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GEOINFORMATICS – RECORDING AND PROCESSING SPATIAL AND NON SPATIAL INFORMATION

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Abstract

The rapid development of technology and the broad use of computers during the recent years have resulted in new emerging opportunities across all technical domains. Thus, there have been developed the ambitious Digital Terrain Models (DTMs) to exploit these opportunities and leverage their capabilities for the common good. The DTMs provide the basis for developing a wide range of applications related to earth sciences. To be more specific, the former in Geoinformatics enable the possibilities of modelling, analysis and performance measurement of spatial phenomena related to topography or other technical areas with similar spatial properties. The DTMs can be used in conjunction with the Geographic Information Systems (GIS) in order to create a system which could be able to provide analytical data and information over terrain properties. In this essay a combination of DTMs with Geographical Information Systems (GIS) is undertaken, in an effort to create a hybrid out of these technologies. The initial thinking was to create a digital database that could provide comprehensive information over the number of fires, land areas and living species and finally the reaction time of the forest office commissions for the entire Greek state. What is more, a secondary objective was to monitor the efficiency degree of land exploitation by using DTMs in a targeted area. To a further extent, the combination of DTMs' information data such as vegetation, air temperature and wind direction, can contribute better in more efficient ways of forest fires prevention and suppression. In addition, the combination of the former along with the lands' efficient exploitation offers unlimited possibilities of spatial planning applications within the national digital cadastre. Subsequently, there are in our disposability unlimited scheduling capabilities to reduce arbitrary structure, violation of forest and other public territories, and an urban and regional environmentally friendly planning. To sum up, the DTMs assist us in a better and more rational development, protection and enhancement of mountainous areas.

Key words: digital database, digital terrain model, forest fires.

Introduction

The concept of land exploitation by human is to meet his diverse needs such as nutrition, housing, relaxation, financial activities, and cultural, educational, religious and other purposes (Arvanitis 2004). The existence of cadastral maps, cadastral records and mortgage consolidation is necessary for the synthesis of cadastre and especially for the inclusion of changes in land use of one area (Resnik and Bill 2003).

In general, digital terrain models are the mathematical approach to the natural terrain. Characteristic tools include the contour diagrams of elevation, but in a digital format suitable for computing processing. Initially the methodology and the creation of 3D digital terrain models were developed from Miller and Laflamme (1958). The necessity to import the obtained data of ground and topographical diagrams into GIS and CAD programs led us to the digital terrain models which are widely used nowadays (De-Cambray et al. 2007).

The technological progress and the increasing role of computers have created new possibilities for harnessing the conventional-analogue model (i.e. diagrams and orthophotos) into the digital model. The digital model is defined as the automation in the identification of the original data, and the organization of the latter to form a database, which results in a set of known data with ground provision in a square grid (grid) or triangular irregular network.

Within the frame of Geoinformatics, DTMs enable surface modelling and performance analysis of spatial phenomena related to topography or other areas with similar spatial characteristics. Modelling procedure and digital data processing of the earth's natural surface can be seen as extensive components of GIS products that are independent from the plane data components without being relevant to the conventional processing functions (e.g. topology of polygons, networks or manipulation of normalized data).

It is worth mentioning that because the non-spatial data describe some characteristics of an object / component, they are also known or referred to as descriptive data. The descriptive data may be non-spatial characteristics of a spatial object, such as name, classification, colour, and can be either quantitative or qualitative.

The "spatial address" of a property (x, y) can be identified easily, thus it is classified as spatial data and its position remains unchanged. However, the owner of the property can change over the time and thus it is classified as descriptive data. Through its operating structures and the variety of available GIS software capabilities, there is in our disposal an interactive relationship between spatial and descriptive data. It is an appropriate way to present the geographic objects in precise patterns. However, this is not the recommended way for data that is characterised by a continuous distribution in a surface.

