GIS-based Decision-Support System Applications in Disaster Management

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ABSTRACT

Effective decision-making mechanism in disaster management requires new tools such as geographic information system (GIS). This study examines how to use GIS tools in disaster management organizations and do they have GIS-based decision support system. Furthermore it investigates whether organizations can collaborate with other organizations and what are the challenges during the crisis or disaster events. We found that respondents in the survey indicated that all of their organization related to disaster management in Marmara region in Turkey use GIS and they strongly agree that their organization has a disaster and emergency response plan. They agree that emergency response is challenging because of criticality of the task itself and limited response time.

Limited time and time pressure is the two major challenges of disaster management because each planning action considered at the ordinary time. But in times of crisis, unplanned situations may occur. That's why disaster management needs to GIS-based emergency response planning and decision support system.

Key Words: *Disaster management, GIS, Decision Support System, recovery, mitigation, vulnerability, risk reduction*

JEL Classification: *M31*

INTRODUCTION

Disasters can be defined as threats to livelihood, properties, human settlements, and environment. Disasters result from natural events or technological/ human-caused reasons. The United Nations International Strategy for Disaster Reduction (UNISDR) defines disaster as "a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resource" (UNISDR, 2009:09). According to World Disasters Report (2015), 6.311 disasters occurred and 839.342 people were killed between the years 2005 to 2014. Total number of reported natural disasters was 3.809 and total number of reported technological disasters was 2.502. Totally 518 disasters which were the lowest number of this decade, were occurred in 2014. In this year, disasters killed 61.5 percent that is higher than the decade's average (55%) of people lived in Asia. In Africa, 18.4% of the total population was killed by disasters. This rate is higher than the average value of the continent, which was 6.4%, for the decade. Total amount of disaster is estimated damage was 1.622.036 million US dollars (WDR, 2015).

Dealing with disasters whether natural or human-caused is complex. Disaster risk reduction practices have been widely implemented by different actors

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including government agencies, private institutions, non-governmental organizations (NGO), and community members; and different levels including local, regional and global (Lee at al., 2011; Dwirahmadi, 2015). Their efforts focus on impacts of the disasters on human lives, responding and recovering from disasters (Gunes and Jacob, 2000). On the other hand, most countries have limited resources or do not have emergency management agencies to manage disasters. Disaster management consists of multiple well-known phases that are expressed as mitigation, preparedness, response and recovery. Traditional disaster management tools characterized by hierarchy and centralization remain weak against disasters becoming costlier and more devastating (Kapucu and Garayev, 2011). Over the past decade, significant trend has been growing in use of information communication technology (ICT) in all phases of disaster management.

Due to the disaster response is varied and also massive, there are several challenges for both individual and group decision-making. Although application of the new improves the speed and the quality of the response operations in disaster management, using of information and other technologies is challenge that requires permanent attention (Knuth, 1999; Comfort, 1999; Kapucu, 2006; Quarantelli, 1997). Based on experiences, in recent years, an increasing number of databases and new technologies have been building for disaster management (Kapucu, 2006). Thus, we first investigate whether organizations use geographic information system (GIS) and have appropriate data to disasters and emergency managements. Then we investigate how to use GIS tools emergency management organizations and do they have GIS-based decision support system. We examine whether organizations can collaborate with other organizations and what are the challenges during the crisis or disaster events. The following questions will be examined in this research:

1. Do organizations have disaster response plan?
2. Do they use GIS?
3. Do they use GIS as a priority tool?
4. What are the studies of Decision Support System (DSS)?
5. Do they have GIS-based collaboration and sustainability?
6. What are the difficulties of using GIS in disaster and emergency management?

To answer these questions, the literature on decision support system on disaster management and GIS-based decision support system was reviewed.

In this study, data comes from a survey done by agencies of disaster and emergency management in Marmara region of Turkey. Marmara region of Turkey was selected because it is one of the most at-risk regions for disasters and emergency events, especially earthquake and technological events, in Turkey. Furthermore, Marmara region needs to be accepted as having the leading disaster and emergency management system in Turkey because of being Turkey's industrial center and variety of industrial fields. This study focuses all metropolitan areas in Marmara region. These cities correspond to the great portion of the total population of Turkey. All cities of Marmara region have their own Disaster Centers which belongs to the governorship, and many NGO's are working in this field in Marmara

region. These various organizations can play important roles in pre-disaster, preparedness, disaster response, and post-disaster recovery (Hu and Kapucu, 2016; Kapucu and Grayev, 2012). According to the Turkey Disaster Response Plan promulgated January 3, 2014/ 28871 by official journal; Disaster Management Center is defined as operates center of response, work on a 24 hour, is equipped with uninterrupted, secure computing and communication systems, and has to serve SProvince Disaster Response Plan. The main idea of this plan is to organize disaster and emergency management against all-hazard in order to build disaster resilient society (TAMP, 2014;Hu and Kapucu, 2016).This provides a rich context for studying disaster management GIS and DSS. Findings of this study can provide practical suggestions that are useful to professionals in all regions of Turkey.

