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Determination of potential hazelnut plantation areas based GIS model case study: Samsun city of central Black Sea region

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Abstract

Turkey is one of the few countries in the world with a favourable climate for hazelnut production. In addition, it has the leading position in world hazelnut production and export, supplying about 70% of world's production. However, hazelnut production exceeds the demand and new some regulations have been enacted to create new land use policies in Turkey. By putting into practice regulations restricting hazelnut plantation areas, a more efficient and productive hazelnut harvest policy could be created. Samsun city is one of the most important hazelnut production centres in Central Black Sea region. The main objective of this study is to determine potential hazelnut areas in Samsun city located Central Black Sea Region according to current regulations using geographic information system technique regarding to support hazelnut policy developers and organizations. According to the criteria dictated by government regulations, potential hazelnut area in Samsun province was determined and 86973 ha of the total area is suitable hazelnut area which is about 9.3% of whole province.

Keywords: Hazelnut, Land Capability Classification, GIS Modelling

Introduction

Turkey is one of the few countries in the world with a favourable climate for hazelnut production. Hazelnut is an important nut species for Turkish economy. In recent years, Turkey's share in the world hazelnuts production has increased. The countries responsible for almost the entire world's hazelnut production and exports are Turkey, Italy, the United States, and Spain. Among these countries, Turkey has the leading position in world hazelnut production and export, supplying about 70% of world's production and export (Kılıc et. al 2008). Hazelnut has always taken first place as an export crop among agricultural products in Turkey. It provides substantial foreign exchange earnings, and has social and economic importance for producers in hazelnut cultivation areas. Particularly in provinces on the east Black Sea coast of Turkey, the basic income source for most farmers is hazelnut production (Kılıc et. al 2009). Most of hazelnut areas on the east Black Sea region are not suitable for other agricultural uses having more than 20% slope (Dengiz, 2008). Lands having secondary importance are productive for other agricultural products covering approximately 100.000 hectares. In Turkey, the hazelnut gardens on average are between 0.4 and 1 hectare in size and are generally sloping. Ideally, a soil pH value of 6-7 and high rainfall of 1250 mm are good conditions for growing hazelnut. On average, 600-1000 kg hazelnut is grown per hectare in Turkey that is under the world average. It is 2000-3000 kg in Italy and 1700-2500 kg in the USA (Marti, 2001). The production area is mostly harvested for commercial purposes and spread densely in the Black Sea region in

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Turkey in an area covering approximately 540.000 hectares over 13 provinces where the hazelnut has been native for the last 2500 years. Most of these areas are not suitable for other agricultural uses having more than 20% slope (Reis and Yomralıoğlu, 2006). Samsun is one of the most important hazelnut production centres. The annual hazelnut production in Samsun is given in Figure 1 (TURKSTAT, 2011).

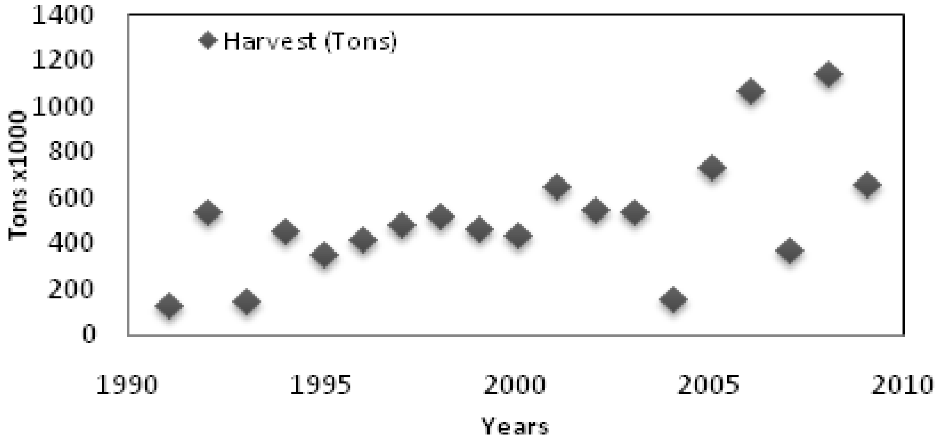

Figure 1. Hazelnut amounts produced in Samsun (TURKSTAT, 2011)

Geographic Information System (GIS) is a powerful tool for collecting, processing and analyzing spatial information (Reis and Yomralıoğlu, 2006; Longley et. al 2001; Yomralıoğlu, 2002; Lioubimtseva and Defourny, 1999). In addition, it contributes to the speed and efficiency of the overall planning process and allows access to large amounts of information quickly. Especially during the last decade, GIS and RS have received much attention in application related to resources at large spatial scales (Green 1995; Hinton 1996; Dengiz et. al 2010). The main objective of this study is to determine potential hazelnut areas in Central Black Sea Region according to current regulations.

