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Case study

Geographic information system software application developed by a regional emergency agency

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ABSTRACT

This paper presents a methodology for risk analysis and assessment to manage territorial data based on Geographical Information Systems from the viewpoints of climatology, geography, disaster science, environmental science, fire safety and urban services. The results in this methodology are intended to support local and provincial government agencies to: make resource allocation decisions; make high-level planning decisions and raise public awareness of disasters risk, its causes, and ways to manage it.

The Autonomous Community of Navarra, as a result of a special administrative status, possesses a number of specific features that have let it build up a high technological development in several fields. The main areas of research are healthcare and renewable energies, but also focused in the implementation of security systems at territorial level. These advances and particularities of the GIS software used by the fire fighters of this community will be the ones shown in this paper, as well as its prospective improvements in the collaboration with the experts responsible for urban planning of a School of Architecture.

1. Introduction

In this explanation, ecological and landscape data are integrated with decision-support techniques in a Geographic Information Systems (GIS) framework [1], which offers a useful communication network that provides a complete picture of what's happening in real time [2,3].

This is a dual system, one online and other offline. The first one opened to different police and emergency services, and the second one for tablet application that the fire fighters officials take with them in their rapid intervention vehicles. A GIS platform has been developed to easily, validly and promptly share and utilize information and tools among firefighting forces, which can locate fire service vehicles, fire fighters operating on georeferenced field and other resources online and in real-time.

This paper will examine how GIS technology is helping the fire service meet the needs of the community more efficiently than before [4].

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2. Antecedents

Effective response cannot be continually achieved without adequate planning and preparedness. One of the emerging tools that is helping the fire service optimize its emergency services delivery is geographic information system (GIS) technology [5]. GIS supports planning, preparedness, mitigation, response, and incident management [6]. GIS extends the capability of maps—intelligent, interactive maps with Access to all types of information, analysis, and data. More important, GIS provides the required information when, where, and how it is needed (Fig. 1) [7].

In this sense, building on a data collection system already in place it was possible to minimize the cost and accelerate the training process, and it is possible to find different experiences from the identification of homes that experienced a fire after an alarm was installed and calculated potential lives saved based on program documentation and average housing occupancy, or to measure an organization's fire safety performance [8].

It is also possible to create a final ranking map of the risk of losing resilience, which is very useful in identifying the "risk hotspots" [9], where post-fire management measures should be applied in priority [10].

We know that fire fighters work under extremely stressful conditions where even their own lives and the lives of potential victims can be at stake. It is clear that there is no room for error and that extensive training and previous information are crucial in this regard. In order to save time the entire database works with photographic images of the real places [11].

May include other information of interest such as maps of the floors of the building, plans on building facilities energetic, sectors of fire, means of protection, access and others to help firefighters in their action on fires and other emergencies

3. Online system

This is an online application with 3G technology, which goal is to provide with a geo-satellite positioning system (GIS) the necessary information for the Fire Department, so that there is a chance to have a better control on a forecast basis and an optimal methodology of reaction in both the time invested and the chosen routes when an emergency call is taken.

This application software is developed by a Navarra-based company dedicated to the development of services based on the use of IT for territorial information and that works both for public administrations and private organizations, contributing to innovation and development in this and other computerized platforms of a similar use [12].

There is the possibility of a private sale but for the moment this market area has not been explored considering the ease of working for the public entity.

It is a useful tool created for Windows (not yet as a Macintosh operating system widget), as well as it is available for tablets and smartphones.

When the program is opened can be seen several on-going and updated incidents thanks to the provision of a series of interconnected digital repeaters located throughout various key points of the geography of Navarra. This application links the communication and distributes the relevant information to the different central government divisions: the Police