In Greece, during the last 25 years, forest fires have increased in terms of conflagrant area volume. It is disappointing that the overall burned areas increased on average three to five times more than in the last century. It is observed that careless operations and audacious activities (42.8%) are to be blamed for forest fires. The majority of these activities constitute of the burning of stubble after harvest period, the burning of dried tree branches and weeds in fields, orchards and gardens. It is worth mentioning that 20 years ago the burning of fields and weeds constituted only the 24% of these unfortunate events. This problem also exists to other countries as the act of burning stubble fields, etc. is also mentioned as a significant cause of fires in Spain and Great Britain. The factors that determine the risk coefficients of fire are divided in two categories. Firstly, there are the permanent factors (i.e. climate, sun radiation, natural hazards, topographic configuration, type of forest combustible materials, and exposure to prevailing wind). Secondly, we have the variable factors (i.e. climatic factors, barometric pressure, state of vegetation, fuel moisture, availability and homogeneity of burning material, initial proliferation capacity, inflammable sources and other external factors). In Figure 1 there is a model of forest fires' risk profile, which is provided by Kailidis and Karanikola (2004).

In this work has been an attempt for recording and processing spatial and non spatial information with the combination of DTM and Geographical Information Systems (GIS), within the scope of Geoinformatics.

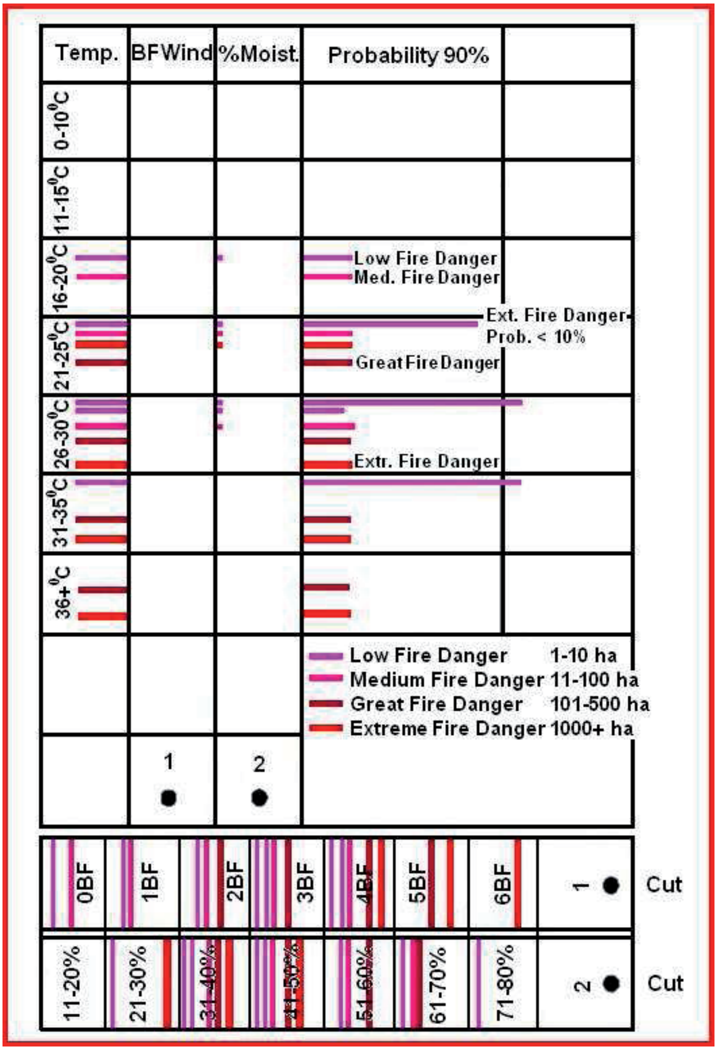

Fig. 1. A model of forest fires' risk profile.

