An Approach to Use Geo-Information Effectively in Disaster & Emergency Management Activities in Turkey

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SUMMARY

Natural and manmade disasters such as earthquake, flood, fire, etc. have been increasing as time goes by and cause important losses. In Turkey, disaster management was governed by three actors until 2009 that are Disaster Affairs, Civil Defense, and Emergency Management governed by different ministries. Laws and activities were focused on preparation and response phases of disaster and emergency management. After 2009, Disaster and Emergency Management Presidency has become operative with the law defining central and provincial structure of this new unit. It is supposed that provincial centers for disaster and emergency management should support the mitigation, preparation, response, and recovery phases of all disaster management activities coordinately. According to the laws and regulations, various actors -including more than 300 public institutions and organizations- should get responsibilities in disaster management activities. Building a good collaboration mechanism and cross-sector services have critical importance to manage emergency tasks that are rather different than their daily work routines. Applying Geographical Information Systems (GIS) functionality provides a powerful decision support in disaster and emergency management and the basis to integrate policies directed to citizens, business, and governments. Geo-data model is being developed as a new approach on geo-data management in Turkey. It is based on standard operation procedures that include scenario-based activity matrix with required data and was prepared according to user needs at the different phases of disaster management. Some case studies were produced to use geo-data interoperable and corporately in emergency management activities as an example for using geo-data in open service architecture.

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1. INTRODUCTION

Disasters have catastrophic effects upon the community and community life in the countries exposed to disaster. Considering especially the last ten years, damage caused by disasters decreases in developed countries with the help of the precautions taken in, contrast to developing countries (UN, 2009; EM-DAT, 2010). Turkey encounters with great loss of life and property in disasters because of its geological, topographical and meteorological features. In Turkey, there have been 237 disasters that are officially recorded between 1900 and 2010. As a result of these disasters, 37.174 people died, 8.840.323 people were affected in a way that they cannot maintain their normal life. These disasters costed Turkey approximately 25 billion USD (EM-DAT, 2010).

Factors causing disasters can be reduced or mitigated with an effective Disaster and Emergency Management (DEM) approach, which should be considered as an integrated system including before, during and after disaster occurs. Integrated DEM includes all valuable resources of all disaster types and emergencies related to the phases of DEM. Integrated definition of DEM means all social, economic, political and cultural factors are taken into account. All organizational and communication methods for implementation of integrated model are determined according to own policies of each country and disaster zones (Bhugra, 2005; GRSP, 2007; Vakis, 2006).

Especially after the earthquake in 1999, DEM has become main point in Turkey. DEM projects were executed by different public institutions until 2009. Then, Disaster and Emergency Management Presidency was established by the Prime Ministry of Turkey by the law N.5902. In this context, the main aim is to coordinate all disaster events under a central administration structure that can provide effective DEM for all provinces within the country. Under this authority, provincial administrations are responsible for managing disaster events at different phases as active. However, disaster types, data standards to manage disasters, disaster actors, and operation procedures have not been determined yet.

One of the most important base for an effective DEM is the accurate geo-data. Maps are the bases that incorporate regional information related to any disaster or potential emergency case (Samadi and Delavar, 2009; Ware, 2003). Decision-making process in DEM is complex because of the need of large spatial data groups and components. Fast, accurate and efficient flow of geo-data must be provided to actors such as police, local services, ambulances and firefighters (London Resilience, 2006). The most important need for coordinated response is to develop a dynamic geo-data provider (Oasis, 2008). GIS supports decision-making processes for DEM and facilitates optimum solution for complex problems. By GIS techniques, information from other sources can be processed, such as road, building, watercourse, land cover, and so on. Geo-data obtained from location-based observations is extensively used in different phases of DEM (Greenwood, 2006; Liu et al, 2006; Aydinoglu et al, 2009).

Required maps and geo-data produced in Turkey could not be qualified for these thematic applications of public institutions and accessing the map information is a difficult task. Poor and unqualified geo-data leads to complexity in response phase especially and hampers coordination between actors involved in DEM activities. Mostly, the geo-data was produced with different scales, accuracies, and standards. It is clear that an effective data flow from different institutions is needed in the activities of DEM (James, 2010; UN/ISDR, 2007).

