Organisational learning and self-adaptation in dynamic disaster environments

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This paper examines the problems associated with inter-organisational learning and adaptation in the dynamic environments that characterise disasters. The research uses both qualitative and quantitative methods to investigate whether organisational learning took place during and in the time in between five disaster response operations in Turkey. The availability of information and its exchange and distribution within and among organisational actors determine whether self-adaptation happens in the course of a disaster response operation. Organisational flexibility supported by an appropriate information infrastructure creates conditions conducive to essential interaction and permits the flow of information. The study found that no significant organisational learning occurred within Turkish disaster management following the earthquakes in Erzincan (1992), Dinar (1995) and Ceyhan (1998). By contrast, the 'symmetry-breaking' Marmara earthquake of 1999 initiated a 'double loop' learning process that led to change in the organisational, technical and cultural aspects of Turkish disaster management, as revealed by the Duzce earthquake response operations.

Keywords: complex adaptive systems, disasters, emergency management, organisational change, organisational learning

Introduction

Sudden and destructive disasters create chaos and disorder for both people and local community organisations. The 'symmetry-breaking' (Kiel, 1994, p. 39) effects of disasters undermine linearly designed and centralised administrative activities. The result is a significant decline in the performance of a disaster response system in organising a timely and coordinated response operation. Communities that do not learn from previous mistakes and lack sufficient capacities for self-adaptation make similar mistakes that increase their vulnerability to disasters. Turkey's location in the eastern Mediterranean sector of the Alpine–Himalayan earthquake belt exposes most of the country to seismic risk. Destructive earthquakes occurred 131 times and represented 60 per cent of all natural disasters between 1902 and 1999 (Ergunay, 1999). Five recent earthquakes between 1992 and 1999 killed more than 20,000 people (Gulkan, 2002). The protection of human lives and property against seismic risk is a crucial responsibility of provincial and central public organisations in Turkey. The destructive consequences of the recent

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earthquakes for human life, property and economic activity require that one explore new ways of diminishing the vulnerability of local communities to seismic risk.

This paper compares, contrasts, and evaluates the emergency response to the Erzincan (13 March 1992), Dinar (1 October 1995), Ceyhan (27 June 1998), Marmara (17 August 1999) and Duzce (12 November 1999) earthquakes from an organisational learning and adaptation perspective. It investigates the factors that promote or inhibit organisational learning and adaptation in dynamic disaster environments in the context of the aforementioned five destructive earthquakes in Turkey. The paper addresses the following research questions: how did the Turkish disaster response system evolve over the course of the five earthquake cases? How did the initial technical, organisational and cultural conditions affect the development of the Turkish disaster response system? What processes facilitate learning and the establishment of an adaptive inter-organisational disaster response system?

Theoretical framework: self-adaptive disaster responses in dynamic environments

The dynamic relationships among physical, social and constructed systems (Dynes, 1970; Mileti, 1999) make organisational learning and adaptation more than necessary for disaster organisations (Wildavsky, 1988; Comfort, 1994; 1999). In their analyses of various disaster cases, Turner and Pidgeon (1997) argue that failure to change culturally accepted beliefs, associated precautionary norms set out in laws, codes of practice, mores and folkways contributes to disasters. According to the authors, as long as an inquiry or assessment is carried out and precautionary norms are adjusted to fit the newly gained understanding of the world through organisational learning, disaster organisations cannot minimise the level of vulnerability of communities to disasters. Organisational learning takes place through shared mental models developed by ongoing dialogue among members of response operations (Stata, 1989; Arygris and Schön, 1996). The shared mental models represent active organisational memory and make the remainder of organisational memory usable (Kim, 1993). However, individuals must learn first for organisational learning to occur (Cohen and Levinthal, 2000). Learning becomes organisational when members of an organisation detect an error or anomaly and correct it by restructuring the organisation's theory of action (or 'theory in use'), embedding the results of their inquiry in the images of the organisation held in its members' minds (mental models) and/or in epistemological artefacts, such as maps, memories and programmes (Arygris and Schön, 1996).

Complexity is a key characteristic of natural and social systems. Many, if not most, social systems are complex systems (Axelrod and Cohen, 1999; Kiel, 1994; Marion, 1999; Stacey, 2000; Uri, 1995; Morgan, 1998; Comfort, 1999; Kauffman, 1993). Complex systems are dynamic and nonlinear, meaning that inputs and outputs are not proportional. Hence, 'if A, then B' statements in which outcome is the simple function of input are not true in complex systems. Complex systems are not in a state of equilibrium or near equilibrium; they are in a far from equilibrium state (Prigogine, 1997).

Therefore, they neither find themselves in the same system state, a fixed stable state, nor demonstrate systematic behaviour like a clock's pendulum (Uri, 1995; Stacey, 2000). This does not mean, though, that these systems do not have some kind of patterned order and boundary. Complex systems build on positive feedback. Amplifying iterations changes a system's behaviour by building on previous states, like compounding interest in a bank account (Uri, 1995). Complex systems demonstrate sensitive dependence on initial conditions, suggesting that systems with very close initial starting points may diverge as time proceeds. Two similar things under the same conditions can have completely different development paths and can produce entirely different results (Uri, 1995).

Building on complexity theory, Comfort (1994; 1999) and Comfort and Sungu (2001) assert that disaster response systems should be designed as self-adaptive socio-technical systems for aiding organisational learning and adaptation. An adequate organisational structure for information acquisition, dissemination, storage and interpretation as well as sufficient flexibility for processing information help organisations to learn and adapt to shifting conditions in their environments. The characteristics of socio-technical systems are classified under three categories: organisational; technical; and cultural (Comfort, 1999). Sufficient organisational capacity necessitates a balance between order and flexibility for achieving a dynamic organisational structure in and among organisations (Comfort, 1999). The flexibility of socio-technical systems enables its participating organisations to relax or eliminate other functions temporarily, when needed. Thus, the organisational structure is continually modified through actions, as the interdependent disaster organisations work together with their dynamic environments (Comfort and Kapucu, 2004; Comfort, 1993). Lateral communication and coordination among a range of organisational and inter-organisational actors and the integration of micro- and macro-level decision-makers through information flow facilitate learning and adaptation (Dynes, 1970; Garnett, 1992). Besides sufficient information flow and lateral coordination, state of human resources and emergency response plans are important indicators in developing sufficient organisational capacity (Comfort, 1999).