Material and Methods

In order to create a digital database that could provide comprehensive information over the number of fires, land areas and living species and finally the reaction time of the forest office commissions we were used as research area the entire Greek state. Furthermore, the development and processing of three-dimensional digital model of the suburban forest of

Thessaloniki (Seix-Sou) was made using the software package Civil 3D of Autodesk corporation. The suburban forest of Thessaloniki, known as Seix-Sou, extends over the hills surrounding the city between 50–450 m above the sea level. This forest area is extended in a total area of 30,000 acres and it primarily consists of coniferous species (Figure 2). However, in July 1997, the suburban forest of Thessaloniki suffered a terrible ecological disaster, as 55% of its total area (16,640 acres) was burned. The identification of the area being researched was defined with the use of digital photogrammetric method.

A set of aerial photographs (A/P), which had been taken in 1994, were used for the project. After getting digitized (scanned) by a special photogrammetrical scanner, they were edited using the software package Leica Photogrammetry Suite (LPS 9) of Leica Geosystems Corporation.

The relative automated generation of a Digital Terrain Model (DTM) was realized through the application of automatically correlated homologous pixels using the standard frames of the radiometric values of the pixels (area based matching). This method is commonly used in the digital photogrammetry (Wolf and Dewitt 2000). What is more, LPS 9 software allows the generation and the use of the digital images' pyramids in order to improve the final results. The images' pyramids form a helpful tool for identifying the appropriate initial values which are used to further determine the best possible solution to the problem of digital correlation (Kraus 1996). The final derivatives of the photogrammetric process of the aerial photographs (within a research area), are the digital orthophotos for the year 1994. These derive from the differential regression of A/Ps, by eliminating the positioning errors that are entailed due to the terrain morphology/variations. The production of digital orthophotos is the first, fully automated digital procedure in digital photogrammetry (Baltsavias 1996). Then, the researchers created geographic vector data (polygons and lines), based on the interpretation of the study area. These, later, were associ-

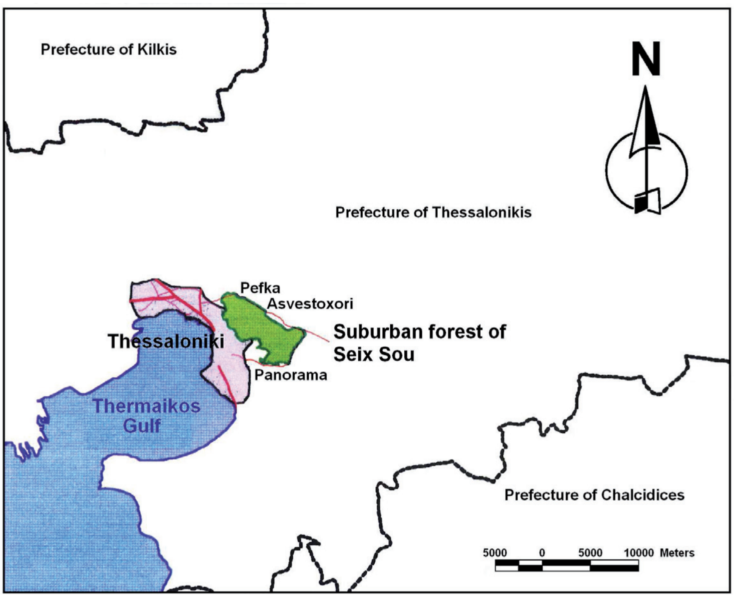

Fig. 2. Orientation map of study area.

ated with the descriptive data within the geographical database of Civil 3D. After defining the relevant topology, the planimetry of the polygons was carried out and the total area for each land use was calculated. Then, the production of the final orthophotomap was followed.

The Civil 3D is an integrated software application of Autodesk for mapping and development of GIS within the environment of AutoCAD. It combines the design capabilities of GIS and the use of surveying efficiency, calculation and design tools of digital terrain models. These characteristics are referred to the specialists of applied design GIS systems, and to surveying and design of technical works.

The ArcView Spartal Analyst package provides an effective way of presenting and analysing geographical objects of this type (It sounds a bit strange to use the term "objects", but is an appropriate one). Instead of being designed as shapes, they are separated on the surface-edge of an anaglyph on which they are represented in an identical size of rectangular cells. Each cell is filled with a numerical exponent that stores the value of the object in the site. So, if there is represented the average daily temperature in Celsius degrees (^{o}C), the cells would have values like 13, 20, 26 etc.

