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GEOGRAPHICAL INFORMATION SYSTEMS AS A DECISION SUPPORT SYSTEM IN FOREST MANAGEMENT

Nurcan TEMİZ[*], Vahap TECİM[**]

[*] Dokuz Eylül University, Faculty of Arts and Sciences, Department of Statistics, İzmir, TURKEY
e-mail: nurcan.temiz@deu.edu.tr
[**] Dokuz Eylül University, Faculty of Economics and Administrative Sciences, Department of Econometrics, İzmir, TURKEY
e-mail: vahap.tecim@deu.edu.tr

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Abstract: Information systems and information technologies are very essential terms in today's information society. Spatial information systems are important branch of information systems. Geographical Information Systems (GIS) are included in spatial information systems category. Most of the problems encountered in the organizations have a spatial aspect. Thus analyzing spatial data has a wide importance for most of the organizations. Decision making is a complex process influenced by several factors. GIS helps decision makers to make the decision and plays an important role in decision making at various levels in organizations. The purpose of this study is to show how GIS can facilitate decision making process and can be used as a decision tool in forest management. The viewshed analyses, constitution of three dimensional, slope and aspect maps of the study area and development of a user interface in MapInfo GIS using MapBasic software are among the analyses done in this study.

Key words: Geographical information systems (GIS), forest management, viewshed analysis, decision support systems (DSS).

ORMAN YÖNETİMİNDE KARAR DESTEK SİSTEMİ OLARAK COĞRAFİ BİLGİ SİSTEMLERİ

Özet: Bilgi sistemleri ve bilgi teknolojileri günümüzün bilgi toplumunda oldukça önemli kavramlardır. Coğrafi Bilgi Sistemleri (CBS), konumsal bilgi sistemleri kategorisinde yer almaktadır. Organizasyonlarda karşılaşılan problemlerin çoğunun konumsal bir yönü bulunmaktadır. Bu nedenle çoğu organizasyon için konumsal verilerin analizi büyük bir önem taşımaktadır. Karar verme çeşitli faktörlerden etkilenen karmaşık bir süreçtir. CBS organizasyonlarda çeşitli düzeylerde karar vermede yardımcı olmaktadır. Bu çalışmanın amacı, CBS'nin karar verme sürecini nasıl kolaylaştırabileceğini ve orman yönetiminde bir karar destek sistemi olarak nasıl kullanılabileceğini göstermektir. Görülebilen alan analizi, çalışma alanının üç boyutlu haritasının, eğim ve bakı haritalarının oluşturulması ve MapBasic paket programını kullanarak MapInfo GIS içinde kullanıcı arayüzünün geliştirilmesi bu çalışmada yapılan analizler arasındadır.

Anahtar kelimeler: Coğrafi bilgi sistemleri (CBS), orman yönetimi, görülebilen alan analizi, karar destek sistemleri (KDS).

1. INTRODUCTION

Geographical Information Systems (GIS) provide forest managers with tools to use in planning forest operations by allowing them to visualize and integrate data into the planning decisions. As forest planning process becomes increasingly complicated, there is a need for assisting forest planners. The use of visualization function of GIS allows forest managers to have a better understanding of the problem they confront.

Increasing amounts of scientific information is important to support the ongoing goals and objectives in managing forests. One goal is to adapt forest management continually to accept new objectives. One goal is to learn how to manage forests sustainably so benefits continue without compromising the needs of future generations. These goals require obtaining the new data and insights through development and deployment of new information technologies, including GIS (FRANKLIN 2001).

The amount of data and information involved in the forest management process is often overwhelming. Integrated decision support systems help forest managers to make consistently good decisions about forest ecosystem management (POTTER et al. 2000). The forest database design is crucial in a forest management. The data should be accurate, properly organized, detailed and it should be obtained easily. The gathering of spatial and nonspatial data and analyzing them determine the quality of forest management (MISIR & BAŞKENT 2002). Compared to previous forest management approaches, new forest management strategies require integration of spatial information technologies, such as GIS, remote sensing, and decision support systems (FRANKLIN 2001).

The main purpose of this study is to show forest managers how GIS can be used as a decision tool in forest management. For this purpose, topographic analyses, including, slope, aspect and three dimensional analyses and viewshed analyses are done to aid decision making process in forest management. After all analyses the graphical user interface application is developed in MapInfo GIS by using MapBasic software.

