DISASTER MITIGATION THROUGH GIS TECHNOLOGY – APPLICATION OF GIS TOOLS TO YALOVA, A CASE STUDY

E. Alarslan[1], G. Kemper², O. Altan³

[1]Dr.Ebru ALARSLAN, Division Chief in the Turkish Ministry of Public Works and Settlement
[2]Dr.Gerhard KEMPER, CEO of GGS – Geotechnik, Geoinformatik & Service GmbH
³ Prof. Dr. Orhan ALTAN, President of the ISPRS

KEY WORDS: Disaster mitigation, GIS technology and tools, earthquake risk, Yalova

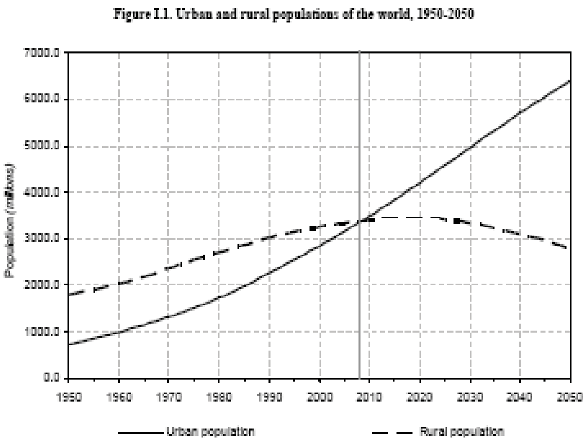
ABSTRACT:

This paper outlines applications of GIS tools for disaster mitigation significant in urban settlements due to high urban disaster risks rather than the other areas as a result of their denser populations, constructions, and service networks. Out of various types of natural disasters, this paper focuses on earthquakes due to high seismic risk in Yalova. Yalova is located in the south-eastern coast of the Marmara Sea, a region exposed to earthquakes (Northern Anatolian Fault Zone). The Marmara region has been seismically active from 1900-2003 when 25 devastating earthquakes - including 1999 earthquakes - occurred with magnitudes ranging from 5 to 7.4. The geologic and geomorphologic features of Yalova made the settlement especially vulnerable to the tremors of the 1999 earthquakes. It is possible to distinguish 5 groups of geological failure areas in Yalova, namely (i) areas with slope instability resulting in deep landslides, (ii) areas of deep fine alluvium and organic material likely prone to liquefaction, (iii) areas with limestone subformations prone to cavitations and collapse, (iv) areas with irregular weathering profiles, and (v) areas with gypsum that initiates deformations and is hazardous to concrete foundations. With a view to the seismic features of Yalova, the application of GIS tools will be outlined in this paper and will relate to the preparation of disaster mitigation plans; the monitoring of changes in existing landuse as well as the compliance with building codes and planning standards; and the building of spatial data infrastructure that leads to sustainable development.

1. HIGHER DISASTER RISKS IN URBAN SETTLEMENTS

Especially, in last twenty years, natural disasters with devastating effects on human settlements have proliferated. The propensity of disasters is increasing in the light of such trends as increasing rate of population in and around urban areas, degrading environmental quality, global heating. By the year 2000, half the world's population will live in urban areas, crowded into 3% of the earth's surface **(**Domeisen & Palm, 1996**).**

While urban settlements exploit natural resources and cause environmental pollution due to their dense population and construction, they are the core area of economic and cultural activities as well as significant cross-roads of transportation routes, technologies, and other modern networks. Despite their disadvantageous features, urban settlements have therefore attracted and are attracting their increasing populations. According to the United Nations' figures, the share of the world's population in urban settlements has risen to 50% from 30% since the 1950s and this share is expected to increase to 60% in 2030 (Munich Re Group; 2004). The increasing trend of urban population can be observed in the following graphics (see fig. 1) in the period 1950-2050 based on the United Nations data. While the global trends of increasing population in urban and rural settlements are shown in the graphic on the left side, the same trend are categorized as the population increase in developing countries and developed countries, respectively, on the right side.