Results and Discussion

With the help of Arc view GIS, classification of the burned species due to forest fires during the years 1992–1997 measured in 1,000 sqm per forest office in Greece is presented. This classification depicts grassy areas and areas with evergreen broadleaves vegetation. Furthermore, classification of the burned areas measured in 1,000 sqm per Greek prefecture throughout the years 1999–2002 is presented, according to the statistics of the fire brigade. The classification is presented through graded color shades of red, which appear in serial number.

As far as the evergreen broadleaves vegetation is concerned, the areas, which have been in danger for the period 1993–1997 (Figure 3), are mainly Southern Greece, Crete and some parts of Western Greece. Large expanses of grasslands have been burned down over the period 1993–1997 (Figure 4) exclusively in Northern Greece, mainly in Northwestern Macedonia and Thessaly and less in Epirus, Thrace and the Islands. On the contrary, in Southern Greece (Central Greece and Peloponnese) the burned grassy areas are negligible.

The overall burned areas in Greece through the years 1999–2002 (Figure 5), according to the fire brigade's information, are differentiated (with the common feature of the quantity of fires).

As a result, in 1999 significant areas in Thrace and Thessaly have been burned down and Macedonia as well as the Northern Aegean Islands follows in this year. In 2000 extended areas in Central Greece, Peloponnese and the prefecture of Evros have been burned down. Finally, in 2001 and 2002 uniformity is presented, as the most burned areas are centralized in Peloponnese and Central Greece, but they differ in Thrace and Crete respectively.

The science of forest fires demands that we should avert the fire spread-

Fig. 3. Burned broadleaved evergreen 1993–1997.

