DESIGNING GEOGRAPHIC DATA MODEL FOR DISATER-EMERGENCY MANAGEMENT: FIRE CASE

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ABSTRACT

The coordination and effective intervention of fire, ambulance, civil defense and other actors participate in disaster and emergency situations has become a priority need. Interoperable geographic data is urgent need for Disaster-Emergency Management, in mitigation and preparation phases, access to the region, monitoring of rescue operations, control and management activities of various logistics services depending on the quality of data. In this study, actors that could act in a GIT based Disaster-Emergency Management are defined, activities in mitigation, preparedness, response and recovery phases of the possible fire disaster and need of geographical data to manage these activities, were determined according to the principles of interoperability.

1. INTRODUCTION

Due to the geologic and topographic structue and climate attributes of Turkey, it is frequently confronted with natural disasters which lead to immense loss of life and property (Pinar and Gunok, 2009). In the maps shown as Figure 1 , it can be seen that landslide, flood and earthquake occurs most frequently in Turkey. Likewise, total numbers of disasters in Turkey is ranked at the top throughout the world.

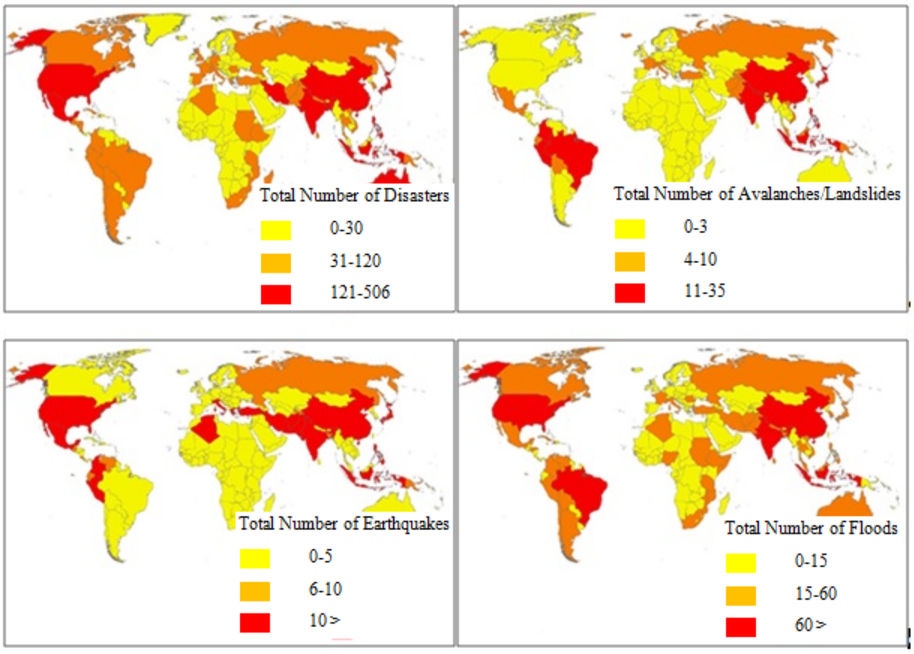


Figure 1: Total number of disasters and occurrence number of avalanche/ landslide, earthquake and flood disasters: 1974-2008 (EM-DAT, 2010)

In Turkey, there have been 237 disasters that are officially recorded between 1900-2010. 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).

In Figure 2, the maps that are arranged by worldwide disaster data are shown. countries according to their disaster density are shown by 5 different colors. While Turkey exists in yellow group according to frequency of disasters and caused deaths, it exists in the orange group according to affected people and material damage. With functional and effective DEM this situation can be reversed, how often the disasters take place, the harm can be kept in minimum.