Technical capacity is a key component of socio-technical disaster systems. Simon (1997) stresses the importance of information flow and technology for individual and organisational learning. Computers and other information technologies permit individuals and organisations with different intentions, capabilities and responsibilities to create communication and information storage, retrieval, dissemination and exchange mechanisms (Simon, 1997; Comfort, 1999; Alavi and Tiwana, 2003). Information technology thus supports individual and organisational learning as well as organisational interactions. Timely and accurate information acquisition, processing and dissemination decrease uncertainty, thereby enhancing the inter-organisational problem-solving capacity and the effectiveness of the overall emergency response system (Comfort and Cahill, 1988). The existence of emergency management centres, adequate resources and the implementation of earthquake codes are also important in developing ample technical capacity for a disaster system (Comfort, 1999).

Organisational culture shapes the type of learning and the shared mental models in use. Complexity and change require mental models that are open to transformation. Disaster organisations should be able to alter their contemporary practices and adapt

to shifting conditions upon receiving reliable information (Comfort, 1999). To achieve such a goal, individual decision-makers and organisations need to be open to valid information and take action to obtain it (Arygris, 1993). Moreover, control must be replaced by an ability to trust individuals and groups to carry out critical organisational tasks without close supervision (Edmondson and Moingeon, 1999). A dynamic disaster management system that can learn from its mistakes and adjust to rapidly changing disaster conditions is required for reducing the vulnerability of local communities in Turkey. Sufficient organisational and technical capacity supported by a change-oriented organisational culture can facilitate inter-organisational coordination, learning and adaptation, too.

A survey of organisational learning, complex adaptive systems and the socio-technical systems yields important insights into developing a disaster management model that can aid inter-organisational learning and adaptation to dynamic disaster conditions. The dynamic conditions of disaster environments require a complex and adaptive disaster response and recovery system that can facilitate inter-governmental learning and self-adaptation to the emergent chaotic conditions following a disaster. A self-adaptive disaster response system must focus on building necessary organisational, technical and cultural capacities before disasters occur, since initial conditions play a significant role in complex systems. Continuous interaction and information flow along with cultural openness to new information and change can aid uninterrupted inquiry into governing values as well as strategies before and after earthquakes. Such an inquiry supported by ample information leads to learning by individuals and organisations respectively. As a result, a disaster response system and its actors can take necessary organisational, technical and cultural steps to mitigate and prepare for disasters. Once adequate organisational flexibility, information infrastructure and cultural openness exist for facilitating system-level organisational interactions and information flow, disaster organisations can effectively coordinate and collectively respond to a disaster.

The theoretical framework of this study contains the following assumptions regarding inter-organisational coordination and self-adaptation: as interactions among organisations and jurisdictions rise, they share information and reallocate resources. As the information flow between organisations increases, their decision-making capacity for innovative action also receives a boost. As sufficient information technology exists, the system has an adequate information infrastructure for enabling information flow between organisations and jurisdictions. As organisations and jurisdictions share more information and resources, their integration and coordination intensify. As the information search, exchange and distribution increases among organisations and jurisdictions, organisational learning and adaptation can occur. As organisational learning and adaptation improve, performance of a disaster response system also gets better.

Methodology

This study is a small-n exploratory case study analysis (Yin, 1993; 1994). The exploratory state of the study of nonlinear complex systems in social sciences makes use of

a small-n comparative research design, an appropriate research method for assessing disaster response systems (Comfort, 1999). The research explores the factors that inhibit or facilitate organisational learning and adaptation on the part of a disaster operation system. Organisational learning and adaptation refer to an interactive collective process of change that occurs by correcting errors and anomalies, in response to altered conditions, through information processing and improved collective knowledge and understanding. The research draws on organisational, technical and cultural capacity to determine whether individual response systems engage in inter-organisational learning and adaptation during seismic response operations. Various sub-factors are employed to measure organisational, technical and cultural capacities, as shown in Table 1. A semi-structured interview questionnaire was put together to explore these variables. The paper does not present all frequencies and percentages for these sub-factors. Instead, important figures and statistically significant results are presented in tables and stated in the text.

Interviews and content analyses were the main data sources for the information on the sub-factors listed in Table 1. Eighty-one semi-structured interviews were conducted between 5 October and 20 December 2002 to identify the organisational, technical and cultural characteristics of the Turkish disaster management system. Responses, therefore, were based on the retrospective evaluations of interviewers. The semi-structured interview questionnaire contained some questions that allowed an interviewee to provide multiple responses, meaning that he/she could choose more then one answer. A daily Turkish newspaper, *Cumhuriyet,* also featured in content analyses: news reports that appeared for 21 days after each earthquake were examined. Official reports, the reports of international and domestic organisations, post-disaster situation reports by participating organisations and previous on-site observations were used to corroborate interviews and the content analyses of news reports. The research used Analysis of Variance (ANOVA) and the Tukey Multiple Comparison Method to measure the statistical significance of change between five seismic response operations.

