Chapter 3. Disaster Management

3.1 Damaged Area Estimation Based on DMSP/OLS Nighttime Imagery

In a large earthquake disaster, it is important to allocate limited human and physical resources efficiently, and it is also necessary to grasp the spatial distribution of the damaged areas in early time for these response actions. Shortly after a disaster, interruptions of communication and confusions of information would interfere precise assessment of the disaster situation, and relief actions would concentrate to only a few media-reported areas, which may have less damage than the communication-disrupted areas. Therefore, the early information of damaged area distribution is indispensable for effective disaster responses. We estimated the damage areas using nighttime images observed by the Defense Meteorological Satellite Program's Operational Linescan System (DMSP/OLS) for the purpose of supporting relief and recovery activities by the central governments, non-governmental organizations and non-profitable organizations.

3.1.1 Estimation Method

It can be expected that city lights will observably decrease after a large earthquake due to various reasons such as electricity failure, building collapses, evacuation to shelters or the suspension of commercial activities. Therefore, the significant reduction in nighttime lights can be an indication of possible impacted areas due to earthquake disasters. The satellite images observed by the DMSP/OLS are suitable for the early identification of the damaged areas for following reasons:

1) Due to the sensitive scanner, nighttime images are available.
2) The nighttime images are observed, at least, twice a day by two DMSP satellites.

These mean that we could detect significant reduction in nighttime lights at any day on a daily basis. The DMSP/OLS imagery has spatial resolution of 2.7km, and the resolution is not as high as that of the Landsat/TM or the SPOT/HRV. But the recurrent periods of the satellites with high-resolution sensors are more than two weeks and the chances to observe the image immediately after a disaster are very low. Consequently, the short recurrent period is necessary for emergency use of the observed imagery.

The steps of damaged area estimation are shown in Figure 3.1.1. Each pixel in the visible-near infrared (VNIR) images has digital number (DN) ranging from 0 to 63. We calculated the differences of DNs on a pixel basis between before and after the earthquake in the sampled area. The cloud influences were checked using the thermal infrared (TIR) images and the stable light images. Based on the histogram of the differences, the areas that show the reduction in nighttime lights with $p > 0.995$ were determined as significant reduction due to the earthquake disaster (Figure 3.1.2). The result maps were disseminated to the world through the Web page of EDM (http://www.miki.riken.go.jp/).

3.1.2 Estimation Results

We estimated the possible impacted areas of the earthquake disaster. The DMSP/OLS images in this region were provided from National Oceanic and Atmospheric Administration's National Geophysical Data Center (NOAA/NGDC). The nighttime VNIR images before and after the earthquake are shown in Figures 3.1.3 and 3.1.4, respectively. The corresponding TIR images are shown in Figures 3.1.5 and 3.1.6, respectively. The two VNIR images have little cloud influence considering the TIR images. The histogram of digital number differences between two VNIR images is shown in Figure 3.1.7.

The estimated impacted areas spread widely in Yalova, Kocaeli, Sakarya, Bursa, Eskisehir, and Bolu provinces (Figure 3.1.8). The disaster damage reported by General Directorate of Disaster Affairs, Earthquake

Research Department, Ankara, Turkey is shown in Table 3.1.1, which is the latest information on October 10, 1999. These estimation results showed with a high degree of correspondence with the real damage distribution.