2. GEOGRAPHICAL INFORMATION SYSTEMS (GIS)

GIS has the ability to answer geographical questions, based on the information in digital maps with associated attribute databases. The most important point in GIS is digital map database (NÆSSET 1997).

Environmental management has been the main motivator for the developments in GIS. When these systems were first developed in the early 1960s, they were no more than a set of innovative computer-based applications for map data processing. But GIS grew very fast and became an important component of the information technology (FRANKLIN 2001, LO & YEUNG 2002). The development of GIS technology makes it possible to compile, store, retrieve, analyze and display vast quantities of spatial data.
GIS relates geographic information to the attribute information. Its primary task is to store, update, manipulate, analyze and display geographically referenced data. The most important feature of GIS that differentiates it from the other computer mapping systems is its ability to link spatial data with geographic information about a particular feature

on the map. GIS does not hold maps or pictures, it holds a database and this is the main difference between GIS and other computer mapping systems. GIS can be used to do query or ask questions to show specific relationships among data on a map. It is a powerful tool for increasing decision-making abilities.

GIS is a specialized database management system, displays maps on the computer screen and performs queries. It is devoted especially to analyze spatial and non spatial data (CHAKHAR 2003). As stated by LANG (2001), GIS technology integrates common database operations such as queries and statistical analyses with visualization and geographic analysis offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes and planning strategies. The most important applications of GIS include those that support decision making. GIS technology offers combined power of both the geography and the information systems and provides ideal solutions for an effective natural resource management (KLEYNHANS et al. 1999, SHAMSI 2005).

3. FOREST MANAGEMENT

Forest management is the process of organizing a collection of forest stands so that they produce the resources that the landowner wants from the forest. Common goal for forest management is to produce the resources demanded by the landowner and society to maintain a sustainable supply of resources over time. Management typically begins with forest management plan (YOUNG & GIESE 2003).

Forest management includes management of harvesting and recreational areas, protection of endangered species and archaeological sites. Management of forest resources is a complex task due to multi-functional nature of these resources. Therefore, forest management and planning problems usually involve decisions which have to be made in the presence of multiple objectives (KAZANA et al. 2003, MOHREN 2003).

In the context of surface analysis the terms digital terrain model (DTM) and digital elevation model (DEM) are very important. DTM is a digital model of topographic surface using height, slope, aspect information and other topographic features. DEM is a data file containing an array of elevation values (ARONOFF 1995, HEYWOOD et al. 2002). The two terrain parameters commonly used are slope and aspect. Slope is the rate of change of elevation. It is the steepness or gradient of a unit of terrain, usually measured as an angle in degrees or as a percentage. Aspect is the direction that a unit of terrain (or surface) faces, and expressed in degrees from the north (HEYWOOD et al. 2002). One of the common uses of DTM is viewshed analysis, which is the identification of terrain areas that can be seen from a particular point on a terrain surface (HEYWOOD et al. 2002). In this study viewshed analysis is done as a prototype study to determine the hypothetical location of fire towers in the study area.

4. GIS AS A DECISION SUPPORT SYSTEM

Decision Support System (DSS) is a computer application which combines data, sophisticated analytical models and tools, and user-friendly software into a single system to assist decision makers in the decision making process (GORDON et al. 2004). In forest ecosystem management (FEM), a DSS contains a user interface, database, GIS, simulation and optimization models, data visualization and decision methods (POTTER et al. 2000). Decision making is a complex process, influenced by several factors. GIS applications can not make decisions for people, but it can provide many simulated results to help the decision makers. The main advantage of GIS is its ability to manage and integrate with the existing database. It is possible to see not only spatial data but also databases at any time (DIAH 1997). GIS is gaining importance and widespread acceptance as a tool for decision support in land, infrastructure, environmental management and spatial analysis. With the development of GIS, environmental and natural resource managers increasingly make use of information systems (SHARIFI 2002).

GIS combines and analyzes data from a wide range of sources. The integration capability of GIS allows to pull together different datasets and to create a complete picture of a situation. This enables the decision makers to make better and informed decisions based on all relevant factors. An important benefit of GIS is its ability to integrate and analyze spatial data to support decision making process. The use of a common database in GIS eliminates the differences in presentation, evaluation and decision making based on using different types of data (SHAMSI 2005).