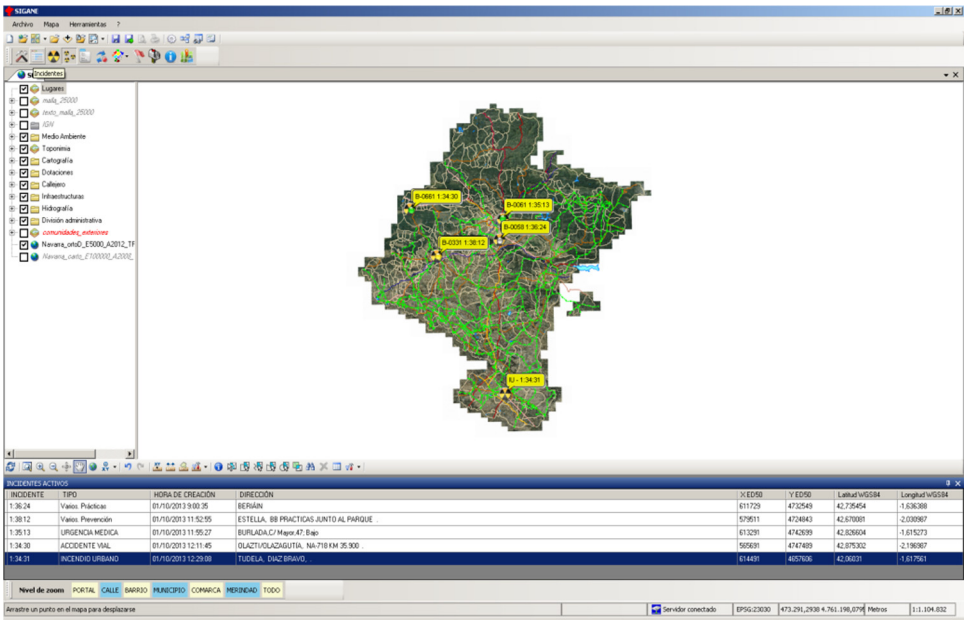

Fig. 1. Navarra territorial map showing incidents that concern the Fire Department.

Department, the Fire Department or the Forest Guard so that there are specific adaptations of the main parent program for the different use requirements.

This physical placement it is shared with television and telephone repeaters stations to optimize the resources and improve the maintenance, because some areas of Navarre can be troublesome due to the different types of climate and abrupt orography. Accordingly, a Volkswagen vehicle will be available as a mobile repeater station in order to be used when the server shutdown and needs a reboot.

The running of the program distinguishes between the different incidents that may be faced after an emergency call, for example an occupational accident or a forest fire [13], and match them with the specific geographical coordinates corresponding to a street number in case it is settled in an urban area, or just identifying a delimited region among a rural or mountainous environment.

Apart from the occasional emergency cases that are located in the territory, every change of staff or routine movement of any vehicle working around Navarre is reflected in the application. As soon as these vehicles leave from the fire stations, they are guided to the points where the emergency calls to 112 have located the incidents. These locations will be continuously updated on the program map depending on the type of each vehicle: every minute for the ambulances and the helicopters of the rescue teams, every two minutes for the rest of the GPS-tracked vehicles, and finally every four minutes for the walkie-talkies.

A very visual example of a useful and unmistakable identification is the use of different colors for each information on the traffic conditions and emergency transport, for example, a fire truck it is shown in grey if it is placed in the fire station and in green when is already attending an emergency call. (Fig. 2)

Another of the main aspects in which must be focused the article is the option of the tracking that is given to every user by the application (Fig. 3). This involves a possibility to store information over a three-month period about every route that any of the official vehicles have taken so that the administration can benefit from this database for further use. Some of the interesting applications can be saving public resources in terms of improvement in the distance travelled by enhancing the entrances and optimizing the intervention capacity and the reaction time of the emergency services [14].

It can also be used to testify in trials and trying to help in the prevention of prospective accidents by identifying the most critical points of the traffic network. One last possible use of the program is as a spatial triangulation method, which could be later used to delimit search areas in forested zones. For example, marked in yellow would be an already registered clean area, and in purple another one that would only be briefly checked with patrol dogs that cannot guarantee the absence of the objective.

When an urban area such a small city is registered, there is a building stock relevant enough to be included in the application. In this way, a PDF file will be created about every building indicating its entrance with a blue rhombus (Fig. 4). This could be key information for any rescue patrol attending an emergency call. These data sheets have been developed by external staff including architecture students or convicted people who have been ordered to perform community service, and will contain photographs, contacts, important facts or figures, or links that would provide the fire fighters extra tools in their fire prevention task. Obviously, the essential location of the place in *X* and *Y* coordinates will be included.