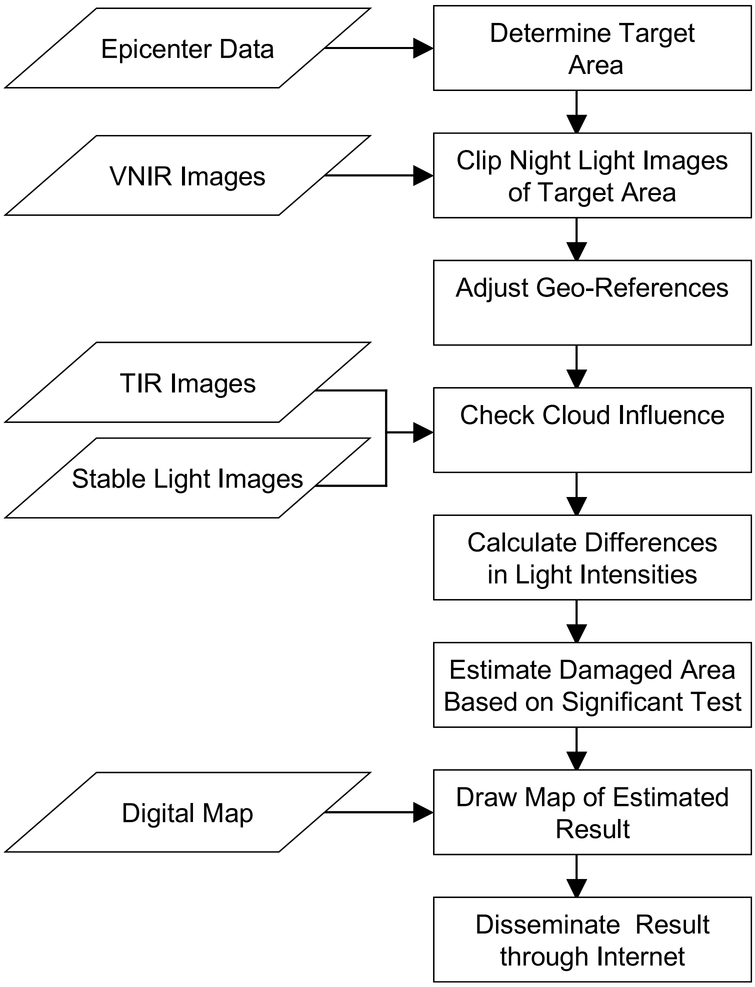


Figure 3.1.1. Flowchart of damaged area estimation.

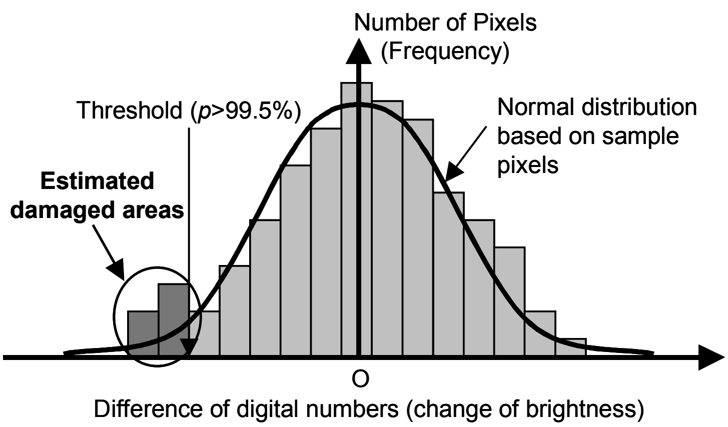
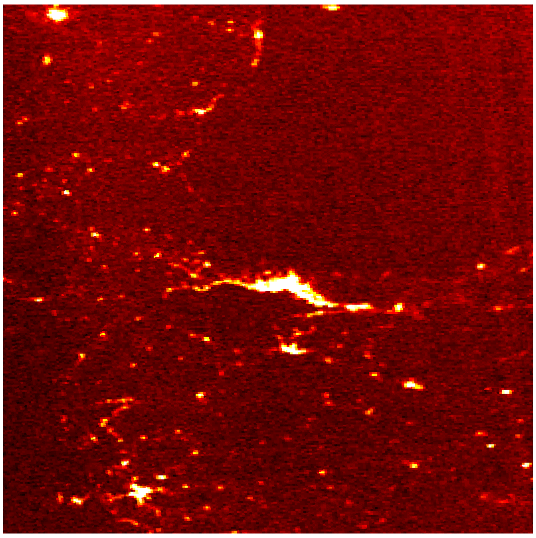
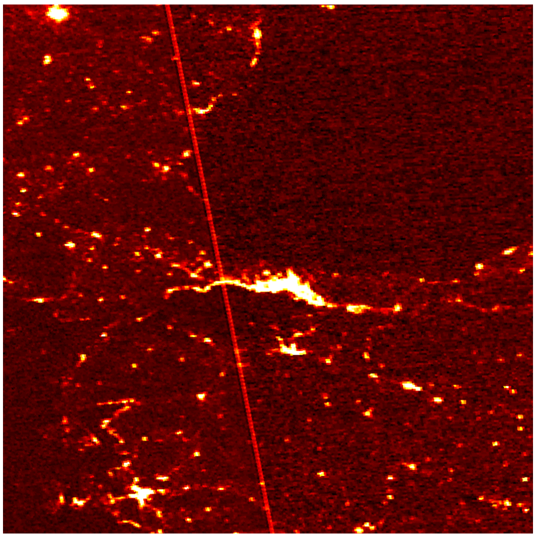


Figure 3.1.2. Criteria of damaged area estimation.