Materials and Method

Field description

This study was carried out in Samsun province in the Central Black Sea region of Turkey. The Province of Samsun is situated between 37° 08' - 34° 25' west-east longitudes and 40° 50'- 41° 51' north-south latitudes in the middle of Central Black Sea region (Figure 2). Total area of the Samsun is 9579 km^2. The Samsun city has Bafra, Ondokuzmayıs, Tekkeköy, Terme, Havza, Vezirköprü, Ladik, Yakakent, Kavak, Salıpazarı, Asarcık, Ayvacık, Alaçam, Merkez and Çarşamba districts. Proximity to the sea results in a temperate climate where summers are generally warm, winters are mild with an overall annual average temperature of 15 ºC and annual average precipitation of Samsun province is 788.1 mm (Anonymous, 2005). Except for the Çarşamba and Bafra plains (approximately 190 000 ha), most of the region have precipitous, sloping and complicated topography. Elevation of the area varies from sea level to 1900 m. Flat areas are mainly used for agricultural activities while the upper land with high slope is placed in forest and pasture areas. However, hazelnut and willow trees are cultivated in Çarşamba plain (Güler et. al 2007).

Data analysis

In Turkey, law number 2844 was brought into force in June 1983. The aim of this act has increased hazelnut yield and regulated production by determining hazelnut planting areas. The latest regulation was created in January 2002 and published June 2003 to reduce the hazelnut areas and enhance productivity. According to this regulation, the hazelnuts can be harvested from;

- Areas in which the maximum elevation is 750 m.
- Agricultural area which has III LCC class.
- Areas where slope is more than 6%.
- IV or upper class of LCC (Turkish official journal, 2002).

