacity to cope with disasters.

The vision of the Turkish Red Crescent Society is to be a humanitarian aid organization that embraces and is embraced by the entire society, constantly enhancing its reputation and quality of service at national and international levels.

The Red Crescent is a legal entity and subject to the stipulations of private law; a non-profit and volunteer social service organization, of which relief and services are free and which works for the benefit of the public.

The organization of the Red Crescent consists of the General Headquarters and branches. All the positions outside the Red Crescent General Directorate organization are honorary.

**Fundamental Principles of the Red Crescent**

**Humanity :** The Red Crescent, born of a desire to bring assistance without discrimination to the wounded on the battlefield, endeavors, in its international and national capacity, to prevent and alleviate human suffering wherever it may be found

**Impartiality** : The Red Crescent makes no discrimination as to nationality, race, religious beliefs, class, or political opinions.

**Neutrality :** In order to continue to enjoy the confidence of all, the Red Crescent may not take sides in hostilities or engage at any time in controversies of a political, racial, religious, or ideological nature.

**Independence :** The Red Crescent is independent. While an auxiliary in the humanitarian services of The Republic of Turkey and subject to the laws of Turkey, it always maintains its autonomy so that it may be able at all times to act in accordance with the fundamental principles of the International Red Crescent-Red Cross.

**Voluntary Service :** The Red Crescent is a voluntary relief movement not prompted in any manner by desire for gain.

**Unity :** There is only one Turkish Red Crescent Society in Turkey and no other organizations can be established in Turkey with the same purpose and name. It is open to all. It carries on its humanitarian work throughout its territory.

**Universality :** The Red Crescent is a worldwide organization and has equal status with all foreign National Societies and shares equal responsibilities and duties in helping each other with them.

### 5.1.4. Emergency Reactions by The Disaster Management Centre of İstanbul City - AKOM

The Disaster Management Centre of Istanbul City, code named **AKOM**, was constructed and installation of the necessary equipment related on disaster information collection and dissemination systems had been completed in 2001.

The object of AKOM is to coordinate tasks among organizations within Istanbul Metropolitan Municipality. In order to manage a large-scale earthquake disaster, this center should be networked effectively with district offices or other disaster-related offices by secure telecommunication systems. These telecommunication systems must be maintained and operated at the time of an earthquake disaster occurrence to collect damage information, dispatch necessary orders for rescue operations, and communicate with each related agency.

Developing and adhering to standards is of utmost importance in the design of information systems. Large systems such as urban information system or a disaster information system necessitate the coordination and information sharing of many institutions. In many cases, a distributed information system formed by different databases may be appropriate.

To minimize plausible losses first of all it should be recognized that the more successful the pre-earthquake plans and their implementations are, the lower will be the financial burden after the earthquake. Moreover, the allocation of funds before an earthquake occurs is certainly needed for humane reasons, and also technically easier

To carry out the pre- and post-disaster management activities, the current legal structure and organizations are evaluated, distribution of authority among the central and local government bodies is analyzed, responsibility and coordination mechanisms are identified, and the insufficiencies in the system have been determined. and recommendations and legal requests are made to Governmental Institutions for additional clauses for risk mitigation.

### 5.1.5. Republic of Turkey İstanbul Governorship Special Provincial Administration İstanbul Coordination Unit

**İstanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP)**

In order to prepare Istanbul for a probable earthquake the Republic of Turkey and the International Bank for Reconstruction and Development signed the İstanbul Seismic Risk Mitigation and Emergency Preparedness (ISMEP) Loan Agreement with an amount of €310 Million on October 18, 2005. The loan agreement became effective as of February 3, 2006. Istanbul Project Coordination Unit (IPCU) was established within the İstanbul Special Provincial Administration (ISPA) for the implementation and supervision of the overall Project.

The ISMEP project is expected to be completed in 2018.

The project aims to enhance the institutional and technical capacity of the emergency management related institutions; raise public awareness in emergency preparedness and response, fesibility studies of the priority public buildings against seismic risks and as to assessment reports the retrofitting or reconstruction of these buildings; support to the national disaster activities; inventory of cultural heritage buildings, carry out seismic risk assessment of selected cultural heritage buildings, prepare retrofitting project designs; and to take supportive measures for effective building code enforcement to prepare İstanbul for a potential erathquake.