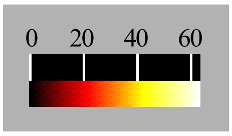
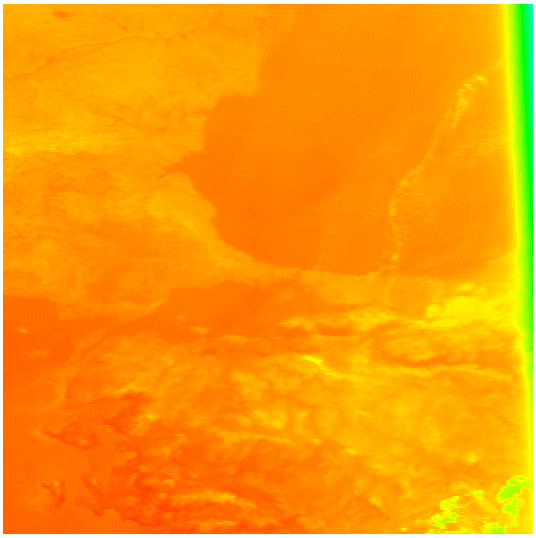
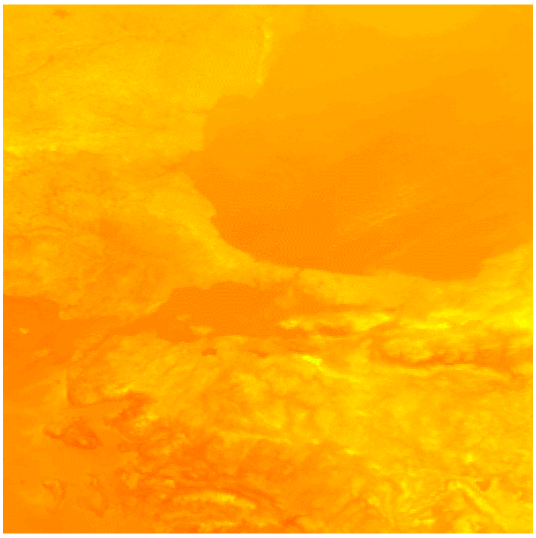


Figure 3.1.3. VNIR image before the earthquake (around 11:30pm, August 16, 1999; Refer to color Figure 2).

Figure 3.1.4. VNIR image after the earthquake (around 11:10pm, August 17, 1999; Refer to color Figure 3).





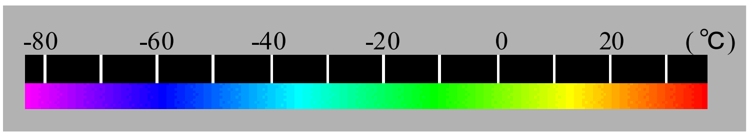


Figure 3.1.5. TIR image before the earthquake (around 11:30pm, August 16, 1999).

Figure 3.1.6. TIR image after the earthquake (around 11:10pm, August 17, 1999).

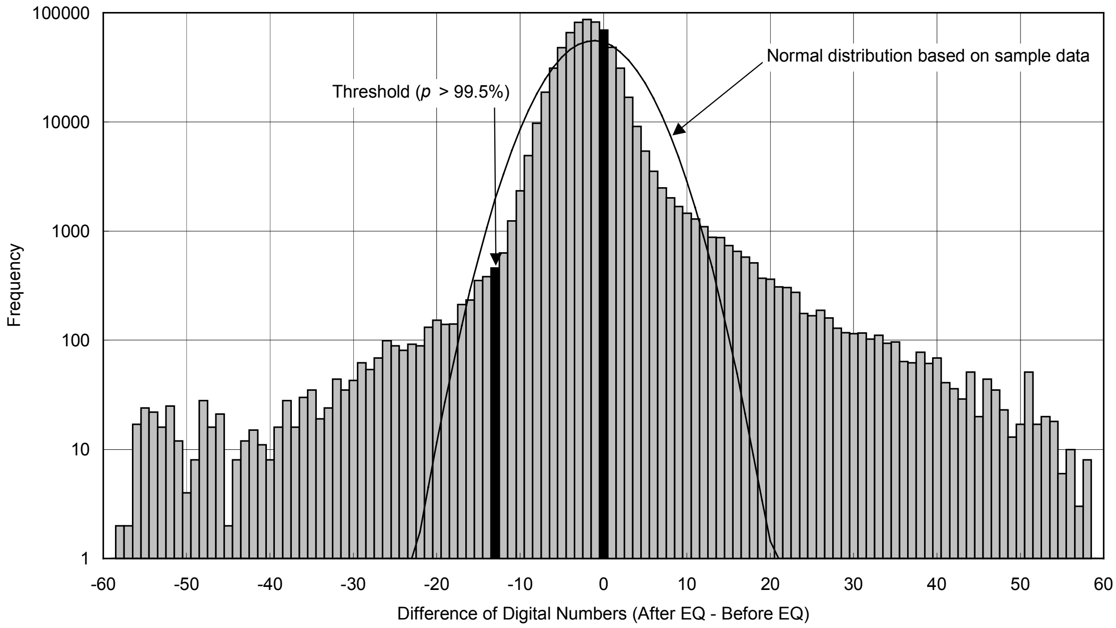


Figure 3.1.7. Histogram of digital number differences between two images (log-scaled).