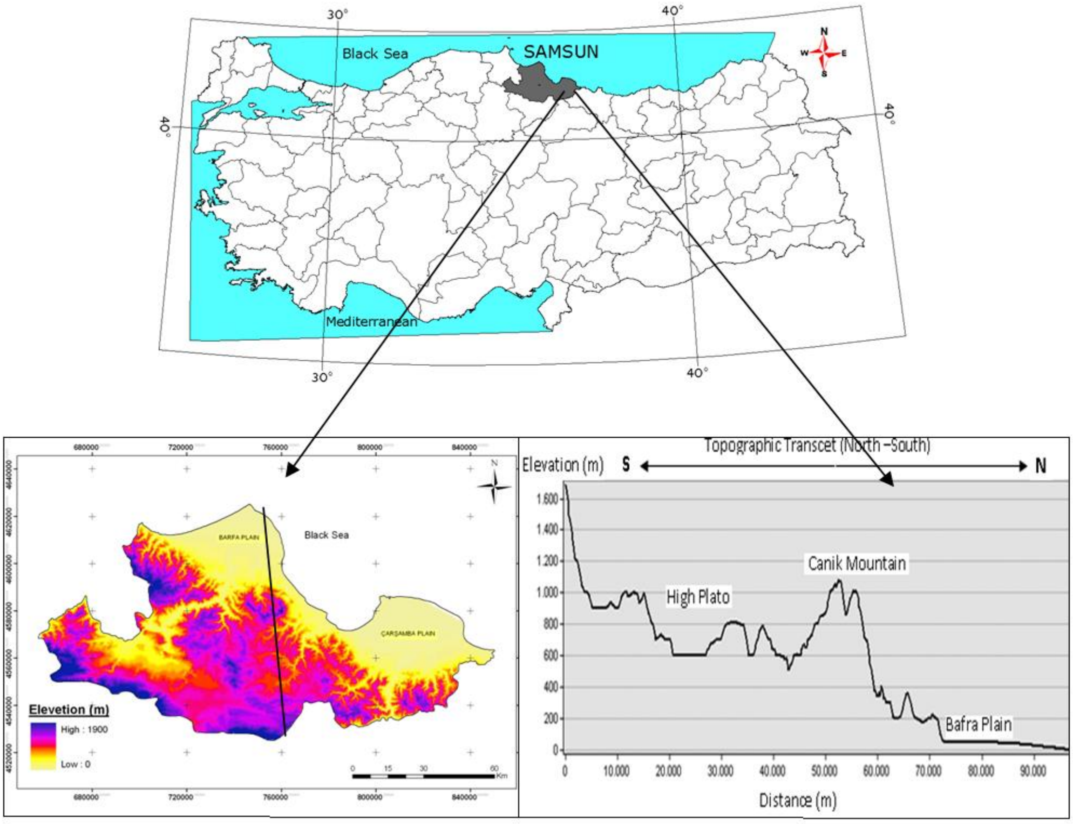

Figure 2. The Study area

Digital Elevation Model-DEM, digital soil, land use-land cover and topographic maps, and meteorological data were used as materials for determination of potential hazelnut area and all these data were analysed using of ArcGIS 9.3v programme. The model shown Figure 3 involves the computation of three basic factors (soil, topography and land use-land cover) which were combined in the assessment procedure. Each factor is considered as a thematic layer in the GIS. In first stage, land capability classification map was generated using digital soil data base prepared by the General Directory of Rural Affairs. In second step, the DEM was digitized from 1/100.000 scaled standard topographic maps. The contours on these maps are drawn at 100 m intervals. The DEM of the study area was created by using ArcGIS software. The slope map (classified in percentages) and elevation figures were generated by using this DEM. The pixel dimensions of this slope map are 50 x 50 m. Land use and land cover information were derived from the General Directorate of Rural Services. According to regulation, potential hazelnut areas will be determined using the land cover and land use maps, the slope map obtained from the topographic map and the class of LCC map obtained from digital soil map. The hazelnut trees will be removed from the sites, if they fall outside the categories listed above. The farmers will then be encouraged to grow alternative agricultural products. All layers were then spatially overlaid to produce reliable result map. Schematic chart of the spatial overlay showing the land and soil characteristics are illustrated in Figure 3.

Results and Discussion

In this study, the various procedures were applied to determine the potential hazelnut harvesting areas in Samsun, Turkey. First, LCC was determined using digital soil database. LCC was established by the Soil Conservation Service de USA according to the system proposed by Klingebiel and Montgomery (1961) and has been widely used throughout the world with numerous adaptations. It is a categorical system that uses qualitative criteria. The inclusion of a soil within a class is made in the inverse manner that is, without directly analysing its capacity, but rather its degree of limitation with respect to a parameter according to a concrete use. Some factors that restrict soil use can be used to define the productive capacity (intrinsic: soil depth, texture, structure, permeability, rockiness, salinity, soil management; extrinsic: temperature and rainfall) and yield loss (slope of the terrain and degree of erosion).

