# DESIGN AND APPLICATION OF DISASTER INFORMATION SYSTEM INFRASTRUCTURE ON THE NORTH ANATOLIAN FAULT ZONE (NAFZ)

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**Commission VIII, WG VIII/2**

**KEY WORDS:** Data Integration, Decision Support System, Design, Disaster Management, Geo-Information Management

**ABSTRACT:**

People often face with natural hazards on the earth. They affect not only the public and the environment but also the cultural wealth. A multidisciplinary work should be done to solve the problems caused by natural hazards such as earthquake, landslide, avalanche and flood. GIS is one of the most efficient methods in the disaster management. North Anatolian Fault Zone (NAFZ) is one of the important active fault zones of the world. As there are large settlement areas on the NAFZ, they have highly risks.In this study, disaster information system infrastructure was designed and implemented to take measures against natural hazards, especially earthquake on the NAFZ for prior to natural disaster. During the system design, Unified Modelling Language (UML) was used as the object oriented modelling language which enables us to understand real world objects in an information system clearly. The created system consists of geological, geophysical, topographical data and very high resolution satellite image. It is tested in Erbaa city of Tokat province of the Turkey on the NAFZ.

## 1. INTRODUCTION

A Natural Hazard is a natural event of unusual magnitude that people don't expect and cannot control. Natural hazards threaten people's lives and their activities and can forever change their ways of living. A natural hazard event can become a Natural Disaster when causes the destruction of people's property or their injury and/or death. It is significant to be aware of natural hazards due to the fact that human activities can sometimes increase their frequency and their degree of their severity (Shield, 2004).

Natural disasters are often classified according to their sources. Disasters from geological factors are earthquakes, volcanoes, floods, landslides and tsunamis. Disasters from atmospheric factors are fires, storms, snow, ice and fogs. Natural disasters are interconnected. One disaster may be accompanied by another. For example, a volcanic explosion may produce a significant earthquake or even a tsunami, which in turn may produce other disasters such as fire, flooding or slope failure. Scientists try to decipher these interactions and find ways to mitigate the effect of combined hazards (Shield, 2004).

Natural hazards rarely happen alone. It is very common that certain hazards cause or activate other hazards to occur. For example, when an earthquake happens, it contains factors such as sudden shaking of the ground surface and surface faulting. It is given the information about interaction of hazards in Figure 1. On the other hand, atmospheric hazards can have wide and different effects. Figure 2 explains the interaction between some of them.

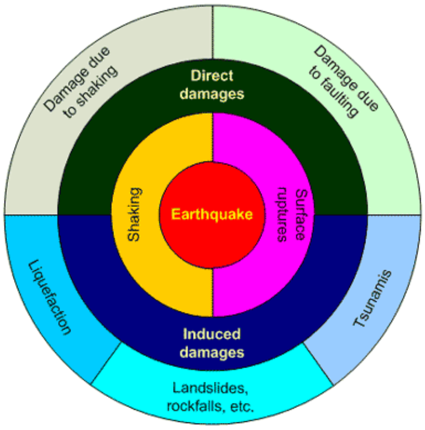


Figure 1. Relationship between earthquake and triggering hazards by earthquake (Shield, 2004)

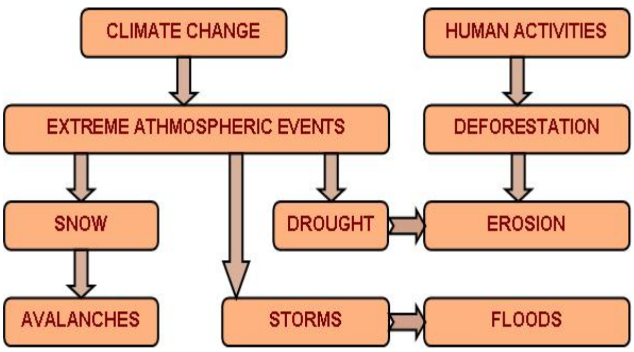


Figure 2. Interaction between atmospheric hazards (Shield, 2004)

Disasters are natural or human-made in Turkey. Turkey has always been vulnerable to various kinds of natural hazards, on account of its orogenic system, geology, topography, and metrological condition. These hazards, coupled with high physical and social vulnerability, have caused unacceptable losses of life, injury, and damage to property (JICA, 2004).