Figure 3.1.8. Estimated damaged area (Red: possible impacted areas, Gray: incapable of estimation due to saturated data; Refer to color Figure 4).

Table 3.1.1. Damages of the 1999 Kocaeli, Turkey earthquake reported by General Directorate of Disaster Affairs, Earthquake Research Department, Ankara, Turkey.

	Casualties*	Damaged house units **		
		Collapsed or heavily damaged	Moderately damaged	Slightly damaged
Sakarya	2,629	19,043	12,200	18,720
Golcuk	5,025	12,310	7,789	9,299
Kocaeli	4,093	19,315	21,287	22,452
Istanbul	981	3,073	13,339	12,455
Yalova	2,502	9,462	7,917	12,685
Bolu	264	3,095	4,180	3,303
Bursa	268	29	104	401
Eskisehir	86	76	47	315

*: The information from the Crisis Center in Ankara, Turkey (the latest on October 10, 1999).
**: The damage evaluation report of the General Directorate of Disaster Affaires of the Ministry of Public Works and Settlement (the latest on October 10, 1999).

3.1.3 Geographic Information to Support Relief Activities

The estimated damaged areas based on DMSP/OLS imagery are represented in grids system of 90 arc second by 90 arc second. They have the longitude and latitude location value but have little expression power without other map, and it is difficult to recognize which cities have high probability of damage. Thus, it is important to convert them to the suitable geographic information. In other words, the spatial relationship can be expressed when you make the composite image with geographic features like shorelines, rivers, roads, railways and so on.

In a developed country, even 1:2500 city maps are available in digital data, but the largest scale of digital map covering all over the world is 1:1,000,000 of the Digital Chart of the World (DCW). Figure 3.1.9 shows the estimated damaged areas on the DCW around Adapazari during the 1999 Kocaeli earthquake, Turkey. The figure indicates the relative location of damaged areas with the lake and junctions of roads and railways, and it is easy to grasp which parts of the city have high probability of damage.

After the onset of the earthquake, many parties delegated the damaged areas for relief activities and academic investigation, and they had troubles to obtain the useful map for their purposes. Only available are the road maps showing major national highway and maps for sightseeing tours, and it was difficult where they were in a city due to strange place. Though portable global positioning system (GPS) have been put in practical use and it can tell the longitude and latitude within a-few-hundred-meter margin of error, you can not know the topographic relationship with the destination and can not choose the route without a large scale map. Therefore, geographic information that is comparative to the large-scale map is necessary to support the field activities in damaged areas.

For that sake, Landsat and SPOT can provide enough resolution imagery. Figure 3.1.10 shows the estimated damaged areas on the Landsat/TM imagery, which has 30m of ground resolution. The narrow roads and distribution of urban areas and green areas, which are not expressed in the DCW, are represented and these are very useful for the field activities. The estimation results have a-few-pixel error, which comes from geo-reference accuracy, but the thematic map shows which regions are the estimated damaged areas, and the map is much better than that on the digital map. The Landsat/TM imagery is available of any part of the world and it is one of the powerful data resources to support the disaster management activities. It is expected that the imagery assists the emergency and relief activities when it is provided with the estimated damaged areas.

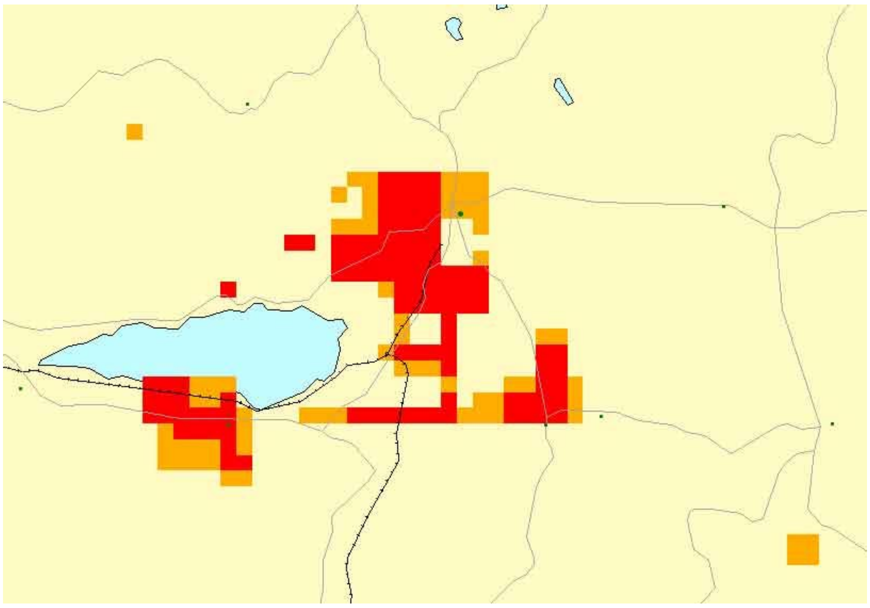


Figure 3.1.9. Estimated damaged areas on the digital map.