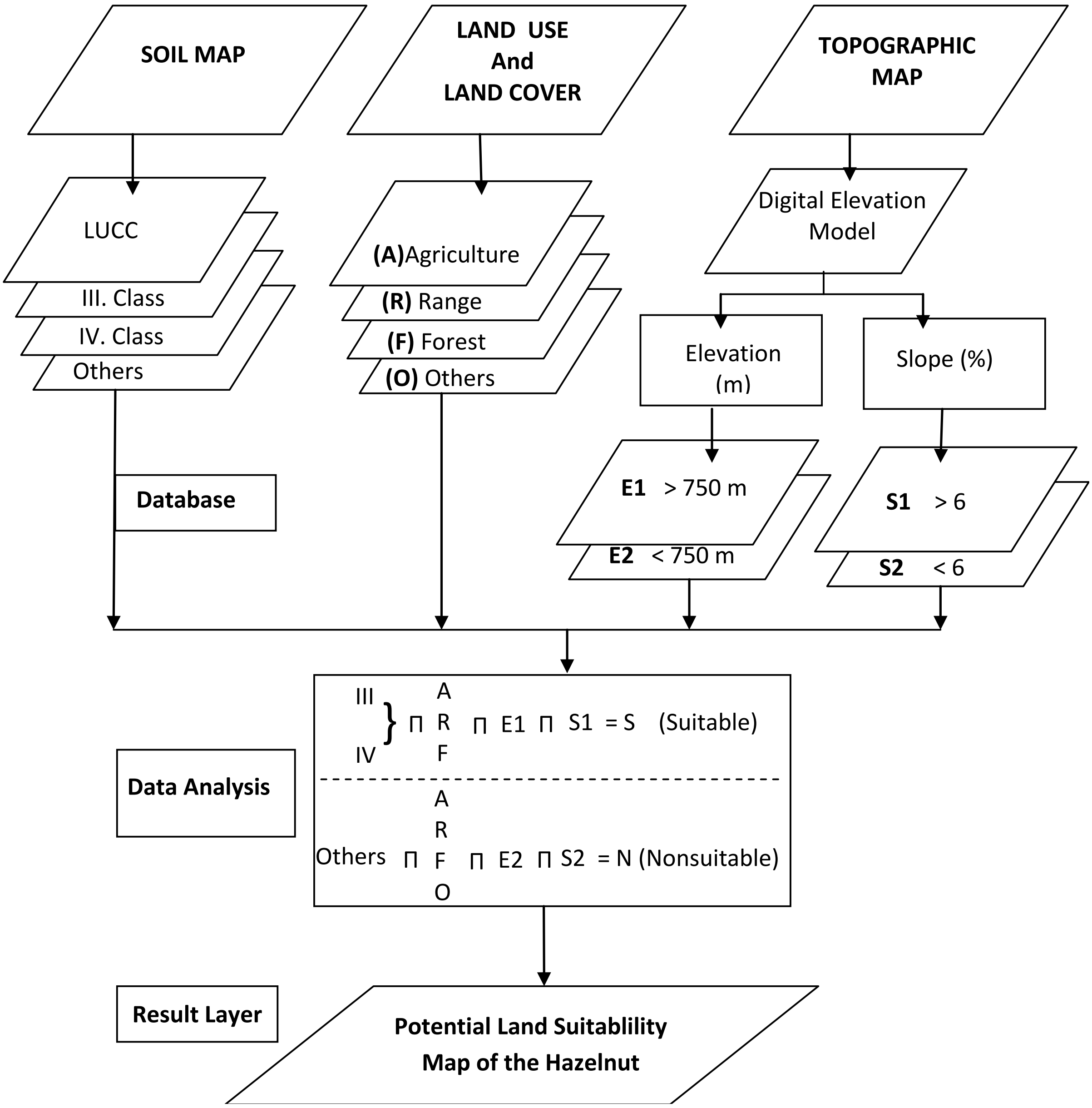

Figure 3. Flowchart of potential hazelnut area determination procedure.

Five systems of permanent agricultural exploitation are considered: permanent soil cultivation, occasional soil cultivation, pasture, woods and natural reserves. This system seeks maximum production with minimum losses in potential. Three levels of classification ware established: classes, subclasses and units. Also, VIII classes with increasing limitations in use are defined from I to VIII. As a function of the permitted uses, 4 use groups can be distinguished: permanent soil cultivation (or any type of exploitation; Class I, suitable soils; Class II, good soils but with some limitations; Class III, soils acceptable but with severe limitations), occasional soil cultivation (pastures, woods or natural reserves; Class IV, not recommended for agricultural use for severe limitations and/or required careful management); no soil cultivation, only pastures (in forests or natural reserves; Classes V, VI and VII) and natural reserves (Class VIII). The capability units represent similar proposals of use and management. According to regulation, LCC was divided into three classes on the soil map. The first class is labelled absolute agricultural land and involves I and II classes of LCC while the second involves III and IV class of LCC. The last class involves V, VI, VII and VIII of LCC in this study area. It was determined that there is total 49014.6 ha absolute agricultural land while, 104787.4 ha of the total area is second class. In addition, 59.8 % of the study area is third class that has severe limitation factors such as high salinity, steep slope, soil erosion and shallow soil depth etc (Figure 4).

