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THE USE AND SIGNIFICANCE OF MODERN DECISION SUPPORT SYSTEMS (DSS) IN THE SERVICE OF HUMANITY AGAINST FOREST FIRES

Abstract:

Forest fires constitute one of the greatest hazards for the viability and sustainable development of forests with consequences both on natural and cultural environment, undermining the economy and the quality of life of local and regional populations. Thus, the best strategic to grapple with forest fires while taking under consideration both functional and economic efficiency is considered of primary importance. To this effect, great share have the usage and adoption of decision support systems (DSS) which contain tools of G.I.S. and satellite technology and function as information systems which support the managers responsible for eliminating the forest fires. Definitely, the sub-systems of the most DSS can be used independently depending on the main purpose, such as for prevention or suppression procedures; for the financial estimation of the planned mission; for the smoke detection and the prediction of its repercussions on the human health etc. Hence, the paper aims to a comparative assessment of the most contemporary DSS which are in use in different geographic scales -such as national and federal level- as well as to a thorough exploration of the effectiveness and contribution of such systems to the confronting of forest fires.

Keywords:

forest fires, decision support systems, g.i.s., remote sensing

The use and significance of modern Decision Support Systems (DSS) in the service of humanity against forest fires

Introduction

Forest fires constitute one of the greatest hazards for the viability and sustainable development of forests with consequences both on natural and cultural environment, undermining the economy and the quality of life of local and regional populations.

The outbreaks of forest fires could stem from either natural (thunders) or anthropogenic causes (carelessness, accidents, arsons). The latter usually compose the greatest percentage of ignition of forest fires especially at the Mediterranean regions (Carmel et al. 2009; Christopoulou 2011; Demir et al. 2009).

At the European Union (EU) level, for the reference year 2011, 55.543 forest fires have burst out, which corresponds to 269.081 ha of charred land. At lower geographical level, at the same year (2011) in Greece, 1.613 forest fires have broken out (3% of the overall forest fires which took place at the 5 most vulnerable[1] regions in EU) and destroy 29.144 ha[2] (11% of the overall burnt area of the previously mentioned countries). From this figure, 89 forest fires sized above of 40 ha have burnt out 36.872 ha (www.fire.uni-freiburg.de, 2011).

For those reasons, the best strategic to grapple with forest fires while taking under consideration both functional and economic efficiency is considered of primary importance. To this effect, great share have the usage and adoption of DSS which contain tools of G.I.S. and satellite technology and function as information systems which support the managers responsible for eliminating the forest fires. As a result, managers' ability is strengthened so that they can prevent and suppress effectively the forest fires implications on the natural and build environment as well as to the fully protection of human life which constitutes the framework and milestone of our society.

Basic characteristics of DSS and their exploitation/utility on different spatial scales

Structural elements of DSS

DSS constitute a valuable tool for prevention and fighting against forest fires and lately they are adopted at growing rate at global level. The basic models-subsystems which comprise the structural elements for confronting forest fires and most DSS use are the

[1] Portugal, Spain, France, Italy and Greece.

[2] The share of forest land corresponds to 19.348 ha and the share of non-forest land amounts to 9.796 ha (www.fire.ini-freiburg.de, 2011).

following (Bonazountas et al. 2007; Dimopoulou and Giannikos 2004; ec.europa.eu 2012; Giovando et al., no date; Glasa 2009; Gumusay and Sahin 2009; Kalabokidis et al. 2011; Keramitsoglou et al. 2004; Lee et al. 2010; Noonan-Wright et al. 2011; Wybo 1998):

- Retrieval, analysis, update, edit and prediction models of geospatial (geomorphology – topography, socioeconomic and environmental data), meteorological and satellite data,
- Risk indexes and thematic maps (past fire incidents - records, moisture data etc) of indigenous vegetation and forest fuel,
- Fire propagation and behavior models and
- Utilizing of interactive programs for the preparation, plans establishing, coordination and prompt dispatch of specific forces of the fire department (human force, number and kind of fire machinery – land or aerial forces or even a combination).

Local Level – National Scale

One of the first DSS that exploited the usage of several technological tools and constitutes the precursor of the subsequent and advanced technologically DSS for prevention and fighting against forest fires is the application of Wybo. The key in that system is the fact that the DSS incorporates in their databases a certain number of pre-processed scenarios which correspond to specific fire incidents and consequently, there is no need for composing new scenarios from scratch, for instance in case new meteorological data is received. Hence, valuable time is saved up during the process of monitoring, management and fighting of each fire incident in real time (Wybo, 1998).