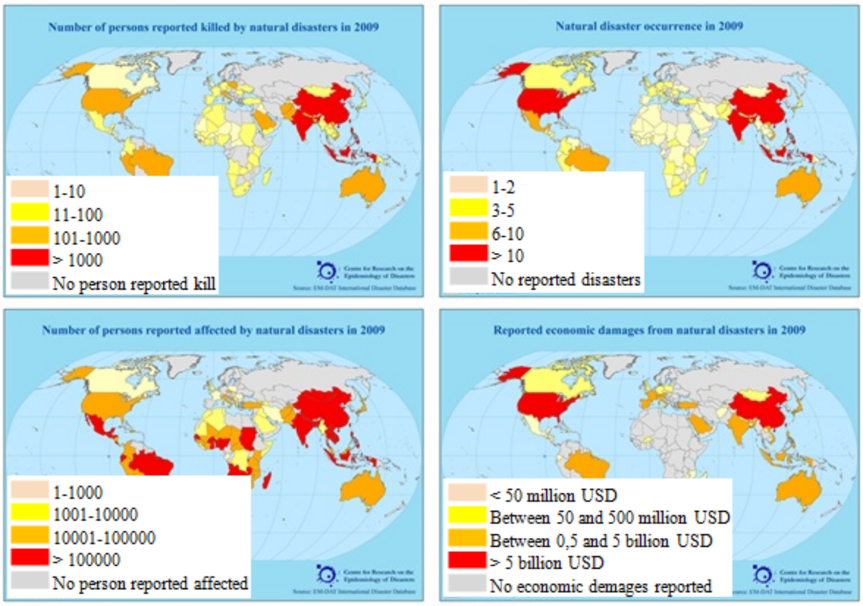


Figure 2: Comparison of disaster effects on different countries (EM-DAT, 2010)

2. AN APPROACH TO MANAGE DISASTER AND EMERGENCY ACTIVITIES

There is an absolute need of effective DEM in order to mitigate loss and damage of disasters. Healthy and proper map information in other words geo-data is important requirement for management effectiveness of disaster and emergency. In this context, general conceptual approach of DEM is can be defined with Actor-Sector-Activity-Task-Data upper classes. Explaination of framework is;

- *Actor* expresses units like planning and mitigation, response, recovery, civil defense department, earthquake department service groups, fire department, ambulance, police, municipal police, search and rescue teams, etc. that take in charge in DEM.

- Every actor work in different *Sector*; like security, municipal, health etc.

- *Activity*, expresses geo-data use required situations during loss mitigation, preparation, response and recovery phases of DEM. To illustrate; flood and fire-risk maps can be produced in loss mitigation phase. Traffic accident and gas explosion etc. can be explained as activity during emergency response phase.

- Every activity are formed by *task* in specific phases. For example, record of scene of the accident, establishment of fire-fighter team route, determination of affected zones etc. are works that appointed as part of activity.

- *Actor* execute the task such as when response department execute works like determination of routes and fire event zone, fire-fighter teams execute firefighting.

- Actor is in need of *geo-data* and can produce new geo-data during the task performing. Hereby, the task needs existing data or dynamic data in database. Furthermore, produce dynamic data in database during emergency response process. Geo-Data Exchange Model of Turkey (UVDM) is based on geo-data used in this study.

There are plenty of actors involved in different levels to act on for mitigation, preparation, response and recovery phases of DEM. The actors which take part in DEM activities are leveled and displayed 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.

Actors of emergency management sectors need base existing geo-data that was maintained by local government and public institutions. On this scope, TURKVA:UVDM can be accepted as a base model of emergency management activities because it was supposed that UVDM includes the date shared by all geo-data users at local level.

Every upper divisions include related sub divisions (Figure 3).

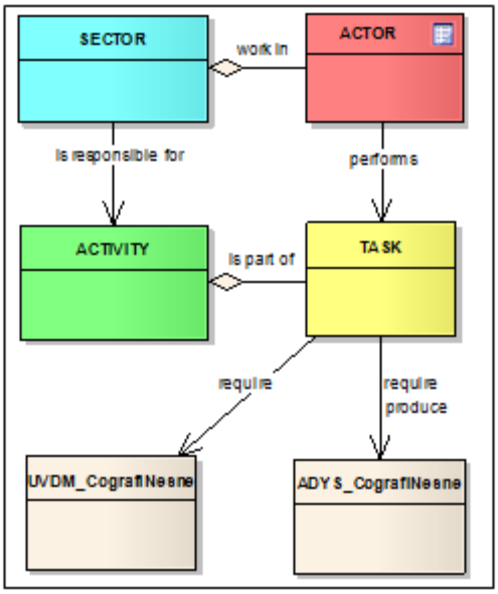


Figure 3: Actor-Sector-Activity-Task-Data Approach

2.1. GEO-DATA MODEL

2.1.1 Turkish GII: geo-data exchange model

For this study, The Turkish GII: Geo-data Exchange Model (TURKVA:UVDM) that was produced by Aydinoglu (2009) in a research was accepted as a base and existing data model. It is accepted that UVDM is a harmonized GI model of Turkey and was designed to get the data enabled for multiple uses. UVDM as a geo-database model is based on the geo-data user requirements and defines specifications of geo-data themes with documents and application schemas on a platform independent from any particular software or hardware.