The Project consists of the following components:

**Component A) Enhancing Emergency Preparedness**

The component supports: -

- Improvement of emergency communications system
- Establishment of an emergency management information system
- Strengthening the institutional capacity of the Provincial Directorate of Disaster and Emergency
- Upgrading the emergency response capacity of the first responding agencies (İstanbul Search and Rescue Unit, Provincial Directorate of Health, Provincial Directorate of Disaster and Emergency, Red Crescent) on the occurrence of a disaster
- Public Awareness and Training

**Component B) Seismic Risk Mitigation for Priority Public Facilities**

The component supports: -

• Retrofitting or reconstruction of priority public facilities, including hospitals, clinics, schools, administrative buildings, student dormitories, social service facilities
• National Disaster Activities
• Development of an inventory of cultural heritage buildings under the jurisdiction of Ministry of Culture and Tourism and seismic risk assessment of these cultural heritage buildings; preparation of retrofitting designs of selected cultural heritage buildings
• Analyzing the current land management policies and instruments for identification of the different models and methods required for mitigating earthquake risks on public buildings with improved management and generation of new financial resources

**Component C) Enforcement of Building Code**

The component supports: -

• Ongoing and additional studies and activities to enhance guidelines and regulations for better enforcement of building code and land use plans.
• The voluntary training of engineering professionals
• The enhancement of the technical and institutional capacity of the pilot municipalities to streamline issuance of building permits and ensure transparency in enforcement of building code and land use plans.

### 5.1.6. Emergency Reaction of İstanbul Metropolitan Municipality Disaster Prevention/ Mitigation Basic Plan in Istanbul

Respect to the arrangement between Istanbul Metropolitan Municipality (IMM) and Japan International Cooperation Agency (JICA) which was sealed by the Council of Ministers with the 2000/1885 count, The Study on A Disaster Prevention/ Mitigation Basic Plan in Istanbul including Seismic Microzonation in The Republic of Turkey was started in 2001. In this project, it was aimed to examine the buildings and the possible damage possibilities of infrastructures by sampling based on district for the determination of the areas which have high risk in a macro level. The study was completed in 2002 after the data collection process such as existing data (maps, soil, building, and population etc. information), field observations (boring, geological-geophysics-geotechnical measurements, and sample buildings); data processing in GIS environment; evaluation and interpretation of findings. It was aimed to use and develop the knowledge gained from the study in projects for earthquake damage reduction.

The processes realized during the project are as follows (IMM, 2002):

• Administrative organization about the development and the disaster laws; existing organizational system related to the disaster management were brought up. The authorizations and tasks of the central administration, Governorship, IMM, District Municipalities about the disaster management were examined, and lawful, organizational proposals for enhanced disaster management and the disaster management plan proposal were brought up.

•The present condition of the natural situation with the topography, geology, geotechnical and earthquake data; social situation with the population, building, road, bridge and infrastructure data; flammable- explosive establishments were derived for the earthquake disaster management.
• Calculations of the damages based on sub-districts and life losses based on the districts were made according to the scenario earthquakes.
• Vulnerability for the buildings, important public facilities, infrastructures, bridges, roads, seaports and harbors was determined. Then, fire and traffic problems were held and some proposals were made.
• Buildings and their structures were analyzed from the vulnerability aspects, some precautions were proposed for the weak structures for strengthening. Some of the proposed precautions are special for the preserved areas. Urban regeneration is one of the precautions.
• Proposals for land use and regulations, similarly, some explanations about the earthquake resistant construction were made.
• Consequently, short, middle and long term precautions for mitigation were proposed.

### 5.2. NGO Emergency Reactions in Turkey

Disaster especially Earthquake emergency reactions are complex and involve many variables and factors. Successful disaster reduction strategies involve careful efforts to combine knowledge, technology, expertise, institutional capacities, management skills, and practical experience for optimum results, which would not be possible without proper collaboration between the two key players: state and civil society.

In Turkey in emergency reactions and in disaster preparedness NGO involvement is a new concept of forecasting and taking precautionary measures prior to an imminent threat when advance warnings are possible. After the 1999 Marmara Earthquake NGO involvement started to be increased in emergency reactions and preparedness planning which highly improves the response to the effects of a disaster by organizing the delivery of timely and effective rescue, relief and assistance. In emergency reactions and in disaster reduction NGOs started to be innovative, rooted to the ground and participatory in their approach while government can replicate best practices for larger impact.

Emergency Reactions and disaster management system of a country is very important and in the emergency reaction system NGOs are the important elements. In Turkey NGOs should be considered that have important role in disaster response and mitigation in different fields.

In the literature NGOs mostly divide earthquake mitigation aspect in two sections. These sections are social and engineering aspects. However, in Turkey the concept of this separation should also include the approach of pre and post disaster reactions too.

Mainly emergency reaction approaches and disaster preparedness must be seen as an active, on-going process. Such a Country, in Turkey NGO aspect preparedness plans should be considered dynamic ventures which need to be reviewed, modified, updated and tested on a regular basis. From the point view of NGOs' in Turkey it can be pointed out that; after the disaster the affected community continuously must not be seen as "helpless citizens who wait for aid" instead they can be seen as "productive and decision maker citizens who can rebuild community life".

Major problems of Turkish functioning NGOs which work in the field of emergency reactions and emergency relief include a lack of funding, not enough qualified staff, technology and other infrastructure issues.

NGOs in Turkey should stress the vital importance of mobilizing additional resources in order to realize the emergency reactions and also Network's potential. Information about sources of funding should be disseminated through the established Networks and this concept should be highly supported.

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