AYDES: An All-in-One Solution for Geospatial Information Technology Based Disaster Management and Decision Support

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Abstract The Disaster Management and Decision Support System (AYDES) is a software, data and analysis platform that provide accurate and current disaster and emergency data, reports, statistics, job inspections, queries, analyses etc. at every stages before and after the disaster. AYDES is a holistic platform integrated with many internal and external systems and services, including desktop, mobile and web-based applications that utilize GIS and RS technologies. It has been developed according to the content of the National Disaster Response Plan of Turkey and designed to be easily used by the National Disaster and Emergency Management Agency of Turkey (AFAD), collaborative Ministries, private institutions and provincial organizations. AYDES consists of three core components with their sub components, namely "Incident Command System", "Spatial Information System" and "Recovery Information System". Mobile software tools that can deliver real-time information to the web-based core components of AYDES that consists of applications used for mapping during both post-disaster damage detection and pre-disaster risk reduction. Additionally, in case of a need to disaster event

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inventories, potentially vulnerable assets, hazard—risk data, affected areas of probable or actual disasters, damage detection results and such data and analyses, two software tools have been developed, namely AYDES-RS, a desktop image processing and analysis software and AYDES-CS, a web-based crowdsourcing software tool whereas two of them enable to allow the use of imagery acquired by remote (space/aerial) technologies for various analyses before and after a disaster. In this chapter, we introduce AYDES and related literature survey about similar disaster management platforms and systems in the world.

1 Introduction

IT based disaster management is one of the specific fields of Industry 4.0 consisting of hardware, software, services, data, personnel and methodology components. If one needs to pay more attention to one of these components, data seems to be self-evident as in the all IT based systems. And the satellite/areal images are primary data sources to process and analyse in order to extract for and disseminate to the disaster community, institutions, academia and public. Although the online web map services such as "Google Maps, Yahoo Maps, Bing Maps, etc". support the disaster community with a large amount of satellite imagery, they are not data-distribution platforms for disaster responders, since they are closed system which don't allow to download the original images which are required for processing and analyzing with GIS and remote sensing tools within an IT based disaster management system.

Geographical Information Technologies (Geo-ITs) constitute geo-spatial components of the IT based disaster management systems in addition to the non-spatial parts, rather say infrastructure components such as computer, communication, internet, software, database and other technologies. Regarding the usage of Geo-ITs (especially GIS and Remote Sensing technologies) in disaster management, there have been a number projects and studies worldwide. These projects and studies can be evaluated in five aspects: system architecture, geographical area of interest, type of disaster, phase of disaster and target users. In terms of the system architecture, some of them are limited to stand-alone tools, web portals or mobile applications whereas some others are combinations of them. In regard to the geographical area of interest of those projects and studies, some of them are confined to a small region (as in some case studies), some deal with a city, country, continent or the whole world. As the type of disaster regards, the majority of these studies and projects are based on a specific type of disaster such as earthquake, flood, tsunamis, wildfires, mass-migration, etc. The fourth aspect is the phase of disaster: prevention/mitigation, preparedness, response, recovery which is/are the working area of the projects and studies. As for the target users, some of them aim at academia only and the target users of some others are public or institutions. It's really hard to find an "all-in-one" system covering all scopes of those four aspects of the evaluation.

Apart from region based projects, one of the well-known example of the projects at national and international level is the "HAZUS" (FEMA 2018) which is a desktop software on earthquakes, floods, hurricanes and tsunamis in the USA for public to be used during respond phase of disaster (to estimate potential losses).

An example for the Disaster Management at national level is "National Database for Emergency Management portal (NDEM 2018) which is hosted at Indian Geo-Platform of ISRO (NRSC 2017). Having the all phases and types of disaster, serving to the public, integrated with two mobile applications (Geo-spatial database on emergency facilities, disaster relief management), NDEM system (NDEM User Manual 2017) seems near to an all-in-one solution (with lack of desktop tools) for disaster management.

The inventory of resources that enlists equipment and human resources for disasters is managed by a separate non-spatial web portal "India Disaster Resource Network-IDRN" (IDRN 2018) which is not public and not integrated to NDEM portal.

UNOSAT LIVE Map (UNOSAT 2018) is a web portal which shows only damage assessments after a disaster (Fig. 1) and Disaster AWARE Platform (DAP 2017) developed by Pacific Disaster Center (PDC) is another web portal which displays active hazards in the world.

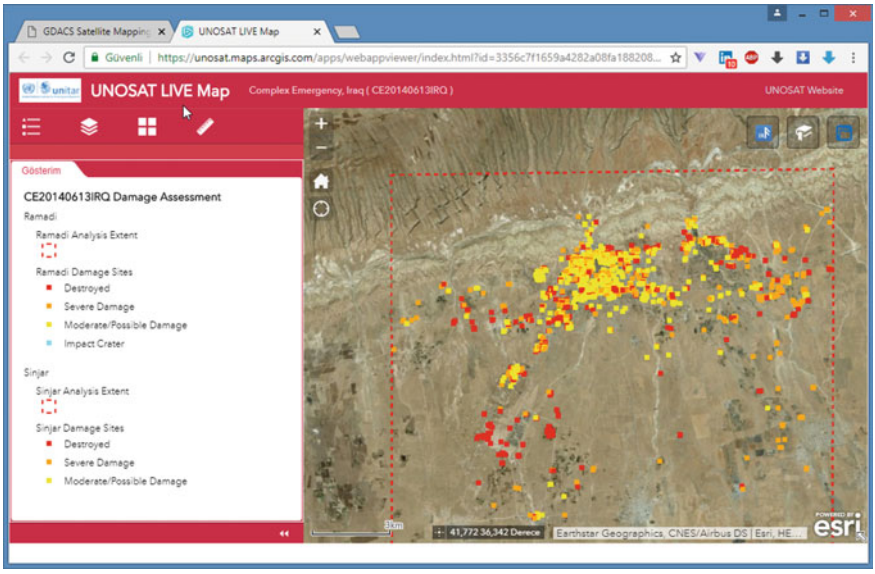

Fig. 1 Screenshot of *UNOSAT LIVE Map* Web Portal (© 2018 UNOSAT Team) (The screenshot of *UNOSAT LIVE Map* web portal (© 2018 UNOSAT Team) at the URL https://unosat.maps.arcgis.com/apps/webappviewer/index.html?id=3356c7f1659a4282a08fa188208036d7 is used with the permission from "*UNOSAT Team*".)

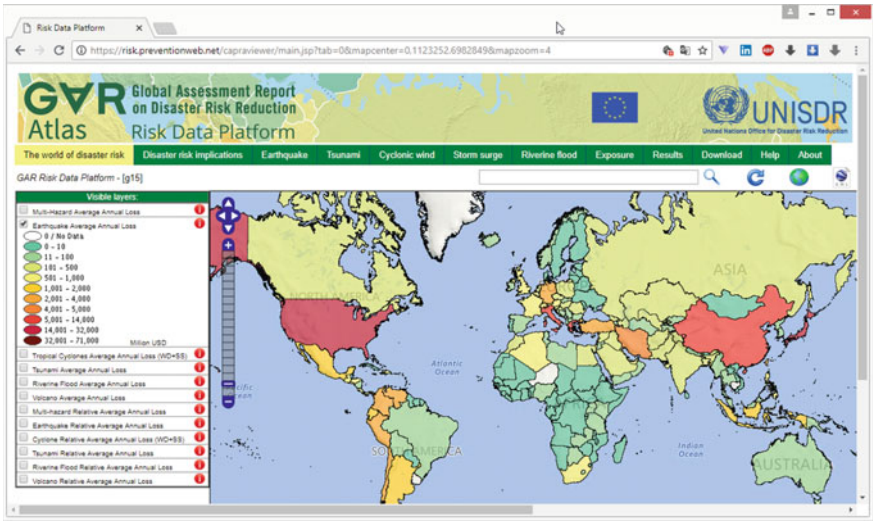

Fig. 2 Screenshot of *GAR-ATLAS Risk Data Platform* (© 2018 UNISDR) (The screenshot of *GAR-ATLAS Risk Data Platform* (© 2018 UNISDR) at the URL https://risk.preventionweb.net/capraviewer is used with the permission from "*Mr. Ricardo Mena, Chief of Supporting and Monitoring Sendai Framework Implementation Branch at United Nations Office for Disaster Risk Reduction (UNISDR)*".)