UVDM is complying with ISO/TC 211, INSPIRE data specifications, and Turkey National GIS vision. UVDM is an object-relational data model that enables users to store objects and their associated attribute data in a single geo-database system. UVDM is a semantic model because a harmonized model provides a common domain of interaction and the related information. UVDM is designed with UML.

UVDM generic conceptual model specifies the components to determine the application schemas of geo-data themes and to harmonize geo-data. These components were defined and divided into two sections, scope/application area and technical components (Aydinoglu et al., 2009);

• Scope and Application Area Components include; Standard Hierarchy, Scale-resolution, Generalization Approach, Building Province Level GII

• Technical Components include; Principles, Terminology, Reference Model, Application Schema Rules, Spatial and Temporal Aspects, General Feature Model, Identifier and Versioning Management, Registers and Registries, Portrayal, and Multiple Representation.

This model is focused on the application and use of information, rather than a specific workflow for an organization. The base principle is that if a geo-database is modeled for a province, it could then be a model from local to national level.

The spatial hierarchy approach enables the collection of data at province level, larger than 1:5000 scale and 50 cm resolution, and then generalizes to different levels.

The UVDM geo-data themes are Administrative Unit (IB), Address (AD), Land Ownership/ Building (MB), Hydrography (HI), Topography (TO), Transportation (UL), Land Cover/Use (AR), and Geodesy (JD). Application schemas of UVDM data themes were described with documentation, feature catalogues, and UML application schemas. Feature types in data themes are defined with definition, geometry, attributes, attribute values, relationships, topology, and constraints.

If the use of UVDM data themes on disaster management is emphasized;

• IB data theme can be effective on the coordination of disaster management activities.

• AD data theme provides a simple data structure for address matching and controlling locations of actors and emergency structures.

• MB data theme includes classes of buildings and parcels. It is related to address information. Detailed building information provides enough detail for emergency management personnel to effectively respond to local emergencies.

• HI data theme includes data about rivers and lakes that can be used on controlling floods.

• TO data theme includes elevation and surface data that can be used on determining landslide and flood risks.

• UL data theme is to capture basic infrastructure information for water, air, road, transit and rail networks. This can be effective on logistics and navigating emergency actors.

• AR data theme includes classes that relate to environmental monitoring and response. Most of these are oriented more towards natural disasters and recovery efforts rather than environmental monitoring for homeland security purposes.

2.1.2 Designing geo-data model for disaster-emergency management

UVDM includes the date shared by all geo-data users at local level. This is a starting point to create sector models in different thematic areas like DEM. DEM geo-data Model, abbreviated as TURKVA:ADYS, is being developed as an extension and sector model of TURKVA:UVDM.

ADYS has the same conceptual model components as an extension of UVDM. ADYS has existing and dynamic data to use during emergency events. For example; Incident, Casualty, DisasterArea, and RiskArea are continuously changing data during emergency events as seen on Figure 4. Incident manages information about incident time, type, time, and like these. Casualty stores trapped, wounded, missing as a result of an incident. While DisasterArea stores the spread of disaster, RiskArea controls possible risk zones if disaster continues. EmergencyBuildings includes buildings that need to get special attention during disasters such as schools, shopping areas, governmental buildings, etc. Emergency Buildings can be related to Building (YAPI), Address (ADRE) via YAPI, and other feature types in UVDM. Incident can be related to ADRE and Road (YOLH) to get the location and route information.