5. MATERIALS and METHODS

This study shows the use of GIS as a decision support system for the Izmir Forest Administration Chief Office. Izmir Forest Administration Chief Office is a subsidiary of the Izmir Directorate of Forest Administration. This institution has eleven forest administration chiefs, and our study area is one of them. Figure 1 shows the thematic mapping of the forest area for the Izmir Forest Administration Chief Office. The general area is 39270 ha and 50.88 % of this area is forested land. Total forest area is 19983.5 ha of which 11494.5 ha (57.52%) is productive forest and 8489 ha is unproductive forest.

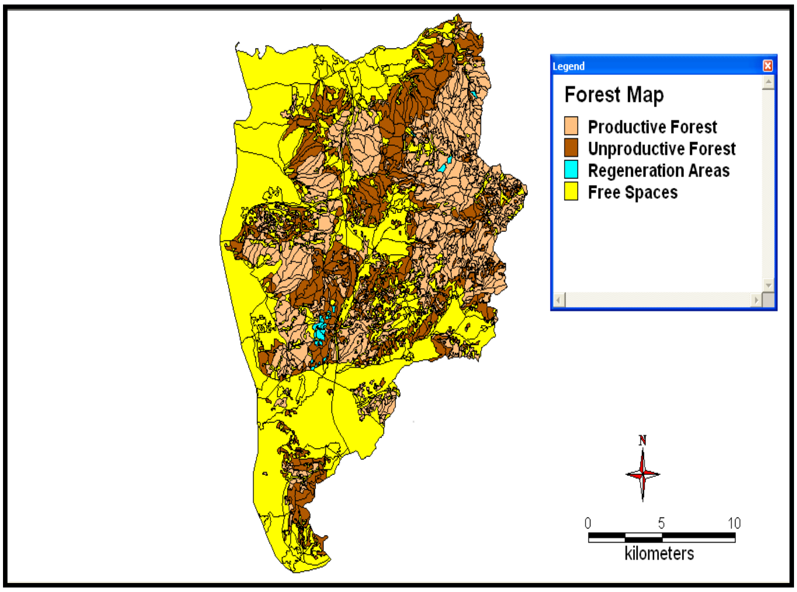

Figure 1. Thematic mapping of the forest area.

At the beginning of the study data collection and database design were done. Prior to analyses, all of the maps obtained from the Izmir Regional Directorate of Forestry were transformed into MapInfo compatible format and forest database of the study area was designed. MapInfo, Vertical Mapper and MapBasic Software packages were used for analyses.

6. RESULTS

In this section the results of the geocoding of the water resources and fire crews; the constitution of the three dimensional, aspect and slope maps; viewshed analyses and graphical user interface application are represented in detail.

6.1. The geocoding of the water resources and the fire crews

There are four water resources and three fire crews in the study area. The information about the locations of the water resources and fire crews were available only as an attribute data with coordinate information. In order to display these points on a map, firstly, coordinates of all water resources and fire crews were converted to decimal degrees and then to the meters. After converting process the databases of water resources and fire crews were designed. The locations of the fire crews and water resources are shown in Figure 2.