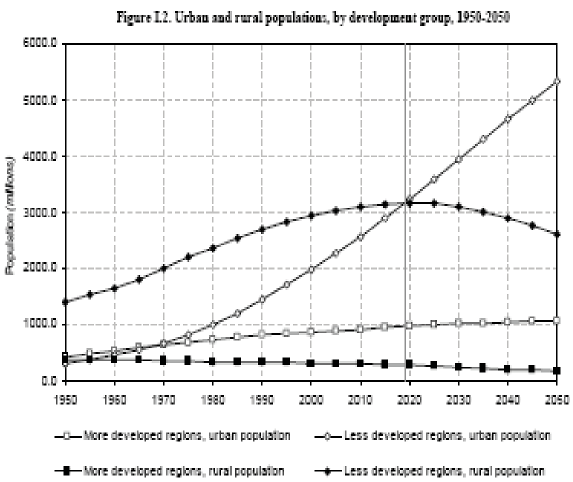


Figure 1: Urban vs Rural Population Increasing Trends Comparing to Figures in Developing and Developed Countries (*Source:* The United Nations; 2008)

Owing to the density of population, construction, and accumulation of investment, urban settlements are especially prone to high risks of natural disasters (Management of Natural Disasters in the Eastern Mediterranean Region, 1998). The statement above emphasizes two remarkable issues, namely (i) urban settlements are at risk of natural disasters and (ii) this risk is high due to their density of population, construction, and accumulation of investment. Hence, variables of disaster risks may be grouped in two main categories, namely "Variables of the Urban Settlement" and "Variables of the Natural Disaster". An assessment of variables of the urban settlement will start with an analysis of peculiar existing features of urban settlements under consideration such features include the site of the settlement (coastal settlement, hillside settlement, alluvial plain settlement …), the ground survey of the settlement (whether urban settlement sits on firm ground or not, land liquefaction factors, ground water levels…), the planning standards and criteria of the settlement, land-use, population density, population profile and public awareness for disasters (social indicators), construction density and quality of the settlement, the quality in urban infrastructure & services, economic profile of the settlement (sectors, employment rate and profile, scale of production such as domestic scale production or country scale or international scale). The variables of the natural disaster can be expressed in terms of magnitude and range of the natural disasters; the frequency, the occurrence time and duration of disasters, and type of disasters, e.g. only earthquake or earthquake + flood triggered by earthquake. While each variable is equally effective on the risk, the combination of all below variables would determine the degree of risks of a certain urban settlement prone to natural disasters. A third variable can possibly be taken into consideration, namely the coping capacity of urban settlements. The main determinants for the coping capacity of an urban settlement are risk perception, institutional and public awareness, organizational, administrative, technical, and financial structure and equipment (Alarslan, 2009). Despite the different disaster risk features of urban settlements in developing and developed countries, respectively, losses of urban settlements for both groups of countries can be categorized as i) environmental losses such as contamination of air, soil, water, damage to flora & fauna, etc.; ii) human resource losses such as casualties, accidents, epidemics, etc.; iii) property losses such as livestock, movables, immovables, etc.; iv) economic losses such as financial losses, business interruptions, etc. (Munich Re Group, 2004).

2. DISASTER MITIGATION THROUGH GIS TECHNOLOGY IN URBAN SETTLEMENTS

Upon mentioning the risk profile and assessing the coping capacity of an urban settlement, an effective disaster mitigation approach can be designed especially by means of GIS. Unless new planning strategies together with disaster mitigation approaches are applied to the urbanization process, urban settlements will remain exposed to high and probably increasing natural disaster risks. Some main principles, policies, strategies, and standards are proposed to guide disaster prone urban settlements on disaster mitigation. Because of the multi-dimensional structure of disaster mitigation, approaches to policy-making, organizational structure, legislation and control, scientific research and technological integration will be explained with a view to urban settlements prone to natural disasters. In the light of the following questions, the relevant GIS instruments for designing a disaster mitigation process will be outlined:

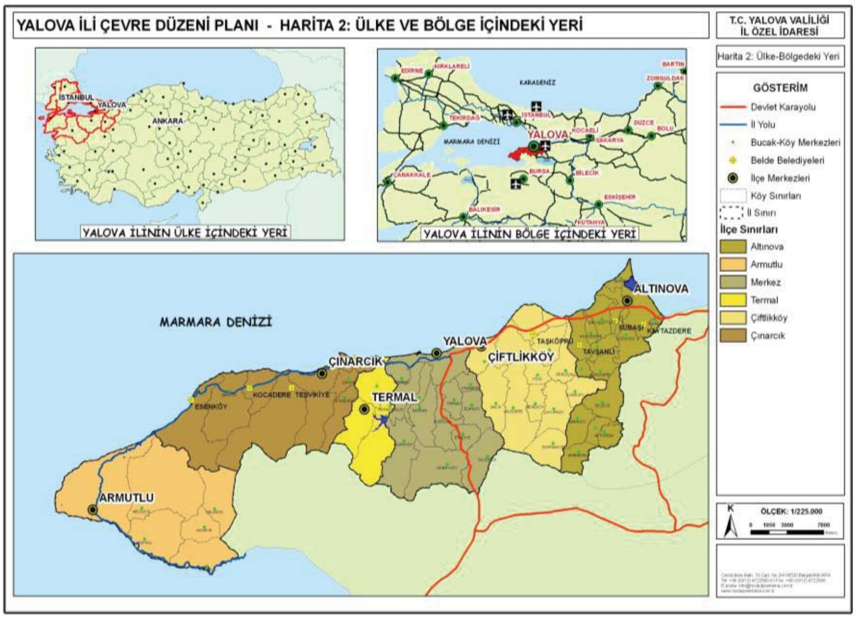
- What particular features of urban settlements imply risks and challenges for a disaster mitigation policy?
- What particular features of urban settlements are supportive of a disaster mitigation policy?
- What long-, medium- and short-term approaches can be envisaged towards preparing disaster mitigation plans of urban settlements?
- What processes and instruments may be available in implementing disaster mitigation policies?

Mitigation plans provide guidance on coordinating outputs of risk analyses and risk management activities in various sectors, such as housing, transportation, infrastructure, public services, etc. They serve to assess risks, generate methods for risk reduction, prepare multi-stakeholder mitigation programs for the short-, medium-, and long-run, prepare public training and awareness programs and projects, and organize monitoring programs for mitigation activities. On this basis, mitigation plans should interact with micro-zones in urban settlements. In this context, it is strongly recommended that various GIS tools especially in the preparation of spatial plans will be very useful. Some other tools of GIS will also be useful to monitor and audit the planning standards and building codes by periodically updated geographical and spatial information of a given urban settlement.

Similar to mitigation plans, the GIS tools will be helpful to facilitate the preparation of an emergency plan on the basis of a spatial plan. Preparing an emergency plan for an urban settlement requires an analysis of the existing situation, a risk analysis, and the development of possible disaster scenarios. Due to different risk features of urban settlements, emergency plans for urban settlements are developed on the basis of spatial plans. Emergency plans should include action programs with clear determinations of responsible institutions, management and control procedures, resource management, evacuation plans, communication, public information, early warning, etc. (Kadıoğlu & Özdamar, Eds.2006).

3. A CASE STUDY: YALOVA

3.1 The Brief Information on the City of Yalova



The Yalova province, one of the 81 provinces in Turkey, is located in the south-eastern coast of the Marmara Sea (see fig.2). The central district bears the same name and is the host of the provincial government. Yalova city, the capital of the province, is well known in Turkey as a famous tourist resort given its natural thermal springs and its location by the Marmara Sea. The origin of the city can be traced to the Phyrigians in 1200 B.C. In the year 1325 A.D., Yalova became an Ottoman town and in 1930 it became a district of Istanbul in the Republic of Turkey.

The province is divided into six districts and 10 smaller municipalities. The districts are Yalova-Center, Altinova, Armutlu, Cinarcik, Ciftlikkoy, and Termal. (The Governorate of Yalova & the Municipality of Yalova, 2006).

According to the population census data of the Turkey Statistics Institute, Yalova had 168,593 inhabitants by the year 2000. However, given its condition as a tourist resort, its population increases temporarily every summer. As a consequence of the 1999 earthquake, the urban population increased less than the population in rural areas. According to the recent data (2009) on population, 202,531 inhabitants live in Yalova. The area of the city is 847km^2 (See also www.yalova.gov.tr).

Figure 2: The Location Map of Yalova Encompassing Country to Local Scales (**Source**: The Governorate of Yalova & the Municipality of Yalova, 2006)

In the context of earthquake risks, Yalova, like many other provinces in Turkey, is located in a region exposed to earthquakes. According to various researchers (Yücemen et al., 2005), there were many destructive events between 281 BC and 1899 AD. Catastrophic earthquakes occurred in the Eastern Marmara Region in the years 358, 447, 553, 1719, and 1754. Since 1509, the Marmara Sea has been affected largely by six major earthquakes with magnitudes above 7 in the Richter scale. The most recent 7.4 magnitude Eastern Marmara Earthquake (17 August, 1999[1]) provoked the following damages in Yalova: 9,474 dwelling units (12% of total) and 726 work places (10% of total) destroyed; 22,162 dwelling units and 3,021 work places were damaged to varying degrees. In addition the Eastern Marmara Earthquake caused 2,505 casualties and 5,937 injuries in Yalova (JICA, 2004; pp. 6-7).