In parallel with the technological development, in the use of geo-data from different sources, Spatial Data Infrastructure (SDI) concept which provides interoperability through communication networks has emerged. Development of a SDI is a critical step for decision-makers and increasingly considered for effective delivery of government services and DEM (Aydinoglu, 2009; Chertoff, 2008).

In this study, as a preliminary work to use geo-data effectively in DEM activities, current legislation and projects relating to DEM were examined. Actors and geo-data use were determined at different phases of DEM. Deficiencies and expectations were revealed. A case study with standard operating procedure was developed to show use geo-data effectively between actors for DEM.

2. DISASTER AND EMERGENCY MANAGEMENT IN TURKEY

In Turkey, DEM was governed by three actors until 2009. These are General Directorate of Disaster Affairs under Ministry of Public Works and Settlement, General Directorate of Civil Defense under Ministry of Interior, and General Directorate of Turkey Emergency Management under Prime Ministry. With the law N.5902 issued in 2009, the activities of those three departments were ended and the Disaster and Emergency Management Presidency has become operative since 17 December 2009. The Law N.5902 defines the central and provincial level structure of this new unit (Aydinoglu and Demir, 2010). According to the Law N.5902 there are six departments at central levels. These are Departments of Planning and Mitigation, Response, Recovery, Civil Defense, Earthquake, and Administrative Affairs. Among the Governmental, Non-Governmental Organization (NGO) and private institutions, this presidency provides coordination and implements policies. Director-General of the Presidency conducts the Presidency' services according to legislation provision, development plans, strategic plans, policies, performance criteria, service quality and standards, and integrated disaster management policies of the Presidency (AFAD, 2010).

Provincial Directorate for Disaster and Emergency Management should be built in each province, which is directly attached to the governor of the city. Determination of the disaster and emergency risk of the city, constitution and application of response plans for the cities, and managing the logistic services at the time of disaster and emergency are the roles of Provincial Directorate for Disaster and Emergency Management. Loss and damage assessment, preparation and application of civil defense plans are the authorization of this directorate. They also manage Management Center for Disaster and Emergency coordinating the response in disaster and emergency. The center is appointed with secure data processing and communication emergency services (Aydinoglu and Demir, 2010; AFAD, 2010).

2.1 Legislation

In Turkey, there are 30 laws, 3 decree laws, a guideline, 3 manuals, 8 bylaws, 6 instructions, and 20 regulations about DEM. A part of these is directly related with DEM, relation of another is indirect. This legislation about DEM is examined to determine the actors on duty for DEM and the activities of DEM performed by actors. For mitigation, and response phases of DEM, there are detailed descriptions in legislation, but for preparation and especially recovery phase descriptions are not detailed. This deficiency is tried to remove by adopting resolutions on any change about the laws and enactments after disasters. There are totally 71 statutes in DEM legislation deficient for activity based DEM approach with multi-actor.

The necessary conditions for any disaster event are mentioned in the "basic rules related effectiveness of disasters regulation" which is not suitable for all disaster approach of integrated DEM. The general approach in the legislation is to address special studies and efforts for common types of disasters in the country. A comprehensive study to determine the types of disaster has not been done officially in Turkey.

Not also DEM actors but also responsibilities of different institutions and organizations are defined in some directives:

- For mitigation phase; "regulation on the planning and organization principles for emergency aid",
- For preparation phase; "bylaw on execution of organization, planning, supply and other services of hospitals to be established in sensitive areas", "regulation on prevention, extinguishing and rescue precautions for the fires on land or fires at sea, port and shores which can access and spread to the lands or for the fires on land which can access to coast, ports and seas", "regulation for protection against sabotages", "regulation for radiation security", "regulation on the organization and measures to be taken for civil defense by public"
- For response phase; "national application regulation on status of nuclear and radiological hazards"
- For recovery phase "bylaw on construction of buildings in earthquake region"

To define actors for DEM according to legislation, DEM applications and projects should be examined in addition to various statutes. Also, various laws and organization regulations should be examined to determine the activities of any actor. To illustrate;

- For determining the activities of municipality at different phases of DEM; "municipal laws", "tasks of interior ministry law", "special provincial administration law" and "private security services law" are examined.