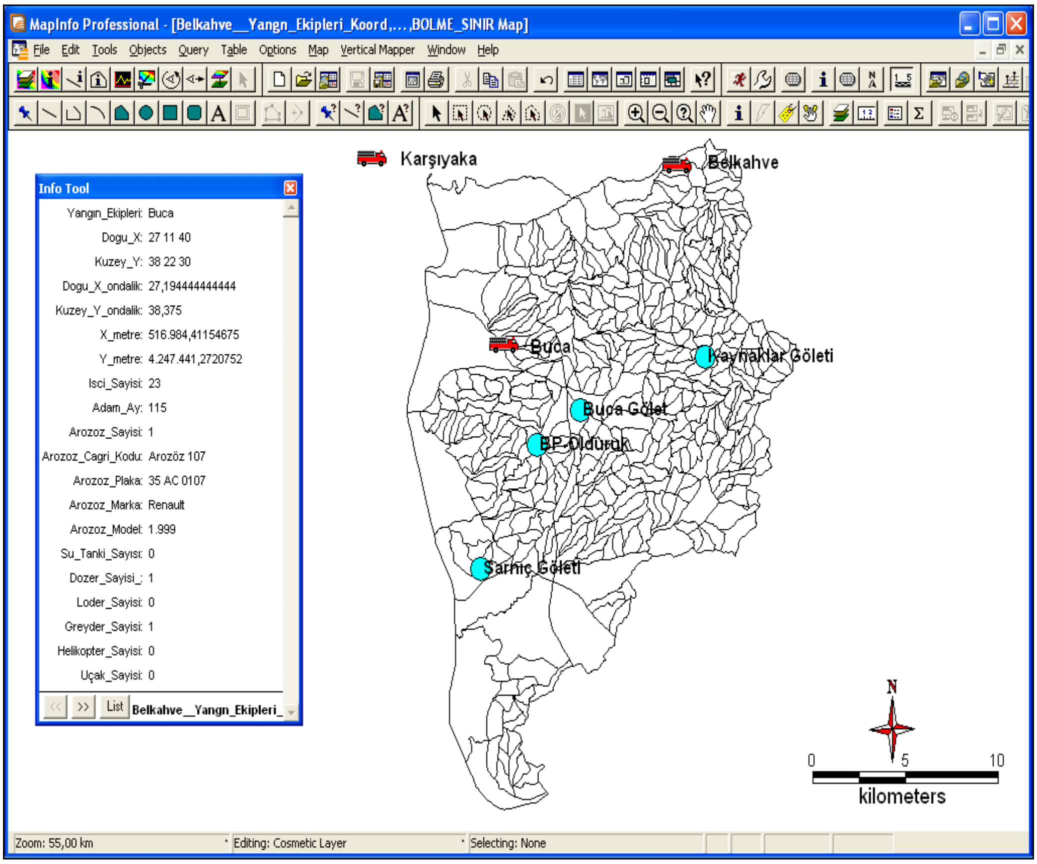

Figure 2. The geocoding of fire crews and water resources

6.2. The constitution of the three dimensional, slope and aspect maps

In this section the topography of the study area was evaluated. Three dimensional, slope and aspect maps were constituted by using contour map of the study area. Vertical Mapper module of MapInfo Professional software package was used for analyses. Figure 3 shows the three dimensional map of the study area.

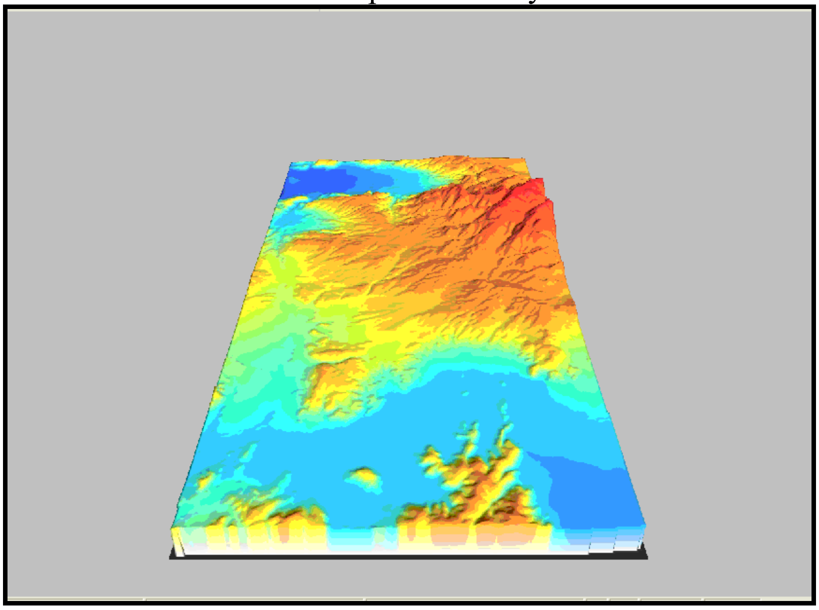

Figure 3. The three dimensional map of the Izmir Forest Administration Chief Office.