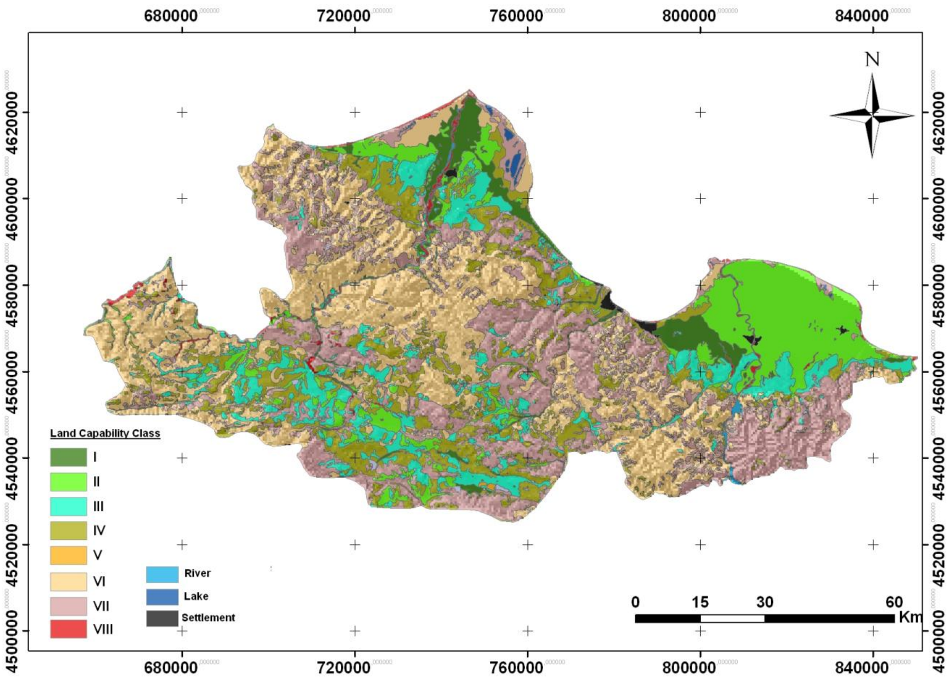

Figure 4. LCC map of the study area

Topography or relief so strongly affects hazelnut production in terms of its quality and yield production. Therefore, it is undoubtedly one of the most important determinants according to regulation. Two parameters (slope and elevation) were used for criterions in determining the general potential hazelnut areas. Slope groups and elevation derived from DEM are presented in Figure 5 and Figure 6. It can be seen that 37.8% of the study area has less than 10 % slope (very gentle and gentle) and 62.2% has more than 10% slope, varying from steep to very step.