- For determining the actors of forest fire disaster; "village law" and "forest law" are examined.

2.2 Actors

There are plenty of actors involved in different levels to act on for mitigation, preparation, response and recovery phases of DEM. The DEM actors, which are determined in statutes, are leveled as governmental, national, regional, provincial and local accordingly to their hierarchical relation. In this regard, there are 17 actors determined on governmental level. There are 187 actors in national level which are composed of; 37 of them (actors) are on central organization of the governmental level, 39 of them (actors) are on permanent/related organizations of Governmental level, 29 of them are in the related governmental organizations, 3 of them are in the in-charge-organizations of the governmental level and 79 of them are in the central organizations of related organizations of the governmental level. Along with 102 actors on Provincial level, the actors in charge at DEM are determined as 306 in totals. It is expected from DEM that active duties of every single actor from local to national level should be predetermined.

The actors in governmental level have plenty of activities that take part in regarding the legal contents. These are composed of a bunch of activities such as composing the standards in mitigation phase, protecting the security required buildings within its constitution in preparation phase, providing coordination and external support afterwards of the big disasters in response phase, and creating new living quarters for sufferers in recovery phase. Besides this, it has many important responsibilities and duties such as determination of DEM policy, forming related central institution and organizations, making country-wide security, safety policies, furnishing international support and coordination along with national institutions.

The national level actors are composed of institutions, which are directly connected to governmental level actors. In addition, it is responsible for the actors performing the activities at provincial level, the coordination and processes of these actors. Disaster and Emergency Management Presidency, which is directly connected to prime ministry, stands as the head actor at national level. It is legally responsible for planning DEM of country, acting in phases of DEM and directing Provincial Directorate of DEM.

The actors in provincial level are directly responsible for efficient response actively. At the response phase, coordinated and effective work of provincial units is at the utmost importance in terms of saving lives and minimizing damages and costs for all kinds of disasters. Considerable part of provincial level actors is composed of national level actors' sub-units. Therefore, planning the activities of these actors is up to national level authority.

To illustrate, gendarmerie could be counted among local level actors, which take part in most legal contents with many significant roles in its different activities. Gendarmerie is under responsibilities of Province Gendarmerie Headquarters at provincial level, General

Gendarmerie Commander at national level, and Ministry of Internal Affairs at governmental level. When all these activities performed by gendarmerie in different level are analyzed, one of the important activities that gendarmerie is in charge of at the local scale is the disaster response activity at which it coordinately collaborates with civil defense.

2.3 Projects

Various DEM projects have been developed in Turkey after 1999 Kocaeli Earthquake. Most of these are related to earthquake especially and use GIS techniques on their applications. The most important projects can be seen below;

Turkey Disaster Information System (TABIS): The system can be utilized as a decision support system for the central and provincial administration. The other objective of the system is to improve standards providing a basis for countrywide GIS-based information and management system. The project creates regional, environmental and administrative information systems by generating standards that provide coordination between provinces regarding disaster planning and management of Turkey. Expected benefits of TABIS-OK (Object catalogue) prevent uncontrolled growth of data and management of same data by different institutions, by interdisciplinary work increase efficiency and provide basis to standards regarding data exchange. TABİS reference model is composed of two basic object oriented and vectoral models called digital disaster model (SMM) and digital space model (SAFM). TABIS object index is composed of Basic Topographic-Spatial Fields Catalogue (TABIS-TOK) and TABIS- Disaster Management Object Fields Catalogue (TABIS-AOK) that prepared in parallel with SMM and SAFM approaches.

Istanbul Disaster Information System (ISTABIS) Project: ISTABİS creates provincial cooperation standards related to disaster management/planning of Turkey. TABIS object catalog was utilized as GIS-based administrative database within the context of disaster management. Object oriented database model TABIS-OK and relational database model IBB-VT (experimentally established by Istanbul municipality) were compared and differences between models were introduced for logical database design. A new object catalog was produced as a joint product in consequence of this interrelated improvement of two databases.

Rize Disaster Information and Meteorological Early Warning System (RABIS) Project: The objective of RABIS is carrying out a system which minimizes loss of life and tangible damage against natural disasters in Rize by using remote sensing technique, GIS and meteorological early warning systems. Project conducts a system, which can be used for emergency preparation planning and implementation, and also disaster management and damage estimation.

