Journal of Applied Sciences 4 (4): 542-546, 2004
ISSN 1607-8926

A Study on the Determination of the Land Use, Elevation and Slope of the Land to the West of Soke by Forming a Digital Elevation Model and Satellite Image

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Abstract: In this study, the distribution of land use, slope and elevation was determined by forming a Digital Elevation Model (DEM) on the land to the west of Soke showing mixed-slope features. In planning the method of use of the land with slopes, elevation above sea level and slope facets were used as basic data. There is a direct relationship between slope and soil depth and erosion– another basic soil feature. Slope groups and their height above sea level can be determined by using the Digital Elevation Model (DEM). By using the Digital Terrain Model (DEM), which is a further stage to be accomplished after this study, surface relief can be formed and the present form of land use and geo-morphological units can be determined by overlapping current data onto this model. For this purpose, digital contours, prepared by The General Command of Mapping, were used. Studies were conducted in laboratory conditions using such software as Image Analyst, MGE Terrain Analyst and Civil Engineering (Intergraph). Landsat-5 image was overlapped onto the Digital Terrain Model and types of land use were determined together with elevation and topographic structure.

Key words: DEM, land use, slope, elevation

INTRODUCTION

Analyses of the topographic features of the land by digital models of terrain, elevation and field studies have recently gained currency in the field of engineering. The Digital Elevation Model can be produced by using contours as well as by adding x, y, z coordinates of the ground control points on the predetermined land or aerial photos or satellite images taken in appropriation with stereo techniques. In the Digital Elevation Model (DEM), the precision of which depends directly on the scale and the accuracy of the topographic data taken as sources, all indirect features related to the morphological structuring of the land can geographically be examined. The hydrological cycle and erosion, which play an important role on land formation, bring into play the functions of eroding, transferring and depositing. Resulting continuous changes in land formation have secured the present landscape. Features of erosion slopes also depend on the climate, geological material and vegetation of the region as well as their elevations and degrees of slope. Soil erosion is a major problem in many parts of the world. Apart from the nature of the soil and vegetation coverage, the complex relief is a key factor of the erosion problem. The integration of soil erosion models with geographical information systems (GIS) enables researchers to carry out quantitative analysis of spatially distributed erosion processes. Digital elevation model have become a main source of topographic data for soil erosion research[1].

One such source of information is topography. Modern methods e.g., field surveying by laser or satellite positioning, automated analysis of aerial photographs and remote sensing allow digital elevation models DEM of terrain to be generated rapidly with very fine spatial resolutions. It has been an axiom of soil science that topography is a factor influencing soil development[2]. Not only do topographic factors directly influence pedogenetic processes but also variations in landform may reflect underlying changes in parent material and differences in age of the soil profile. In principle at least, a DEM should contain information, which could be used to improve the precision with which soil conditions may be predicted[3].

The development of DEMs generally relies on different data sources such as contour map, photogrammetric and any other data collected from field studies. Frequently used structures of DEM are the rectangular grid and the triangulated irregular network (TIN). One of the most important parts of DEM building is interpolation. The best-known methods for interpolation were described and discussed by Watson[4].

A Digital Elevation Model forms the preliminary stage in engineering studies for land use. The Digital Terrain

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Model involves DEM data for digital terrain and three-dimension surface model. The digital terrain model is the name given to the process of forming structure that depends on basic x, y, z coordinates. From this structure, an elevation model is obtained. In order for a digital terrain model to be composed, it is necessary that elevation data be entered. To be able to create surface areas from elevation data, which are entered in the form of points and lines, the second step is made up of a formation of triangular planes. The surface formed by a set of three-dimensional triangular planes is defined as triangulated irregular network. Triangular planes are formed by drawing lines through the points that determine the surface. These files of data are shown on the computer as in the format of "TIN".

Catenary soil development occurs in many landscapes in response to the way water moves through and over the landscape. Furthermore, terrain attributes can characterize these flow paths and the interactions with the soil attributes. Moore *et al.*[5] found significant correlation between quantified terrain attributes and measured soil attributes. Slope and wetness index were the terrain attributes most highly correlated with surface soil attributes. They accounted for about one-half of the variability in a horizon thickness, organic matter content, pH, extractable P and silt and sand contents.