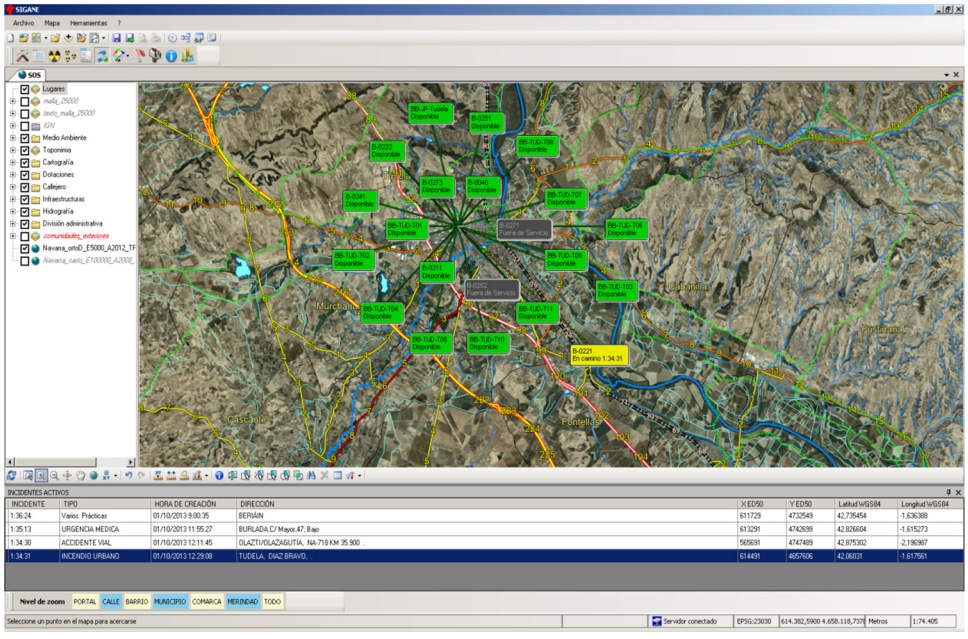

Fig. 2. Different colors depending on the type of vehicle used for the emergency.

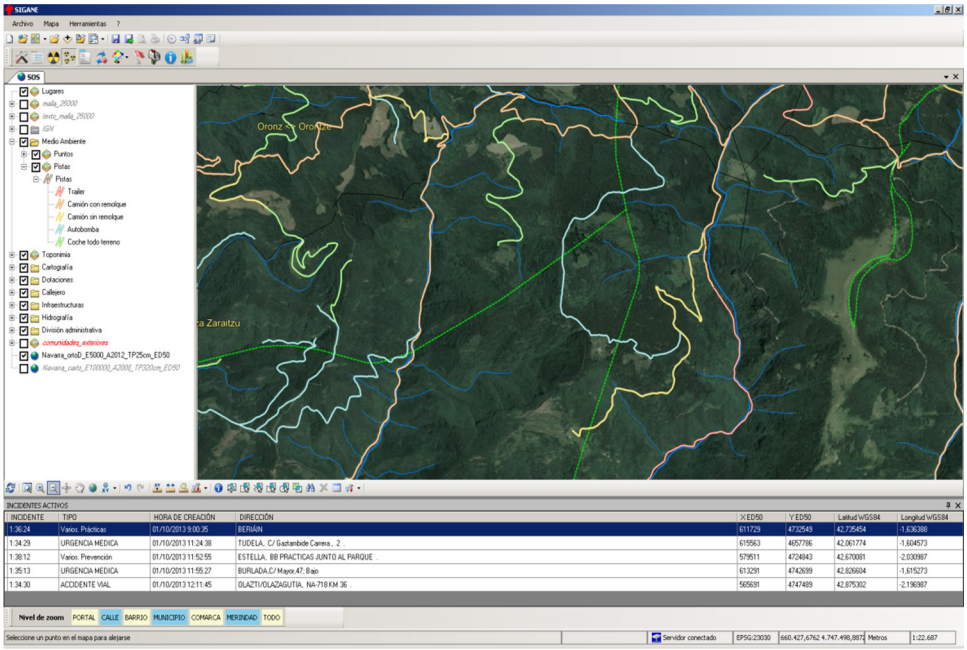

Fig. 3. Tracking: different colors marking the type of road that can be used for the emergency.