The purpose of this study is to describe the use of GIS in disaster and emergency management efforts for all phases of disaster management and overemphasizes GIS-based DSS to rapid and effective response for Marmara region of Turkey. The findings of this study may contribute to eliminate the deficiencies of GIS-based DSS in disaster and emergency management in Turkey. This study also provides practical recommendations how to develop preparation activities, how should be GIS database, how to use these databases and how should use technological resources during emergency or disaster events.

DECISION-MAKING IN DISASTER MANAGEMENT

Prime Ministry Disaster and Emergency Management Authority (AFAD) has the phases of Comprehensive Emergency Management System as follows;

- The preparatory or planning period. It includes policies and programs to mitigate the impact of all hazards,
- Preparedness period which includes training the organizational response and providing of adequate resources,
- Situation assessment to rapid response, critical resources allocation, command and control,
- Post-crisis response and long term recovery and processes of return before emergency

Each of the four phases has their own information requirements.

Mitigation is defined as preventing or minimizing the effects of the possible future emergencies or disasters. Mitigation is defined as preventing future emergencies or disaster minimizing their effects. It includes any activities that prevent an emergency, reduces the possibility of an emergency or reduces the damaging effects of inevitable emergencies. Mitigation activities take place before and after emergencies (NACSW, 2012).

Preparedness includes plans or preparations made to save lives and to help response and rescue operations. Preparedness activities take place before an emergency occurs.

Response includes actions taken to save lives and prevent further property damage in an emergency situation. The response put your preparedness plans into action. Response activities take place during an emergency.

Recovery includes actions taken to return to a normal or an even safer

situation following an emergency. Recovery activities take place after an emergency (FEMA, 2016). In this purpose, there are varieties of emergency and disaster management agencies, either formal or informal to serve planning during an emergency or disaster. This study examines how to use GIS and how to collaborate these agencies before and during disaster or emergency situation to make an effective decision.

GIS AND DSS IN DISASTER MANAGEMENT

UNISDR has strongly emphasized the importance of science and technology within disaster risk reduction. The Conference in 2016, UNISDR Science and Technology Conference on The Implementation of The Sendai Framework for Disaster Risk Reduction, held on support from Mexico, Korea, Turkey, Indonesia, Australia and other countries All organizations working on disaster risk reduction were invited to the conference. The conference stressed that national governments ought to support all application of science and technology regarding decision-making with disaster risk reduction (Kim, at al., 2016).

At first, it is important to understand what are the GIS and DSS for disaster management to better figure out of the GIS-based DSS in disaster management. In this section of the article, the uses of information technologies (IT) and the DSS to disaster management are described. Then it focuses on inter-agency coordination problems in disaster management. Over last decades, it has become important to manage disasters with using new technologies against increased severity of human-made and natural disasters (Kapucu and Garayev, 2011). Information technology, or IT as a concept more commonly used today, is defined as a digital storing and all kinds of hardware and software technology used for processing and transport of information (Arda, 2013, Drabek &Hoetmer, 1991). Information technologies are not only used to gather data but also to share information and resources and to take collaboration (Hu and Kapucu, 2016).Throughout history, humans have had to deal with both natural and technological sudden events which threatening life and human activities.

Governments taking into account urban risks attempt to "manage" the impact of these events and prevent or at least mitigate. Information technology such as GIS, remote sensing, wireless technology can play growing role in this effort (Wallace and Balogh, 1985). Using of the information technologies is available during all phases of disaster management and it can be classified into five broad areas. These are; advanced computing, GIS, remote sensing, expert systems, the internet and wireless technology (Cutter, at al., 2007). One of them GIS is a system that builds it possible to examine data from various sources at the same time considering the relationships between each other. GIS techniques are considered as reliable resources in terms of damage reduction, and easy and fast use. GIS data, as utilized in computer applications, is essential component in dealing with many kinds of emergencies (Walker, 1997). The reasons for using GIS in disaster management can be summarized as follows controlling destruction, reducing effects of a disaster, protecting lives and resources (Demirci and Karakuyu, 2014; Greene, 2002; Yomralıoğlu, 2000; Bilir, 2009).

To rapid effective response to disasters, real-time information, defined as a data comes from diverse communication channels and agencies engage disaster response, gathered from different channels is very important. Therefore, varies information technologies such as geographical information system (GIS) have been utilized to help institutions or decision-makers in disaster management. As one of the most important technologies of IT, GIS can be a valuable tool for analysis purposes throughout each cycle of disaster management (Hu and Kapucu, 2016; Gunes and Kovel, 2000; Cutter at al. 2007). Most of today's research has focused on how to use information technology especially GIS and how to use GIS for decision-making with disaster management. In a study, Assilzadeh and Mansor, (2016) indicated that local government institutions need to build up their capacities such as infrastructures, detailed databases in order to meet the rising demands in disaster management. (Assilzadeh and Mansor, 2016). For this reason, GIS-based disaster management are going to become a feature of hazard risk management procedures of local governments.