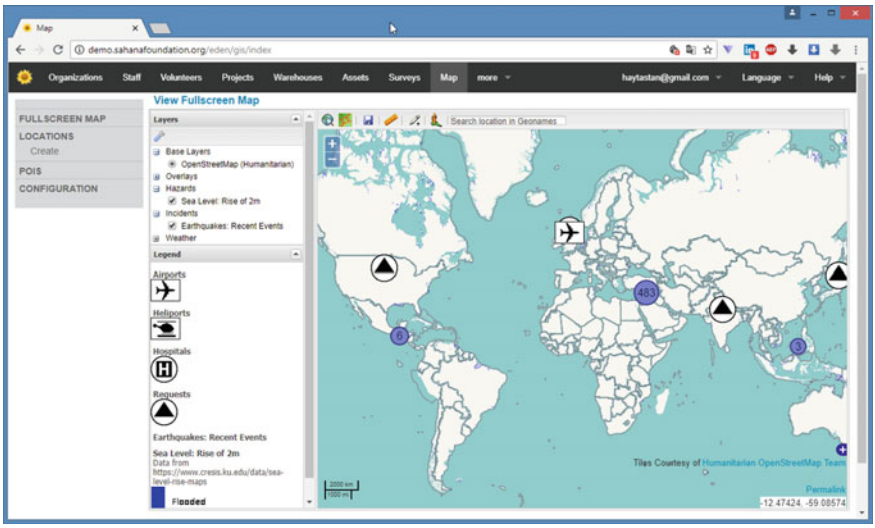

Fig. 3 Screenshot of *Sahana-Eden Humanitarian Management Platform* at the remote server (© SAHANA Software Foundation) (The screenshot of *Sahana-Eden Humanitarian Management Platform* at the remote server at http://demo.sahanafoundation.org/eden/gis/index is used with the permission from "*Dr. Devin Balkind, President at SAHANA Software Foundation*".)

Global Disaster Alert and Coordination System (GDACS) web portal (GDACS 2018) developed by UN&EU, "Reliefweb" web portal (RELIEFWEB 2018) developed by OCHA are web portals which have been broadcasting about the disasters in real time in the world, as a list and on a map, respectively. GAR-ATLAS Risk Data Platform (GAR-ATLAS 2018) developed by UNISDR (United Nations Office for Disaster Risk Reduction) shows the average annual loss numbers for each type of disaster together with the disaster risk implications and disasters in the past in the world (Fig. 2).

Sahana-Eden is the world's most popular open-source information management system for disaster and humanitarian aid management (SAHANA-EDEN 2018). It can support all phases of the emergency cycle *out of the box* (SAHANA-EDEN Demo 2018) at the remote server (Fig. 3) or be customized at the local server after setup (Fig. 4) to meet the specific needs of agencies and organizations.

Ushahidi is an open source collaborative web mapping platform used also for crises response (USHAHIDI Software 2018). This web platform can be used at "ushahidi.io" domain with a payment plan (mapper for free, surveyor with 9/month, responder with $499/month, solutions with negotiation) (Fig. 5) or can be downloaded (USHAHIDI Platform 2018), installed and used with a GPL license at local WAMP/XAMPP server.

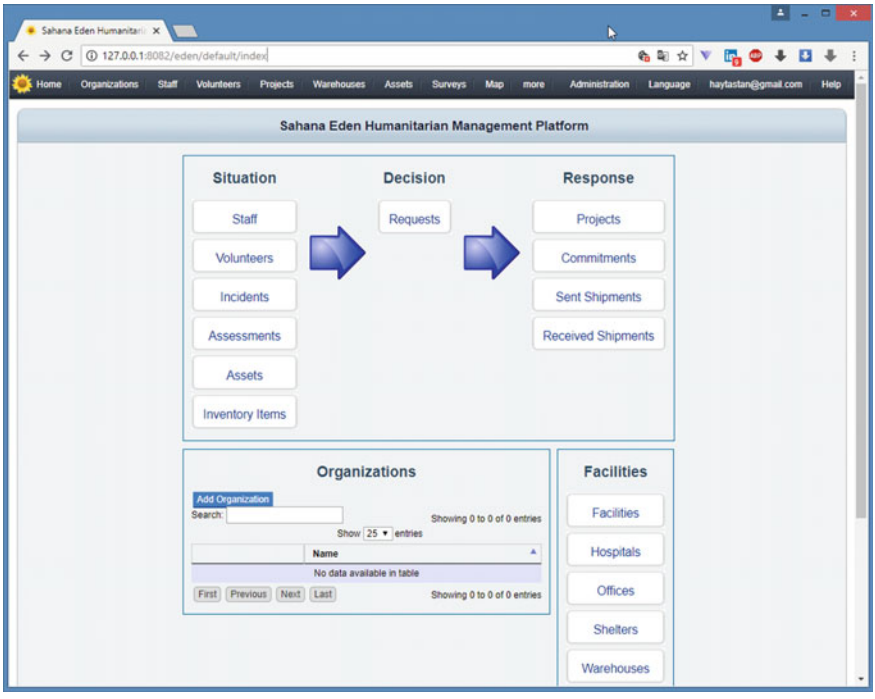

Fig. 4 Screenshot of *Sahana-Eden Humanitarian Management Platform* at the local server (© SAHANA Software Foundation) (The screenshot of *Sahana-Eden Humanitarian Management Platform* at the local server at https://hayatitastan.ushahidi.io/views/map is used with the permission from "*Dr. Devin Balkind, President at SAHANA Software Foundation*".)

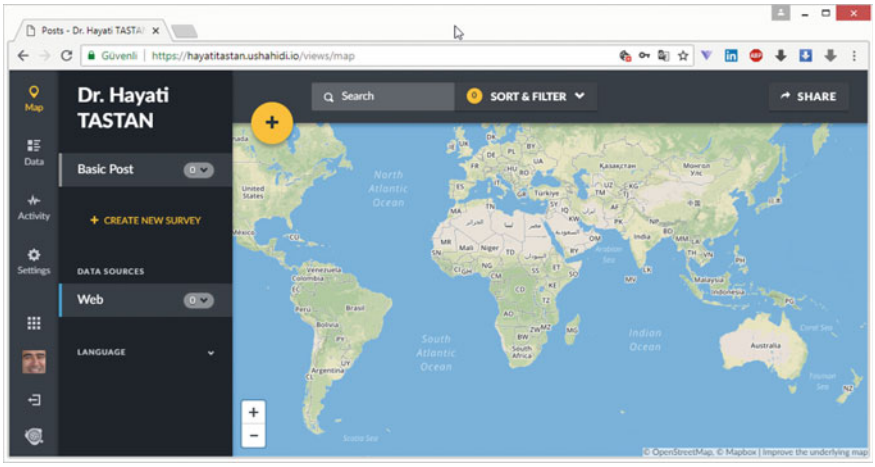

Fig. 5 Screenshot of the free *Ushahidi web platform* at *ushahidi.io* domain (© 2018 USHAHIDI) (The screenshot of the free *Ushahidi web platform* (© 2018 USHAHIDI) at *ushahidi.io* domain at the URL https://hayatitastan.ushahidi.io/views/map is used with the permission from "*Staicy Gitau, Innovation Engagement Officer at USHAHIDI*".)