At the scale of the neighborhood, the satellite view lets the consultant approach to a maximum view of 1/5000 scale and

Fig. 4. Image of the PDF file containing the typical information that can be found in any sheet.

in that level of detail it is also interesting to emphasize the corresponding information to hydrants, gas cocks or dry column system, not only focused on the fire fighters activities but to anyone interested in the field. All of these devices are represented with its corresponding symbolism.

Some of the GIS additional features, which has been expressly created by the Fire Department side by side with the developing company, are the following ones:

- It is not using Google Earth or any other advanced cartographic support to establish the database so this means that the area of mapping is confined just to Navarre (a 10 km extension around its frontiers is in development process) (Fig. 5).
- The system allows to search and locate the prescribed burnings or the barbecues in rural areas, as well as the less used tracks have been evaluated by the foresters in order to classify its maintenance and possibility of passage.
- The database live updates are being regularly implemented after a brief notice, but the change is taken with immediate effect. As a consequence, this is a great improvement in terms of logistical organization and optimization of the administration resources.

Fig. 5. Screenshot of an aerial view with the graphic symbols of the legend.

- Another option of the application consists on locating the possible facilities for the distribution of evacuated families when catastrophes happen. Thanks to this, the Navarra Emergency Agency is able to prepare specific plans for each risky situation such us moving people to a school or a Sports center due to its big capacity (Fig. 6).
- There is also an extra feature that includes a map with a layer of the river basin, which identifies the flood-prone areas of Navarra so that accidents and human damages can be avoided when the flood stage reaches [15].

This system has three different screens: one including a notification board, another one explaining the resources and the last one with the Geographic Information Systems (GIS). As a result, this whole application has been required for other regional administrations to be used as their reference framework.

Fig. 6. Screenshot of an aerial view at the scale of the city with the graphic symbols legend.

4. Offline system

This system consists on a tablet without an Internet connection that has been developed with an Android application and Silling browser (Fig. 7). In the specific case of Navarre, there are 16 units distributed throughout the territory, 12 of them in each one of the main Fire Stations and the other 4 for the operational management positions.

The reason why there is no online connection is because there are several Fire Stations that owing to the complicated terrain and the abrupt orography cannot get the enough telephone coverage or the signal reaches inconstantly. Apart from this fact, there was a limited budget for the development of the application, and the huge database required to show the whole cartography forced the decision of reducing the scale of the maps to a maximum of 1/1000.

Among the different options or tools that this application allows us to control, here there are some of them:

- The accesses to the railway tracks, where can be checked the bridges or the underpasses (Fig. 10).
- The extrication of vehicles considering the type of vehicle, the location of the airbag or the electrical system.
- The activity of the wind farms existing in Navarra. (Fig. 8)
- The freight transportation.
- The Glasgow coma scale to know the specific medical condition of the people who suffer accident.
- Action protocols and tactical flow chart. (Fig. 9)

5. Discussion

At this point another agencies might ask two questions before investing in this kind of endeavour.

First question: how is data to be kept up to date and validated in the future?

The data acquisition system is done through reliable sources, whose owners require to have them updated for its regular work. This applies for example to the gas distribution networks and cutoffs, the agency water distribution, electricity distribution services or other critical infrastructure services that require continuous data updates. Regarding to rural roads, forest guards do the update for their own interests.

Updating the mapping and the layers themselves (swamps, rivers, aquifers and other) is for the whole Government of Navarra and therefore shared, having a developing and maintaining group that integrates information from different points and in different formats. With regard to the buildings files, businesses and other points of interest, it is something new that has begun in recent years and currently only generate new records given their characteristics.

The second question could be what recommendations would make the authors to another agency wishing to follow this example: a crucial aspect is the transversal information. There are many public and private agencies working aspects of information for continuous improvement, information which in turn is of interest to better manage emergencies, so try to develop all the tools and information bases domestically, requires a technological, economic and human, very difficult to do at the present time.