By using stereo images together with Landsat-7 ETM satellite images, Wag *et al.*[6] determined flood plains in the Tar region (Greenwille, W.C. USA). In spite of them lying under forest cover. During their studies, they constituted DEM. Using this model, they determined sedimentation areas.

As Gemmell[7] did in the London area, using reflection values from Landsat-5 TM satellite images and inversion model, he investigated the effect of conifer vegetation. The most important point here is the features of the surface and atmospheric corrections. The results of precision analysis suggested that there was strong influence between reflection values and slope, aspect and plant tissue. It was seen that misinterpretations occurred where negligible slopes were not taken into account in the inversion process. This model was tested by using feature data about forests by DTM and reflection values of Landsat TM satellite images. The results indicated that the effects of sloping terrain would preclude the retrieval of forest coverage unless terrain effects were specifically included in the inversion process.

Digital terrain data have been used for soil feature prediction by many researchers[8-11]. In studies aimed at determining soil properties, slope and depth of soil are especially important in terms of determining their suitability for cultivation. With any rise in slope, an increase in erosion occurs. As it decreases, erosion likewise decreases and accumulation of substances carried down from highlands occurs. As a result, a change in soil depth was noted. In it identifying "land use capability classes", the slope of the land is important because of its being a factor both directly and indirectly. While planning land use, changes in elevation, depending on the local climate, are important factors. In determining the features of elevation and slope, which is geographically important and in presenting them to the users in cartographical terms, it is also very important to use data with high accuracy and data that can be analyzed easily. After Digital Elevation Model and the Digital Terrain Model statistics were obtained, slope and elevation maps were drawn and the surface area of each elevation and slope group in Western Soke was determined.

MATERIALS AND METHODS

The study area is situated within the Büyük Menderes water catchments area in the west part of Turkey. In the study area lie smooth, gently-slope land formations with the main substance being alluvium formed by the function of the Büyük Menderes River and mountainous areas parallel to them. Land cover types of the study area change according to slope and elevation. Common plant types of the research area are cotton, olive growth, fig, vineyard, almond, pasture, brush land and forest.

The Büyük Menderes water catchments area is composed of two horst and graben and was formed during the period from the mid third. The Menderes plain is composed of a graben that occurred during the sixth geological period and it took its present day appearance after the sedimentation of geological material carried by streams and rivers and as a result of erosion from slopes on both sides. The Menderes Basin, taking on mountainous, peneplain and plain landform formations, extends towards the west, the peneplain and hilly parts extending extends from the mountains towards the plains, it is generally composed of mosaic formations consisting of Neozoic calcareous sediments and of independent clastic material. Smooth physiography appears as plains, which are formed as floodplains, sporadically creating marshland.

In this study, methods of the DEM and DTM were used in order to obtain data about basic soil properties and geographical distribution of elevation groups. Four digital contour maps of 1/25.000 scale covering the study area, lying to the west of the basin and Landsat-5 satellite images taken in May 2001, were used in the study. Digital contour map was obtained from The General Command of Mapping. Graphical data with line characters was obtained using "dgn" formatted digital contours and points on these lines, which form the contours and are dealt with in the process of triangulation. Data about a terrain model is composed of such data as contours consisting of broken lines and data in the form of points about the borderlines. This digitized data is obtained by making use of stereo pair images or topographic maps at hand[12].

Determining the distribution of land use, slope and elevation of the land under study was carried out in three stages by using the Digital Elevation Model;

Stage 1: The surface was formed using digitized contour maps of the research area obtained from The General Command of Mapping. At the stage of forming surface from graphics, triangulation, land modeling and elevation modeling were observed, respectively.

Stage 2: Three-dimensional surface of the land, which shows the features of the terrain was formed by using such software as Terrain Analyst and SideWork (Intergraph). Using digital elevation and land data by which the elevation was formed and the data involving x, y, z coordinates, five elevation and seven slope groups were formed. The geographical distribution areas of each group were determined. Landsat-5 image was supervised classified and land use map created.