GIS technology can be used for natural hazard especially flood and earthquake assessments to show where hazardous are likely to occur at a national or local level of planning. This also enables planners to assess the risk posed by natural hazards combined with information on natural resources, population, and infrastructure can and to identify critical elements in high-risk areas. (OAS, 1991). GIS is also widely used for flood damage assessments to reduce damage and to protect people from the flood. Researchers and practitioners of disaster management have significant attention regarding vulnerability assessment both before and after disasters since devastating natural disasters occurred highly populated urban areas in the world, and a huge amount of human, structural, and socioeconomic losses were brought because of these disasters. In this respect, advanced technologies such as notably remote sensing and GIS, have become significant new tools in disaster management (Yamazaki, 2001).

GIS can be used in several fields. Some of them are used as a planning tool related to risk decision-making in natural hazards, regional flood frequency analysis, or using of Rural-Urban Environments (Danielle at al., 2001; Altan at al., 2001; Chan at al., 2001), others are to resource and asset management. According to using fields in GIS is clearly seen as a DSS tool. Although, GIS data or geographic data play an essential role in many aspects of DSS for disaster response (Walker, 1997), the lack of systematization and standardization of data collection is a major weakness when it comes to long-term planning. Disaster management personnel need accurate information quickly and in the right form to make the right decisions and they need plans to anticipate contingencies, assess developments, and effective response and recovery operations (Gunes and Kovel, 2000). Decision support systems (DSS) are defined variously by practitioners and researchers. A DSS is defined as a computer-based interactive system that supports decision makers and focuses on the effectiveness (Eom, at al., 1998). In other words, DSS is an information system and relief for disaster and emergency management and it is an intelligent system to help planning activities. It is used to damage assessment,

thematic hazards maps, propose solutions, early warning, decision support, risk prediction, and situational analysis (Assilzadeh and Mansor, 2016).

For disaster management, DSS can be considered a technology that is designed to complement the cognitive processes of humans in their decision making. According to Wallace and Balogh (1985), essential components of DSS occurred from a data bank which contains information about a particular environment, a data analysis capability, normative models and technology for display and the integrative use of the data and model. The DSS interacts with two external elements: the disaster manager and the disaster response environment. DSS as a new technology or as a part of the evolution of management information systems has to design to following situations:

- Supply support to decision makers and their stake- holders;
- The users have more familiar with the technology
- Become more interactive and controllable;
- Acknowledge their non-routine, but consequential use (Wallace and Balogh, 1985).

Due to the complexity of managing disaster (Comfort, 1999), it is crucial for participating organizations for effective decision-making process before the response (Kapucu and Garayev, 2011). For this reason, many organizations, institutions, and agencies which are related to disaster management use new developments to facilitate disaster response, on the other hand, many researchers have studied GIS-based DSS. One of them is Von Braun (1993) indicated that GIS is particularly useful for integrating modelling result in time and space, for assessing exposure and risk and for assisting remedial decision-making. Another example in literature is described by Cavallin and Floris (1995) raster-based GIS applied to ground-water pollution risk assessment. These studies show GIS-based DSS provides not only short term risk assessment but also long term risk management. A good model to long term risk management is provided integrative case study of GIS used erosion modelling and multi-criteria decision-making methods by Hickey and Jankowski (1997).

As stated previously, GIS-based disaster management has been widely addressed by scholars as a decision support system for long term applications in disaster management. Some of the scholars indicated that GIS technology can be effectively used planning for pre and post disaster management that involves predicting the area and time of a possible disaster and the impacts on human life, property, and environment. These literatures also presented a number of GIS-based disaster assessment models (Liyanage at al., 2013, Cheong at al., 2014; Hickey and Jankowski, 1997;Jefferson and Johannes, 2016).One study of Cavallin at al., (2011)showed that GIS techniques as a tool of decision support system achieved to reduce landslide risk in the Corvara in Badia test site besides mobile technologies.

The literature is not limited to GIS-based DSS. Much more studies such as collaborative decision-making in emergency or disaster management or communication technologies for emergency management emphasized GIS-based

DSS due to its contribution to increase response effectiveness and reduce casualties (Kapucu and Garayev, 2011; Hu and Kapucu, 2016)

GIS AND INTER-AGENCY COORDINATION USE IN DISASTER MANAGEMENT

The nature of disasters requires rapid and effective response with partners. Due to the disaster management is characterized by adversity and uncertainty, it is essential for organizations to have a fast thought and effective process (Kapucu and Garayev, 2011). Both natural and technological disasters are generally induced by chaos that results from an inadequate response. Coordination of agencies is addressed in the mitigation and preparedness phases of disaster management since disasters occur where environmental conditions change and the nature of emergencies is to be unpredictable. These can be classified communication and transportation infrastructure, monitoring and assessment tools and collaborative tools and services for information sharing (Abramson at al., 2006)