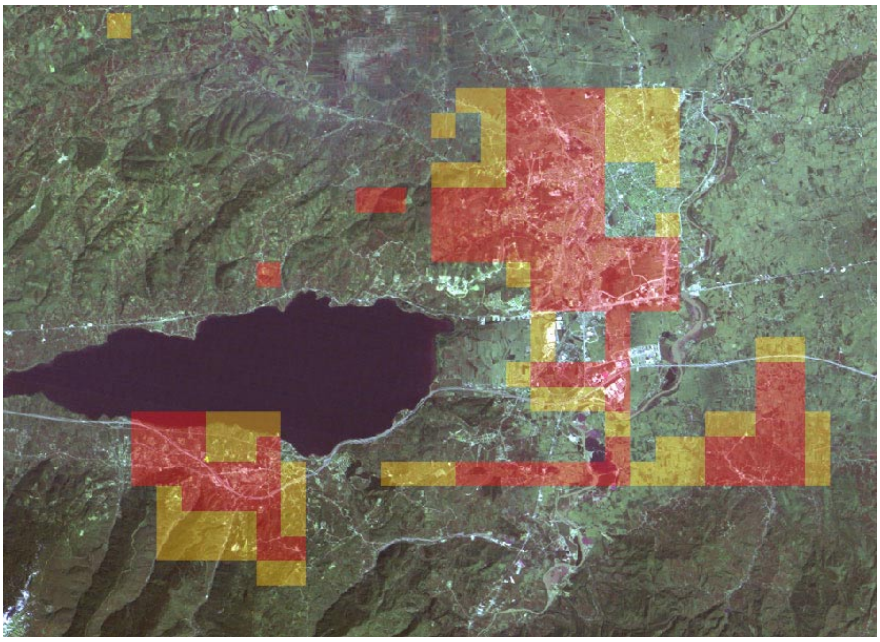


Figure 3.1.10. Estimated damaged areas on the Landsat/TM image (Refer to color Figure 5).

3.1.4 Summary

We proposed method of the damaged area estimation and applied the 1999 Kocaeli earthquake. It is revealed that the estimation is considerably accurate at least in case that the cloud influence is little and the observational interval is short, but further examinations are needed to devise a robust and reliable estimation method under various conditions.

It took three weeks since the onset of disaster to disseminate the final results, including one week to acquire the relevant DMSP/OLS images from NOAA/NGDC. The entire process should be reduced to less than 24 hours since the onset of the disaster by establishing a proper procedure of analysis and dissemination processes.

Acknowledgements

The DMSP-OLS images used in this study are provided by NOAA/NGDC. We wish to thank NOAA/NGDC and Dr. Haruhiro Fujita for the cooperation.

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3.2 Disaster Response after Marmara Earthquake Disaster

3.2.1 Progress of Damage

Causalities

Though there is no official declare about the number of damage, the growth of deaths and injuries stopped to 17, 127 death and 43, 953 at three months after. Number of death shows the number of the body. Figure 3.2.1 shows the progress of human damage.

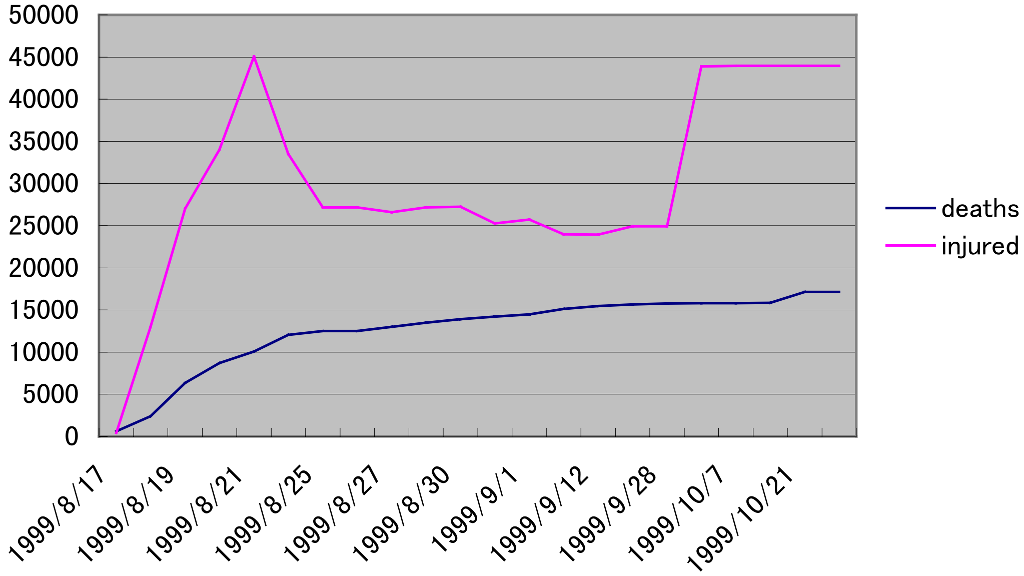

Figure 3.2.1. Progress of human causality.