3.2 The Earthquake Risk in the City of Yalova

Yalova city lies on the Northern Anatolian Fault Zone, which is the source of the seismic hazard to which the city is exposed. The earthquakes in the region are all result of tectonic processes, which take place within the crust of the earth. Tec-

Figure 3: The Satellite View of Yalova (*Source:* The Municipality of Yalova, 2001)

[1] This particular earthquake is internationally known as the *1999 Izmit, Turkey earthquake*.

tonic deformation in the Middle East and Eastern Mediterranean region is occurring at the boundaries between three major tectonic plates, namely, the Eurasian Plate, the African Plate, and the Arabian Plate. Smaller, relatively rigid, blocks or micro-plates, including the Anatolian and the Iranian micro-plates, separate these major plates. The Anatolian macroplate is bounded to the north by the 1200km long Northern Anatolian Fault Zone and to the south and east by the Eastern Anatolian Fault Zone. The relative movement between the major plates results in the westward movement of the Anatolian micro-plate (BECT, 2000, p.2.7).

The movements along the Northern Anatolian Fault Zone have been shaping the Marmara Sea Region. The main fault lines in Yalova are, Taskopru, Tavsanli, Subasi, Yalova, Cinarcik, Calica, Kocadere, and Laledere faults as parts of the North Anatolian Fault Zone (Yücemen et al., 2005). Another severe hazard risk stems from the fault ruptures in the Marmara Sea Region as a result of various earthquakes, where larger ruptures can easily cause a real fatal tragedy. Furthermore, experts in geo-seismology suggest that fault ruptures in the Marmara Sea are worse than those in the land (BECT, 2000).

Yalova city lies in a coastal fringe (see also fig.3) largely composed of recent quaternary deposits, a result of active erosion of the landscape. The geological formation of the city is shaped in the form of low hills between the coastal region to the north and the mountainous region to the south. As a result of tectonic disturbance, mountains characterized in terms of weak rocks weather easily into soil which is eroded into the valleys. In addition, a high water table exists in these mountainous regions, which together with the low shear strength creates slope instability (BECT, 2000). Thus, the geologic and geomorphologic features of Yalova expose the city to a variety of hazards such as landslides, liquefaction, cavitations and collapse (BECT, 2000). Thus, the following kinds of sub-hazards are triggered by earthquakes in Yalova:

- **Liquefaction** or loss of strength in saturated granular soil due to a built-up of pore water pressure under cyclical loading.
- **Fault-related displacements,** which can prove damaging to structures constructed across a fault. However, only the more powerful earthquakes result in surface rupture. In this case, determination of the location of active faults is an essential component of the seismic hazard mitigation process. In the Yalova region, there are many active fault segments associated with the North Anatolian Fault Zone.
- **Landslides and mud flows**, often triggered by liquefaction of a soil stratum. Although the landslide hazard is present in Yalova, it poses only a moderate risk for people and properties, as urban areas have historically been constructed away from zones prone to landslides. Landslides can affect roads, pipelines, and cables.
- **Tsunamis or sea waves**, which are caused by the sudden change in sea bed level that may occur in an offshore earthquake. Wave heights tend to increase as they enter shallow water. At least 9 tsunamis have occurred in the Marmara Sea in the last 500 years. The last one happened on 17 August 1999. Reports indicated that wave heights at the coastline are were in the range of 1 meter to 2.5 meters, with a maximum height of 4 meters reported near Gölcük located in the east of Yalova. However, no significant damage was reported from these waves so far in the Marmara Region.
- **Seiches or waves** in lakes due to resonance of the water with the earthquake motions. Nevertheless, no seiche or other surface wave in the lakes or water reservoirs in the Yalova region have been reported subsequent to the 17 August 1999 earthquake.