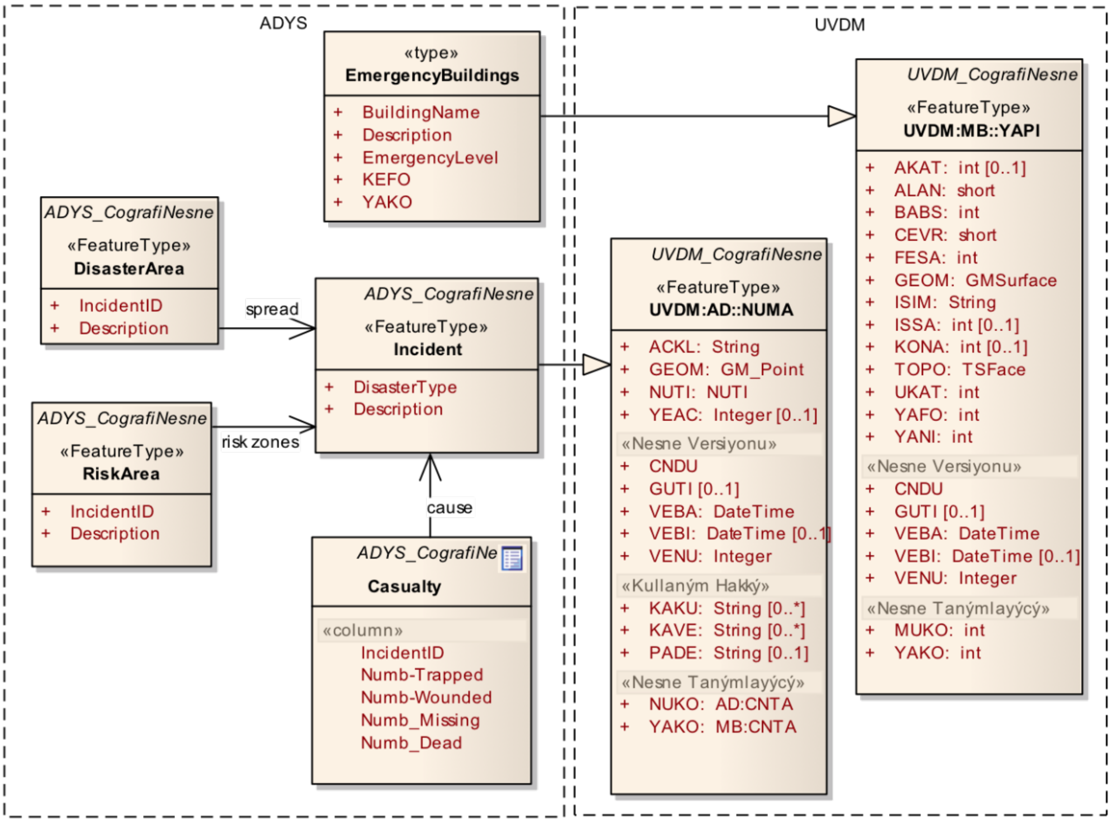


Figure 4: A profile of UVDM and ADYS geo-data model (Aydinoglu, 2009)

3. CASE STUDY FOR FİRE EVENT

3.1 STUDY AREA AND SCOPE

In this study, Beşiktaş district used for exercising is selected as a pilot area (Figure 5). Beşiktaş is a district of İstanbul provience which is reserved one fifth of population of Turkey. Beşiktaş district incorporated great numbers of shopping center, trade center, building complex and historical building with great population is in need of active response in disaster event.

Various activities performed by different actors has been defined for urban-fire event. These 13 activities has been specified with 77 sub-activities.Each sub-acticity has tasks to perform the activity which is responsible of the actors.

3.2 YAN.O.01.02: Production of fire risk map

Production of fire-risk map is a sub-activity of planning base maps creation activity which is the part of fire event mitigation phase. Analyzing fire events as a first sub-activity of planning base maps is the requirement for fire risk map production as a second sub-activity of planning base maps.

Fire-risk map provide an integrated national assessment of risk based on digital fire event data and web-accessible data. Lead and support national, provincial and local communities to effectively engage in risk-based mitigation planning resulting in sustainable activities. Fire-risk map information and tools help communities develop informed mitigation plans that will reduce losses from fire events (USG, 2010).

Fire risk differs from a society to another society according to social structure and urban infrastructure. In this study, Regulation on Protection of Buildings from Fire, the fire risk research of

Istanbul Fire Brigade and the statistics formed by Istanbul Fire Briagde have been used to specify the risk criterias for Istanbul provience.

The fire risk research of Istanbul Fire Brigade has evaluated the fire events occured for ten years, industrial plants, other workplaces and norrow streets on the basis of quarter within the scope of research. In this scope, risk levels of buildings has been determined. Explosive substances, filling facilities, industrial plants, factories, museums and palaces have been determined as first level risk group and buildings, shopping centers, hotels and manufacturing plants have been determined as second and third level risk group (IBB, 2010).