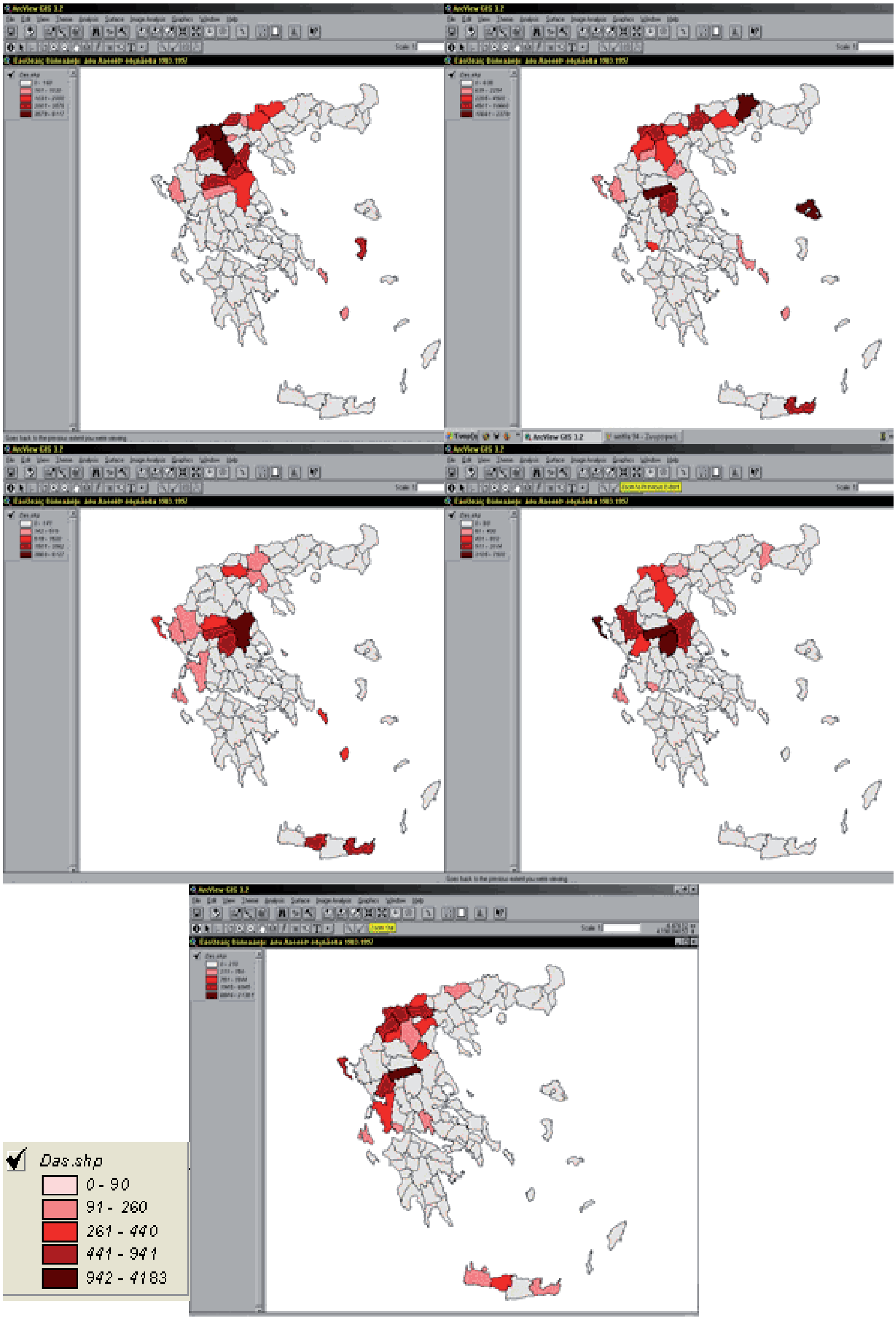

Fig. 4. Burned grassy areas 1993–1997.