According to Kamensky et al (2004), "collaboration occurs when the people from different organizations produce something together thought joint effort, resources, and decision-making, and share ownership of the final product service" (p.8). Disaster Coordination Center of a city has to serve as the central coordination point for information and resources during a disaster. Partnerships and collaboration are essential component to operate this service efficiently and all stockholders have to work together for this common goal with all the facilities. According to Smith and Dowell (2000), the problem of inter-agency coordination lies in the interaction between the structure of this emerging disaster management system, and techniques of individual and team decision-making. Coordination can be defined as the resolution of interdependencies between the activities of different organizational units and it requires dynamic and distributed decision-making. The lack of coordination between the various agencies is a persistent problem in the management of response to natural or technological disasters. These agencies include not only the emergency services but also local and national government bodies, private sector organizations and volunteer groups and successful operations are often attributed to inter-agency coordination (Smith and Dowell, 2000).

The collaborative organization includes the capacity of either any one organization or stakeholder to the common goal. Also, it requires diversity of participants and long-term collaboration. Valid and on time information sharing is critical in emergency response operations to act effectively in disaster because it requires sharing and using information effectively. One result of the study determined in emergencies by Kapucu (2006) showes that utilization of information technologies (IT) is 30%. According to results, the organizations use IT to improve their organizational response capacity (Kapucu, 2006).

One of the major challenges is interoperability that requires the collaboration of many relevant institutions when a disaster occurred. It is a known fact that it is impossible to have in prospect a consolidated exclusive approach for institutions, collaboration produces stronger and more effective to deal with disasters (Kapucu, 2008; Kapucu, 2011). Indeed, most of systems such as GIS

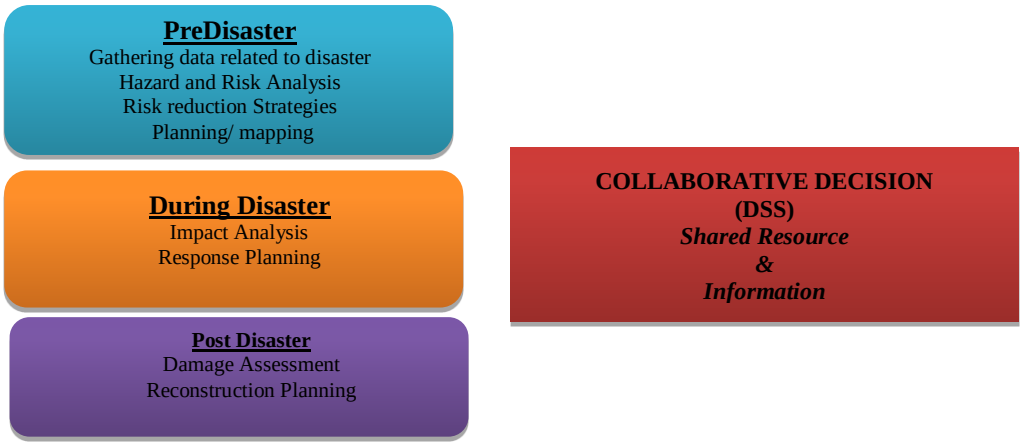
actually are designed to work together and that can be combined. But, the problem is different organizational cultures and preferences of people never worked together (Kapucu and Garayev, 2011; Kapucu, 2011). Some scholars analyzed disaster or emergency decision-making at the organizational level and focus on how they should approach decision-making during disaster (Quarantelli, 1997; Rosenthal &Kouzmin, 1997). Many studies and also literature generally focus on training, decision support systems and the other technologies that would improve decision-making in disaster or emergency (Crihton at al., 2000; Inzana at al., 1996; Lin &Su, 1998; Lindell at al., 2005; Wallace& De Balogh, 1985). All of these techniques purpose to improve organizational capacity and skills in order to reduce the negative impact of disasters.

CONCEPTUAL FRAMEWORK

Using GIS technology becoming accessible for local governments has adopted it in various ways. These are traffic and transit information provision, addressing and decision making According to Ganapati (2011), although there is much growth in adopting GIS for providing information, using of GIS in decision making has not increased a significant foothold yet (Ganpati, 2011).

A theoretical framework, as shown in Figure 1, was developed based on literature. The framework includes the basic factors affecting GIS-based decision support systems to before, during and after a disaster, emergency, or crisis.

Figure 1. Theoretical Framework of GIS-based Decision Support System (DSS)



Kaynak:(Kapucu and Garayev, 2011; Akbulut and Gerdan, 2016)

Using of GIS can be summarized to disaster management process.

- Before the disaster; locating areas which are at risk, determining regional disaster types, times and durations, determining the superstructures and infrastructures that might be affected, determining the facilities and needs areas (drinking water) that can be used during the disaster, and planning shelters and food sources,
- During the disaster; GIS provides location for managing the search and rescue and first aid activities after locating the disaster and the affected areas

(such determining demolished or damaged buildings or industrial establishments and roads),

- After the disaster; GIS can play an important part in damage assessment and planning needs (Akbulut and Gerdan, 2016; Sharma et al., 2016).