The identification of key actors was important to this study. The unit of observation is the public and non-profit managers and researchers who played important roles in the response to the five earthquakes. We pinpointed major public actors (central,

Table 1
Sub-factors that explain organisational, technical and cultural capacities

Organisational capacity	Technical capacity	Cultural capacity
Organisation and coordination	Information infrastructure	Ability to learn from experience
Emergency planning	Emergency management centres and resources	Ability to learn and adapt during response operations
Professional personnel and reserves	Implementation of earthquake codes	–
Emergency communication	–	–

provincial, district and municipal, as well as non-profit) that satisfied selection criteria upon examination of available official and private reports, post-disaster critiques, news reports (through content analyses), website pages and the Disaster Law and Regulations (Afet Isleri Genel Mudurlugu, 1998). These actors can be classified as formal and informal. Formal actors are ones that are assigned roles in response and recovery by Disaster Law Number 7269 and Regulation Numbers 12777/1988 and 8716/1996. Informal actors are the public and non-profit organisations that were not specified in the Disaster Law and Regulations but were actively involved in response and recovery operations. Selecting a sample from among these actors based on the principles of stratified sampling design was vital for data collection (Singleton and Stratis, 1999). Stratified sampling design contributed to the validity of the results and saved research time and money. We conducted interviews with two groups of organisations:

- public organisations that were responsible for, or played an active part in, disaster response and recovery; and
- non-profit and expert organisations that actively participated in response operations or did research in the field.

The criterion employed to select from among the non-profits was active involvement in response operations. The criteria used to choose expert organisations included the extent of research carried out and their involvement in the five earthquake response operations. Table 2 lists the primary responsibility of organisations interviewed.

Of 81 respondents, 11 (14 per cent) responded to the Erzincan earthquake, 12 (15 per cent) responded to the Dinar[1] earthquake, 14 (17 per cent) responded to Ceyhan[2]

Table 2

Primary responsibility of organisations during the response operation

Primary responsibility	Number	Percentage
Seismic risk monitoring and reduction	8.0	9.9
Crisis organisation and coordination	18.0	22.2
Health and medical services	7.0	8.8
Public safety	7.0	8.6
Communication	7.0	8.6
Academic research	15.0	18.5
Search and rescue	6.0	7.4
Mass care	3.0	3.7
Other: multiple functions in accordance with emerging needs*	10.0	12.3
Total	**81.0**	**100.0**

Note: * Most of these organisations were local municipal public agencies.

Source: interviews, 5 October–20 December 2002.

earthquake, 24 (30 per cent) responded to the Marmara earthquake and 20 (25 per cent) responded to the Duzce earthquake.[3]

The study methodology also had its limitations. First, since we used stratified sampling to select the communities and organisations, the research did not include all stricken cities and response organisations, because of time and cost restrictions. Second, the interviewees came with their own biases. Their opinions may have been affected by these preconceptions as well as by poor recall and imprecise expression of memories. Third, the position of managers in public agencies, their involvement in previous response operations and the reputation of disaster organisations might have affected responses. Fourth, the content analyses were based on a daily newspaper, yet the news coverage of each earthquake could not possibly encompass all interactions that took place among actors. However, the research design minimised the threats to the validity and reliability of findings by drawing on multiple sources of evidence.

Context of the cases

The five earthquakes took place between 1992 and 1999 and reached 5.9 or more on the Richter scale (Table 3). Almost all were unexpected and found local communities virtually unprepared. The earthquakes claimed the lives of 19,126 people,[4] injured 53,931 others and caused damage of more than USD 20 billion (approximately nine per cent of Turkey's budget). The earthquakes disrupted communications, power and water systems, and left public personnel and citizens traumatised. Fires significantly increased the number of deaths in Duzce in 1999 and almost ignited a major refinery in Izmit.

The Dinar earthquake hit the district centre, Dinar city. Both Dinar city and nearby Kaynasli city suffered heavy damage. The Ceyhan earthquake hit the district centre

Table 3
Destructive earthquakes in Turkey (1992–99) and their impacts

Earthquake	Date	Magnitude	Deaths	Housing units damaged	Housing units collapsed or razed	Estimated cost in USD billion
Erzincan	13 March 1992	6.8	645	8,000	1,450	0.75
Dinar	1 October 1995	6.1	100	6,500	2,043	0.25
Ceyhan	27 June 1998	5.9	150	21,000	2,000	0.5
Marmara	17 August 1999	7.4	>18,000	320,000	26,000	>20
Duzce	12 November 1999	7.2	812	10,100	800	1
Total			**>19,707**	**365,600**	**32,293**	**>22.5**

Source: Gulkan (2002); Bagci et al. (2000); Erzincan Valiligi (1993, pp. 47–49); Adana Valiligi (1998); Dinar Ilcesi (1996, pp. 16, 35).

of Ceyhan, Ceyhan city, and caused considerable damage in the province centre of Adana.[5] The Erzincan earthquake primarily affected the province centre of Erzincan. The Marmara earthquake, though, produced a regional disaster, impacting heavily on Avcilar (Istanbul), Kocaeli, Sakarya, Yalova, and Bolu provinces—a region that geographically lies between Istanbul and Ankara provinces.

During the response operations, central and local authorities focused first on rescue and medical aid, while attempting to restore power and communications and provide security, second on removing debris and assisting victims, and third on reconstruction or repairs to damaged property and facilities. The National Emergency Plan (Regulation 12777/1998) identified some 12 ministries as well as the Turkish Armed Forces and the Turkish Red Crescent Society as key national actors. Nine service groups and a district/province coordination committee (rescue and relief committees in the first two earthquakes and crisis management centres in the last three) were supposed to serve the local communities by doing the things listed above.

Findings

The content analysis conducted for each earthquake (Table 4) identified the domestic and international public, non-profit and private organisations involved in the response to all five earthquakes. Response and recovery operations in Marmara involved the highest number of organisations: 314. As for the others, 183 organisations participated in Duzce, 106 in Erzincan, 92 in Dinar and 70 in Ceyhan.