Yalova is mainly at high risk due to its urban vulnerabilities which are exposed to earthquake hazards. The 1999 earthquake revealed the vulnerability of buildings (dwelling units, social services such as schools, hospitals, administrative buildings, etc.), transportation routes, sewerage and drinking water pipelines, electricity and telecommunications networks, and industrial sites. Among the factors which contributed to the risks that were exposed by the 1999 earthquake, the following deserve explicit mention:

- The complex and cumbersome set of norms and measures targeting land-use and building norms, and the incapacity of local governments to oversee their enforcement their implementation by private developers.
- A relaxed view to risk management practices by developers taking into consideration the fact that their customers are tourists, who may not inhabit properties all year long, but only on a temporary basis considering the trend of Yalova as a summer tourist resort.
- A void in the adoption of responsibilities concerning land-use norms by the local authorities in a period of time when the central government was delegating such responsibilities to local authorities, which was used by unscrupulous real estate developers to establish risks by locating infrastructure in areas exposed to seismic hazard and related sub-hazards formerly used for agriculture and forestry.
- A weakness in institutional and public awareness concerning earthquake risks, despite a solid awareness concerning earthquakes in Turkey.

As a result of the stipulated factors above, earthquakes can also trigger other urban risks such as floods due to dam failures, fires in fractured gas pipelines, explosions of gas and oil tanks and spills of other dangerous chemicals (BECT, 2000).

3.3 The Risk Mitigation by Means of GIS in the City of Yalova

After the earthquake hit Yalova in 1999, Implementation Plans at the 1/5000 and 1/1000 scales were elaborated by the Ministry of Public Works and Settlement for new settlements areas of citizens who were affected by the disaster. Simultaneously, the Ministry approved a framework to provide guidance to municipalities in preparing such spatial plans in Yalova in 2002. This framework explains principles and standards of spatial plans and establishes rules and standards for buildings in various earthquake prone areas such as alluvial lands, land slide areas, etc. In addition, the Municipality of Yalova elaborated a new Master Plan at the 1:25,000 scale in coordination with the Provincial General Council which was approved on the 8th of June, 2007. In the context of spatial planning at the local level, which is essential in the context of prevention, responsibilities are divided among governorates and municipalities. Municipalities have the responsibility to elaborate spatial plans at the local scale in addition to their administrative responsibilities (The Governorate of Yalova & the Municipality of Yalova, 2006). By August 2008, the Ministry of Public Works & Settlement also prepared and approved a large scale plan for Yalova and the Izmit Gulf area in light of the significant earthquake risks in these regions. The plan was prepared incorporating the concept of Integrated Coastal Zone Management along the Izmit Gulf and Yalova coastal areas at the 1:50,000 scale. It sets out main policies and principles for land uses in this region[2].

The Ministry of Public Works and Settlement also carried out geotechnical and geomorphologic surveys in earthquake prone areas. Considering the fact that the extensive damage provoked by the 1999 earthquake was attributed to unplanned urban development and constructions with insufficient consideration of geological and ground conditions, the Ministry performed numerous geological and geotechnical studies in Yalova as well as other earthquake prone cities. In these studies, the Ministry gave a priority to accomplishing geotechnical and geomorphologic surveys in permanent housing areas for earthquake-struck citizens. According to results of those surveys, permanent housing areas were grouped into three zones, namely (i) zone with no need for a geotechnical study, (ii) zone with a need for the geotechnical study, (iii) zone with hard soil sedimentation (can only be suitable for green areas). Special technical requirements for constructions were adopted for the first two zones. While new housing units were constructed, damage assessment and categorization studies of existing building stocks were carried out by the Ministry. For the purpose of damage assessment studies, the existing building stock was categorized according to the damage level. Moderately damaged buildings were rehabilitated while heavily damaged ones were demolished. According to damage assessment and categorization studies in Yalova, 14,646 units (dwelling units +offices) were determined as heavily damaged and/or collapsed, and 15,699 units (dwelling units +offices) were determined as moderately damaged (The Turkish Ministry of Public Works & Settlement, 2000).

4. CONCLUSION

Although Yalova is a city prone to earthquakes, disaster mitigation techniques and approaches are not reflected in spatial planning methods and procedures to the full extent possible. As adaptation to earthquake hazards can only be accomplished through spatial planning standards and building codes, earthquake mitigation techniques should be inserted in tools of spatial planning and construction works. Natural disaster mitigation techniques should thus become an integral part of national and local level planning activities.