Collaborative Decision (DSS) involves several steps for disaster and emergency management. First step is for pre disaster includes collecting information and data related disaster, hazard and risk analysis, risk reduction strategies, planning and mapping, second is for during disaster includes impact analysis and response planning and the last is for post disaster includes damage assessment and reconstruction planning. All of them are part of planning model called Collaborative Decision (DSS). All these besides; DSS needs shared information and resource to make a best decision. And also experience of the disaster management is another important factor for decision makers.

METHOD

Surveys widely used are research methods to collect data (Marsden, 2011). The questionnaire of survey was developed based on a study of Hu and Kapucu (2016), a study of Kapucu and DeChurch (2009) and a study of Kapucu (2006). Prior to the survey, items were presented to instructors working in different disciplines and civil defense expert to get their expert opinion. Firstly, a pre-test was done for the survey to make sure the questionnaire of survey understood. Corrections were made after receiving their feedback. Between August and September of 2016, all set of data was collected by online from of all agencies responsible for emergency and disaster management Marmara region in Turkey; a total of 34 (11 provinces municipalities include district municipalities, 11 Provincial Directorate of disaster and emergency management called AFAD, 11 Directorate of Cadaster, and Istanbul Disaster Coordination Center that use GIS) agencies were invited to participate and most of these agencies responsible for disaster and emergency management in Marmara region in Turkey.

The survey was reminded participants 3 different times via auto e-mail message to in order to reach the number of targets. We have collected 87participants.This number is considered eligible by the experts working in this field (Büyüköztürk, 2002). A total of 81 were eligible for analysis after data cleaning.

There are 4 primary agencies listed in Table 1. Respondents were asked to identify among the list of agencies collaborate related to emergency management before, during and after emergency and disaster. Besides the using GIS as a decision making tools, IT utilization and the level of disaster preparedness were also collected. On a five-point Likert-type scale was used. Response options of survey ranging from ‘strongly disagree-1’ to ‘strongly agree-5’ with ‘neither agree nor disagree-3’ at the midpoint. Two open-ended questions related to using GIS were included. Statistics were run to provide a general understanding of GIS using, GIS capacity and GIS-based DSS in the emergency management in the regional level.

Table 1. The distribution of the institutions surveyed

Agenties	**Frequency**	**Percent (%)**
AFAD	10	12.3
MUNICIPALITIES	65	80.2
AKOM	1	1.2
TKGM	5	6.2
Total	**81**	**100.0**

As shows in Table 1, of the 4 different agencies surveyed, the great majority of agencies (80.2%) are municipalities, and only one (1.2%) is Istanbul Disaster Coordination Center (AKOM). The respondents include 15 (18.5%) directors of municipalities, AFAD, TKGM and AKOM (Table 2). 34.6% respondents are female and 65.4%are male. Distribution according to age groups is that under 29 age is 16%, 30-39 age is 50.6%, 40-49 age is %23.5 and up 50 is %9.9.

Table 2. Positions of respondents

	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Engineer	28	34.6	34.6	34.6
Architect	3	3.7	3.7	38.3
Technician	5	6.2	6.2	44.4
Manager	15	18.5	18.5	63.0
Data Preparation	2	2.5	2.5	65.4
Officer	12	14.8	14.8	80.2
Expert	5	6.2	6.2	86.4
Chef	8	9.9	9.9	96.3
Programmer	2	2.5	2.5	98.8
Other	1	1.2	1.2	100.0
Total	**81**	**100.0**	**100.0**	

SPSS 14.0 software was used to statistical analysis of the survey.

FINDINGS

In this section, findings were given the GIS-based decision support system in disaster management according to the research conducted in the Marmara region. The level of participation of respondents about their agencies disaster and emergency response plan is given at Table 3.

Table 3. Disaster and emergency response plan of agencies

	t	$\overline{X}$
Our organization has institutional disaster and emergency response plan	42.351	4.35802
Our organization has institutional crisis management team	38.944	4.24691
Gathering areas and other details were identified in disaster response plan	39.511	4.22222
Crisis management team has information about their responsibilities	31.056	3.92593
Crisis management team has training regarding the their missions	31.564	3.79012
The crisis management center is determined in the disaster response plan	36.486	4.12346
Our organization has a protocol with national mobile service providers to rapid response	20.727	3.11111
Our organization has enough technical and technological infrastructure to manage of disaster	25.739	3.50617

According to Table 3, the respondents strongly agree that their organization has a disaster and emergency response plan ($\overline{X} = 4.35802$), but they agree that their organization has a protocol with national mobile service providers to rapid response during the crisis ($\overline{X} = 3.11111$).The survey results indicate that % 100 of agencies participant in the survey at the Marmara regions use GIS and they collaborate with other organizations.Table4 is given that result of use of GIS in institutional level for disaster and emergency management.