With regard to domestic public organisations, the number of central and province organisations exceeded the number of district and municipal organisations. The total number of domestic public organisations was 179 in Marmara, 120 in Duzce, 71 in Erzincan, 57 in Ceyhan and 53 in Dinar. Diversity and varying but generally increasing numbers of organisations from one earthquake to the next made the response and recovery operations more complex. More organisations from different jurisdictions and sectors with different organisational cultures and work methods had to work together.

Table 4
Type and number of domestic and international organisations involved in disaster response operations

Earthquake	Public	Non-profit	Private	Total
Erzincan	88	11	7	106
Dinar	71	21	_	92
Ceyhan	59	7	4	70
Marmara	179	49	86	314
Duzce	153	23	7	183

Sources: *Cumhuriyet* news reports and interviews, 5 October–20 December 2002.

Table 5
Type and number of domestic public organisations involved in response and recovery operations

Earthquake	Central	Province	District	Municipal	Total
Erzincan	38	26	3	4	71
Dinar	28	13	8	4	53
Adana	28	16	8	5	57
Marmara	88	56	16	19	179
Duzce	51	47	9	13	120

Sources: *Cumhuriyet* news reports and interviews, 5 October–20 December 2002.

The rise in the number of participating organisations resulted in more resources being made available to affected communities. However, it inhibited inter-sectoral and inter-organisational coordination.

Organisational capacity

This section reviews inter-organisational coordination, emergency planning, professional personnel and reserves, and emergency communication vis-à-vis the five earthquake response systems.

Inter-organisational coordination

Despite changes to increase the effectiveness of the formal disaster response system, the existing organisational structure inhibited inter-organisational coordination in response to all five earthquakes. The formal structure mostly ignored the non-profit sector and did not pay significant attention to the neighbouring provinces and municipalities that contributed to the response and recovery operations. The root of the problem was the use of linear public policies to address a complex policy issue. Change essentially occurred by introducing new linear strategies, without altering governing values. Nevertheless, this 'single loop' learning process repeatedly failed to create a dynamic disaster response system for complex disaster environments. Hiring rescue professionals after the Erzincan earthquake of 1992 and shifting responsibility from the Ministry of Public Works and Settlement to the Prime Ministry Crisis Management Centre for response and recovery operations in 1997 (after the Dinar earthquake) are examples of such linear strategy modifications.

The central government perceived coordination as a post-disaster event (Balamir, 1999). The commissions responsible for central-level coordination of national ministries, the Turkish Armed Forces and the Turkish Red Crescent Society in regular times were not more than proposed entities (Ergunay, 1999). The disaster organisations in the provinces and districts generally existed on paper and were activated following disasters until the 1999 Marmara earthquake.[6] Even if the size of their populations

was considerably high, communities such as Derince and Degirmendere, which did not enjoy district or province status, lacked even a formal disaster response system before the 1999 earthquake.

Responding to major earthquakes requires the integration of critical organisations from different public jurisdictions and the non-profit sector. Although the coordination of response and recovery operations improved considerably in Ceyhan, this was due to various exceptional factors, including the limited damage caused by the earthquake to the information infrastructure and human resources, the role of the provincial leadership and the involvement of Turkish amateur radio operators.

The Marmara earthquake was a turning point, changing the nature of the response to the 1999 Duzce earthquake. The central government established a temporary Regional Coordinator Governorate to allocate resources among Bolu, Kocaeli, Sakarya and Yalova provinces. Individual and organisational learning along with increased interaction among the stricken communities facilitated a shift in organisational coordination during the Duzce response operations. Table 6 outlines interviewee responses on the level of timely inter-governmental coordinated action.

Seventy per cent of respondents asserted that the level of coordination was great or good in Duzce. By contrast, no respondent identified the level of coordination as great or good in Erzincan in 1992, and only 16.7, 28.6 and 4.3 per cent of respondents in Dinar, Ceyhan and Marmara, respectively, said that the level of coordination was good. The analysis of the data for all five earthquakes supports a pattern of positive change from the Marmara to the Duzce earthquake. The ANOVA presents produces

Table 6
Inter-organisational coordination

To what extent were public organisations operating at the central, provincial and local level coordinated to ensure timely collective action after the earthquake?						
	Erzincan	Dinar	Ceyhan	Marmara	Duzce	All earthquakes
	No./%	No./%	No./%	No./%	No./%	No./%
To a great extent	0/0	0/0	0/0	0/0	2/10	2/2.5
To a good extent	0/0	2/16.7	4/28.6	1/4.3	12/60	19/23.8
To some extent	6/55	4/33.3	7/50	1/4.4	5/25	23/28.7
Not to any extent	5/45	6/50	3/21.4	13/56.5	1/5	28/35
Not at all	0/0	0/0	0/0	8/34.8	0/0	8/10
Other	0/0	0/0	0/0	0/0	0/0	0/0
Total responses	**11/100**	**12/100**	**14/100**	**23/100**	**20/100**	**80/100**

Note: results of ANOVA analysis: F-Statistic=21.473; P-Value=0.000.

Source: interviews, 5 October–20 December 2002.

a significant F-statistic value (F=21.473 and P-Value=0.000 at a five per cent significance level. The Tukey Multiple Comparison Method indicates that interviewees perceived the level of coordination during the Duzce operation significantly different from that during the Erzincan, Dinar and Marmara operations. Although coordination was viewed as better in Duzce than in Ceyhan, the difference is statistically significant only at a six per cent significance level.

When interviewees were asked about the factors that facilitated an inter-organisational response, 81 informants, through their multiple responses, identified the following factors:

- a new organisational design that helps to enable coordination and collaboration (21 per cent);
- qualified personnel (14 per cent);
- the capacity of response units (11 per cent);
- realistic contingency planning (13 per cent);
- the existence of volunteer emergency organisations (nine per cent);
- a shift in focus to pre-disaster policies (nine per cent);
- decentralisation of administration (eight per cent);
- regulation of transportation after the earthquake (five per cent);
- timely information (five per cent); and
- a change-oriented organisational culture (five per cent).