| Event | Date | Killed | Injured | Affected |
|---|---|---|---|---|
| Earthquake (Erzincan) | 13.03.1992 | 653 | 3850 | 250.000 |
| Avalanches (S. Anatolia) | 1992 - 14 events | 328 | 53 | 30.000 |
| Avalanches (E. & S. Anatolia) | 1993 – 31 events | 135 | 95 | 300 |
| Mud Flood (Senirkent-Isparta) | 13.07.1995 | 74 | 46 | 10.000 |
| Earthquake (Dinar) | 01.10.1995 | 94 | 240 | 120.000 |
| Flood (İzmir) | 04.11.1995 | 63 | 117 | 300.000 |
| Earthquake (Çorum-Amasya) | 14.08.1996 | 0 | 6 | 17.000 |
| Flood (W. Black Sea) | 21.05.1998 | 10 | 47 | 1.200.000 |
| Earthquake (Ceyhan-Adana) | 27.06.1998 | 145 | 1600 | 1.500.000 |
| Earthquake (Marmara Region) | 17.08.1999 | 17480 | 45953 | 15.000.000 |
| Earthquake (Düzce) | 12.11.1999 | 763 | 4928 | 600.000 |
| Earthquake (Sultandağ-Afyon) | 03.02.2002 | 42 | 327 | 222.000 |
| Earthquake (Bingöl) | 01.05.2003 | 177 | 520 | 245.000 |
| **TOTAL** | | **19.964** | **55.802** | **19.494.300** |

Table 1. Natural disaster in Turkey since 1990 (GDDA, 2004)

| Type of Natural Disaster | Number of Destroyed Units | Percentage of Total |
|---|---|---|
| Earthquakes | 495.000 | 76 |
| Landslide | 63.000 | 10 |
| Floods | 61.000 | 9 |
| Rock Falls | 26.500 | 4 |
| Avalanches | 5.154 | 1 |
| TOTAL | 650.654 | 100 |

Table 2. Dwelling units destroyed by natural disasters in Turkey (GDDA, 2004)

Earthquake is the most dangerous natural disaster for Turkey as well as appeared in Table 1 and Table 2. Turkey is located in one of the most seismically active regions of the world. It lies within the Mediterranean sector of the Alpine-Himalayan orogenic system. The Alpine orogeny is produced doe to the "compressional" motion between Europe and Africa, whereas the Himalayan orogeny has resulted from the India-Asia collision. Turkey is surrounded by three major plates: African, Eurasian and Arabian, and two generally acknowledged minor plates, Aegen and Anatolian (JICA, 2004).

GPS measurements had been implemented towards major fault zones in Turkey during the period of 1988-1998. They reveal valuable information about the rate of motion of the plates relative to one another in the region. The relative motion between the Eurasian and Arabian plates and the westward motion of the Anatolian block under this compressional plate motion are the main causes of the earthquake hazard in Turkey (JICA, 2004).

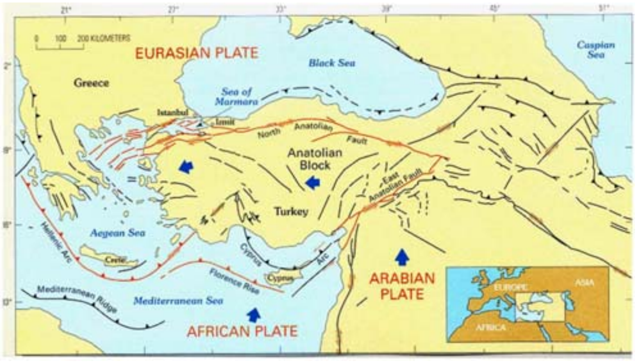


Figure 3. The relative motion between Eurasian, Arabian plates (JICA, 2004)

The disaster history of Turkey is dominated by earthquakes. Turkey lies on active fault lines. In addition, it is prone to major earthquakes. An official Earthquake Hazard Zoning Map of Turkey based on probabilistic considerations has been commissioned in 1996 by GDDA. 66 percent of the surface area of Turkey lies on Zones 1 and 2 levels of seismic hazard, and the fraction of the population living in these risk areas is 71 percent. In Turkey, most of earthquakes happen on the NAFZ which can damage to many constructions. The North Anatolian Fault Zone (NAFZ) is the major tectonic feature of Turkey. It is an active right-lateral system about 1500 km long which bounds to the north Anatolian block. It represents a transform margin that mainly follows a pre-existing zone of crustal weakness: a suture zone inherited from an earlier collisional phase (Sengor and others, 1981; Sengor and others, 1985; Okay, 1989; JICA, 2004; Yilmaz, 2004).

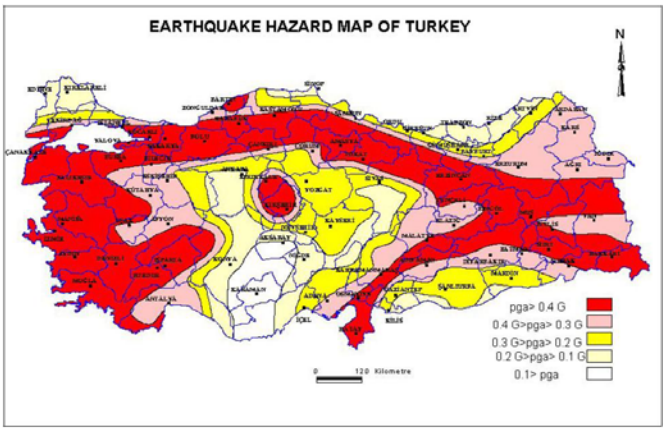


Figure 4. Earthquake hazard zones and provinces of Turkey (GDDA, 1996)

It is clear that natural disasters cause the loss of life and assets. GIS is one of the most efficent methods in order to mitigate risks caused by natural hazards.