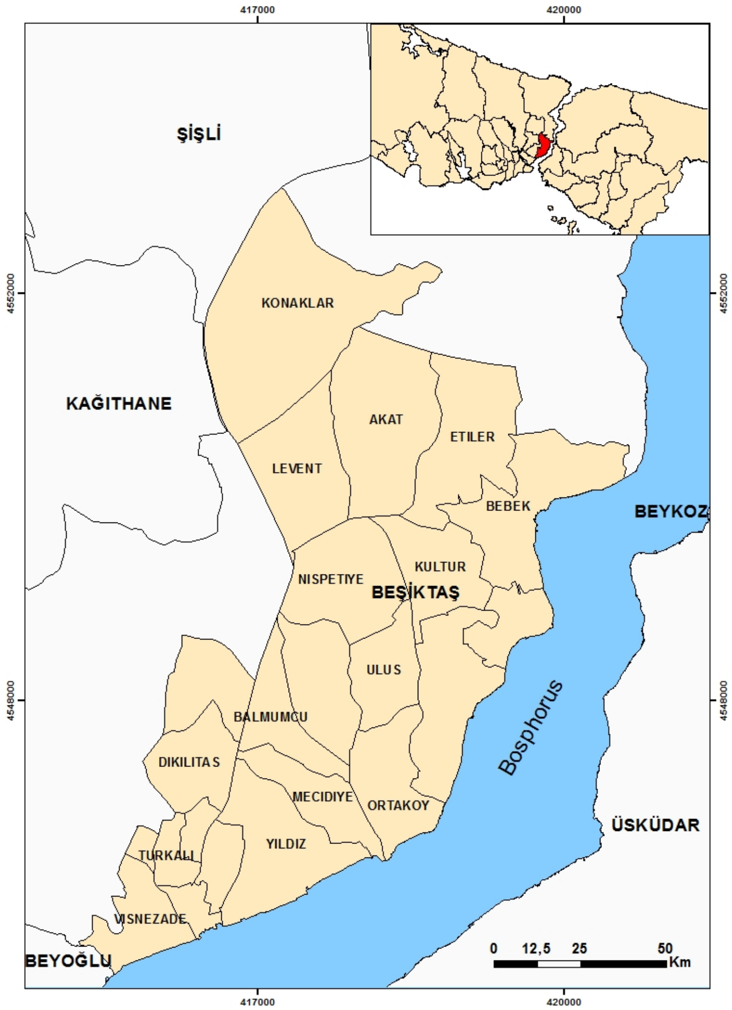


Figure 5: Study area: Beşiktaş

Statistical data for fire reasons shown as Figure 6 an fire places shown as Figure 7 provided from Istanbul Fire Brigade website have been evaluated when determining the fire-risk criterias.

Once the risk criterias are specified, rate each risk with 4 being the most significant and 0 being the least significant. The tasks of fire-risk map production are shown in the Table 1. A statistical approach was used in the construction of the model, on the basis of the level of risk.

Use-case description arranges in order of tasks to perform the sub-activity. Use-case descriptions are used by users wtih Service-Oriented architecture (SOA) approach to perform their responsibilities.

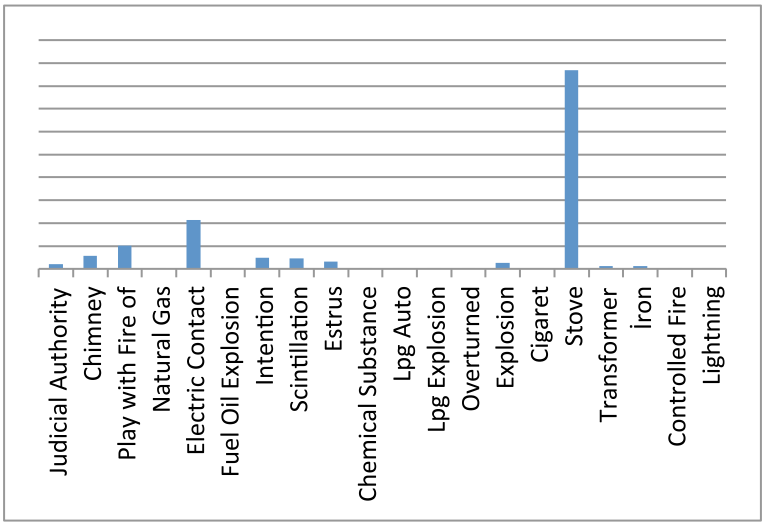


Figure 6: Fire reasons for Istanbul (IBB, 2010)