Stage 3: On the digital terrain model, which was brought about through the computer, Landsat-5 image covering west Soke was overlapped and soil cover type, soil and geological formation were noted.

In the first stage of forming a digital elevation model, a surface was formed from the graphical data belonging to the region. Then, in the second stage, the process of "forming triangulated plane" or "triangulation" was carried out.

Drawing lines between points, which determine the surface, forms triangulated planes. On the computer, these files are shown in "TIN" format. The data about triangulated planes involves data about neighbor planes of each triangulated plane, vertical scale, z-value, field and other detailed data about the coordinates. A three dimensional surface is composed of a set of three-dimensional planes (Fig. 1).

The digital terrain model of the research area was set up by using triangulated planes. The triangulated planes used for this process were formed according to triangulation algorithm by using x, y, z coordinates of the valid points carried over from the graphic file belonging to the surface. Taking "Dealuney's" criteria as basis, this algorithm constitutes small-triangulated planes, which define the surface. Since the coordinates of each triangulated plane are known, the elevation value of a surface point that was set up by triangulated planes can easily be calculated by interpolation. After completing the triangulation process, if the lengths of sides that constitute the triangles are smaller than zero or larger than the defined maximum value, these are ignored and long triangles are not used in surface formation. Triangulation is brought about by using the data of the file by which a surface is to be formed. Software processes linear points first followed by regular points. Linear points are those that have definite data and they can not be points with approximate values formed by interpolation. With surface data which was formed from triangulated graphical data, maps of slope and elevation belonging to the research area were created.

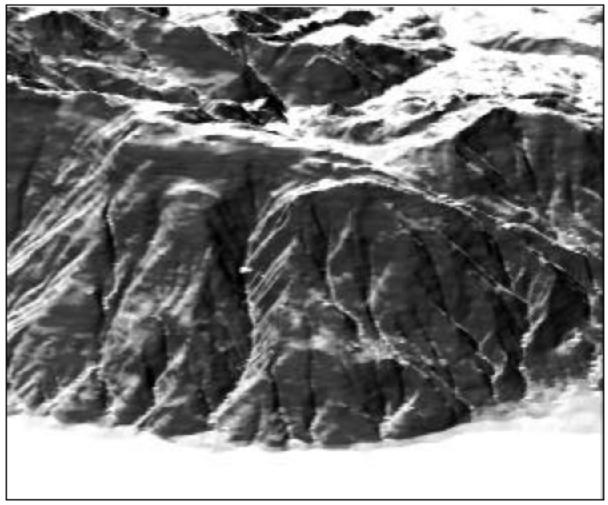

Fig. 1: Three dimensional surface of study area

RESULTS

Using digital elevation involving x, y, z coordinates and terrain data constituting the surface, five elevation groups were set up with intervals of 0/50, 50/100, 100/150, 150/250, 250^+ meters (Fig. 2). In this research area, which has the characteristics of pilot study, it has been observed that olive trees are densely populated at altitudes of up to approximately 150 mt and that olive vegetation lessens between 150 and 250 mt. Additionally at over altitudes of 250 mt it is replaced by shrub land and forest vegetation. Since olive vegetation is dominant in the region's slope terrain, elevation groups were formed at intervals mentioned above. Sloppy lands are generally