## 2. AIM OF THE STUDY

Turkey often faces with natural disasters. Earthquake is a type of the most encountered natural disasters in Turkey. Combat with disasters is composed of very complex processes. Multi-disciplinary works should be done to cope with sufficiently risks caused by natural disasters.

This study is aiming to take measures effectively in order to mitigate or to accomplish risks from natural disaster especially earthquake in the shortest time prior to natural disasters. Furthermore, its goal is to create a Disaster Information System (DIS) data infrastructure and to use it as a decision support system. It should also be added that this study has been performed as a Ph.D. Thesis Project.

## 3. METHODS APLLIED FOR THE STUDY

Erbaa city of Tokat province of Turkey was selected as the pilot project area due to the fact that it has large population and high risks for the earthquake on the NAFZ. Location of the pilot area is showed in Figure 5.

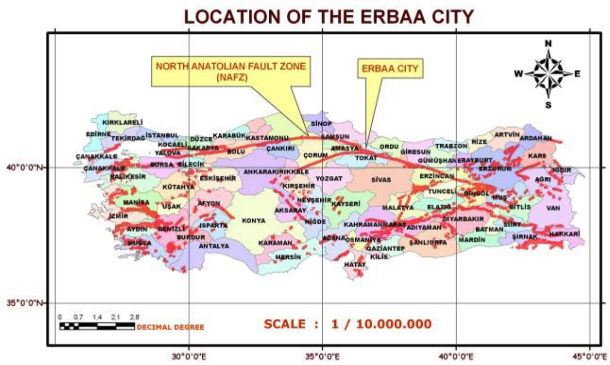


Figure 5. Pilot project area

Firstly, existing condition was determined to create the data infrastructure of the DIS in Erbaa. In addition, requirement analysis was performed and expectations from the system were evaluated. Finally, system design and implementation have been executed in the pilot area.

During the conceptual and physical design of the system, UML diagrams were used. It provides visual modelling. Moreover, Microsoft Visio 2003, Arc GIS 9.2 and Zeiss Imaging software were used to apply the study. UML Class diagram is showed for geological formation layer in Figure 6.

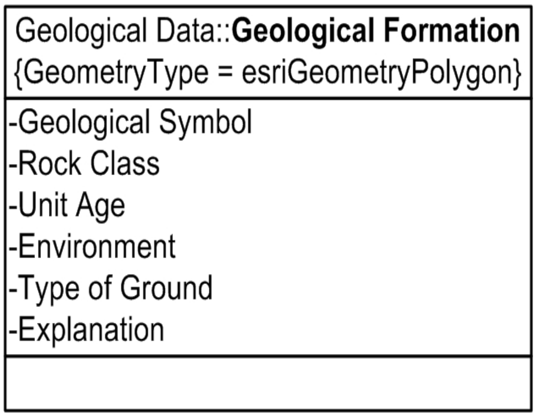


Figure 6. UML class diagram for geological formation layer

The system consists of following data.

- Geological data (Produced by General Directorate of Mineral Research & Exploration),
- Geophysical data,
- Topographical data,
- City block and building data,
- Very high resolution satellite image (IKONOS 2006),
- Aerial photo pairs (1972 and 2006 aerial photos – taken by General Command of Mapping) of the study area,
- Non-geographical data.

Building data obtained from map sheets by digitizing (scale at 1/1000). In addition, direction of urbanization of the city was determined by stereo-digitizing of aerial photos in different periods. Thus, this study contributes to determine of the risk in the city (buildings how to near the fault line).

Therefore, this study shows that photogrammetry, remote sensing and GIS is how too important for mitigation risks caused by natural disasters.

## 4. RESULTS AND DISCUSSIONS

The created system provides the significant information related to the study area such as;

- Geological formation of settlement areas (Figure 7),
- Information about boring points,
- Relationship between fault line and settlement areas (Figure 8),
- Query and spatial analysis among data in the system.
- Determination of the changing direction of the study area and existing situation of the building and city block (Figure 9 and Figure 10).