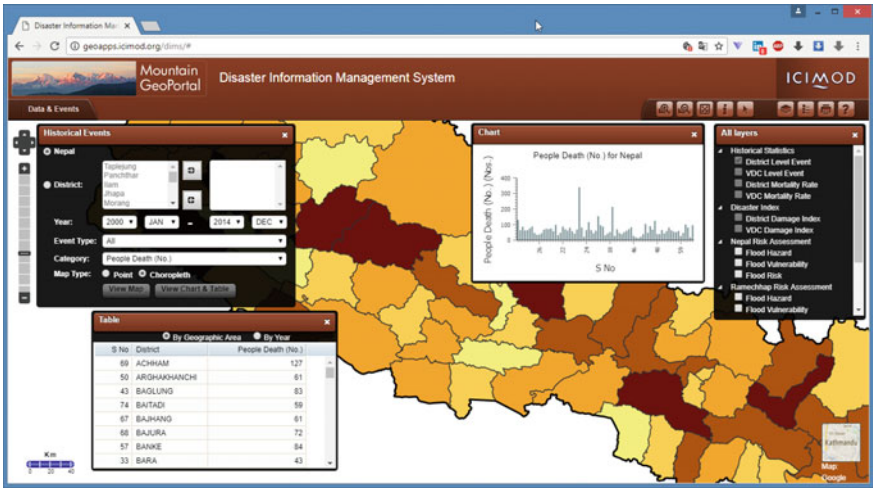

Fig. 6 Screenshot of the *Nepal Mountain GeoPortal—Disaster Information Management System* (© 2018 ICIMOD) (This application was developed as part of the SERVIR Hindu Kush Himalaya (SERVIR-HKH) initiative. SERVIR is a joint development initiative of the United States Agency for International Development (USAID) and the National Aeronautics and Space Administration (NASA). SERVIR-HKH is implemented by the International Centre for Integrated Mountain Development (ICIMOD) in its regional member countries, prioritizing activities in Afghanistan, Bangladesh, Myanmar, Nepal, and Pakistan. The screenshot of this application is used with the permission from "*Birendra Bajracharya, Regional Program Manager at ICIMOD*".)

Mountain Geoportal—Disaster Information Management System (DIMS 2017) is a web portal developed by the International Centre for Integrated Mountain Development (ICIMOD 2018) which gives map based statistics about disasters in Hindu Kush Himalaya—Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan in the past years (Fig. 6).

2 Methodology

Disaster Management and Decision Support System (AYDES) is an information system which is developed for performing the processes of disaster and emergency management efficiently. The system is an integral platform connected to other internal and external systems and applications and composed of desktop software, GIS based web applications (2D and 3D) and mobile applications. AYDES is prepared properly to the content of Turkey Disaster Response Plan (TAMP). The system presents a holistic approach for effective and easy usage in disaster management processes and is designed to be used by Disaster and Emergency Management Presidency (AFAD), relevant ministries and provincial organizations.

AYDES consists of three main components as "Incident Command System", "Spatial Information System", "Recovery Information System" and subcomponents belong to these (Fig. 7). Mobile software tools that can deliver real-time information to the web-based main modules are developed in accordance with the field data collection and consist of applications used in mapping studies within the scope of risk mitigation as well as post-disaster damage detection. In addition, disaster event inventories, potentially vulnerable assets, hazard—risk data, areas of probable or actual disasters, etc. AYDES-RS "desktop image processing and analysis software and AYDES—Crowd Sourcing software have been developed for the use of

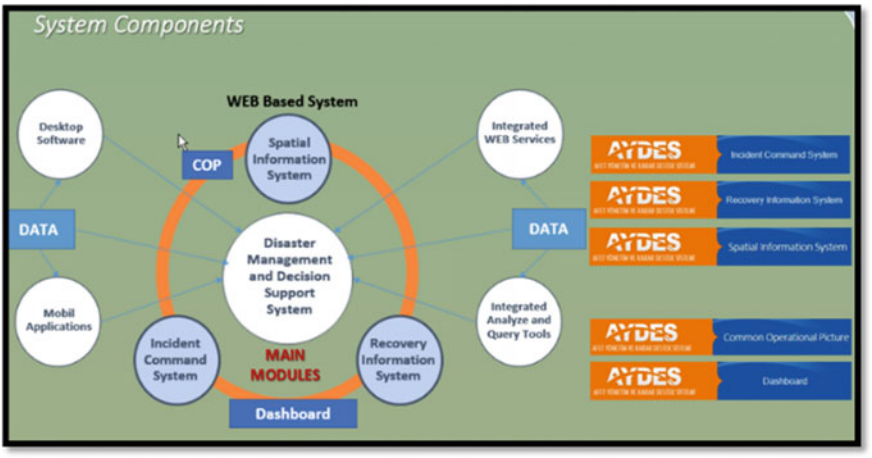

Fig. 7 System components of AYDES

remote (space/air) sensing technologies in various analyses before and after disasters. AYDES is a software and data platform that provide accurate and current disaster and emergency data, reports, statistics, job inspections, queries, analyses etc. at every stages before and after the disaster.

3 Main Components

3.1 Incident Command System

Incident Command System (ICS) is an AYDES component which allows the holistic management of the processes of disaster preparation, planning and response phases that are described in TAMP. Software based management model supports disaster and emergency preparedness and response activities at the local and national level through the main management processes (resource management, transport, demand management) flexibly and effectively. When a disaster event occurs at national or local level, event notifications can be sent to teams by SMS and e-mail so that via the instant messaging and e-mail, service groups (defined as part of TAMP) can remain in continuous interaction and communication.

Data pool and data analysis framework was set up so that 28 service groups could process the processes related to their own specialization fields and data that could be needed in the management of service groups could be entered into the system during various stages of disaster.

Sub-menus in ICS are as follows: (1) Incident identification and listing, (2) Organization structure, (3) Address book, (4) Facility management, (5) TAMP documentation, (6) Service Group Recovery procedures, (7) Resource management,

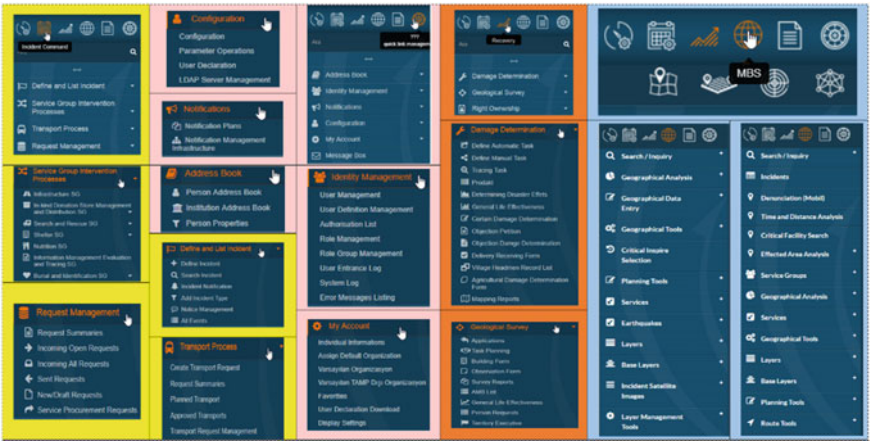

Fig. 8 Menus and sub-menus of AYDES

(8) Demand management, (9) Transportation and transfer operations, (10) Scenario panel, (11) Identity management, (12) Message box, (13) Notifications, (14) Reports, (16) My Account. Figure 8 shows the menus and sub-menus of AYDES.

ICS is designed according to the content of TAMP. A post-disaster use of ICS can be summarized as follows. After a disaster, the need estimate is automatically calculated by AYDES ICS using the information obtained from the disaster area. Search and rescue teams demand the equipment they need from the system.

The tasks and transactions of service groups carried out within the scope of the tasks and responsibilities, what requests are made, whether they are met or not and all response operations are monitored and can be monitored and reported in real time from the system. Figure 9 shows the ICS and Fig. 10 shows the dashboards of ICS for the number of total evacuated, identity status and injured information.