Figure 4 shows the slope map of the study area in degree units. As the degree raises slope also increases and this indicates that the land is steep. The slope is very important factor in aforestation studies, in fire fighting operations. In steep land fire fighting operations will be more difficult. Figure 4 shows that the study area is not very steep and has a slope commonly between 10 degrees and 30 degrees.

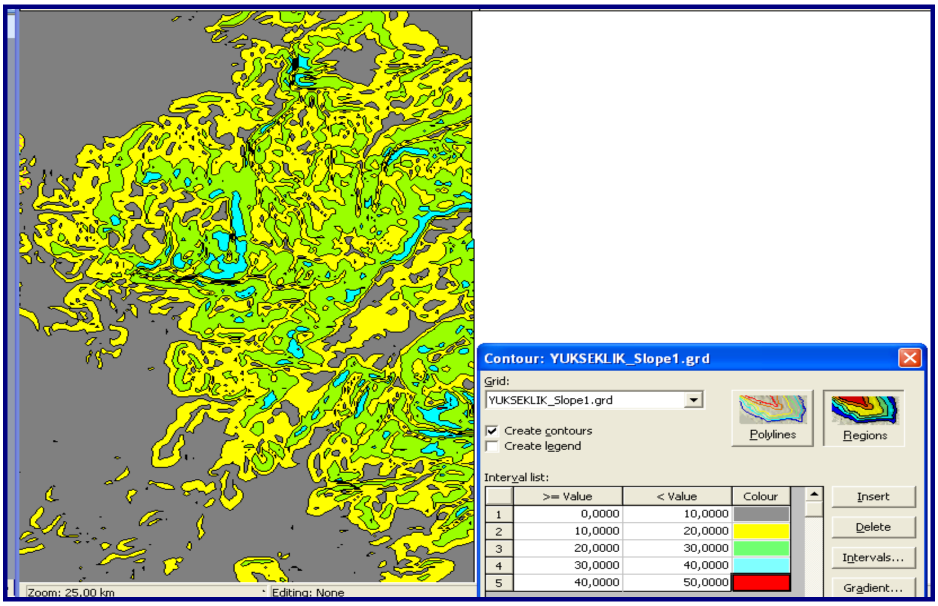

Figure 4. The slope map of the study area.

The aspect map shows visible area by taking the north aspect as a base and the direction that hillside looks. Figure 5 represents aspect map of the study area. In this map all values are in degree units. The degrees 0, 90, 180, 270 and 360 show the north, east, south, west and north aspects, respectively.

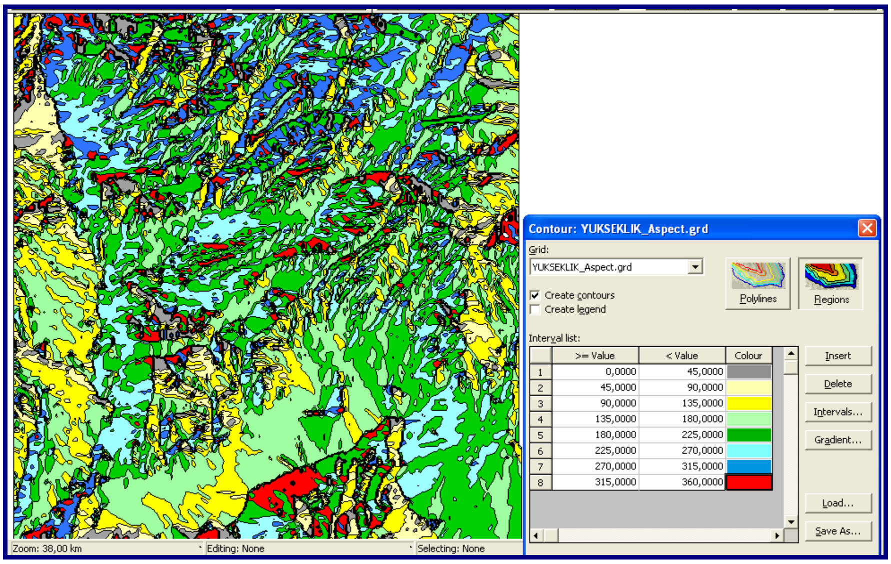

Figure 5. The aspect map of the study area.