Table 4. Using of GIS in institutional level

	N	$\overline{X}$
Use of IT	81	3.8519
Use of GIS	81	4.0741
Update of GIS data	81	3.7654
Relevance of GIS for Disaster and Emergency Management	81	3.6543
All crisis management officers are registered at GIS	81	3.1728
All the assets in the region are registered in GIS	81	3.4198
How to use the assets belonging to the region during disaster is determined in GIS	81	3.2593
Information on industrial institutions in the region is also registered at GIS	81	3.3210
Crisis centers information is also recorded in GIS	81	3.2963
Structural information and critical points are also recorded in GIS	81	3.2469

Table 4 shows that the thoughts of the respondents that their organization uses IT. Although respondents strongly agree of using GIS is high ($\overline{X} = 4.0741$) in their organization, they agree all crisis management officers are registered at GIS ($\overline{X} = 3.1728$). Also respondents agree that structural information and critical points are not recorded in GIS ($\overline{X} = 3.2469$) and agree the assets belonging to the region at the time of disaster is determined in GIS ($\overline{X}$ =3.2593).

The results of as a priority tool GIS are given at Table 5, the results of part of the research on the decision support system are given at Table 6 and the results of GIS-based collaboration and sustainability are given at Table 7.

Table 5. As a priority tool GIS

	PLANNING		**INVENTORY**		**URBAN SERVICES**		**DECISION SUPPORT**	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
MINIMUM PRIORITY	6	7.4	9	11,1	7	8.6	12	14.8
MEDIUM PRIORITY	11	13.6	21	25.9	14	17.3	14	17.3
PRIORITY	30	37.0	34	**42.0**	32	**39.5**	31	**38.3**
MOST PRIORITY	34	**42.0**	17	21.0	28	34.6	24	29.6
Total	**81**	**100.0**	**81**	**100.0**	**81**	**100,0**	**81**	**100.0**

Table 5 shows that the thoughts of the respondents that their organization uses the GIS most priority as a planning tool 42.0% (f=34) and 42.0% (f=34) respondents think that GIS uses priority as an inventory tool. Level of uses GIS as

an urban service tool is 39.5% (f=32). According to respondents, using GIS as a decision support tool is %38.3 (f=31).

Table 6. Studies of Decision Support System (DSS)

	N	$\overline{X}$
GIS-based damage estimation	81	2.9877
GIS-based impact analysis	81	2.8765
GIS-based emergency plan	81	3.1605
GIS-based rapid response system	81	3.0247
Our organization has a Decision Support System (DSS)	81	3.2716
Our organization has a GIS-based Decision Support System (DSS)	81	3.0864

The results show that the agreement of the respondents that their agencies have an agreement of the respondents Decision Support System (DSS) ($\overline{X}$ =3.2716) and GIS-based Decision Support System ($\overline{X}$ =3.0864), but not agree regarding it contains GIS-based damage assessment and impact analysis studies ($\overline{X}$ =2.9877, ($\overline{X}$ =2.8765)

Table 7. GIS-based collaboration and sustainability

	N	$\overline{X}$
Our organization has GIS-based cooperative studies	81	3.4074
Our organization develops short-run relationships with other organizations	81	4.0617
Our organization develops long-run relationships with other organizations	81	4.0988
Our organization uses GIS data with other organizations	81	3.2963
Our organization participate in common practices with other organizations	81	3.7778
Our organization sustains cooperation with other organizations except disaster or emergency situation	81	3.9630
Our organization still sustains cooperation with other organizations regarding the role of preparation and response to disasters and emergencies.	81	4.0988
Our organization sustains cooperation with other organizations during disaster or emergency	81	3.8642
Our organization makes some application like drill and meeting with other organizations except disasters and emergencies situation	81	3.8519
Inter-institutional relations which are related to disaster and emergency response activities are becoming official in time	81	4.0123

According to the Table 7, respondents indicated that they agree their organization develops long-run relationships with other organizations ($\overline{X}$ =4.0988) and their relations are becoming official in time ($\overline{X}$ =4.0123).

The result of challenges in using GIS in disaster and emergency management is shows in Table 8.

Table 8. Challenges in using GIS in disaster and emergency management

	N	$\overline{X}$
Emergency response is challenging because of criticality of the task itself and limited response time	81	4.0617
The GIS-based emergency response is challenging because it is connected to many functions	81	3.4321
The GIS-based emergency response is challenging because it requires keeping all the data up-to-date	81	3.6790
GIS-based emergency response is challenging because it requires cooperation and information sharing with other institutions	81	3.4198
GIS-based emergency response is challenging because it requires quick evaluation of the synchronicity of information from many different institutions	81	3.4815

Although GIS-based emergency response may be challenging ($\overline{X}$ =3.4321), participants generally agree that the emergency response is more challenging because of time limited ($\overline{X}$ =4.0617).