Building Damages

The number of damaged housing units was estimated to 60,000 at preliminary report on 24 August (1 week after). On 28 August (10 days after), the number of damaged building was officially published to be 54,294 as the ongoing damage survey data. From 30 Aug, PMCMC (Prime Minister's Crisis Management Center) begun to report the data of each province and level of damage about housing damage assessment data, Collapsed 1332, Condemned 1423, Heavy 13681, Moderate 14701, Light 1788. On 31 August, the classification of damage has changed and reported by following classification. Destroyed 19324, Uninhabitable 31322, Inhabitable 38113, total 88,759) and on 18 September, the intermediate but practically final report about building damage was published (Table 3.1.1). Though the data of Table 3.1.1 is published on October 10, the amount of damage is same with September 18.

Economic Impact

World Bank has published Executive Summary of Report, "Turkey: Marmara Earthquake Assessment" on 14 September. It tells about direct loss, indirect cost, and secondary effect. The direct cost is range from US$ 3.0-6.5 billion on the basis of the partial data available. It corresponded to 1.5-3.3% of GNP (Table 3.2.1). This is the only data that is available about economic impact.

Table 3.2.1. Direct losses (Quoted from World Bank, Executive Summary of Report, "Turkey: Marmara Earthquake Assessment", 1999).

	Damage assessment (US$ million)	
	Lower bound	Upper bound
Housing	1100	3000
Municipal Infrastructure	70	70
Environment	NA	NA
Road, bridge and highways	78	78
Port	12	12
Railway, railcar factory	72	72
Telecom	38	38
Electricity	82	82
Oil and Gas (includes Tupras Refinery)	387	387
Enterprises (rounded)	1100	2600
Education	100	100
Health	37	37
Total	3076	6476

3.2.2 Preparedness

Disaster management system in Turkey was started from the earthquake in 1509 at Istanbul. After the establishment of Republic of Turkey, there was no regulations or laws about disaster management. In 1944, the law on "measures before and after earthquakes" was established from the lessons from the earthquake between 1939-1944. In 1958, "Civil Defense Law" was established. In 1959, "the Preventive and Protective Measures to be taken against disaster affecting the daily life in general" was established. This law has the statement about individual recovery. It defined that the government has the responsibility of rebuilding of all the houses hit by disasters. However, the completion rate of rebuilding by the government is only 30.5%. In 1968, the regulation named "Emergency Aid Organizations and Program Related to Disaster Management" was established. This law has defines that the Ministry of Pubic Works has the responsibility about disaster management. In 1988, "Regulations on Emergency Aid and Planning for Disasters" were established and amended in 1993. These amendments stated that the Ministry of Public Works is primarily works for disaster management agency but the disaster management organization direct under the Prime Minister would be established in case of catastrophic disaster. The organization directory under the Prime Minister conducted disaster management for Marmara Earthquake Disaster.

3.2.3 Disaster Response

Organizations

As mentioned in post-event countermeasures, the ministry of construction is the primary organization for disaster response. However, the scale of disaster was catastrophic and disaster response was conducted under the Prime Minister and Prime Minister's Crisis Management Center (PMCMC) was established on 18 August.

Countermeasures for Response; Sheltering Process

Countermeasures for Response has been written in repot of JICA that was made with the cooperation of EDM researchers. The sheltering process of Marmara Earthquake Disaster is highlighted in this report. The amount of tents and tent cities would be shown in Table 3.2.2. Providing organization of tent cities were classified to four types of organizations, 1) Red Crescent, 2) Armed Forces, 3) International Donors, 4) Private Sector.

Table 3.2.2. Amounts of tent and tent cities (Sep. 16, quoted from Turkey - Earthquake OCHA Situation Report No. 22).

Red Crescent	Armed Forces	Int'l Donors	Private Sector	Total Tents	Tent Cities
38,080	2,122	54,841	7,970	103,013	121

There are two points about sheltering process in Marmara Earthquake Disaster comparing with Hanshin-Awaji Earthquake Disaster. One is that anxiety about the safety of housing was the key factor of evacuation. Many people lived in the tent set in front of their original houses without damage. It continued the lifelines had already recovered. Second is that the evacuation from affected area is preliminary factor for sheltering process. It is because the kin-relationship is stronger than the case in Hanshin-Awaji Earthquake Disaster. The expected sheltering process is shown in Figure 3.2.2.