Emergency planning

Turkey's Disaster Law introduced emergency planning in 1958 and disaster regulation provided for a National Emergency Plan that was introduced in 1988 (Afet Isleri Genel Mudurlugu, 1998). As required by Disaster Law Number 7269 and Regulation Number 12777, province and district administrations drafted their own emergency plans to coordinate local response operations. Regrettably, these plans did not consider the complexity of disaster environments. Internal audits and satisfaction of the legal requirement rather than minimisation of seismic risk were the source of motivation in planning for the first four earthquakes.[7] This perception started to alter by the Marmara earthquake, but the change was not reflected in the district emergency plan in place at the time of the Duzce earthquake.[8]

Significant difficulties were encountered in implementing the emergency plans in the cases of the Erzincan, Dinar, Ceyhan and Marmara earthquakes. Although the respondents had a better view of implementation vis-à-vis the Duzce earthquake, the reason was not really to do with the plans per se, but rather with the implementers, who learned when, what and how to do things during the Marmara response and recovery operation. Interviewee responses revealed the difference between the Duzce response and recovery operation and previous efforts: nine per cent of respondents in Erzincan, 8.3 per cent in Dinar, 28.6 per cent in Ceyhan and zero per cent in Marmara reported that emergency plans were implemented to a good or some extent, compared with 75 per cent of respondents in Duzce (Table 7). Both the ANOVA analysis and Tukey Multiple Comparison Method statistically supported a pattern of positive

Table 7
Implementation of emergency plans

To what extent was your organisation able to implement the National Emergency Plan and other disaster procedures immediately after the earthquake?						
	Erzincan	Dinar	Ceyhan	Marmara	Duzce	All earthquakes
	No./%	No./%	No./%	No./%	No./%	No./%
To a great extent	0/0	0/0	0/0	0/0	0/0	0/0
To a good extent	0/0	1/8.3	2/14.3	0/0	11/55	14/17.3
To some extent	1/9	0/0	2/14.3	0/0	4/20	7/8.6
Not to any extent	6/55	4/33	7/50	9/37.5	2/10	28/34.6
Not at all	4/36	6/50	3/21.4	15/62.5	3/15	31/38.3
Other	0/0	1/8.3	0/0	0/0	0/0	1/1.2
Total responses	**11/100**	**12/100**	**14/100**	**24/100**	**20/100**	**81/100**

Note: results of ANOVA analysis: F- Statistic=13.246; P-Value=0.000.

Source: interviews, 5 October–20 December 2002.

change in the Duzce seismic response operation. At a five per cent significance level, the Tukey Multiple Comparison Method indicated that interviewees perceived the implementation of emergency plans in Duzce very differently from in Erzincan, Dinar, Ceyhan and Marmara.

The multiple responses of 81 interviewees also pointed up the variables that were influential in the implementation of emergency plans:

- consideration of complexity (27 per cent);
- access to required information (16 per cent);
- traumatic effects of the earthquake on public personnel (16 per cent);
- competence of the responders (14 per cent);
- organisation of disaster management (nine per cent);
- learning from previous disasters (six per cent);
- sufficiency of emergency resources (five per cent);
- time of a disaster (four per cent); and
- scope of a disaster area (three per cent).

Professional personnel and reserves

The skills and number of professional public personnel were not at a satisfactory level before the first four earthquakes. Although the nation had available human resources and some investments had been made in training programmes, these efforts were not sufficient to develop reserves and ensure the presence of well-educated, trained public

personnel capable of operating effectively in Erzincan, Dinar, Ceyhan and Marmara.[9] The General Directorate of Civil Defence (GDCD) did not have any professional rescue staff before the Erzincan earthquake. By contrast, it deployed approximately 45 professionals in Dinar. The number increased to 110 with the establishment of additional centres in Erzincan and Istanbul before the Marmara earthquake. Military personnel, police officers and medical staff were experts in their fields but were not cross-trained for emergencies like earthquakes.[10] Similar problems existed with regard to heavy machinery operators, who also joined the rescue and recovery operations. The doctrine for employment of the equipment for emergency purposes was not completely developed or communicated to the public organisations that were accustomed to using the machines in regular times.

The Marmara earthquake of 1999 led to a significant change in the readiness of public personnel in Duzce and other stricken provinces. Public organisations learned through their members when and how to respond to an earthquake. Most public personnel who were involved in Marmara quickly moved to the cities of Duzce and Kaynasli. The Marmara earthquake also resulted in the creation of many volunteer and public rescue organisations. The non-profit search and rescue association, AKUT, became a leading model for the non-profit sector. Many of these newly established organisations responded to the Duzce earthquake.[11] When interviewees were asked about the existence of professional personnel and reserves during the Duzce operation, 44 per cent stated that they were available, while 28 per cent said that they were not. None of the respondents declared that professional personnel or reserves existed in any other past operation. Moreover, Tukey Multiple Comparison Method revealed that the level of professional personnel and reserves in Duzce had risen significantly compared to other seismic response operations.