The three dimensional, slope and aspect maps support decision making process in aforestation, erosion control, forest road and forest fire fighting studies. The slope map gives information about the degree of slopes and the aspect map gives the information that hillside looks. Steep areas will require more aforestation because they are more erosion prone than the other areas. Therefore aforestation of these areas is very important. The slope and the aspect maps will also be helpful in forest road studies. In forest road studies the areas that have a slope between 2 % and 10 % and south aspect areas are preferred. From a fire management perspective in steep areas, it will be more difficult to cope with forest fire so fire crew allocation must be adjusted according to information that slope map gives. The aspect map will be helpful in predicting the spread of fire by looking at the aspect of hillside.

6.3. Viewshed Analyses

In this section the 4 points were selected randomly from the north, south, west and the east region of the study area as the locations of hypothetical fire towers. This analysis is done to decide the optimum location of fire tower. The main objective is maximize the visibility of the area. The Vertical Mapper module of MapInfo Professional software package is used for viewshed analysis. Figure 6 shows the coordinates of points chosen from the north region of the study area in the X and Y box and Figure 7 shows the result of this analysis for the point selected from the north region of the study area. In Figure 7 red areas show invisible and green areas show visible part of the study area when the hypothetical fire tower (shown as grey box) is positioned in the north as shown in Figure 7. Figures 8, 9 and 10 show results of the viewshed analysis for the south, east and the west region of the study area.

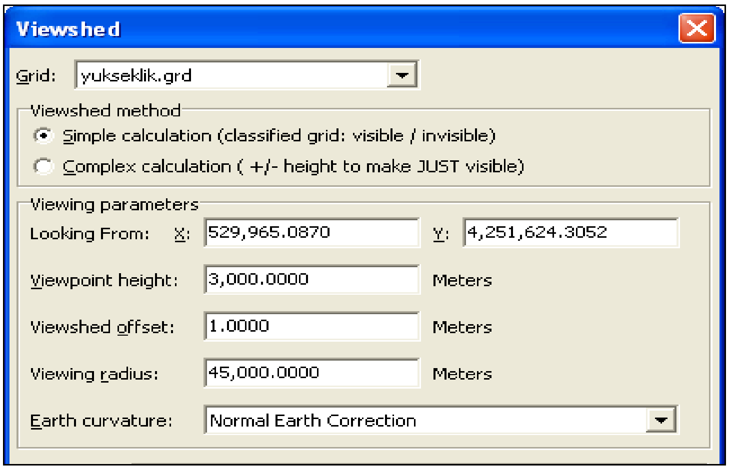

Figure 6. The coordinates of the point chosen from the north

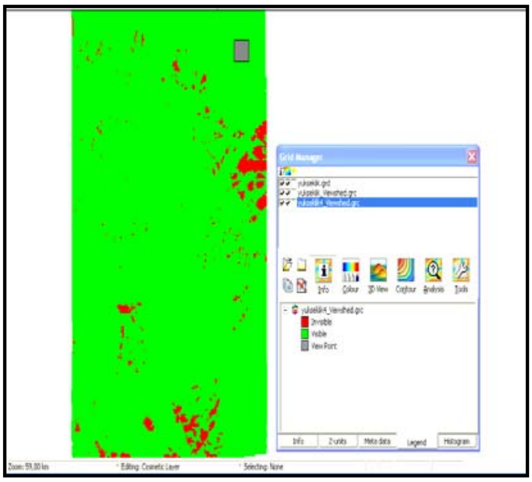

Figure 7. The result of the viewshed analysis for the north.

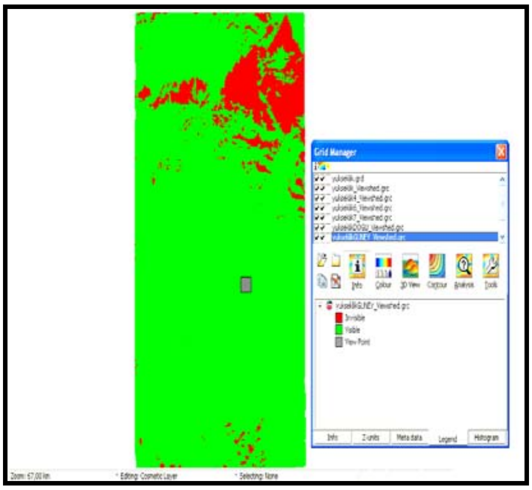

Figure 8. The result of the viewshed analysis for the south.