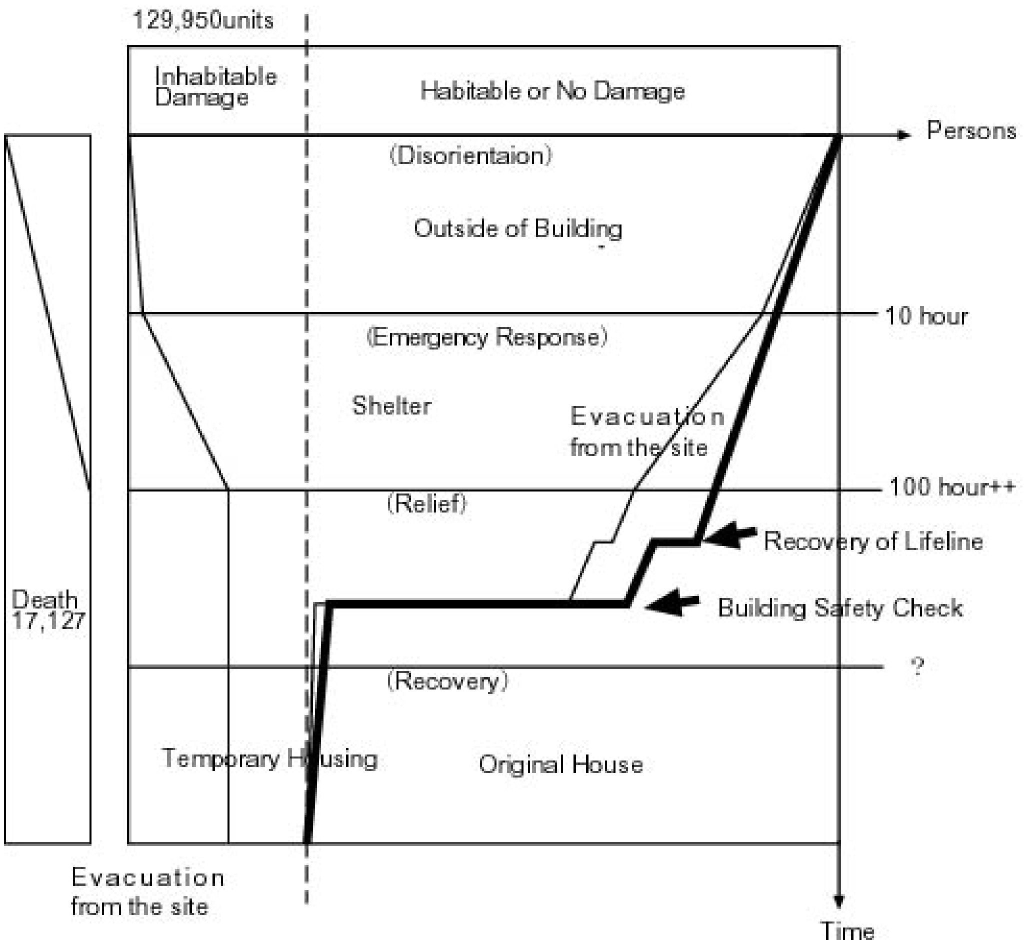

Figure 3.2.2. Sheltering process after Marmara earthquake.

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3.3 Experience Sharing and International Cooperation

3.3.1 EDM Attempts for Helping the Recovery from the Marmara Earthquake Disaster in Turkey

Hyogo-Kobe Mission was dispatched to support the recovery process from Marmara Earthquake Disaster. It was for diplomatic commitment by Japanese Foreign Minister Takamura when he visited Turkey right after the event. Hyogo-Kobe Mission had many “First Case”. 1) First Case for Local Government Officers to be dispatched for disaster management in other country based on a formal request by national government, 2) First Case for them to use their experiences to express their gratitude for the supports they received from the international communities, 3) First Case for them to use their expertise to express their gratitude for the supports they received from the international communities, 4) First Case for JICA to coordinate this kind of mission.

EDM sent two researchers, Prof. Haruo HAYASHI, team leader and Dr. Norio MAKI to support and clarify following things, 1) The knowledge about disaster response on Hanshin-Awaji Earthquake Disaster of local administrator can be effective to support the recovery in Turkey or another countries, 2) This types of mission can be a new framework of Japanese international cooperation about disaster management, 3) What kind of problems exist in this types of mission, 4) How can this types of mission be fruitful, 5) What is necessary to continue this types of mission.

3.3.2 Facts about Hyogo-Kobe Mission

Hyogo-Kobe Mission was dispatched as a JICA Disaster Relief Team from August 27th～September 9th. Mission member was consisted from 6 Hyogo Prefecture Government Officers, 5 Kobe City Government Officers, 5+ JICA Supporting Staff, 3 JICA Interpreters (Japanese-Turkish). Expertise of each administrators was sheltering, urban planning, volunteer, healthcare, education, disaster management, accounting.