Emergency communication

Difficulties associated with information search, exchange and distribution caused major problems in terms of coordination and adaptation in all five earthquakes. The local search and rescue committees or crisis management centres found it hard to coordinate public and non-profit organisations. As the communication capacity was extremely limited, there were not any inter-jurisdictional or inter-organisational databases to provide information on the characteristics of the earthquake area and local communities and on their needs during the first four earthquakes. The first inter-provincial intranet network established in the Marmara region after the Marmara earthquake helped in reallocating resources in response to the Duzce earthquake.[12]

The lack of noteworthy open information channels between the affected provinces and the central government along with chaotic traffic conditions interrupted the nation's contemporary information infrastructure during the Marmara earthquake. The limited information flow between medical emergency centres, rescue teams, police, military and volunteers significantly inhibited timely informed action, especially during the first three days of the Marmara earthquake (Comfort and Sungu, 2001). Authorities could not acquire site-specific information in order to send the right

type of aid to the correct locations (Gulkan, 2000). Without information on local infrastructure and on the various characteristics of local communities, it was hard to manage rescue efforts. Due to the absence of information sharing, the central government could not discern the impacts of the earthquakes and launched slow and uncoordinated responses.

While attempts to increase information capacity did not appreciably alter the country's information infrastructure, experience gained by local, regional and central organisations throughout the Marmara response, as well as their increasing understanding of the importance of information, resulted in faster and more coordinated responses.[13] Many public and non-profit organisations, including even broadcasting companies, quickly reacted to the needs of the cities of Duzce and Kaynasli. External assistance and swifter reallocation of modern communication means enhanced the information search, exchange and distribution initiatives of response organisations.

As the data indicate, the degree of openness of communication channels reached its zenith in Duzce. Three (30 per cent) respondents in Erzincan, four (40 per cent) in Dinar, four (29 per cent) in Ceyhan and one (four per cent) in Marmara reported that open communications existed, compared to 10 (58 per cent) respondents in Duzce. However, the transition in relation to information capacity was in its initial stages when the Duzce earthquake occurred. Despite the progress, the difference between the availability of communication channels in Duzce and other seismic operations was not significant, as indicated by ANOVA results (F-Statistic=1.458 and P-Value=0.226).

Technical capacity

Information infrastructure

Information infrastructure was one of the most important aspects of technical capacity that affected the success of responses to all five earthquakes. Of 75 respondents, 84 per cent stated that the information infrastructure significantly influenced rescue and relief efforts. Although the respondents kept highlighting information infrastructure as an important factor, this did not provoke necessary investments until the Marmara earthquake. All of the earthquakes disrupted telecommunications, because of damage and overload of telephone lines. According to the multiple responses of interviewees, the most used communication mean in the first three days after the earthquakes was the post-disaster special lines of Turk Telecom (29 per cent). Other means of communications were utilised during the response operations: two-way radio (23 per cent), face-to-face meetings (16 per cent), amateur radio (13.9 per cent), military communication channels (4.4 per cent), vehicles (6.8 per cent), cell phones (2.7 per cent), media (1.5 per cent), neighbour city communication channels (1.9 per cent) and megaphone (0.8 per cent). Mobile telephones could only be used sporadically for a short period after the Erzincan, Dinar, Ceyhan, and Marmara earthquakes. Two-way radios and amateur radio instruments were the most important communication devices for reaching neighbouring provinces and central government during all of the earthquakes. The military phone line was the only communication channel that allowed the civil authority to inform the President of Turkey about the Erzincan earthquake on the day that it occurred (Erzincan Valiligi, 1993).

The General Directorate of Disaster Affairs (GDDA) and the Kandilli Observatory and Earthquake Research Institute were the main sources of information, especially for central organisations and the neighbouring provinces that did not suffer a disruption in communication with the central government. The network of amateur radio operators, police radio and military communication channels (phone line and radio) comprised the available information technology tools that aided communication between local communities. Field observation attained its peak level during the Marmara response (41 per cent), while the use of technology reached its apex with respect to information search and distribution (50 per cent) during the Duzce operation. The lack of communication technologies encouraged organisations to draw on face-to-face meetings or vehicles for information search, exchange and distribution in all earthquakes. The police department had to use megaphones in Yalova to tell provincial directors to attend the emergency meeting after the Marmara earthquake. The television stations also contributed to communication between the stricken communities and the central government after the Marmara and Duzce earthquakes. Although the central government and some international organisations distributed satellite telephones after the Marmara earthquake, neither the provinces in the region nor Duzce Municipality could use them (Iridium telephones), because the company went out of business shortly before the earthquake.

Central government organisations utilised Geographic Information Systems (GIS), Global Positioning System (GPS) and space technology for different purposes. Unfortunately, these resources could not be harnessed to enable a quick reaction in any of the earthquake areas. The GDDA and the Kandilli Observatory and Earthquake Research Institute used seismic risk monitoring systems in all five earthquake zones. These organisations, though, could not correctly determine the magnitude of the Marmara earthquake (Comfort and Sungu, 2001). Additionally, the GDDA used a damage estimation model for all of the earthquakes. However, it was not developed for employment in a regional disaster like the Marmara earthquake. The GDDA used GPS in a limited fashion only to specify time and coordination information of earthquakes since the one in Ceyhan in 1998.[14]

Despite the limitations, improvements were made to the communication infrastructure in local communities following the Marmara earthquake. The Duzce Department of Health had a radio system installed. Response organisations were also more prepared and introduced radio systems, as in the case of the Istanbul Department of Health.[15] The rapid installation of emergency lines by Turk Telecom was essential for ensuring continuous communication among the crisis management centres. The Regional Coordinator Governorate set up an inter-provincial database to manage resources in the stricken communities after the Marmara earthquake. Although the network did not include Duzce at the time of its earthquake, it supported the reallocation of resources to aid Duzce. At the central level, the GDDA correctly informed the Prime Ministry Crisis Management Centre about the magnitude of the earthquake and possible damage in Duzce via the seismic risk monitoring network and damage estimation models, while the Turkish Armed Forces used helicopters immediately after the earthquake to assess damage in the regions (Comfort and Sungu, 2001).