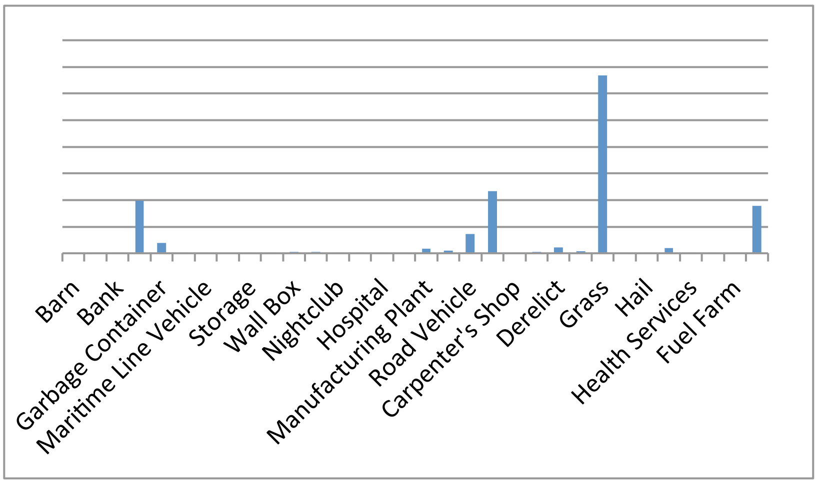


Figure 7: Fire places for Istanbul (IBB, 2010)

Table 1: Use-case description of fire-risk map production sub-activity)

Use-Case Description: YAN.O.01.02	
Name	Production of Fire-Risk Map
Priority	High
Description	The user specifies the fire risk zones for jurisdiction area with using GIS.
Pre-condition	Analyzing Fire Events sub-activity coded YAN.O.01.01
Work-flow	
Task.1	**Import "Building" Feature Class** Import "Building" polygon feature class from UVDM geo-database.
Task.2	**Add "risk" Attribute** Add "risk" attribute column for "Building" feature class.
Task.3	**Determining Risk Groups of Buildings According to "use type"** "use type" attribute of "Building" includes the use types of the buildings. Risk value of historical buildings, filling facilities and industrial plants are equal to 4. Risk values of comminal life places like health facilities, educational institutions, public buildings and shopping centers are equal to 3. Risk values of apartment buildings are equal to 2. Risk values of detached houses and ruin buildings are equal to 1. Risk values of empty houses are equal to 0.

Task.4	**Determining Risk Groups of Buildings According to "structure type"** "structure type" attribute of "Building" includes the structure types of the buildings. Each structure type has different resistance time as defined in regulation. Risk value of structure coded F30 is equal to 4. Risk value of structure coded F60 is equal to 3. Risk value of structure coded F90 is equal to 2. Risk value of structure coded F120 is equal to 1. Risk value of structure coded F180 is equal to 0.
Task.5	**Determining Fire Risk Levels of Buildings** Determine the "risk" values of the buildings taking account of the determined risk groups according to use type and structure type.
Task.6	**Import "LandUse" Feature Class** Import "LandCover" polygon feature class from UVDM geo-database.
Task.7	**Determining Risk Areas in "LandUse" Feature Class** Determine the area featured fire risk and the fire risk values of these araes. "land use type" attribute of "LandUse" includes use type, flora and vegetation cover of the area.
Task.8	**Determining Risk Objects** Merge "Building" polygon feature class and "LandUse" polygon feature class. Composed "RiskObject"polygon feature class has "risk" attribute that defines the fire risks of the objects.
Task.9	**Import "Transportation" Feature Class** Import "Transportation" line feature class from UVDM geo-database.
Task.10	**Determinig Risk Values of Risk Objects** Adjecency of the risk objects must be taken as a parameter while determining the risk values of the risk objects.
Task.11	**Convert "RiskObject" to Point Feature Class** "RiskObject" polygon feautue class should be converted to point feature class.
Task.12	**Determining Fire-Risk Zones** Inverse Distance Weighted (IDW) interpolation method is implemented to specify the fire-risk levels for the region.
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

In this scope, integrated DEM with dynamic data is possible with using actor-sector-activity-task approach. Users can import related data from UVDM and produce data for ADYS. These produced data can use from different actors which are the part of DEM. In Figure 8 actor-sector-activity-task-data relations are showed for fire-risk map production. This relation includes the tasks explained in the use-case description.