What they did in Turkey is 1) Visiting the impacted area to have their first hand knowledge and experiences and many hearings from people in the impacted area, 2) Appearing on the media to give their observations and talk about their experiences, 3) Having two seminars, August 2nd at Istanbul and August 6th at Ankara. The chances to help the recovery process from the disaster are limited to the presentation in seminar.

3.3.3 Evaluation of Seminar

The program of Istanbul Seminar was consisted from 1) Introductory Remarks by JICA, 2) Video Presentation on Reconstruction Project by Hyogo Prefecture (20 min, English), 3) Presentations by Hyogo Prefecture Government Officers, 4) Presentations by Kobe City Government Officers, 5) An Overview of Hanshin-Awaji Earthquake Disaster.

The seminar in Istanbul had many problems. 1) Lack of Framework to connect Individual presentations, 2) Too detailed and narrowly-focused topics reviewing their own experiences (or what they were responsible), 3) Lack of understanding about Turkish culture, 4) Lack of understanding about what audiences want to hear.

The program of Ankara seminar was renovated from the lessons in Istanbul Seminar. The program is shown in Table 3.3.1.

Table 3.3.1. Program of seminar in Ankara.

Seminar on Restoration of Marmara Earthquake Disaster
-Hyogo and Kobe 's Experiences-
< Turkish Japanese Foundation Culture Center-Ankara, September 6, 1999 >

9:00	Opening Remarks	
		Tatsuo YONEBA YASHI, Resident Representative, Japan International Cooperation Agency (JICA) Turkey Office
		H.E. Mrs. Atsuko TOYAMA, Ambassador, Embassy of Japan
		Naoyoshi SASAKl, Disaster Relief Team Leader, JICA
9:30	1st Session: Marmara Earthquake and Hanshin-Awaji Earthquake (T. OHARA)	
10:15	2nd Session: Disaster Relief Activities	
		- Food Distribution and Donations-in-Kind (Y. IWASAKl)
		- Health Care Programs (M. KAWAHISA)
		- Education Programs (T. NAKASUGI)
11:30	3rd Session: Assistance for Disaster Victims	
		- Management of Temporary Housing Communities: Tent Cities and Pre-fabricated Housings (Y. IWASAKI)
		- Social Services at Tent Cities (Y. HAYASHI)
		- Volunteer Activities: CBOs, NGOs and NPOs (S. KASHINO)
		- Financial Arrangements for Self-empowerment (A. FURUKA WA)
12:30	Lunch hosted by JICA Alumni Association of Turkey	
13:30	4th Session: Reconstructing Destructed Cities	
		- Demolition of Collapsed Structures (T. KATO)
		- Debris Removal (T. OZAKl)
		- Housing and Urban Restoration Planning (T. TOMIOKA)
		- Community Disaster Mitigation Strategy (M. TANIGUCHI)
		- 5th Session: Summary (N. SASAKI)
15:30	Workshop	
		- Disaster Relief Activities
		- Assistance for Disaster Victims
		- Reconstructing Destructed Cities

The seminar in Ankara can evaluate to have been fruitful. The reason why it was fruitful is 1) Becoming an unified Team, 2) Systematic comparison between the Marmara and the Hanshin-Awaji at the beginning, 3) Recommendations they came up with their experiences and observations, 4) Limits to the most important three points at most, 5) Japanese to Turkish Interpretation with good understanding of what is said, 6) Concrete and Lively Discussions at the following Workshops.

3.3.4 Toward the Following Missions

The mission shows that the dissemination of lessons about recovery from Hanshin-Awaji Earthquake Disaster can be approved from the countries which had severe damage from the disaster. Many disasters happen all over the world and the requirement to this kind of mission could be produced. At that time, the following points must be considered to make these missions fruitful.

1) Though each country has its unique culture and situations, the similarity in disaster process did exist. The material to introduce lessons from Hanshin-Awaji earthquake disaster systematically must be made in English.
2) The recovery cannot complete in the short period. The support for recovery is not short period task. The long team support is necessary to support recovery. Each mission must establish continuous communication cannel with the dispatched country.
3) The mission for recovery support must be established not only from the administrator from Kobe and Hyogo but also from the administrator from Tokyo and Shizuoka, which has many excellent knowledge for disaster management.
4) This mission was a new framework of cooperation for JICA about disaster management. JICA must establish the coordination function to send this type of mission.

3.3.5 Report Making

EDM researchers have supported report making of this mission. Many lessons about recovery from the Hanshin-Awaji Earthquake Disaster were systematically introduced in this report (JICA, 1999).

Reference

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