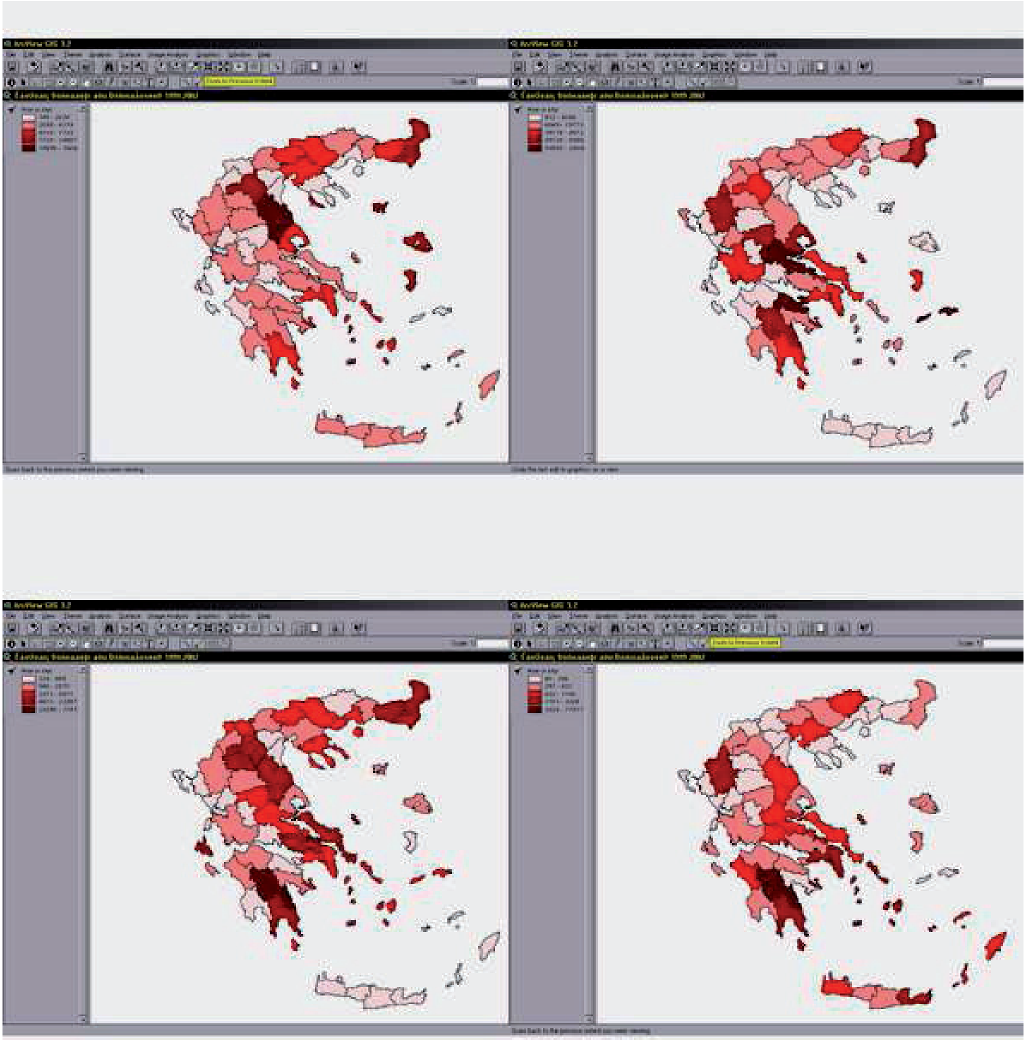

Fig. 5. Overall burned areas 1999–2002.

ing and extinguish small fires. This means, that we should arrive as soon as possible in the location of fire, as to put out a small fire. Given the fact that the fire is immediately or almost immediately noticed, the fire administration center or the nearest fire vehicle is notified; the appropriate vehicles are dispersed throughout the forest, in specific posts and not outside the fire brigade office. The first 15 minutes are considered to be the ideal time of reaction. Until then the extinguishing of fire should have been started. The firefighter crews should be well trained, so that they begin the extinguishing in just few minutes after their arrival in the location of fire. For example in 1983 the majority of fire administration centers were notified in 10–19 minutes but in 1993 in 19–27 minutes (Figure 6).

In Figure 7 we have the TINs model of the suburban forest as it is created from the digital photogrammetric procedure and in Figure 8 shows the three-dimensional representation of Seix Sou from the Civil 3D of AutoCAD. Particular emphasis is given to maps of land use in suburban areas as it is vital not

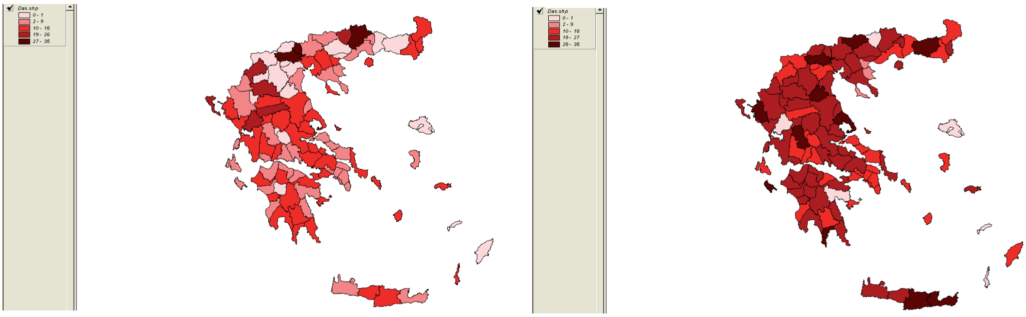

Fig. 6. Notified Fire administration center in 1983 and 1993.