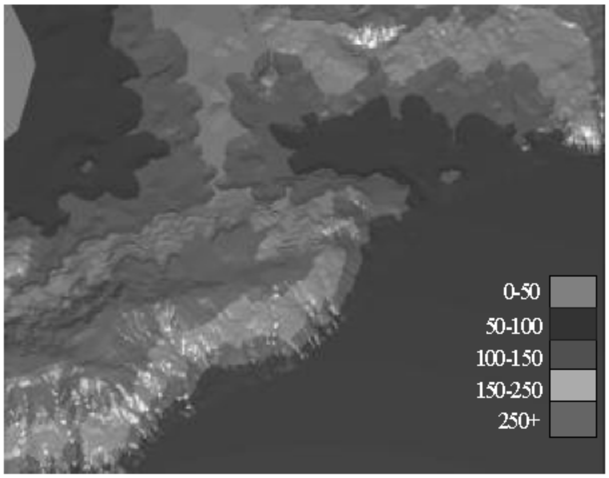

Fig. 2: Three-dimensional map of altitude (mt) belonging to the research area

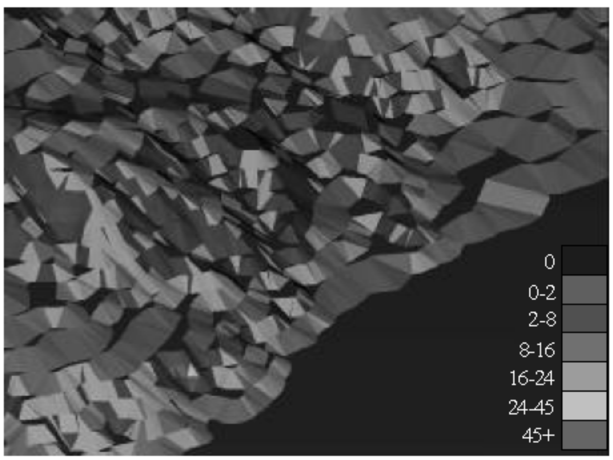

Fig. 3: A three-dimensional map of slope (%) of the research area

taken into consideration as planar in our country, however, it is known that surface area is larger than planar when the surface is taken into consideration and the value of surface area is basic data in land use planning. Values of surface area for elevation and slope groups were measured by digital terrain model and they have been given for both locations (Table 1).

Using the data of the digital terrain model, seven slope groups (%) were set up: 0, 0-2, 2-8, 8-16, 16-24, 24-45, 45^+ (Fig. 3). The slope groups were determined by taking into consideration the relationship between slope and soil depth, which are basic features in cultivated agriculture and values of surface measurement for each slope group were calculated (Table 2).

Land use type of the study area determined by fieldwork and classification process of 453 band composite of Landsat 5. The satellite image was warped

Table 1: Sizes of surface area of the elevation groups of the research area

Elevation (mt)	Area (sq mt)
0-50	846,468.47
50-100	277,422,730.45
100-150	59,193,541.01
150-250	50,013,755.43
250+	296,889,025.96
Total Area	684,365,521.32

Table 2: Sizes of surface area from DEM and planar measuring of each the slope groups of the research area

Slope (%)	Surface area from DEM (sq mt)	Planar surface area (sq mt)
0	127,574,639.11	127,574,639.11
0-2	226,444,446.87	226,431,656.80
2-8	34,835,054.99	34,817,222.01
8-16	22,272,215.40	22,191,913.71
16-24	39,931,675.76	39,393,749.81
24-45	50,601,400.19	49,085,506.23
45+	182,706,088.99	111,465,141.55
Total Area	684,365,521.31	610,959,829.22

on digital elevation model of the research area after atmospheric and geometric correction. Relationships between land cover types and slope-elevation degree of field were observed on 3D terrain model with the color of satellite image. Irrigational agriculture, mainly of cotton, is possible on terrain within the 0-2% slope ratio. On terrain with a slope percentage of 2-8, small sized orchards-citrus, vineyard and other fruit- were determined alongside olives and figs. On low-leveled parts of terrain with a slope percentage of 8-16% it was observed that mostly olive groves and figs, on a small scale, showed distribution while shrub land and forest vegetation abound at higher altitudes. In low-leveled parts of the terrain with a slope over 18%, it was observed that land cover type of olive growth is widespread whereas on high levels shrub land and forest uses dominate.

In this study, the distributions of land use, slope and elevations features were determined successfully by using Digital Terrain Model and Landsat images overlapped Digital Elevation Model. The study also indicated that measuring of field surface in sloppy lands by using Digital Elevation Model provides quick and more reliable results as compare to conventional methods.

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