As a result of the impacts on infrastructure provoked by the1999 earthquake, the central government implemented a variety of complementary measures targeting geotechnical and geo-morphological surveys, land-use planning norms; and enacted legislation targeting building inspections, building insurance, and compulsory earthquake insurance. Such approach is expected to improve the design and construction of infrastructure, avoiding thus the generation of vulnerability as it occurred before 1999. The risk in the settlement of Yalova can be reduced by building awareness concerning existing hazards and designing and building all infrastructure and superstructure with a view to decreasing vulnerability. While many authorities and citizens are already aware of the seismic hazard to a certain degree, because of the multitude of institutional responsibilities for relevant public services such as planning and infrastructure works, the awareness of disasters is not always sufficient to prevent the next disaster hazard. At this point, it is believed that GIS tools and techniques will be very helpful to fulfil planning and construction responsibilities of the relevant authorities efficiently. In terms of efficiency and effectiveness towards earthquake risk mitigation, the GIS tools should be integrated into the following issues:

Site and Location: Ground survey, soil analysis and geological report of the area are basic for all infrastructures and superstructures. Therefore, constructions should be prohibited in geological failure areas, non-stable ground bases, and fault lines.

Construction Quality and Design: For settlement to be established in areas exposed to seismic hazard, the building codes should be different than for other settlement areas. For instance reinforced concrete and shear walls should be required for issuing construction permits. The design of infrastructure and superstructure should be assessed with a view to decreasing risks to an acceptable level. For instance, although building a mosque with minaret is quite an old cultural trend in Turkey, mosques in earthquake-prone areas should be redesigned with a view to lessening hazards of minarets on human life in the course of an earthquake.

Control and Monitoring: The process of control is quite long and multidimensional in the construction field. The whole controlling procedures and processes range from project control over construction control to construction material quality control. In the 1999 earthquake in Yalova, it is notable that many collapsed buildings had a proper architectural design. Nevertheless most of the building stocks were severely damaged due to lack of control of construction and quality of materials employed. For instance, many field surveys in the earthquake area proved that marine sand had been widely used in buildings. Periodical monitoring is another essential service especially in such an often earthquake prone settlement like Yalova. The control and current condition assessment should be done periodically and especially after each earthquake hit.

On a positive note, its important to mention that since the 1999 earthquake, improvements of the legislation and implementation procedures as well as a rearrangement of responsible institutions have taken place, leading to a new framework that minimizes the reconstruction of old risks. In addition, risk-transfer mechanisms introduced via the Building Insurance Law; and the Decree Law on Compulsory Earthquake Insurance should allow Yalova and many cities in Turkey cope with the financial impacts associated with the reconstruction or restoration of infrastructure in case of an earthquake .

[2] Interview with the Division Chief in charge of spatial plans of Yalova in the Ministry of Public Works & Settlement, conducted on the 2nd of September, 2008.

REFERENCES

Alarslan, E., 2009. Disaster Resilient Urban Settlements, Doctoral Dissertation, Technical University of Dortmund - IRPUD.

Balamir, M., 2006. "The Rising Paradigm in Disaster Policies: Mitigation", METU, ANKARA.

Bankoff, G., Frerks, G., Hilhorst, D., Eds.2004. Mapping Vulnerability: Disasters, Development and People. Earthscane Publications. London.

Barredo,J.; Petrov, L.& Sagris, V., 2005. Towards An Integrated Scenario Approach for Spatial Planning and Natural Hazards Mitigation, http://europa.eu.int.

Burby, R. J., Ed.1998. Cooperating with Nature-Confronting Natural Hazards with Land-Use Planning for Sustainable Communities; Joseph Henry Press, Washington D.C.

Chapman, T.J.P. et al., 2002. Identification of Geo-Hazards for the Rehabilitation Plan of Yalova/Turkey, 12th European Conference on Earthquake Engineering, London.

Domeisen, N & Palm, E., 1996. Rapid, Uncontrolled Urban Growth=More People in Hazardous Areas + More Disaster Risks. Stop Disaster, (28), IDNDR Publications.

Gavidia, J., 1996. Disaster Mitigation through Appropriate Plans and Codes. Stop Disaster, (28), IDNDR Publications.

Godschalk, D. R. et al., 1999. Natural Hazard Mitigation-Recasting Disaster Policy and Planning. Island Press, Washington D.C.

Greiving, S. et al., 2006. ARMONIA Project: Deliverable 4.1 Report on the technical glossary of a multi hazard related vulnerability and risk assessment language, Dortmund.