The information infrastructure started to improve after the 1999 Marmara earthquake and many information technology projects targeting affected communities and the central government were continuing at the time of the Duzce earthquake. The multiple responses of 81 interviewees identified the factors capable of maintaining a constant information flow between organisations and jurisdictions:

- accurate information flow among public organisations and jurisdictions (30 per cent);
- use of advanced information technology (23 per cent);
- planning and coordination among public organisations and jurisdictions (15 per cent);
- a new organisational design for inter-organisational information flow (14 per cent);
- educating public personnel about emergency communication (11 per cent);
- coordination of information technology investments by different public organisations (three per cent); and
- psychological measures to avoid deliberate interruption of communication by depressed personnel (one per cent).

A small proportion of respondents (three per cent) perceived communication as a secondary issue and recommended more emphasis on mitigation efforts.

Emergency operation centre and resources

The stricken communities, except Istanbul, did not have an emergency operation centre before the Marmara earthquake.[16] The latter taught Duzce District the importance of having an emergency management centre to coordinate public organisations. Shortly after the Duzce earthquake, the district manager set up an emergency management centre in the front yard of a public building and later converted the flagpole into an antenna for use by amateur radio operators.[17] Local communities generally did not invest in rescue equipment prior to the first four earthquakes.

Public and private medical supplies existed in districts and provinces for use in daily operations, yet there was no significant preparation for an emergency among local communities. The Dinar Department of Health reorganised available internal resources following early minor earthquakes, but its effort failed to attract the support of the province government.[18] Duzce District was also able to draw on some supplies and equipment left over from previous operations. However, it was the neighbouring provinces and the central government that brought in sufficient quantities of medical supplies, equipment and heavy machinery for the response and recovery operations.

Implementation of earthquake codes

Turkey's earthquake construction code[19] came into existence in 1945 and was revised in 1975 and 1998 in response to new seismologic findings. The code, though, was generally not observed in building construction before the five earthquakes (Duzce, Marmara, Ceyhan, Dinar and Erzincan) (Ulusal Deprem Konseyi, 2002; Youd, Bardet and Bray, 1999; Erdik, 2000). Similar to the implementation of construction codes,

most land use decisions did not comply with the Development Law (Balamir, 2002; Youd, Bardet and Bray, 1999). Although the Development Law required a geological evaluation of an individual construction site, it left the survey and the assessment of soil to the investing parties, the contractors, who did not implement this provision in most places (Balamir, 1999). While micro zoning in local communities could not take place, the central government and provinces did not seriously consider the fault lines in construction projects. According to the General Directorate of Mineral Research and Exploration, the land use decisions with regard to highways, railways and other transportation routes did not seriously consider seismic risk (Emre and Duman, 1999). The Marmara earthquake led to a change in organisational mental models regarding the implementation of the earthquake code. However, this could be reflected on only after the Duzce earthquake. While there was greater willingness to implement the earthquake code after the Marmara earthquake, the Duzce earthquake occurred three months after the one in Marmara. The effects of the change could be better observed, therefore, following the Duzce earthquake.

Identification of major vulnerable facilities was also not a common practice of provincial or district administrations. This research did not find any significant evidence of such a move before the Erzincan, Dinar, Ceyhan and Marmara earthquakes. The Ministry of Public Works and Settlement initiated the identification process after each earthquake for the purposes of damage estimation and reimbursement. The case of the Duzce earthquake was somewhat different from that of previous earthquakes. The Ministry of Public Works and Settlement had already examined the building stock to appraise damage caused by the Marmara earthquake. Temporary housing and tents had replaced many residencies and public offices. This situation significantly decreased the number of deaths and the level of trauma among public personnel in Duzce. Fifty-nine per cent of respondents stated that major vulnerable facilities were identified before the Duzce earthquake, while zero per cent of respondents in Erzincan, Dinar and Ceyhan and only five per cent in Marmara said that the identification process was in place. ANOVA and the Tukey Multiple Comparison Method at a five per cent significance level produced statistically important results that indicated progress in identification of major vulnerable facilities to seismic risk before the Duzce earthquake.

Cultural capacity

This section compares, contrasts and evaluates the cultural capacity of the seismic response operations in Erzincan, Dinar, Ceyhan, Marmara and Duzce. It also examines organisational learning and adaptation after the Marmara earthquake.

Learning from experience

Seismic risk is a well-known threat to lives and property in most local communities in Turkey. From 1903–98, there were 131 destructive earthquakes, and most of the affected provinces had suffered earthquakes in the past. Previous earthquakes aside,

did Turkish disaster management learn from the earthquakes between 1992 and 1999? This research reveals that there was not any significant level of organisational learning within Turkish disaster management as a result of the Erzincan (1992), Dinar (1995) and Ceyhan (1998) earthquakes. There were attempts to address organisational problems, but these were limited to changing the strategies rather than the governing values of Turkish disaster management. These limited strategy changes can be described as 'single loop' learning, since they ignored core issues until the Marmara earthquake. Contrary to the assumptions of Disaster Law 7269 and Regulation 12777, the provinces and districts did not have sufficient capacity and commitment to reduce seismic risk. The Erzincan, Dinar and Marmara earthquakes caused chaos among the public personnel who were supposed to respond to these events. All five earthquakes disrupted regular communication channels, significantly inhibiting inter-organisational coordination and adaptation, and the reallocation of resources from different jurisdictions and sectors. The Marmara earthquake was a 'symmetry-breaking' event. It certainly changed the level of commitment not only in Duzce but also in other stricken communities and in central government.

Learning and self-adaptation during response operations

The cultural characteristics of the first four response operations pointed to a low level of cultural openness to change. Although the Duzce earthquake occurred nearly three months after the Marmara earthquake, the response and recovery operations indicated a shift in cultural characteristics. The local communities failed to search for continuous, accurate and relevant information on the Erzincan, Dinar, Ceyhan and Marmara earthquakes, and the provincial administration did not seriously assess the shocks before the Dinar earthquake. However, the Marmara earthquake was a turning point. Information search projects were completed and continued in Duzce and other affected communities after the Marmara earthquake, taking the form of regional intranet, GIS and analysis of seismic risk. Outside help and swifter reallocation of contemporary communication means in the region also enhanced information search, exchange and distribution among response organisations.