CONCLUSION AND DISCUSSION

This study examines the GIS based DSS and the role of IT to achieve effective decision-making goals. Disaster management requires multi organizational activities such as coordination and communication because of involving multiple actors (Kapucu, 2006). According to the result of a study conducted by Kapucu at al., 2010, local agencies are faster and more effective in responding to disasters. Therefore, it needs to improve local level capacity in response to disaster (Kapucu at al., 2010) and using GIS technology is an important part of improving local level capacity.

Effective disaster management systems need strategic plans. To achieve success, this system has to include disaster data and information management system and stakeholders such as decision makers and managers at national and local levels, professional bodies, financial institutions, NGOs and voluntary organizations should give prime importance this issue. Disaster management applications need to expand because local government institutions need to build up their capacities in order to meet the growing demands in the area of disaster management and provide to the participation of the range of stakeholders. National and local level institutions should be enhanced to assist and advise in formulating all phase of disaster management such as short and long-term disaster preparedness, mitigation, and prevention techniques. (Assilzadeh and Mansor, 2006).

This study is limited to municipalities and institutions which are related to disaster management in the Marmara region of Turkey. The level of use of GIS is the worth high due to the Non-governmental organizations (NGOs) was not participating in this work. Since all of municipalities have powerful budgets in Marmara, they generally use GIS-based applications. Due to the anticipated Marmara earthquake, these agencies are positively developing their attempts to use GIS-based decision support systems.

The agree level of the respondents about "our organization has a protocol with national mobile service providers to rapid response during the crisis ($\overline{X}$ ==3.1111)" is less agree then the others. This result can be interpreted as that the work to be done is not a sufficient level. However, in the event of a crisis, rapid access to information using mobile technologies is crucial to keeping losses and damage at a low level. Another important issue that needs to be improved is that the technical and technological infrastructure to manage of disaster since the agree level of the respondents is less than the other results ($\overline{X}$ =3.50617).

The agree level of respondents about "how to use the assets belonging to the region during disaster is determined in GIS ($\overline{X}$ =3.2593)" and "structural information and critical points are also recorded in GIS ($\overline{X}$ =3.2469)" are less than the others. However, it is very important to know how to use these assets for response during an emergency and disaster.

In the section on GIS-based collaboration and sustainability, the agreed level of respondents about "the organization use GIS data with other organization ($\overline{X}$ =3.2961)" is less. This result shows that it needs improving to since the common use of GIS data is necessary for decision makers to manage the process of the during the crisis.

Interesting results of the study is in the section of Decision Support System (DSS).Although respondents strongly agree about the use of GIS, the level of agree about GIS-based damage estimation and GIS-based impact analysis are less than middle level ($\overline{X}$ =2.9877, $\overline{X}$ = 2.8765).This result clearly indicates that the DSS is lacking in terms of disaster and emergency management and due to the anticipated Istanbul earthquake, these studies should be completed as soon as possible.

In this study, the respondents are actively use GIS in their organization in managerial position. They agree "emergency response is difficult because it has critical tasks and limited response time ($\overline{X}$ = 4.0617)" more than "GIS-based emergency response is difficult because it requires quick evaluation of the synchronicity of information from many different agencies ($\overline{X}$ = 3.4815)". Limited time and time pressure is the two major challenges of disaster management because each planning action considered at the ordinary time. But in times of crisis, unplanned situations may occur. That's why disaster management needs to GIS-based emergency response planning and decision support system. This system should be up-to-date and include cooperation with all of the agencies related to disaster management.

As emphasized in the theoretical framework, disaster management system for better operation needs the collaborative decision and the use of IT. In the other words the collaborative decision, sharing resource & information of institutions are necessary for all phases of disaster management. Pre-disaster activities such as gathering data, hazard and risk analysis, risk reduction strategies, planning/mapping are complex like during disaster and post-disaster activities and not carry out without IT, especially GIS, and institutional collaboration. The results of this study show that although institutions which are related to disaster use GIS, their cooperation is inadequate. The thought of responders is that the GIS-based emergency response is challenging because it is connected to many functions and they do not fully agree that their organization uses GIS data with other organizations. Responders agree that their DSS doesn't contain GIS-based damage assessment and impact analysis studies. Because these results do not provide the basic factors which include theoretical framework, it is difficult to mention a GIS-based decision support system in disaster management in the municipalities in which work is carried out.

In places where natural disasters like earthquakes cause great damage like Turkey developing technologies to manage of disasters should be utilized at the top level and the necessity of maintaining cooperation between institutions should not be forgotten. This study only focuses on GIS-based Decision Support System in Marmara region of Turkey. Future research can focus different regions of Turkey,

since many natural or technological disasters occur in many different regions of Turkey.