Buildings are evaluated with respect to fire risk according to the use type of buildings shown as Figure 9. This figure is the outcome of Task 3. for the fire risk map production sub-activity. Use type attribute of the buildings consist of industrial, historical, commercial, health, education, house, public, ruin, empty, fuel filling and shopping centers. Buildings like historical buildings, filling facilities and industrial plants are grouped as fourth risk level. Comminal life places like health facilities, educational institutions, public buildings and shopping centers are grouped as third risk level. Apartment buildings are grouped as second risk level. Detached houses and ruin buildings are grouped as first risk level. The result map of sub-activity of the fire-risk map production as a part of fire disaster management mitigation phase is shown as Figure 10.

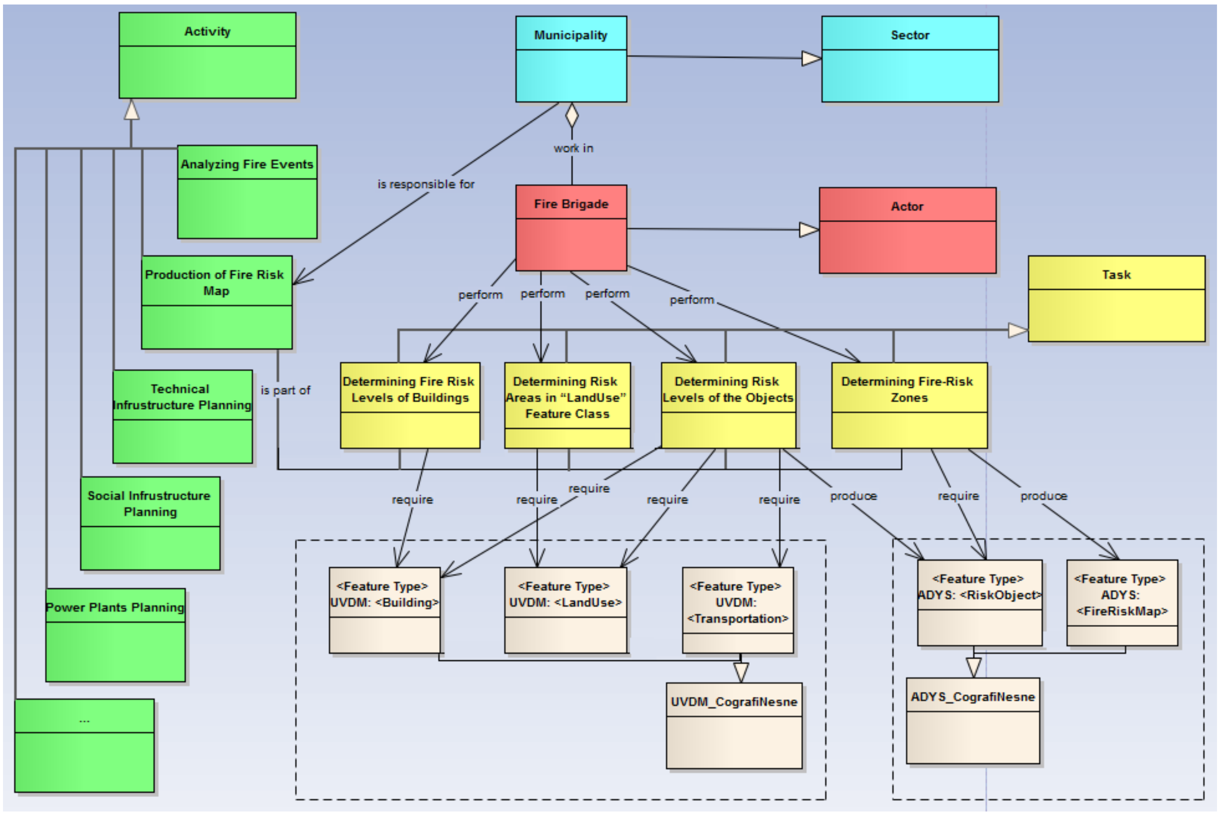
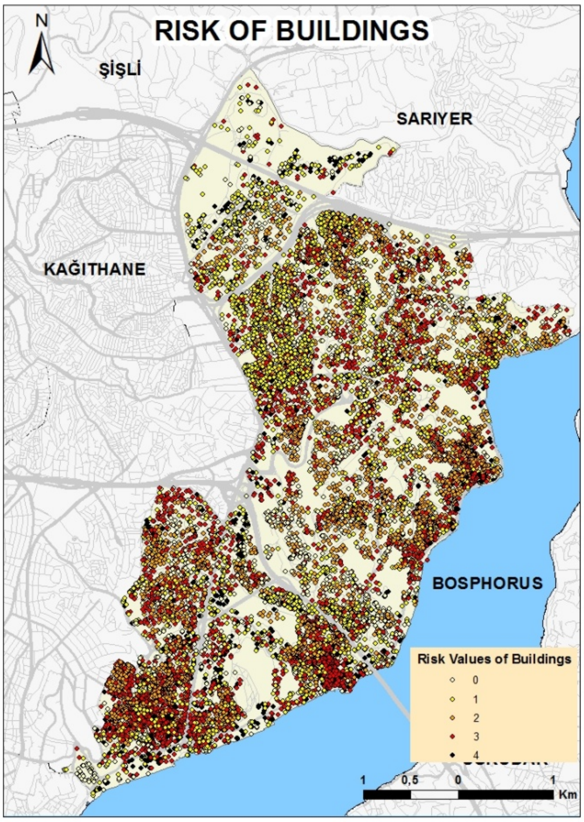