Dimopoulou and Giannikos (2004) exploited an integrated information system on which the databases of G.I.S. include and provide all the necessary spatial information to the subsystem which is responsible for the application of the mathematical programming. Next, through all the appropriate equations and calculations of mathematical programming, the best (spatial) allocation of the fire department units (including the amount and type of the forces) on the study area is estimated, so that the fire-fighting authorities will be prepared to locate the fire and act within 10 minutes (time limit based on international standards) to any possible combustion. Afterwards, the model of fire behavior “sends” the new input, which depends on fire evolution (e.g. not available fire engines, natural barriers across the main roads etc.), to the subsystem of mathematical programming -like an active feedback, so that a new best re-allocation of the fire department units will be achieved, adjusted to the new data, which will lead to the immediate containment of the forest fire (Dimopoulou and Giannikos, 2004).

On the application of DSS from Bonazountas et al. (2007), besides the basic structural elements of DSS, they adopt an additional model of socioeconomic factors (e.g. demographic data, tourism industry) of the study area, where an analysis of the crucial

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socioeconomic factors is conducted which could affect the risk levels for combustion and a thematic map is produced as an output of this model. Furthermore, the probabilistic model contributes to the whole process, so that the managers could effectively plan the best (spatial) allocation of the infrastructure (firemen, land and aerial fire engines etc).

Akay et al. (2011) combine the advantages of G.I.S. and DSS and apply the Network Analysis which incorporates: a) the method of the nearest fire unit-settlement, where the fastest route between each fire unit and the possible area of combustion is estimated, so the fire team, which needs the smallest distance and consequently the least time, is activated (Condoreli and Mussumeci 2010; Gumusay and Sahin 2009; Keramitsoglou et al. 2004;); b) the second method involves the spatial covering (buffers) of forest land from the current fire units. The key in this method is the critical time of response which is necessary from every fire team in order to approach the district of fire. In case that this combination is inadequate (both in travel distance and critical time of response), then it is concluded that more installations of fire brigade must be established, so that every possibility of outspreading of the fire and their consequences can be limited (Akay et al., 2011).

Interregional Level – Federal Scale

At superior geographical level, especially the adopted DSS in USA presents outstanding interest. The comparative advantage of the Wildland Fire Decision Support System (WFDSS) is the integration of all previous management processes of wildfires into a united system, which is provided with all essential inputs (geospatial data, air quality data etc.) as well as additional tools of fiscal evaluation of past fire incidents. All those procedures are manageable in real time, while they are supported (for the usage and exploitation of the application) directly via the internet from many agencies responsible for confronting forest fires at the same time. Besides the basic structural elements of DSS, WFDSS incorporate additional economic and environmental tools. More specifically, WFDSS includes those economic tools which reckon the estimated economic cost on the basis of past fire incidents with similar characteristics. In addition, risk assessment of crucial structures (natural resources and infrastructures[1]) is conducted and these resources are depicted in the fire evolution map based on the fire intensity (Noonan-Wright et al. 2011).

Following the same geographical scale, the corresponding EU information system (EFFIS – European Forest Fire Information System) demonstrates several innovating and quite valuable functions. More specifically, the immediate evaluation of catastrophes whose aim constitutes the mapping of those areas which have been damaged from forest fires

[1] Crucial structures and natural resources: Human settlements, transport, energy, oil and telecommunications infrastructures, habitat with endangered species, historical monuments etc.) (Noonan-Wright et al. 2011).

and are greater than thirty ha. It's worth emphasizing that the comparative advantage of that application is the conjunction of the data of those districts that have been affected from forest fires and their corresponding land coverage, aiming to a more comprehensive study and assessment of the extent and kind of these catastrophes (in terms of quality and quantity of such catastrophes). The land sources of information constitute a recurrent selection of valuable information regarding the forest fires. Their significance is reflected when natural barriers (cloudy weather) or technical restrictions are happening during the attempt to retrieve satellite images and to locate active fire hotspots. So, all the relative information is collected through RSS method from several EU sources (Google news, blogs etc.) in various geographical levels. Following, a filtering and automatic geocoding procedure are conducted and each and every fire incident is located geographically (Giovando et al., no date).

Mavsar et al. (2012) proceed to a comparative study of the economical effectiveness of four DSS, where in addition to the desired protection level which could be culminated in the best spatial allocation of land and aerial fire forces, economic data of the adopted prevention measures as well as of the global operational forest fires planning are taken into account. The evaluation of alternative scenarios in terms of economic and environmental effectiveness will finally lead to the selection of the best scenario. The studied systems are the following: 1) Leopards model (Canada), 2) Kitral model (Chile), 3) Sinami model (Spain) and 4) FPA (USA). Regarding the economic assessment of the aforesaid systems, it should be highlighted that the most integrated program, which permits the economic analysis of the different management strategies is the Sinami model, which adopts the techniques of the "C+NVC[1]" method and incorporates the economic cost of prevention and suppression planning as well as of natural resources which are affected from any natural catastrophe. The last parameter is absent from the other models (Leopards and Kitral), while FPA adopts Goal Programming techniques (Mavsar et al., 2012).