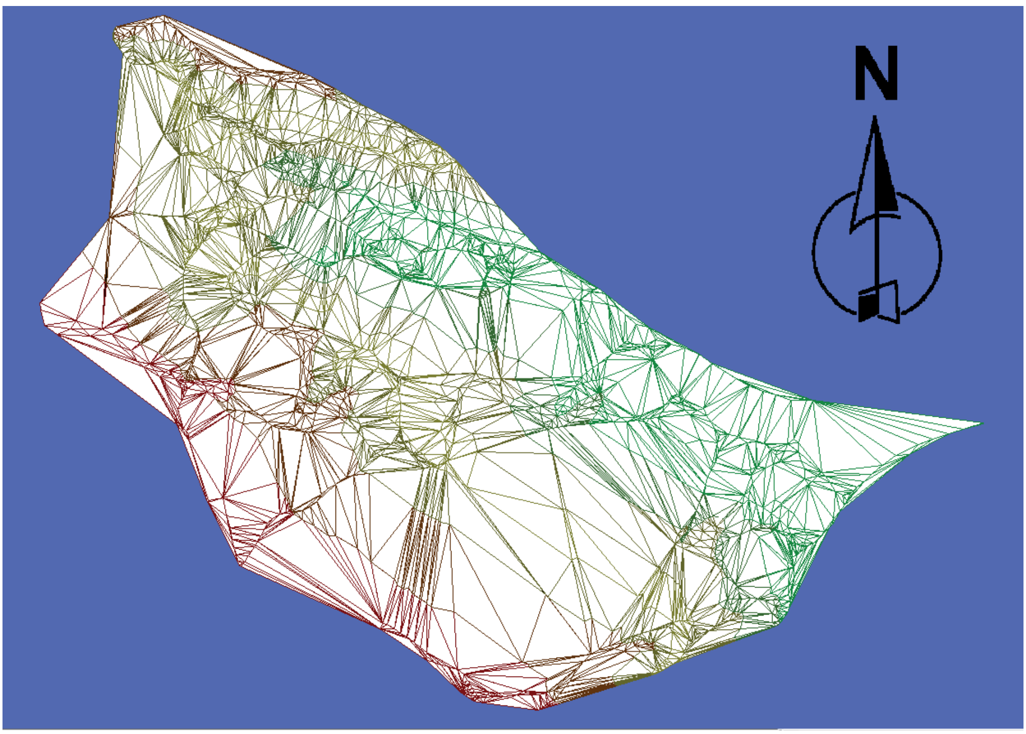

Fig. 7. TINs of Seix Sou forest.

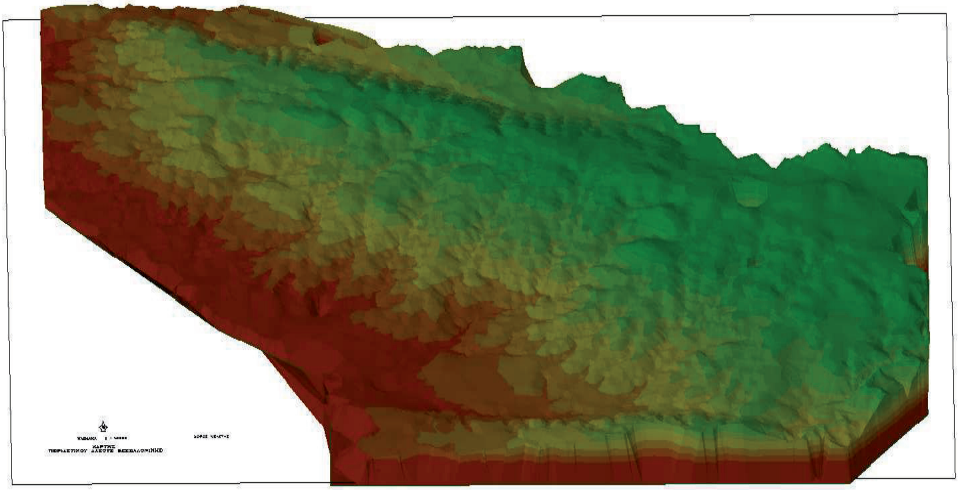

Fig. 8. Three-dimensional representation of Seix Sou.