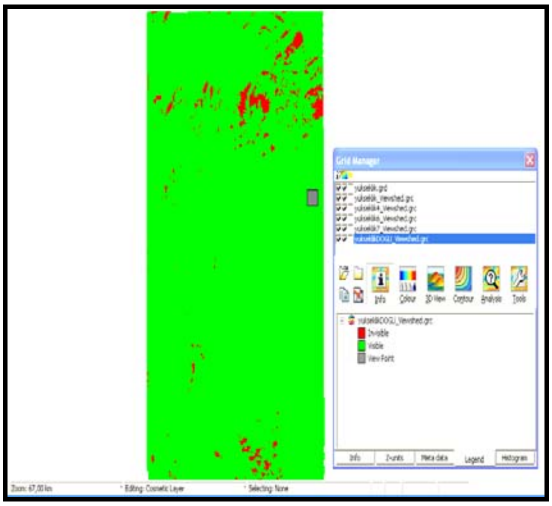

Figure 9. The result of the viewshed analysis for the east

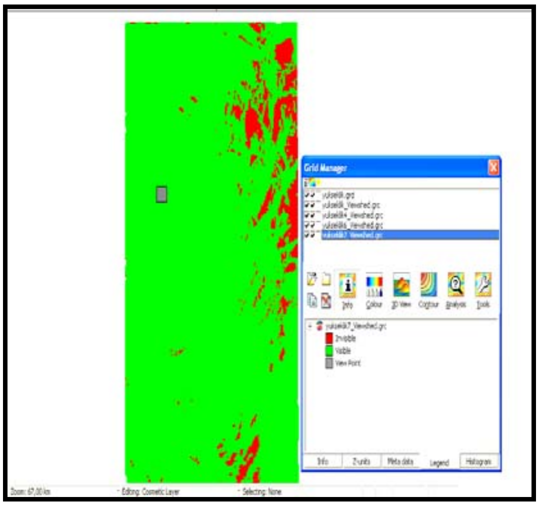

Figure 10. The result of the analysis for the west.

Viewshed analysis is helpful in the decision process of forest fire management. By looking at the result of this analysis it will be possiple to determine the best locations for the fire towers. In this study only a few viewshed analyses were done to develop a prototype study. These analyses can further be expanded by chosing different points as a location of the hypothetical fire tower.

6.4. The Graphical User Interface: MapBasic Application

In this section a special menu, Izmir Forest, was created in MapInfo GIS software by using MapBasic software. The objective is to help decision makers and facilitate their decision making process. Izmir Forest menu provides graphical user interface utilities for decision makers to retrieve needed information in the shortest way. This menu can be expanded according to the information needs of the study area. The menu is both informative and easy to use. It is user friendly also for people who do not know GIS. It enables decision makers, who know and do not know GIS, to reach information in the quickest and the most effective way. The headings of the Izmir Forest menu are shown in Figure 11. When it is clicked on, for example, the contour menu, the output screen will appear as shown in Figure 12. The representation of the compartment and the subcompartment map, the stand type, the streams, hills and settlement areas, fire crews and water resources, contour, altitude, aspect and slope maps are among the heads of Izmir Forest menu.