Hazards Turkey (HAZTURK) Project: GIS based project developed earthquake damage estimation software and methods used for Turkey. The study is separated three major topics; disaster, inventory and vulnerability and earthquake loss analysis survey was prepared.

Japan International Cooperation Agency (JICA) Project: The objective of JICA study was announced in project result report as “prepare seismic micro zonation maps that can provide the basis of seismic disaster prevention/damage reduction plan of Istanbul and environs, make recommendations on building techniques for earthquake resistant urbanization and effective technical transfers on related planning techniques” (JICA, 2001).

IBB Emergency Transportation Network Planning Project: Scientific studies and JICA’s analysis were used as the source data of Istanbul Evacuation Routes and Main Transportation Planning. Quality of roads, risk analyses of demolition of buildings to roads and risk analyses of road blockage were considered during conducting road network. Evacuation routes and main transportation were planned regard to recommended roads in this study.

Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP): Strengthening institutional and technical capacity of emergency management, increasing emergency preparedness and response awareness, reconstruction of priority public buildings, vulnerability inventory and sample retrofitting design for cultural and historical heritage assets and evaluating seismic risk of Istanbul are the objectives of ISMEP.

Kandilli Observatory and Earthquake Research Institute (KOERI) Project: Bogazici University KOERI project conducted “Earthquake Risk Assessment for Istanbul Metropolitan Area” survey aimed to develop risk model of Istanbul metropolitan area. Besides model provide infrastructure and building damage estimation and also the loss estimation.

Disaster Information System (ABIS) Project: Marmara Earthquake Emergency Reconstruction (MEER) project conducts “Disaster Information System Software”, “Software Development”, “National Disaster Archive Data Entry” and “Equipage Purchase” studies for performing “Land Use Management Legislation”.

3. CASE STUDY

To manage emergency activities effectively, it is required to determine Standard Operating Procedures (SOP) with detailed description of actors, activities, and working cycle that describe required geo-data. SOPs are formal written guidelines or instructions for incident response. SOPs have both operational and technical components and enable emergency responders to act in a coordinated fashion across disciplines in the emergency event. The introduction and the projects explained before can also serve to specify the capability or data requirements in which the procedures are being established and provide reasons why the use cases should be established with such procedures. In this study, use case description, which is prepared with SOP approach, defines the sub-tasks of DEM activities. It is supposed that these tasks will be developed as web GIS services in Service-Oriented Approach (SOA) and managed in user interface according to the activity. In this scope, same service can be used for another activity performing the same task. Users access the service for identified activity or access the needed services or the service sets with making a search in catalogue (HS, 2008; HS, 2009; Li and Wang, 2008). In view of GIS components, web GIS services encapsulate all the GIS functionalities by applying SOA methods, which realizes cross-platform, cross-network, and cross-language interaction (Yang et al, 2007; Jia et al, 2005).

For emergency preparation and DEM, key objects include locations of emergency responders such as police stations, ambulances, firefighters, and response resources, such as hydrant. All these actors must be distributed effectively to reduce the damage caused by an event. Optimization process of emergency responders' locations is used to identify the maximum coverage that can be achieved from location specific constraints. It is very effective in evaluating response times of emergency response units that shows the service area covered by the emergency responder within a specific time given specific travel times. With the emergency response units serving as centers, the extent of the coverage available for various desired response can be evaluated and managed by the using geo-data effectively (Easa and Chan, 2000; Parentala and Sathisan, 2007).

3.1 Determining Hydrant Locations

A fire hydrant is an active fire protection measure, and a source of water provided in most urban, suburban and rural areas with municipal water service to enable firefighters to tap into the municipal water supply and to assist in extinguishing a fire (CAG, 2009). Considering rapid spread of fire, it is clear that immediate response to fire is of vital important. Optimal positioning, spacing, location, and marking of fire hydrants can aid the fire service during emergency operations. When determining locations of fire hydrants, consideration should be given to accessibility, obstructions, and proximity to protected structures, driveway entrances and other circumstances where adjustments to a specific hydrant's location would be warranted (OSHA, 2006).