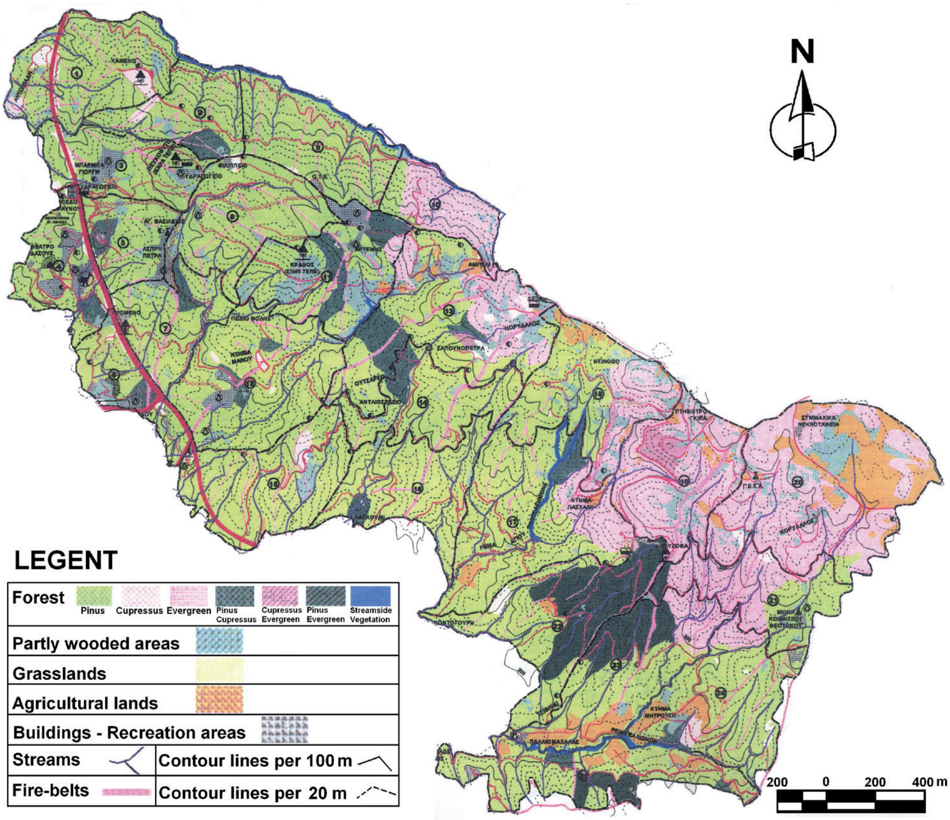

Fig. 9. Land uses map of Seix Sou.

only for the quality of life but the very lives of city's residents (Figure 9).

Conclusion–Suggestions

Within the scope of Geoinformatics, in essay, a combination of DTM and Geographical Information Systems (GIS) is undertaken to record and process spatial and non spatial information. The hybrid out of these technologies is a digital map which is created by specialists.

The protection of forest ecosystems (lifeline), in combination with the principle of exploitation, can only be based on digital maps of land use, by specialists, who will decide as an independent scientific body, if the existence of forest area in terms of forest cover by 15 or 25% or other use is more appropriate.

The digital maps of land use, in combination with the development plan, give a view of development, social cohesion and improving quality of life in the country. However the choices in land use are actually derived from the contemporary land policy. We need to comply with Article 24 of the Constitution, as these choices are the product of scientific investigation and imposed by the needs of society.

Land use maps are maps which provide information about land use. There is a number of different applications for such maps, and in many nations, land use maps are prepared by several government agencies, for a variety of reasons. Individual groups and organizations can also generate maps with land use information. Often, such maps are available to the public, so that people who are interested in land use trends can access them.

One form of land use map is a zoning map. Zoning maps are used to mark out areas designated for specific types of land use, so that people, who are associated with land development know, which kinds of uses will be allowed. The creation of zoning maps is part of the overall process of community planning, in which communities decide how they want to develop themselves into the future. Zoning decisions can include features such as setting aside green space, isolating industrial land, and so forth.

Another type of land use map is a map which shows utilization. Utilization maps are often used in zoning decisions to determine, whether zoning changes need to be made or not. If, for example, only 60% of the land designated for residential use, is in active use or under development, it would be suggested that scheduling more residential zoning is not necessary. Utilization land use maps exhibit, the way land is being used, and may also indicate historic utilization information, and provide information about the development of land use through different periods of time.

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