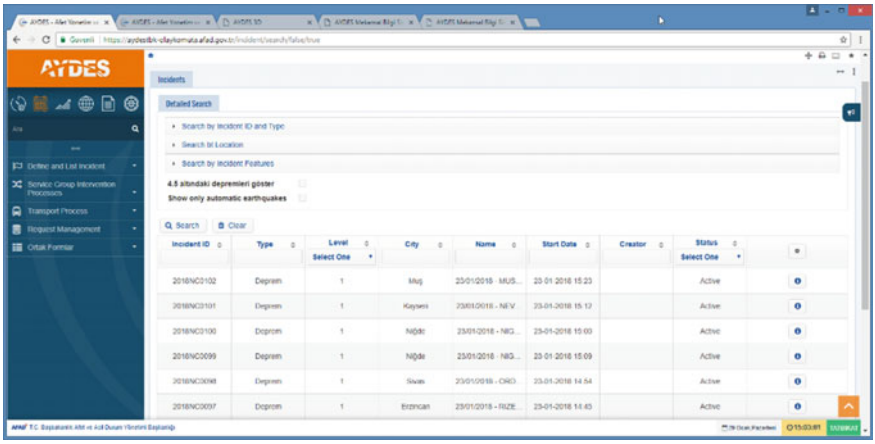

Fig. 9 Incident management system of AYDES

Fig. 10 Dashboards of incident management system

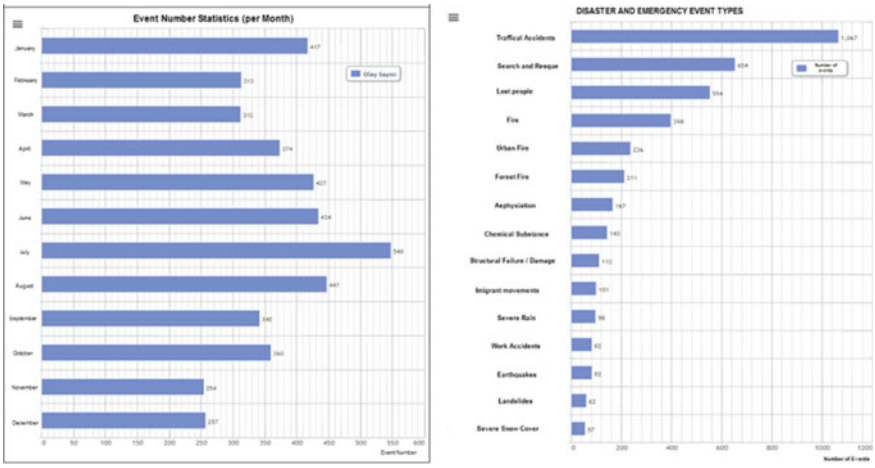

Fig. 11 The monthly numbers of incidents and most disaster and emergency types in 2017

A total of 4442 events were entered in AYDES using Incident Command System in 2017. This shows that AFAD responds on an average of more than 12 disasters every day. Figure 11 shows the monthly numbers of incidents and the most disaster and emergency types recorded in 2017.

3.2 Recovery Information System

Sub modules of the RIS developed already are as follows:

- Damage Assessment
- Geological Hazard Survey
- Beneficiary Management.

The other sub modules of the RIS to be developed are as follows:

- Resettlement Site Selection
- Investment Program
- National Emergency Assistance and Tracking.

The outputs the "Damage Assessment" sub module are used as input to the Beneficiary Management sub module of RIS.

Recovery Information System (RIS) aims to realize post disaster recovery activities in electronic environment with GIS support. Thus, consistency between the different recovery stages (damage determination, geological surveys, right ownership and debiting, resettlement site selection, investment program and national emergency assistance and tracking) that produce input for other stages will

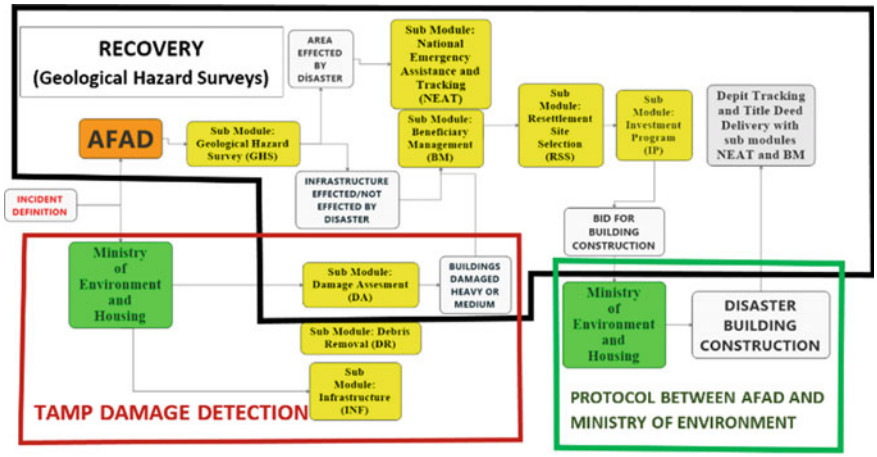

Fig. 12 Relationships between submodules of RIS and TAMP damage detection

be ensured and incorrect operations—caused by repeated or wrong data records-will be prevented. Also, system allows the collection of data by mobile applications from field and near real time location based post disaster data are presented for decision makers and other users of the system. Figure 12 shows the relationships between RIS sub modules and TAMP damage detection sub module.

3.2.1 Damage Assessment Sub Module

With this module, after the earthquake, flood and fire disaster events are defined, the technical teams are assigned to the site and the damage level of the structures (houses, barns, etc.), information about location, owners and tenants of these structures are acquired via web and mobile applications. The owners of heavy and moderately damaged structures are considered to be victims of disaster (possible beneficiary candidates). This information provides input data to the entitlement and beneficiary management module. This information is also used in permanent settlement construction, housing and rent aids (Fig. 13).

3.2.2 Resettlement Site Selection Sub Module

For the victims of disasters, it is the module where the safe residential areas are searched, identified and selected for settlement planning and construction. In the determination of new settlement areas, General Directorate of State Hydraulic Works, General Directorate of Forestry, institutional remarks are collected. The settlement zoning plans, cadastral plans and land registries of the possible settlement areas to be selected are evaluated. If there is no zoning plan in new settlement

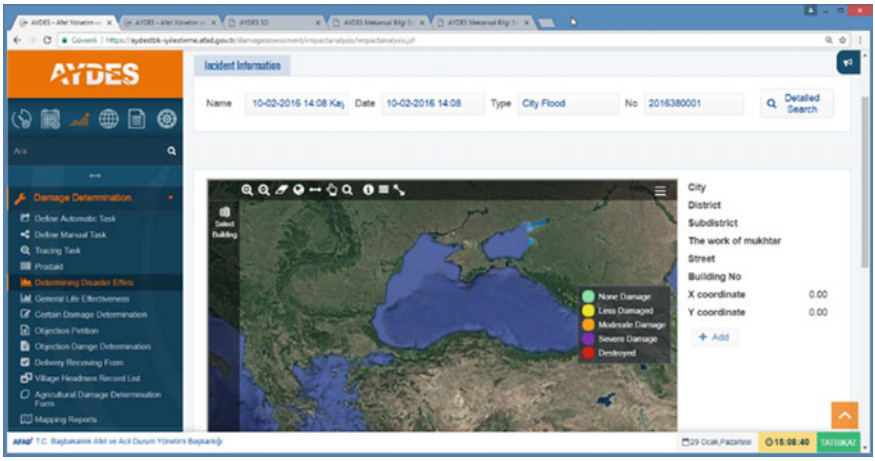

Fig. 13 AYDES-RIS damage determination sub module

areas, zoning plans will be created by taking geological and geotechnical survey studies after mapping the current situation. Site selection report is prepared after technical studies.

3.2.3 Geological Hazard Survey Sub Module

With this module, the ground and building conditions are analyzed together after identifying any disaster events. After the event is defined, all insensitivities in the field caused by landslide, avalanche, flood, earthquake, fire etc. are mapped and areas affected by disaster are marked on the map using web and mobile applications. The location, the owner and the tenant information of the buildings in the areas affected by disaster are collected via the interfaces of this module. This information provides input data to the entitlement and debit module. This information also provides input data to the entitlement and debit module. This information is also used in housing, housing and rent aids.

3.2.4 Investment Program Sub Module

The entitlements to be placed in the new settlement areas where the site selection report is prepared are taken to the investment program list. This list also includes methods of housing construction (e.g. household assistance, tender, TOKI, etc.). Allocation is requested from the Ministry of Development for the beneficiaries of the investment program. It is the module of the works done up to the delivery of the houses made by the above mentioned housing construction methods. In addition, this module is used to list the excess land and houses.