The difficulty of information sharing led to a lack of inter-organisational collaboration between the central government and provincial/district organisations during all of the response and recovery operations. This was due to the different work methods of the military (Turkish Armed Forces) and civil authorities after the Marmara and Duzce earthquakes (Kara Kuvvetleri Komutanligi Egitim ve Doktrin Komutanligi, 2000). Respondents also reported difficulties in collaborating with municipal organisations in Ceyhan and Dinar and with non-profit organisations in Marmara and Duzce. The most important problems highlighted by respondents were getting necessary support on time, willingness to collaborate and lack of trust.

The criteria for resolving the conflict between implementation of organisational policies and organisational goals and values were good indicators of organisational openness to change. The criteria employed by the response organisations in the five earthquakes were different and depended on whether the conflict was addressed during

the response operations or in regular times. Only a small number of organisations took the initiative by ranking organisational goals and values over traditional policies in regular times. Most organisations chose to acknowledge higher authority in finding solutions in Dinar, Ceyhan, Marmara and Duzce. Respondents were split equally with respect to informing a higher authority and following organisational policies in Erzincan. The majority of respondents said that they took action compatible with organisational goals and values during all five emergency operations. Many managers who received information on the Duzce earthquake immediately responded to the disaster without waiting for a direct order from the Prime Ministry Crisis Management Centre or an official request from local communities. The Sakarya Deputy Governor, for example, went to a logistic support centre straight away. The door was locked, because the working day was already over. He ordered his staff to break the lock. After loading the aid materials, he went to Duzce.[20]

Conclusion

Seismic risk poses a constant and significant threat to the lives and property of the members of most local communities in Turkey. Despite continuous and high seismic activity, attempts to decrease the vulnerability of local communities were insufficient until the 1999 Marmara earthquake, the driving force behind the evolution of the Turkish disaster response system.

Turkish disaster management did not question the governing assumptions of the emergency response system until the Marmara earthquake. Changes made after the Erzincan (1992), Dinar (1995) and Ceyhan (1998) earthquakes were limited to the introduction of linear strategies and therefore reflected 'single loop' learning. The failure of organisational learning prevented change in the initial organisational, technical and cultural conditions of the Erzincan, Dinar, Ceyhan, and Marmara response operations. However, the Marmara earthquake facilitated a pattern of 'double loop' learning, which led to the amendment of the governing assumptions of the disaster response system.

Modification of the initial organisational, technical and cultural conditions increased the capacity of Turkish disaster management with regard to self-adaptation at the time of the Duzce earthquake. Although the local community in Duzce District and Marmara region was entering a transition period, organisations and communities were already aware of the dangers associated with high seismic risk and of the importance of timely information search, exchange and distribution, and were experienced in what, when and how to do things in response to a major earthquake.

The information search, exchange and distribution capacities of each contemporary disaster system were essential for inter-organisational learning and adaptation during all response operations. The availability of valid and accurate information and its exchange between organisations and jurisdictions facilitated and prevented learning and adaptation to ensure a timely and coordinated inter-governmental seismic response. Interviews with managers from public and non-profit organisations also revealed that a change-oriented culture and leadership, the transformation of contemporary bureaucracy into

a learning organisation and the existence of a mitigation culture could help to promote necessary amendments to initial conditions. These changes in turn affected organisational learning and the performance of the disaster response system.

Inter-organisational learning and adaptation are important policy challenges that go beyond disaster affairs and are significant issues in the realm of organisational dynamics. Dynamic relationships between organisations from different sectors and jurisdictions make these intricate adaptive and learning approaches relevant to policy actors that are also operating in complex and uncertain environments.

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Endnotes

1 Dinar was a district of Afyon province at the time of the Dinar earthquake.

2 Ceyhan was a district of Adana province at the time of the Ceyhan earthquake.

3 Duzce was a district of Bolu province at the time of the Duzce earthquake.

4 Private sources report a higher number of deaths.

5 Provinces are divided into districts under the Turkish administrative system. Each district has a central city and villages. Villages do not have municipalities. While remaining in the district system, a village can gain municipality status after satisfying certain demographic criteria.

6 Interviews with representatives of the General Directorate of Disaster Affairs (GDDA), 5 October–20 December 2002.

7 Interviews with representatives of the GDDA and the Interior Ministry, Middle East Technical University, 5 October–20 December 2002.

8 Interviews with representatives of Duzce Municipality and the Duzce police department, 5 October–20 December 2002.

9 Interviews with representatives of the General Directorate of Civil Defence, 5 October–20 December 2002.

10 Interviews with representatives of the Prime Ministry Crisis Management Centre, 5 October–20 December 2002.

11 Interviews with representatives of AKUT, 5 October–20 December 2002.

[12] Interviews with representatives of the Marmara Regions Coordinating Governorate, 5 October–20 December 2002.
[13] Interviews with representatives of Duzce District and the Turkish Radio Amateurs Club, 5 October–20 December 2002.
[14] Interviews with representatives of the GDDA, 5 October–20 December 2002.
[15] Interviews with representatives of the Duzce Department of Health, 5 October–20 December 2002.
[16] Interviews with representatives of the Prime Ministry Crisis Management Centre, 5 October–20 December 2002.
[17] Interviews with representatives of Duzce District, 5 October–20 December 2002.
[18] Interviews with representatives of Afyon Department of Health, 5 October–20 December 2002.
[19] Building Construction Regulation in Earthquake Areas, known today as Specifications of Structures to be Built in Disaster Areas.
[20] Interviews with representatives of Sakarya Province, 5 October–20 December 2002.

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