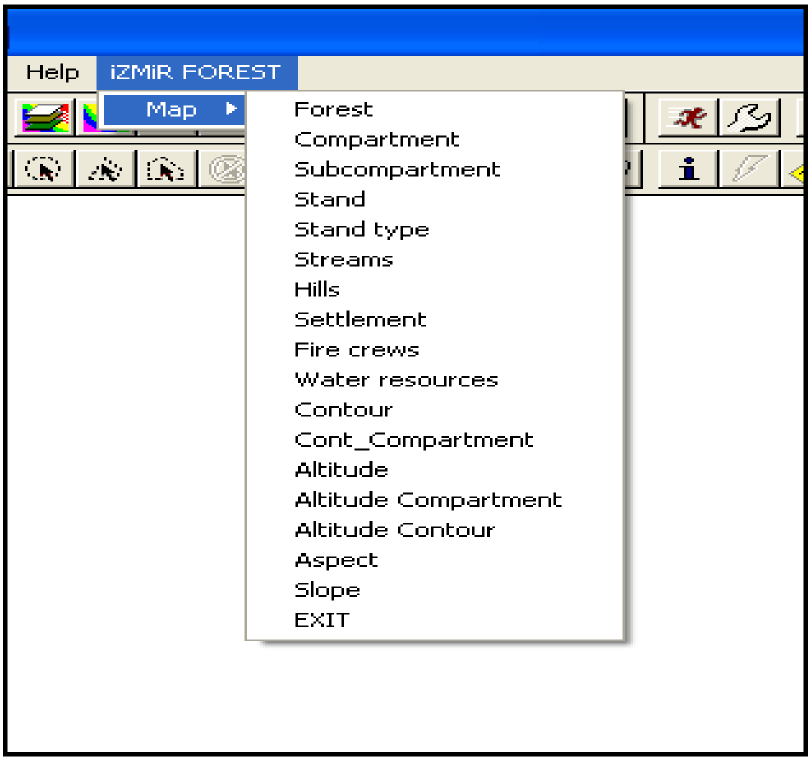

Figure 11. The graphical user interface

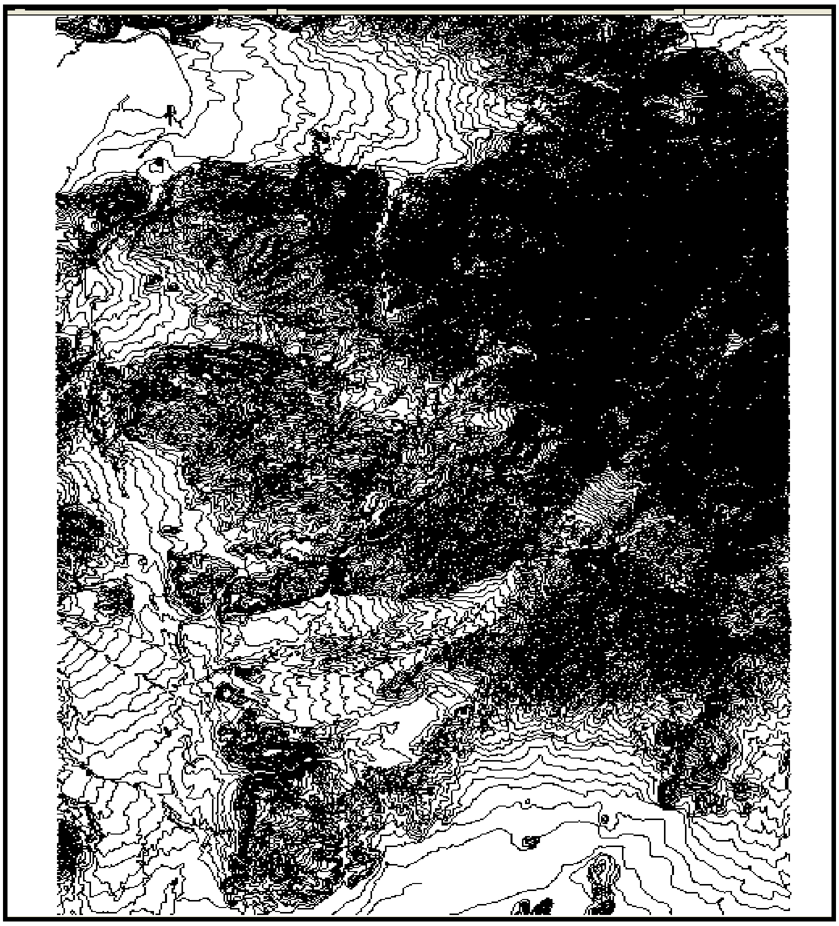

Figure 12. The contour map of the study area.

7. CONCLUSION

Spatial Information Systems and technologies are very important components of decision making in a wide range of applications. They facilitate the decision making process of spatial problems. GIS can not make decisions on behalf of a decision maker but it facilitates decision making process by enabling to do several analyses. It was attempted to discuss forest management by using digital maps in this study. That is, it was tried to launch the first step of the contemporary forest management concept for the Izmir Forest Administration Chief Office.

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