3.2.5 National Emergency Assistance and Tracking Sub Module

Using this module, in accordance with Law No. 4123 on the Execution of Services Related to Natural Disasters Due to Natural Disasters, carrying out are the services that will provide the normal life for the areas affected by the disaster and the requests made in the Governor's offices for the removal of damage and destruction were followed.

3.2.6 Beneficiary Sub Module

With this module, Beneficiary Management commission, created by AFAD's provincial directorate, evaluates the beneficiary management of the disaster victims using the outputs of damage assessment and geological hazard survey modules. After evaluation, they prepare and approve the name lists of the beneficiary disaster victims. Disaster victims who are deemed as beneficiary shall be debited for no interest for a period of 20 years. With this module, repayment of debits is also followed.

3.3 Spatial Information System

Spatial Information System (SIS) is the supplementary part of the whole work to build a sustainable disaster management and decision support system by using geographical information system (GIS) technologies. Spatial data—which can be used in disaster and emergency management—were collected in physical environment or by web services from different governmental or non-governmental agencies to create a geodatabase as part of SIS. It is designed for accurate and quick decision making by spatial queries and analysis with existing and contemporaneously added data pre-disaster, during disaster and post-disaster activities. Subcomponents and menus of the application provide to update, edit and query of the spatial data as real time and allow to view and report the final results. The *Common Operation Picture* (COP), which has basically the same design and common features as the SIS (MBS in Turkish), is an additional component that displays and reports on work and results, especially with respect to the stage of the response to the disaster. Under COP, real-time information from AYDES components is planned to be generated instantaneously by means of this information.

3.3.1 Layers of Geographic Database that Have Been Created Through SIS

Inspire Layers:
(1) Land use cover, (2) Buildings, (3) Geographical grid systems and map indexes, (4) Geographical structures, (5) Energy resources, (6) Hydrography,

(7) Administrative units, settlements, addresses, (8) Geology, (9) Public services, (10) Protected private areas, (11) Population distribution and demography, (12) Agriculture, (13) Transportation Networks, (14) Industrial areas, (15) Topography.

Facility Layers:
(1) Finance, shopping and trade, (2) Sheltering and accommodation, (3) Educational institutions, (4) Critical substructure and superstructure, (5) Public institutions, (6) Health facilities, (7) Industrial and manufactural points, (8) Non-governmental organizations, (9) Socio-cultural facilities, (10) Historical and touristic structures, (11) Telecommunication, (12) Transportation facilities, (13) Food, drink and amusement places, (14) Green zones.

AFAD Layers:

***Disaster Prevention and Response Sub Layers*:**
(1) AFAD and AADYM units, (2) Sheltering, (3) Food production units and facilities, (4) Distribution points, (5) Burial service areas, (6) Warehouses, (7) Debris removal, (8) Food, agricultural and farming, (9) Security and traffic, (10) Communication, (11) Service groups and logistic, (12) Health cares, (13) Technical support and supply, (14) Assembly areas, (15) Warn and alarm points, (16) Fires, (17) Routes to AFAD logistic warehouses of city centers.

***Disaster Inventory–Danger—Risk Zones Sub Layers*:**
(1) Earthquake (2) Faults, (3) Landslides, (4) Rock fall, (5) Floods, (6) Risk Maps, (7) Technological disasters, (8) All disaster inventories (point), (9) Avalanches.

3.3.2 Main Components of the SIS Sublayer

- *Map Tools*: with map tools you can use functions such as get info, zoom in, zoom out, clear map, layer control, active layer, go to coordinate, preview window, scale tool, coordinate system selection tool.
- *Address Search Bar*: provides an option to search for an address or facility on the map.
- *Search and Query Menu*: provides an option to make an inquiry from disaster preparation data, structural data, inspire data and also from the events that occurred.
- *Geographic Analysis Menu*: makes an inquiry by creating a buffer zone for disaster preparation and some analysis processes such as proximity analysis, linear proximity analysis, buffer zone analysis and analysis by drawing areas.
- *Geographical Data Entry Menu*: provides an option to entry geographical data to layer of buildings, disaster inventory risk zones, also primary damage and primary influence area risk analyses.
- *Geographical Tool Menu*: provides an option to load and view kml, shp files.

- *Services Menus*: provides an option to reach services such as YAHOO meteorology, EUMSTAT, KGM, YUVAM, TRAFFIC WFS, AFKEN tent areas and AFAD logistic warehouses.
- *Earthquakes Menu*: provides an option to view all earthquake information on the map which have been supplied by Earthquake Department of AFAD.
- *Layers Menu:* provides an option to reach layers of Ortho-photo, vector tile, Google earth, Bing aerial, TURKSAT Satellite, World imagery, Landsat 2000.
- *Event Dependent Layer Menus*: provides an option to matchup event dependent layers and to view layers that matchup depending on events.
- *Layer Management Tools*: provide an option to view the metadata of layers.
- *Events Menu*: provides an option to search for disaster and emergency situations and locate them on map.
- *Service Groups Menu*: provides an option to view the special info of data that have been entered by command module of COP module.
- *Planning Tools Menu*: provides an option to make geographical planning on map and record it.
- *Route Tools*: provide an option to determine and draw the route between two locations by selecting start and finish points on the map.
- *Preliminary Impact Analysis/Preliminary Damage Locating Menus*: provide an option to view the estimated distribution of earthquake damage made by AFAD-RED, the remote sensing analysis results, the analysis of damaged buildings.

3.3.3 Main Components of the SIS Sublayer

- REGISTRY and CADASTER (integrates spatial land/parcels data to SIS by using title parcels services and land registry)
- KGM (displays the roads that are closed or under construction with the help of web services supplied by the General Directorate of Roads)
- GEZGIN (connects to services that shows metadata and coverage service Ares of RASAT satellite images)
- TRAFIK WFS (integrates up-to-date data of traffic situation, roads, real-time speeds and speed limits in Turkey that have been acquired by Başarsoft web services by using 4 different colors according to the traffic density)
- NVI-UAVT (connects National Address Database (UAVT) to SIS to locate the address of the user)
- METEOROLOJI (integrates weather forecast acquired by meteorology to SIS)
- YAHOO (integrates YAHOO weather forecasts data to SIS)
- EUMETSAT (integrates EUMETSAAT weather forecasts data to SIS)
- GOOGLE (integrates Google satellite, Google Street, Google physical data)
- BING (integrates BING satellite maps)
- TÜRKSAT (integrates TURKSATMAPS satellite, physical, land data)

- VECTOR TILE, VECTOR LAYERS (integrates vector layers and tiles to SIS.)
- ORTHO-PHOTO (integrates raster data that have been acquired by General Directorate of Registry and Cadaster (TKGM) in 2009, 2010, 2011, 2011, 2013)
- LANDSAT 2000 (integrates Landsat satellite images)
- SETTLEMENT SUITABILITY SERVICE (integrates the data of settlement sustainability areas that acquired by settlement sustainability service which were created by settlement sustainability (YUVAM) project)
- DISASTER AFFECTED ZONES SERVICE (integrates the data of disaster affected zones that have created by settlement sustainability (YUVAM) project)
- AFKEN TENT POINTS (integrates the data of tent points that acquired by AFKEN web application)
- CONTAINER TRACKING (integrates the data of container tracking that have been acquired by logistic warehouse systems applications)
- AFAD LOGOSTIC WAREHOUSES (integrates the spatial data of AFAD logistic warehouse layers with their attributes).

Although SIS and COP menus look alike, they differ in purpose of use and user profiles. COP is a supplementary component for disaster response. Disaster and emergency events that have happened in our country can be viewed by these component. Both components have analysis and query modules. Flood domains, real-time estimations of seismic intensities of earthquakes that happened, interpretation, analyses and queries can be made by these components. Screenshots of components of SIS and COP are shown in Figs. 14 and 15.

3.4 Mobile Applications

After the disaster, damage detection data related to the disaster area and disaster event inventory (landslide, rock fall, avalanche) data can be gathered by mobile applications quickly and efficiently as well as offline while offline data can be transferred to AYDES as soon as the Internet connection is available. The mobile applications developed in this context are as follows.