Determining hydrant locations is a part of the activity determining fire-fighting resource locations, the part of fire disaster preparation phase. Fire-risk map produced with another activity is the requirement for determining hydrant locations. The activity for determining hydrant locations is performed with sub-tasks defined in use case description.

Criteria for determining hydrants location are explained in Regulation on Protection of Buildings from Fire;

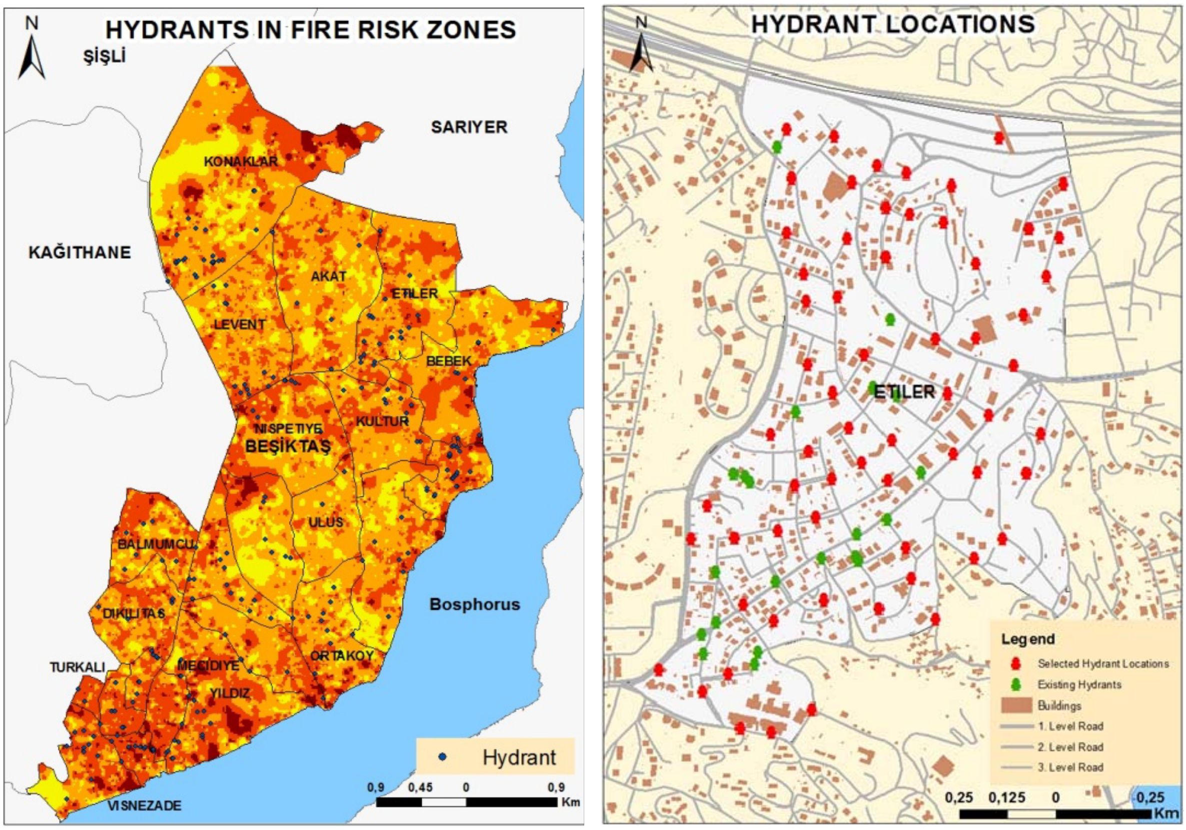
- Fire hydrant system constituted in such a way that covers entire surrounding of the building must be regulated in deference to accessibility of firefighter.
- The maximum distance between fire hydrants must be 50 m in fourth level risk zones, 100 m in third level risk zones, 125 m in second level risk zones, and 150 m in first level risk zones.
- The distance between fire hydrant and protected building must be between 5m and 15 m for security.
- External hydrant system must be constituted in settlements of which land use planning area is greater than 5000 m^2 and of which usage area is various.
- Ground fire hydrants must be constituted in settlements where the transport facilities do not exist.