Gülkan, P., 2002. Setting the Stage for Urban Risk Mitigation: Seismic Risks & Compulsory Insurance Policy Issues in Turkey, 2nd Annual IIASA-DPRI Meeting, Laxenburg.

Gülkan, P., 2006. Another Earthquake Occurs in NW Turkey, METU, 8th Roundtable Meeting, Ankara.

ISDR (=International Strategy for Disaster Reduction), 2003. Disaster Reduction and Sustainable Development, World Summit on Sustainable Development in 26 August-4 September 2002, Johannesburg.

JICA(=Japan International Cooperation Agency), 2004. Country Strategy Paper for Natural Disasters in Turkey, Ankara.

Karanci, N.A., Aksit, B., 2000. Building Disaster Resistant Communities: Lessons Learned from Past Earthquakes in Turkey and Suggestions for the Future. International Journal of Mass Emergencies and Disasters, (18-3), California.

Kreimer, A. et al., Eds.2003. Building Safer Cities-The Future of Disaster Risk. Disaster Risk Management Series, (3), the World Bank Publications, Washington, D.C.

Melching, C., Pilon, P., Eds.2006. Comprehensive Risk Assessment for Natural Hazards. The World Meteorological Organization Press.

Meskouris, K., 2000. Structural Dynamics-Models, Methods, Examples. Ernst & Sohn, Berlin.

METU Group of Professors in Fac. of Arch & Civ. Eng., 1999. The Proposal on A New Settlement & Building Controlling System that is Disaster Resistant in Turkey, Ankara.

Munich Re Group., 2004. Megacities-Megarisks:Trends and Challenges for Insurance and Risk Management, Munich.

Özcebe, G., 2004. Development of Urban Rehabilitation Methods (Less-Loss Seminar), İstanbul.

The British Earthquake Consortium for Turkey (BECT), 2000. Yalova Province- Confidential Report, Ankara.

The Governorate of Yalova (Provincial Special Authority) & the Municipality of Yalova, 2006. Yalova 1/25 000 Olcekli Il Cevre Düzeni Plani Arastirma Raporu- Analiz-Sentez-Degerlendirme, Yalova.

The Public Works Law of Turkey (Law No. 3194), issued in the official gazette of 9.5.1985, no. 18749, http://www.bayindirlik.gov.tr.

The Regulation No. 88/12777 on "Emergency Relief Organization and Planning Principles on Disasters" issued in the official gazette of 8.5.1988, no. 19808, http://www.bayindirlik.gov.tr.

The Turkish Ministry of Public Works & Settlement, 2004. Deprem Surasi-2004/Komisyon Raporlari (The Earthquake Council/Reports of Commissions), Ankara

The Turkish Ministry of Public Works & Settlement (General Directorate of Disaster Affairs), 2006. Integration of Earth Science Data to Spatial Planning Manual, Ankara

The Turkish Ministry of Public Works & Settlement (General Directorate of Disaster Affairs), 2006. Afet Riski Olan Alanlarda Imar Planlama ve Kentsel Tasarim Standartlarinin Belirlenmesi, El Kitabi Hazirlanmasi, Basimi ve Uygulanmasina Esas Mevzuat Yazimi Danismanlik Hizmetleri-1. Asama Nihai Rapor, Ankara.

The Turkish Ministry of Public Works & Settlement, 2000. Post-Earthquake Reconstruction of Urban and Transportation Infrastructure in the Eastern Marmara Earthquake Region, Ankara.

The United Nations Disaster Relief Co-ordinator Office, 1979. Disaster Prevention and Mitigation (7), New York.

Vale, L. J./ Campanella, T. J., Eds.2005. Resilient City: How Modern Cities Recover from Disaster, Oxford University Press.

Villagrán de León, J.C., 2006. Vulnerability- A Conceptual and Methodological Review. UNU-EHS, Bornheim.

Wisner, B. et al., 2004. At Risk. Routhledge (2nd edition), London.

ISDR, 2007. Yokohama Strategy and Plan of Action for a Safer World" ISDR Basic Documents, http://www.unisdr.org/eng/about_isdr/bd-yokohama-strat-eng.htm.

Yücemen, M. S. et al., 2005. Determination of Guidelines for the Development of Seismic Hazard Map and a Pilot Study-Phase I Report, Ankara.