3.4.1 Disaster Event Inventory Data Collection Mobile Application

Spatial data related to disaster events such as landslide, rock fall and avalanche (landslide area, rock fall source-spread area, falling blocks, avalanche areas etc.) and descriptive data (feature attribute values) can be collected on-line and off-line by this mobile application. The roads, points of interest (parks, public institutions, shopping centers, industrial areas, etc.), topographic maps, geological maps and satellite images (in on-line mode) as well as provincial, district and neighborhood border data can be used as base layers. The collected data can be displayed in the

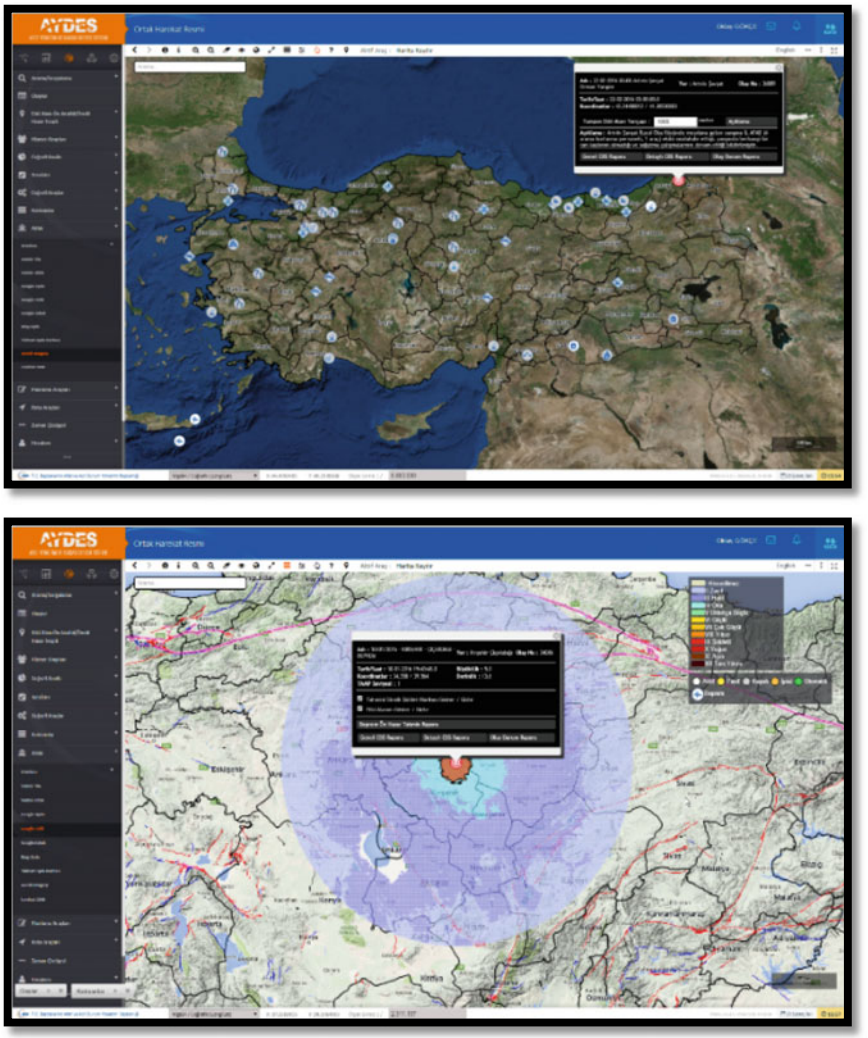

Fig. 14 SIS and COP components (1) of AYDES

main component of the SIS in real time. Figure 16 shows screenshots of this Disaster Event Inventory Data Collection Mobile Application.

3.4.2 Damage Assessment Mobile Application

Spatial On-line and off-line, geo-located damage detection data can be collected using damage detection forms in different detail. Unauthorized transactions are

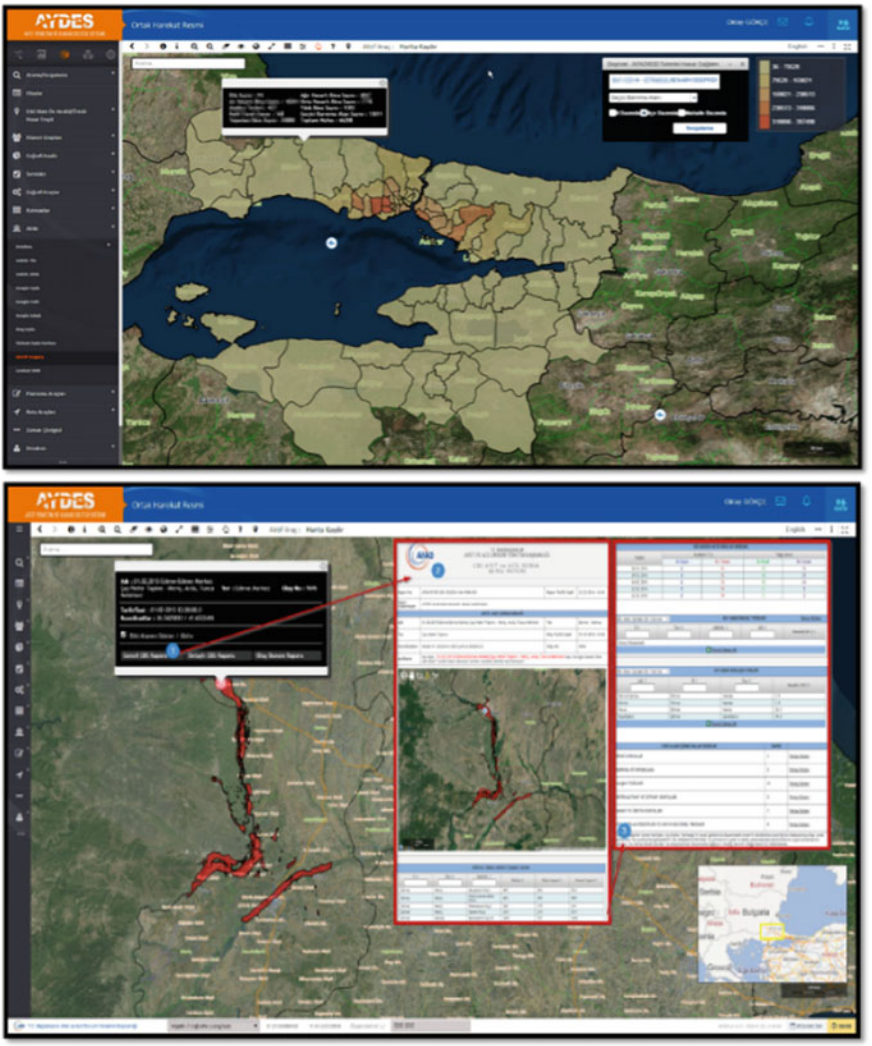

Fig. 15 SIS and COP components (2) of AYDES

prevented by interrogating the personnel information to be assigned to the damage assessment studies during the data entry. In practice, it can be used as a base by taking the roads, important points (parks, public institutions, shopping centers, etc.), topographic maps and satellite images—on-line—on the mobile device memory as well as provincial, district and neighborhood data. The collected data can be displayed in real-time on the relevant screens of SIS and Recovery components.