The procedure for determining fire hydrant locations is presented with use case description in Table 1 briefly. This defines sub-tasks of the activity respectively with required and produced data, GIS functions and processes, and actors taking responsibility in the tasks. Depending on this use case description, tasks and required data are determined for all activities at different phases of disasters, such as fire. This use case is the base for creating an object-oriented geo-data model to manage DEM effectively. The data model is designed with Unified Modeling Language (UML) to produce geo-data exchange model with Geography Markup Language (GML). Geo-database for case applications were developed in view of this data model. This SOP approach can be a preliminary work to manage geo-data with web GIS services, based on SOA.

Table 1: Use case description of determining hydrant locations sub-activity

Use Case Description: YAN.H.02.06	
Name	Determination of Hydrant Locations
Priority	High
Description	The user determines the locations of hydrants as a source of water provider for jurisdiction area.
Pre-condition	Production of Fire Risk Map sub-activity coded YAN.O.01.02
Work-flow	
Task.1	Import “Hydrant” Feature Class
Task.2	Import “FireRiskMap”
Task.3	Import “RiskObject” Feature Class
Task.4	Determining Security Required Buildings
Task.5	Import “LandUse” Feature Class
Task.6	Import “Transportation” Feature Class
Task.7	Import “Hydrography” Feature Class
Task.8	Determining the Risk Zones of Existing Hydrants
Task.9	Add “Risk” Attribute for “Hydrant” feature class.
Task.10	Appoint the Risk Value to Hydrants
Task.11	Determining Hydrant Locations According to Risk Zones
Task.12	Determining Hydrant Locations According to Protected Buildings
Task.13	Determining Hydrant Locations According to Transportation
Task.14	Determining Hydrant Locations According to Land Use
Data source: UVDM-Conformant Data Set Provided by Focal Point	
Description	Turkish GII: Geo-data Exchange Model (TURKVA: UVDM)
Data provider	National Focal Point
Geographic scope	Turkey wide, although a smaller area may be selected
Thematic scope	TURKVA:ADYS
Scale, resolution	As made applicable by data provider
Delivery	Textual report and associated geometry information
Documentation	TURKVA:UVDM

Hydrants are evaluated with the fire risk zone in which these hydrants exist. Hydrants in Besiktas-Istanbul are shown in Figure 2.a within their risk zone. Hydrants take the risk value from the risk value of the zone. There are 21 existing hydrants in Etiler and these hydrants are not enough for fire safety precautions. In this way, with the using of GIS techniques, fire hydrant locations were determined according to regulation as described in the use case description. In this regard 63 hydrant locations were determined, which are composed of; 12 of them are in first fire risk zone, 22 of them are in second fire risk zone, 18 of them are in third risk zone and 11 of them are in fourth fire risk zone. Finally, numbers of hydrants in Etiler should be increased from 21 to 84 for fire disaster preparedness. Figure 2.c shows the location of these hydrants.



(a) (b)

Figure 2: (a) Hydrants in fire risk zones in Besiktas county, (b) Determined hydrant locations

4. CONCLUSION

Statutes related to DEM are complicated and deficient for activity-based and multi-actor approach at different levels of disaster types. That shows us there is a need of detail research on the determination of actors and activities of DEM in accordance with statute. Despite the fact that detail definitions and descriptions are made, there is not any integrated task description to coordinate work between institutions. The main reason of this deficiency is scattered presence of content in statute. Yet again, it is required to determine the activities at different levels of the DEM and to determine the sub-tasks with their responsible actors, from local to national level.

To perform the tasks of the activities for each disaster types, geo-data used by actors has great importance at different phases of DEM; preparation, mitigation, response, and recovery. As DEM is a multi-disciplinary activity, the most fundamental asset is the data itself that needs to be shared or to be integrated between different actors. SDI provides the tools giving easy access to distributed databases for DEM actors who need geo-data for their own decision making and emergency tasks. The activities with sub-tasks were defined in use case description with SOP approach. The activities were formalized sequentially while required data for each task was defined in view of user requirements and the background of existing DEM projects. Within SDI mechanism, it will be possible to manage and to use geo-data effectively on electronic networks when applications are developed with SOA approach. Actors can manage and update the data at a place where the data is maintained effectively. In this way, the fire case examples may be a preliminary work to manage geo-data effectively in DEM.

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BIOGRAPHICAL NOTES

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