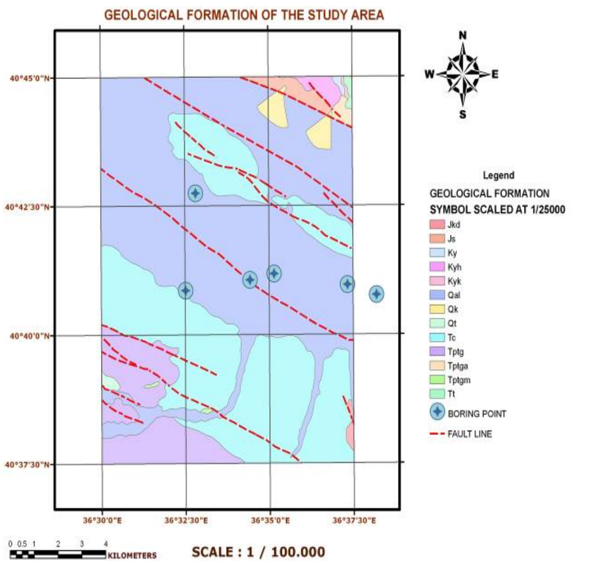


Figure 7. Geological formation of the pilot project area

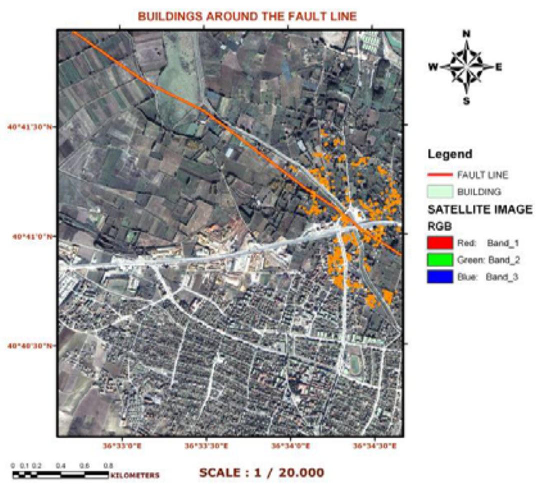


Figure 8. Buildings around 500 meters of the selected fault line

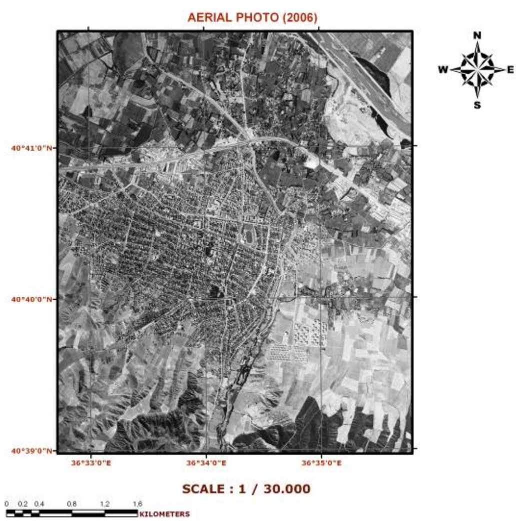


Figure 9. Aerial photo of the study area (2006)

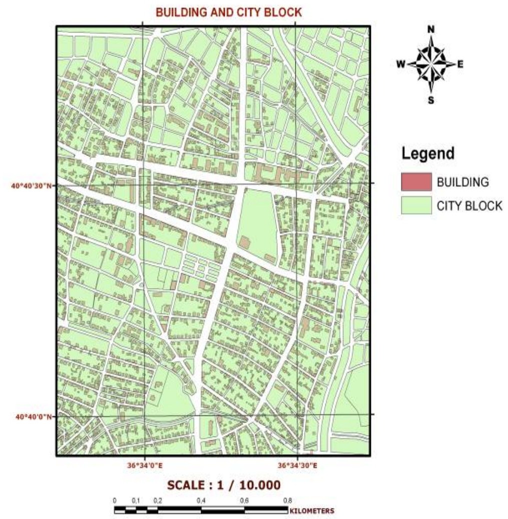


Figure 10. Buildings and city block (after stereo-digitizing)

## 5. CONCLUSIONS

Natural disasters affect lives of people and settlement areas negatively. Effective measures should be taken in order to in order to protect from natural disasters. GIS is one of the most important methods to cope with natural disasters.

Photogrammetry and remote sensing are the most efficient data collection methods for GIS. Therefore, they are important for GIS. GIS and these data collection methods are commonly used in natural disaster management in the world.

NAFZ is one of the most active fault zones of the world. Settlement areas on the NAFZ are under the risk of being destructed by the earthquakes. Erbaa is one of the riskiest cities on the NAFZ. In this study, DIS infrastructure was designed and implemented to reduce risks and dangers caused by natural disasters (especially earthquake).

The created system performs processes such as determination of the risk for the city, taking the measures for probable dangerous.

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**ACKNOWLEDGEMENT**

Authors would like to thank Sivas Cumhuriyet University and Yıldız Technical University for their financial support.