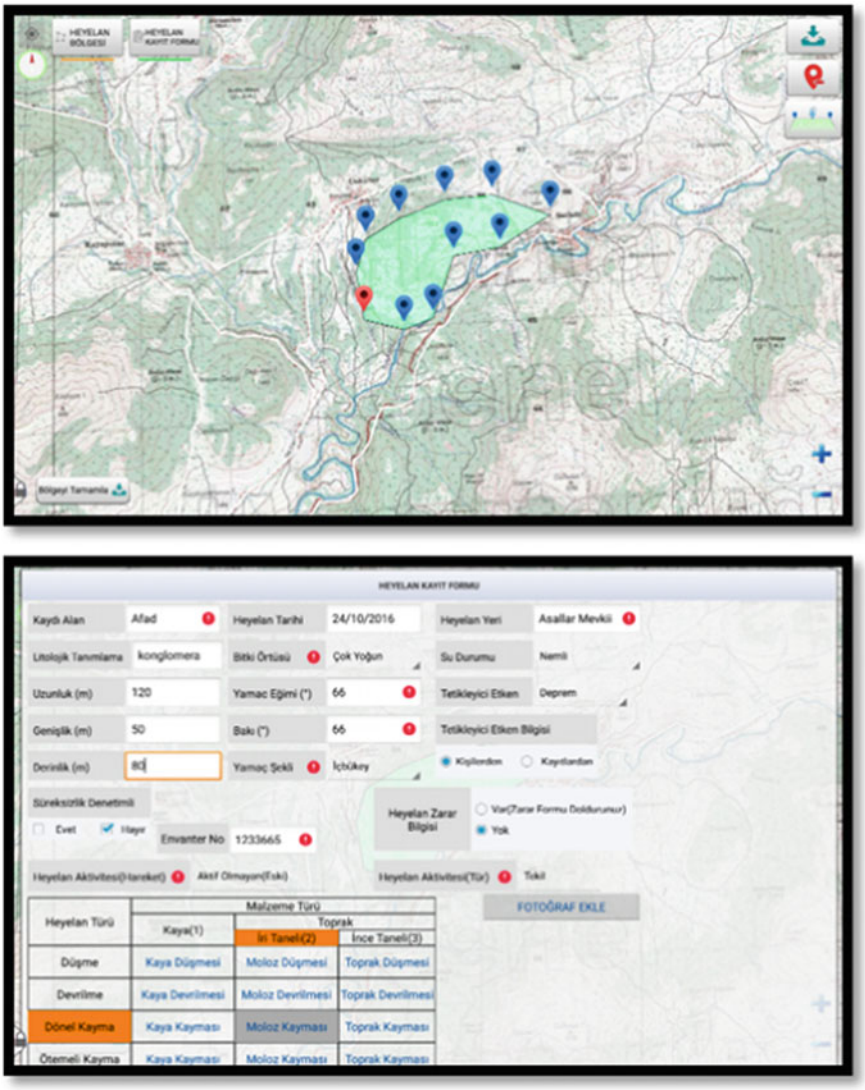

Fig. 16 Disaster event inventory data collection mobile application

3.4.3 Geological Hazard Survey Reports Mobile Application

Spatial data (survey area, landslide area, area exposed to hazard etc.) determined in geological hazard survey reports and related descriptive data (disaster victim list, disaster situation etc.) will be collected on-line and off-line. The collected data can be displayed on the relevant screens of the SIS and Recovery components in real time (to be developed).

3.4.4 Resettlement Site Selection Mobile Application

This software will allow the collection of spatial data (parcel, area, etc. determined for site selection) and relevant descriptive data (feature attribute values) specified in the site selection protocols and works. The collected data can be displayed on the relevant screens of the SIS and Recovery components in real time (to be developed).

4 Image Processing and Analysis Tools of AYDES

Remote sensing technology provides an important data source that can be used in disaster management. A lot and various data and evaluations related with disaster event inventory, vulnerable assets, hazard-risk, disaster prone areas, and damage assessment results etc. are needed in context of disaster management and decision support systems. For this purpose, AYDES-RS software and AYDES-CS platform have been developed to use in processing and evaluating the images provided by remote sensing (space/aerial) technology for several disaster managements related analyses in terms of Disaster and Emergency Management Authority (AFAD)'s needs. Evaluation results are integrated directly to AYDES and shared publicly by AFAD web site.

4.1 AYDES-RS (Remote Sensing) Software

AYDES-RS (AYDES-UZAL in Turkish) is a desktop software that process and analyze synthetic aperture radar (SAR) electro-optic (EO) satellite images/aerial photos. It is developed in Java by using ESA's open source libraries and contains specific applications for identifying preliminary affected area and hazard/damage assessment caused by disasters like earthquake, flood and forest fire. Different applications and algorithms also provide change detection, supervised/unsupervised classification, object based image analysis and fabric analysis. The primary aim of AYDES-RS is to offer an integrated software solution of visualizing, processing, analyzing remote sensed data, presenting and exporting results into disaster management and decision support systems (Fig. 17).

4.2 AYDES-CS (Crowd-Sourcing) Platform

AYDES-CS (AYDES-KITLEKAYNAK in Turkish) is a web based crowd—sourcing platform. In order to eliminate the deficiency of automatic image processing algorithms or to confirm their results, manual assessment of post-disaster

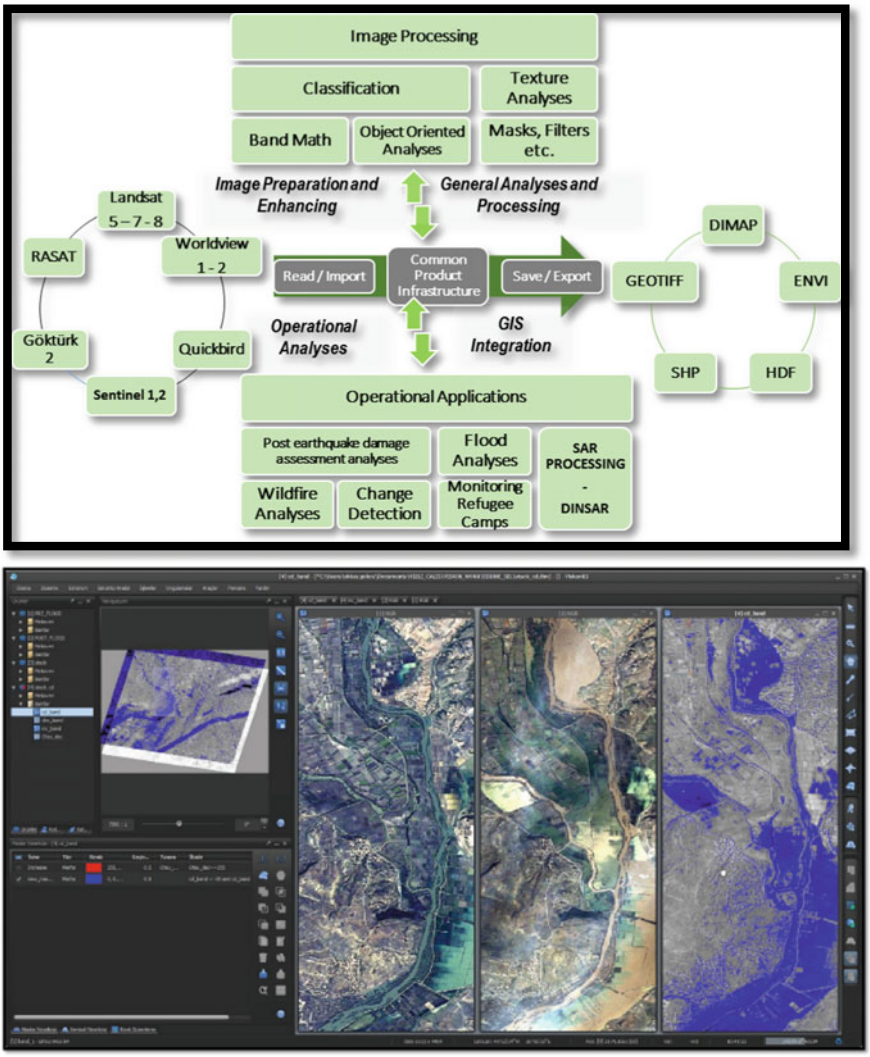

Fig. 17 Main functions and simple analyses with AYDES-RS

images is required. For this purpose, post disaster images are divided into little pieces, tiled and then sent to previously identified users called as crowd through the web. They fulfil their duties by examining the images and marking on them according to type of operation. Same image tile can be sent more than one user. Consequently, the system evaluates the markings of users and produce a final report automatically by using statistical algorithms. The results about the number and location of damaged buildings, location of closed roads, wrecks and landslide flood prone areas etc. are available in minutes (Fig. 18).