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Afet Yönetiminde CBS Tabanlı Karar Destek Sistemi Uygulamaları

ÖZET

Ülkemizin en önemli konularından biri olan afetlerin yönetilmesinde afet öncesi, sırası ve sonrası süreçlerin yönetilebilmesi için coğrafi bilgi sistemi (CBS) gibi yeni araçlara gereksinim vardır. Afet yönetiminde bilgi teknolojilerine ait coğrafi veriler ile bu verilerle ilişkili tüm sözel bilgilerin (verilerin) bütünleşik bir sistem içerisinde yönetilmesi gerekir. Başarılı bir entegrasyon ile CBS verileri afet anında karar destek aracı olarak kullanılabilir. Bu çalışmada, afet yönetiminde çözüm ortağı olan kurumların CBS sistemleri incelenerek, CBS tabanlı karar destek sistemine sahip olup olmadıkları ve ilgili kurumların işbirliği düzeyleri ile kriz / afet sırasında karşılaşılan zorlukların neler olduğu araştırılmıştır.

Araştırma anketi, Hu ve Kapucu (2016), Kapucu ve DeChurch (2009) ile Kapucu (2006)'nun çalışmalarına dayanarak geliştirilmiştir. Geliştirilen anket maddeleri, farklı disiplinlerde çalışan uzmanlar ile sivil savunma uzmanlarına uzman görüşü almak üzere sunulmuş ve öneriler doğrultusunda anket maddelerine son şekli verilmiştir. Anket maddelerinin anlaşılırlığının test edilmesi amacıyla gerçekleştirilen pilot uygulaması sonrasında anket maddelerine son şekli verilmiştir. Elektronik ortamda oluşturulan anket erişimi, 2016 Ağustos ve Eylül ayları arasında Marmara bölgesinde afet ve acil durum yönetiminden sorumlu ve ilgili tüm kurumlara elektronik posta yoluyla gönderilmiştir. Toplam 34 (11 il-ilçe belediyesi, 11 İl Afet ve Acil Durum Müdürlüğü, 11 Kadastro Müdürlüğü ve CBS kullanan İstanbul Afet Koordinasyon Merkezi) kurum çalışanı davet edilmiş ve 87 katılımcıya ulaşılmıştır. Kurumların CBS biriminde çalışan personel sayısının az olması nedeniyle bu sayı uygulama için yeterli olarak değerlendirilmiştir. Anketlerinin değerlendirilmesi sonucunda 81 katılımcıya ait anket analiz için uygun bulunmuştur. Katılımcıların büyük çoğunluğu (% 80,2) belediye çalışanıdır. Katılımcıların % 34,6'sı kadın, % 65.4'ü erkektir. Yaş gruplarına göre dağılım ise 29 yaşın altında % 16, 30-39 yaş arası % 50,6, 40-49 yaş arası % 23.5 ve 50 ve üzeri yaş % 9.9'dur.

Teorik çerçevede vurgulandığı üzere, daha iyi bir müdahale operasyonu için afet yönetim sisteminin kurumlararası işbirliğine dayalı bilgi teknolojilerinin kullanımına ihtiyaç vardır. Başka bir deyişle, afet yönetiminin tüm aşamalarında kullanılması amacıyla kurumların kaynak ve bilgi paylaşımı sağlamaları gerekir. Veri toplama, tehlike ve risk analizi, risk azaltma stratejileri, planlama / haritalama gibi afet öncesi faaliyetler oldukça karmaşıktır ve özellikle CBS gibi bilgi teknolojileri olmaksızın gerçekleştirilmesi de oldukça zordur.

Bu çalışmanın sonuçları, afetle ilişkili kurumların Coğrafi Bilgi Sistemlerini etkin kullanmasına rağmen kurumlararası işbirliğinin yetersiz olduğunu göstermektedir. Katılımcılar, birçok farklı kurumdan alınan bilgilerin hızlı değerlendirilmesinin zor olması nedeniyle CBS tabanlı acil durum müdahalesinin zor olduğunu düşünmektedir ($\overline{X} == 3.4815$). Katılımcılar acil durum esnasında yaşanacak zaman baskısını krizin yönetilmesinin ana sorunu olarak görmektedir. Ayrıca katılımcılar, kurumlarındaki Karar Destek

Sistemelerinin CBS tabanlı hasar değerlendirmesi ve etki analizi çalışmalarını içermedikleri konusunda hemfikirdir. Bu sonuçlar, teorik çerçeveyi içeren temel faktörleri sağlamadığı için, çalışmanın yürütüldüğü kurumlarda afet yönetiminde CBS tabanlı bir karar destek sisteminden bahsetmenin mümkün olmadığını göstermektedir.

Deprem gibi doğal afetlerin, Türkiye gibi büyük hasara yol açtığı ülkelerde CBS ye dayalı teknolojiler en üst düzeyde kullanılmalı ve kurumlararası işbirliğinin gerekliliği unutulmamalıdır.

Anahtar Kelimeler: Afet Yönetimi, CBS, Karar Destek Sistemi, İyileştirme, Zarar Azaltma, Zarar Görebilirlik, Risk Azaltma