Discussion

Decision Support Systems constitute such a tool which conduces to effective prevention, suppression and confrontation of forest fires as well as to the rational incident management and appropriate decision making, especially to emergency situations such as the cases of natural catastrophes.

The combination of operational research models and G.I.S. is of crucial importance while it may cope with the growing spectrum of complicated (of spatial nature and not only) problems which include a great deal and variety of data. So, in case of forest fires, the

[1] C+NVC: Fiscal cost (prevention and suppression planning expenditures) + net value among destructive and beneficial implications of forest fires (Mavsar et al., 2012).

exploitation of G.I.S. and new routing techniques (Vehicle routing models) in the DSS may contribute to the effective decision making concerning for instance with the choice of a number of best routes targeting to the minimization of distance and time of each route as well as to the immediate rerouting with the choice of the second best route for the timely confrontation of every incident due to an extraordinary event.

Another issue of secondary importance -but imperative in situations of global economic narrowness- constitutes the fact of fiscal resources saving through the minimization of fuels consumption and vehicle maintenance with the choice of best routes in terms of travel time (Manusaridis et al., 2007). In this context, the adoption of trustworthy tools for the management of natural catastrophes is a crucial issue aiming to the general saving of resources. The competitive advantage of online applications (Web DSS) is that any distant user does not have to consume extraordinary amount of money for covering substantial needs from such an application like the retrieval, usage and edit of mass volume of geospatial and meteorological data, the needs for sophisticated equipment as well as the long-term periodic maintenance work (ec.europa.eu, 2012; Gumusay and Sahin 2009).

According to Martell (2011), the physical presence, the participation into virtual environment of crisis management of the researchers as well as the interaction between fire managers and researchers are of primary importance, while facilitates the assimilation and the way of approach during (or before) fighting forest fires. Moreover, the necessary combination of theoretical and practical research is highlighted, so that there will be a more comprehensive understanding of such systems. Furthermore, the creation of a global network of natural catastrophes – fire managers which will aim to the ideas exchange and dissemination as well as to the exploring of more effective and suitable solutions is suggested (Martell, 2011). Finally, it should be clear that any DSS cannot substitute the human factor for the appropriate crisis management. However, DSS may highly contribute to the quantification of complex interactions which take place during confronting a forest fire and they may facilitate the timely handling of critical situations. The positive key points of DSS combined with a manager expertise and experience could achieve the moderation of consequences of forest fires to the natural and cultural environment as well as to the economic impact of every fire confrontation mission (Mavsar et al., 2012).

Concluding remarks

As previously discussed, DSS as integrated information systems which incorporate state-of-the-art structural functions constitute a powerful ally for the prevention and confrontation of forest fires. Each and every tool contribute to an immediate, effective and exact operational preparedness and suppression of forest fires aiming to ensuring human life as well as to the rational protection and sustainable management of natural resources which ensure both socioeconomic and environmental profits to the local and regional population.

In the international literature several DSS variations per age and geographical scale are presented, however, most of them are constructed from similar basic subsystems aiming to the fully understanding, analysis, creation and support during rational and best decision making regarding the appropriate activities which should be followed in a narrow time frame. Such issue always constitutes a challenge in this kind of natural catastrophes, which targeting to the minimization of environmental impacts as well as to the corresponding economic cost. Definitely, the fact that each DSS has its own added value in confronting such phenomena like forest fires should be highlighted. Nevertheless, a comparative assessment of various DSS (used in forest fires) would be considerably beneficial, so that the usage and credibility of any DSS can be estimated in terms of functionality and economic effectiveness (from the usage and adoption in any incident), at least in hypothetic level like the fire simulation in similar situations. Certainly, the fact that some DSS may be formatted and adjusted according to the special characteristics of each geographic area in which is aimed to be implemented should not be ignored; however, valuable conclusions could be extracted concerning the effectiveness of the DSS which could be implemented in areas with similar characteristics. So, an opportunity will be given, so that experts could recognize those specific divisions that should be improved or/and entirely revised, even a new combination of compatible subsystems integrated into DSS may be invented. Therefore, synergies may be maximized leading to the full achievement of the same target of preventing and confronting of forest fires.

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