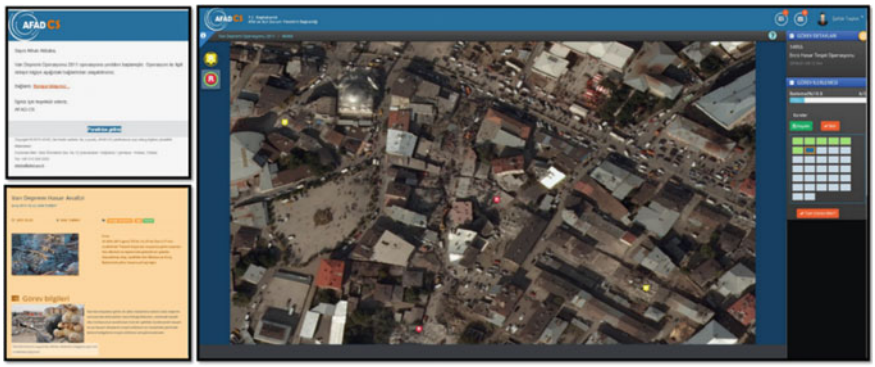

Fig. 18 AYDES-CS platform

The crowd of experts or volunteers are informed that they are being tasked with a manual disaster assessment by SMS or e-mail sent automatically to them. They enter the system via their computers or mobile devices. For example, the buildings destroyed after an earthquake are quickly marked by the crowd. Each user is given a limited size and number of satellite/aerial image tiles. The same image tile can be evaluated by more than one user. Once users complete the marking, the system

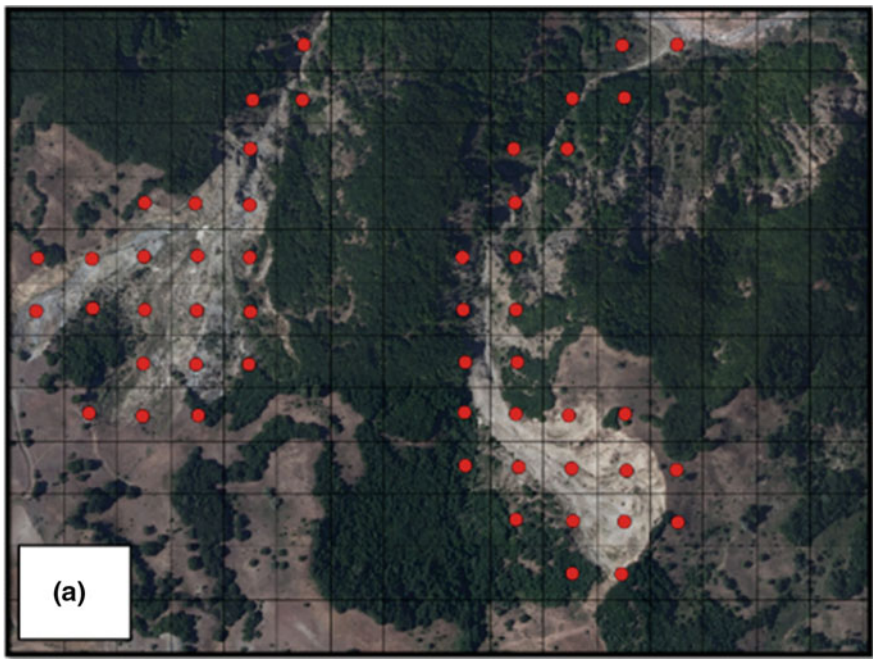

Fig. 19 Digitizing the landslide areas at AYDES-CS platform

Fig. 20 Marking buildings damaged by earthquake at AYDES-CS platform

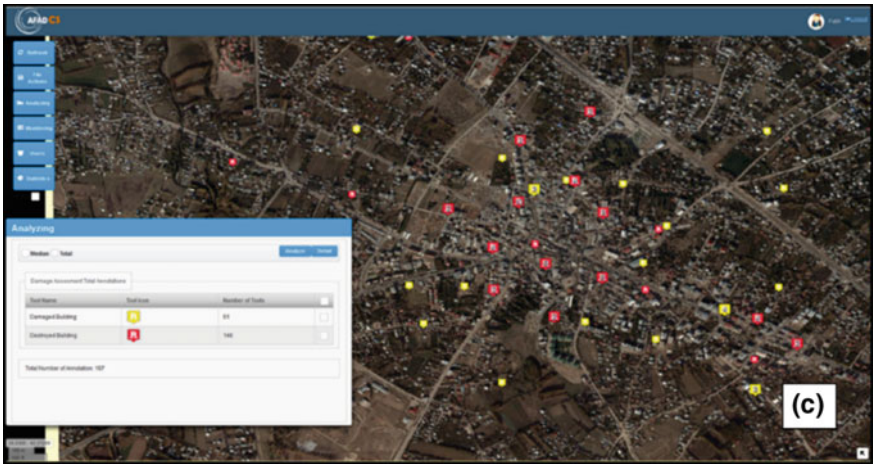

Fig. 21 Integration of AYDES-CS results into AYDES

evaluates the markings with its own algorithms and provides optimal results. When the results are obtained, the user's assessment scores from previous disaster events, stable markings made by different users in the same image tile, etc. are taken into consideration. Figures 19 and 20 show the markings to identify landslide inventory collection (using image tiles with a size 50 × 50 m) and the inventory of buildings damaged by post-disaster floods, respectively whereas Fig. 21 shows their results integrated to AYDES.

AYDES-RS and AYDES_CS have been developed with the cooperation of AFAD and TUBITAK (The Scientific and Technological Research Council of Turkey).

5 Discussion

We have developed an integrated infrastructure with desktop tools, a web platform and mobile applications to support collaboration efforts for all types and phases of disaster in any part of the world and for everybody (i.e. an all-in-one solution for IT based disaster management). Using the web-GIS based technology, we built AYDES web platform to combine vector and raster geographical datasets as the base data layers; using Java technology, we developed desktop tools AYDES-RS and AYDES-Crowd Sourcing to extract information from satellite images for AYDES web platform; and using GNSS & GSM and mobile programming technologies, we developed mobile applications to feed AYDES web platform with up-to-date disaster information and vice versa. Serving AYDES web platform and AYDES-Crowd Sourcing as an "Infrastructure as a service (IaaS)" and serving AYDES-RS as a "Software as a Service (SaaS)" are among our future plans. As compared with the disaster systems/portals/software tools discussed in the introduction section, AYDES is an all-in-one system whereas the others are not or lack of some components of AYDES.

6 Conclusion

Through the Disaster Management and Decision Support System (AYDES) project, efforts are being made to establish and sustain an information infrastructure and decision support system centered management model required for the effective management of disaster and emergency management processes. AYDES, including desktop, mobile and web-based applications based on GIS and RS technologies, is an integrated platform connected to many internal and external systems.

This platform, especially Turkey Disaster Response Plan coverage prepared in accordance with AFAD, relevant Ministries, designed to be used by private organizations and provincial organizations, processes active, care is taken to be an

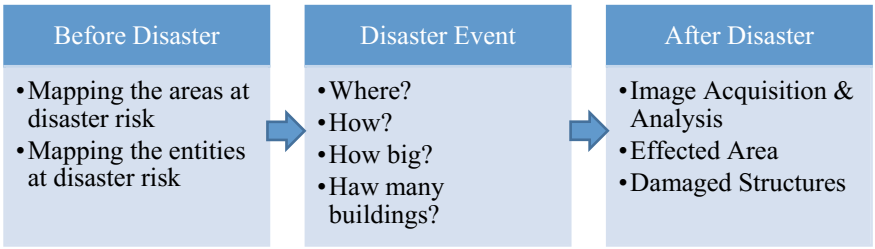

Fig. 22 The procedure at AYDES

integrated framework that allows quick execution. Figure 22 summarizes the procedure at AYDES which is trying to answer briefly about any disaster event.

As a result; within the context of disaster management and decision support system, AYDES is an integrated Geospatial IT based platform comprising procedures, human resources, data, hardware and software tools which provide accurate and current disaster and emergency data and information, various reports, statistics, task monitoring, queries and analysis, etc. at all stages before and after a disaster. As for the future development of AYDES, we plan to update existing modules and add new functionalities according to the feedbacks of the users.

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