Fig. 7. Screenshot showing the main menu of the offline application.

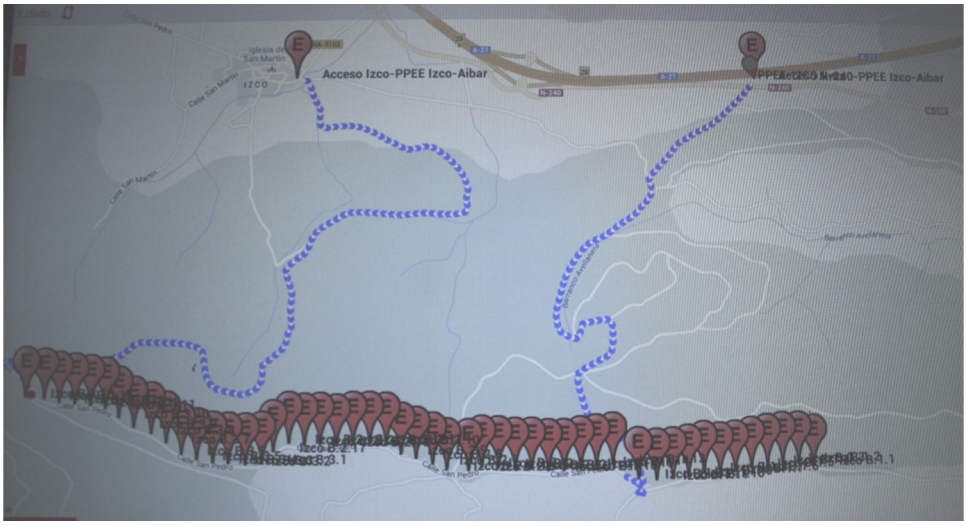

Fig. 8. Screenshot with the geolocated situation of a series of wind farms.

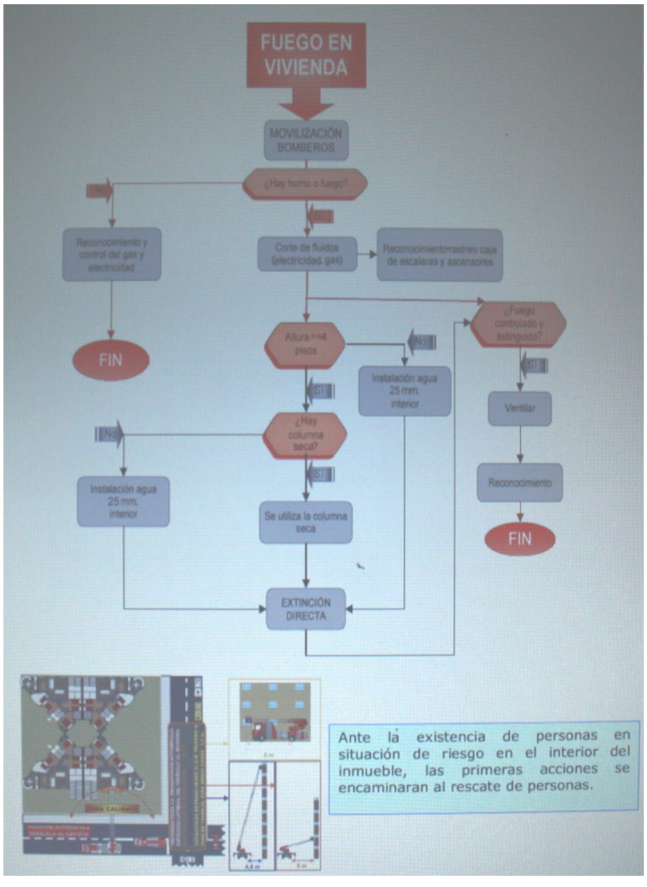

Fig. 9. Flow chart showing the corresponding action protocol.