Figure 8: UML class diagram for the production of fire-risk map sub-activity.

4 CONCLUSION

Geo-data used by actors to perform the tasks has great importance at different phases of DEM; preparation, mitigation, response, and recovery. As emergency management is a multi-disciplinary activity, the most fundamental asset is the data itself that needs to be shared or to be integrated between different partners. GII provides the tools giving easy access to distributed databases for DEM actors who need geo-data for their own decision making and emergency tasks. Processes with tasks were being formalized sequentially while required data for each task were defining to manage emergency events within GII mechanism. When web based user interface developed with Service Oriented Architecture (SOA) is configured on the web and data servers, it will be possible to manage and to use dynamic geo-data on electronic communication networks. Related stakeholders could manage and update the data with GII approach at a place where the data is maintained effectively. With this view as explained the fire case examples with use-case description approach, described data managed in the geo database with GII approach provide actors interoperability in DEM.



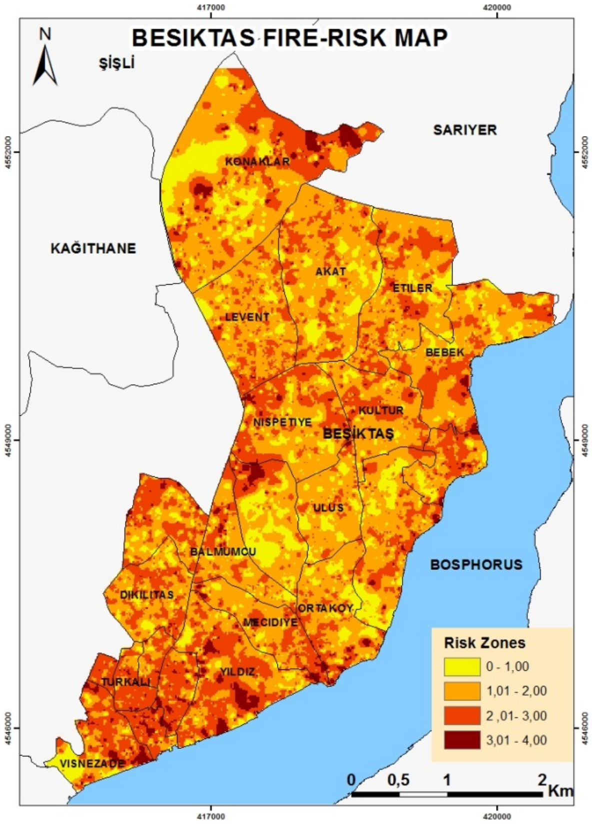


Figure 9: Buildings with fire risk **Figure 10:** Fire-risk map of Besiktas

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