Gobierno de Navarra	FICHA 005	LOCALIZACIÓN DE ACCESOS A LA RED FERROVIARIA INCIDENTES FERROVIARIOS	
ZONA:	TUDELA	Km inicial:	PK74,80 ±
PARQUE:	B02 Tudela	Km final:	PK80,10 ±

PDI	TIPO DE ACCESO – MARGEN DERECHA	COORDENADAS	ICON
05-00 DCA	Entrada por la depuradora, seguimos paralelo a la NA-134, hasta el puente sobre la vía (05-01 DVF).	42° 3'7.78"N 01°34'25.66"O	
05-01 DCA	Acceso desde 04-09 DCA o 05-00 DCA. La pista derecha accede a la vía y PDI's de margen derecha.	42° 2'32.78"N 01°34'43.32"O	
05-01 DPT	Tramo 4x4 de 180 metros de pista que lleva a la zona de 05-01 DVF.	Une anterior y siguiente PDI	
05-01 DVF	Acceso desde la NA-134 por 05-01 DCA. El tramo de pista no es visible en el navegador aunque si el PDI.	42° 2'28.02"N 01°34'46.82"O	

PDI'S PRÓXIMOS QUE LLEVAN A CAMPOS O PISTAS QUE LINDAN CON LA VÍA FÉRREA.					
05-02 DCA	42° 2'36.42"N	01°34'47.32"O	05-03 DCA	42° 2'41.86"N	01°34'52.36"O
05-04 DCA	42° 2'44.41"N	01°34'54.73"O	05-05 DCA	42° 2'50.28"N	01°35'1.07"O
05-06 DCA	42° 2'53.84"N	01°35'5.35"O	05-06 DPT	Pista entre PDI "06" de 140 m	
05-06 DVF	42° 2'51.72"N	01°35'9.78"O	05-07 DCA	42° 2'57.55"N	01°35'9.06"O
05-08 DCA	42° 3'4.50"N	01°35'17.16"O	05-09 DCA	42° 3'5.80"N	01°35'18.67"O

05-10 DAD	Acceso directo bajo el puente.	42° 3'15.70"N 01°35'31.09"O	
05-11 DAD	Tramo de zona paralela con acceso limitado por valla metálica y árboles. Desnivel de 2/4 m bajo nivel.	42° 3'20.81"N 01°35'35.77"O	
05-12 DTP	Punto intermedio de la zona paralela a la vía, citada anteriormente.	42° 3'29.45"N 01°35'44.43"O	
05-13 DAD	Tramo de zona paralela con acceso limitado por valla metálica y árboles. Desnivel de 2/4 m bajo nivel.	42° 3'38.83"N 01°35'54.24"O	
05-14 DAD	Punto extremo de zona paralela con acceso limitado por pared de ladrillo. Desnivel de 2 m bajo nivel.	42° 3'41.26"N 01°35'58.13"O	
05-15 DAD		42° 3'45.61"N 01°36'2.92"O	
05-16 DAD	Extremo de zona paralela con acceso limitado por el talud. Desnivel de tramo, 2/5 m bajo nivel de la vía.	42° 3'48.46"N 01°36'5.47"O	
05-17 DAD	Zona de 850 metros paralelos a la vía, con acceso limitado por talud con desnivel de 2 a 5 m bajo nivel.	42° 3'54.76"N 01°36'12.28"O	
05-18 DAD		42° 4'19.20"N 01°36'25.96"O	
05-19 DCA	Punto de acceso a tramo de pista 4x4 que va a la vía.	42° 4'54.73"N 01°36'20.05"O	
05-19 DPT	Tramo de pista de 60 m, que va a la zona de la vía.	Une anterior y siguiente PDI	
05-19 DVF	Punto de acceso a la vía férrea.	42° 4'56.53"N 01°36'20.56"O	

Fig. 10. Screenshot of the one of the information sheets that allows us to know where the railway accesses are placed.

We believe that sharing experiences and information, foster a more reasonable, sustainable and economic progress, in turn allowing a more rapid implementation; so, it is necessary to relate the fire service with other services, hold meetings to see what others do, offer and request support, learn from the experience of others, integrate knowledge.

6. Conclusions

In short, the application consists on a strategic tool with online and offline availability, that through the utilization of cartographic bibliographic resources applies an important improvement in the operation of the emergency services, apart from the consequent optimization in operative and managing response.

All the building information sheets are freely accessible and there is in developing process and update to transfer the application to mobile devices. For the moment the database requires more memory space than the benefits that applies, but the managing ranks of the emergency services are already equipped with remote controls to conduct management operations.

They are useful in two different ways, the first improvement to the operational field of resources that are working as well as the management and direction of emergency managers. In the second, the position to vehicles and people on a real-time GIS, allows inferences to the perimeter and affected forest fires, floods and other emergencies area, where there is a large deployment of field resources.

References

[1] C. Vasilakos, K. Kalabokidis, J. Hatzopoulos, G. Kallos, Y. Matsinos, Integrating new methods and tools in fire danger rating, Int. J. Wildland Fire 16 (2007) 306–316.
[2] X. Liu, J. Zhang, Z. Tong, Y. Bao, GIS-based multi-dimensional risk assessment of the grassland fire in northern China, Nat. Hazards 64 (1) (2012) 381–395, doi:http://dx.doi.org/10.1007/s11069-012-0244-z.
[3] M. Arianoutsou, S. Koukoulas, D. Kazanis, Evaluating post-fire forest resilience using GIS and multi-criteria analysis: an example from Cape Sounion National Park, Greece, Environ. Manage. 47 (3) (2011) 384–397, doi:http://dx.doi.org/10.1007/s00267-011-9614-7.
[4] K.C. Kowal, Tapping the web for GIS and mapping technologies: for all levels of libraries and users, Inform. Technol. Libr. 21 (2002) 109–114.
[5] B.S. Lee, M.E. Alexander, B.C. Hawkes, T.J. Lynham, B.J. Stocks, P. Englefield, Information systems in support of wildland fire management decision making in Canada, Comput. Electron. Agric. 37 (14) (2002) 185–198, doi:http://dx.doi.org/10.1016/S0168-1699(02)120-5.
[6] D. Vakalis, H. Sarimveis, C. Kiranoudis, A. Alexandris, G. Bafas, A GIS based operational system for wildland fire crisis management I. Mathematical modeling and simulation, Appl. Math. Model. 28 (4) (2004) 411–425, doi:http://dx.doi.org/10.1016/j.apm.2003.10.005.
[7] K. Kalabokidis, N. Athanasis, F. Gagliardi, F. Karayiannis, P. Palaiologou, S. Parastatidis, C. Vasilakos, Virtual fire: a web-based GIS platform for forest fire control, Ecolo. Inform. 16 (2013) 62–69, doi:http://dx.doi.org/10.1016/j.ecoinf.2013.04.007.
[8] J. Santos-Reyes, A.N. Beard, A systemic approach to measuring fire safety pPerformance, J. Fire Sci. 19 (6) (2001) 463–488, doi:http://dx.doi.org/10.1177/073490401773732454.
[9] K. Chen, R. Blong, C. Jacobson, Towards an integrated approach to natural hazards risk assessment using GIS: with reference to bushfires, Environ. Manage. 31 (2003) 546–560.
[10] F.J. Lozano, S. Suárez-Seoane, E. Luis, Assessment of several spectral indices derived from multi- temporal Landsat data for fire occurrence probability modeling, Remote Sens. Environ. 107 (2007) 312–333, doi:http://dx.doi.org/10.1016/j.rse.2006.10.001.
[11] S. Kolmanič, N. Guid, A. Nerat, SIN: multimedia-based teaching tool for computer-supported fire-fighter training, Fire Saf. J. 61 (2013) 26–35, doi:http://dx.doi.org/10.1016/j.firesaf.2013.08.006.
[12] N. Athanasis, K. Kalabokidis, M. Vaitis, N. Soulakellis, Towards a semantics-based approach in the development of geographic portals, Comput. Geosci. 35 (2009) 301–308.
[13] K.D. Kalabokidis, S. Gatzojannis, S. Galatsidas, Introducing wildfire into forest management planning: towards a conceptual approach, For. Ecol. Manage. 158 (2002) 41–50.
[14] M.A. Finney, Fire growth using minimum travel time methods, Can. J. For. Res. 32 (2002) 1420–1424.
[15] S.W. Taylor, M.E. Alexander, Science, technology and human factors in fire danger rating: the Canadian experience, Int. J. Wildland Fire 15 (2006) 121–135.