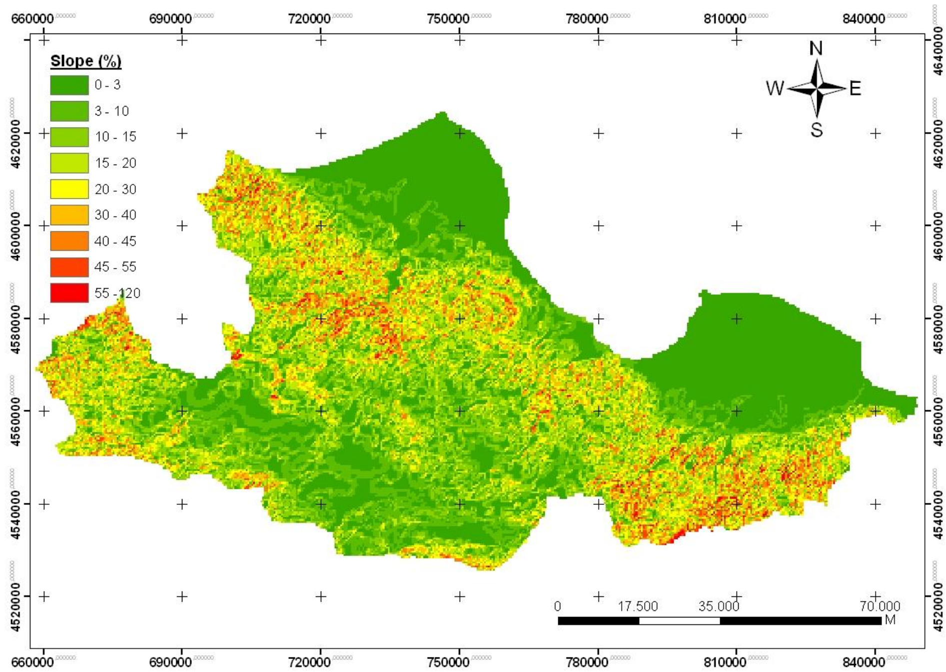

Figure 5. Slope map of the study area

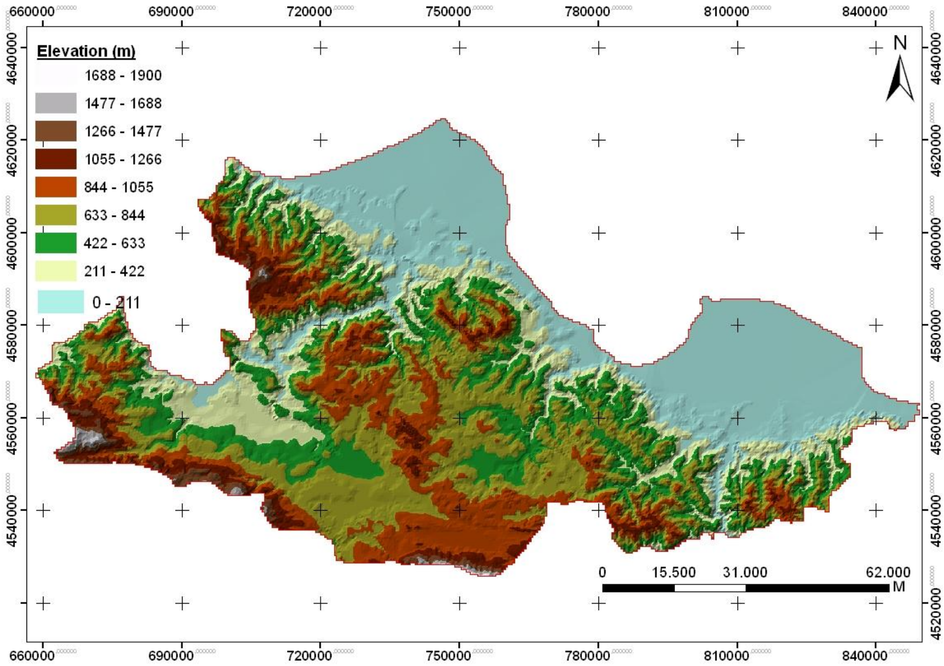

Figure 6. Elevation map of the study area

The main land uses of the study area are forest, meadow, dry farming, rangeland, and irrigated land. It appears that there is 45.2% of the total area dry farming while, 48.5% of the study area has forest and bruch land. Only a small part of the area (3.3%) covers meadow, rangeland and irrigated land (Figure 7).

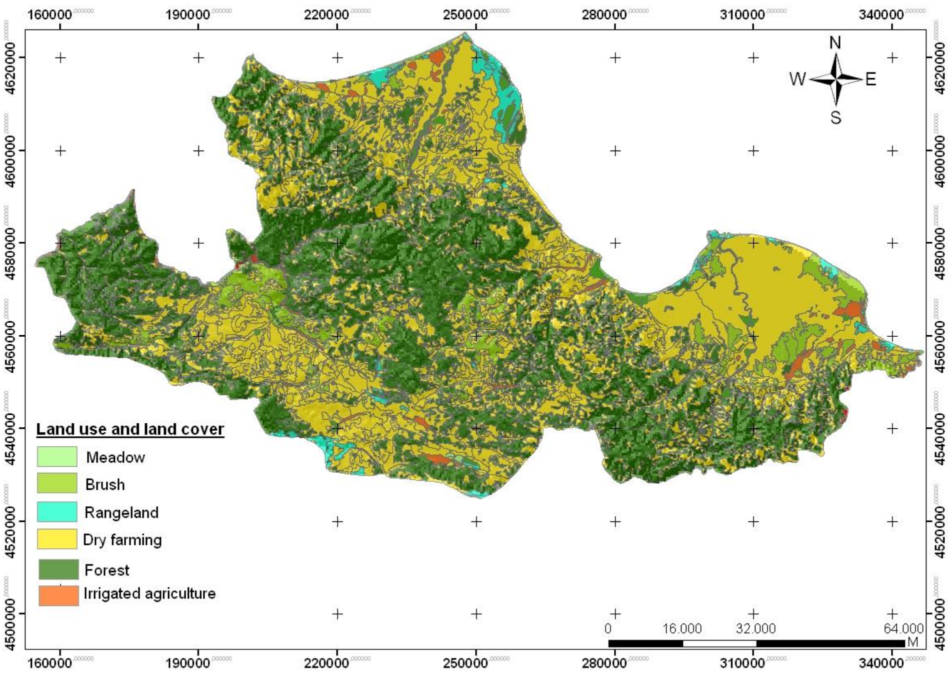

Figure 7. Land use and land cover map of the study area

In the final step, map of the potential hazelnut areas was generated by overlapping LCC map, land cover - land use map, slope and elevation maps and the result is presented in Figure 8. The hazelnut trees will be removed from the sites, if they fall outside the categories listed above. The farmers will then be encouraged to grow alternative agricultural products. According to this analysis, there is total of 86973 ha general potential hazelnut area in Samsun province which is about 9.3% of whole province.

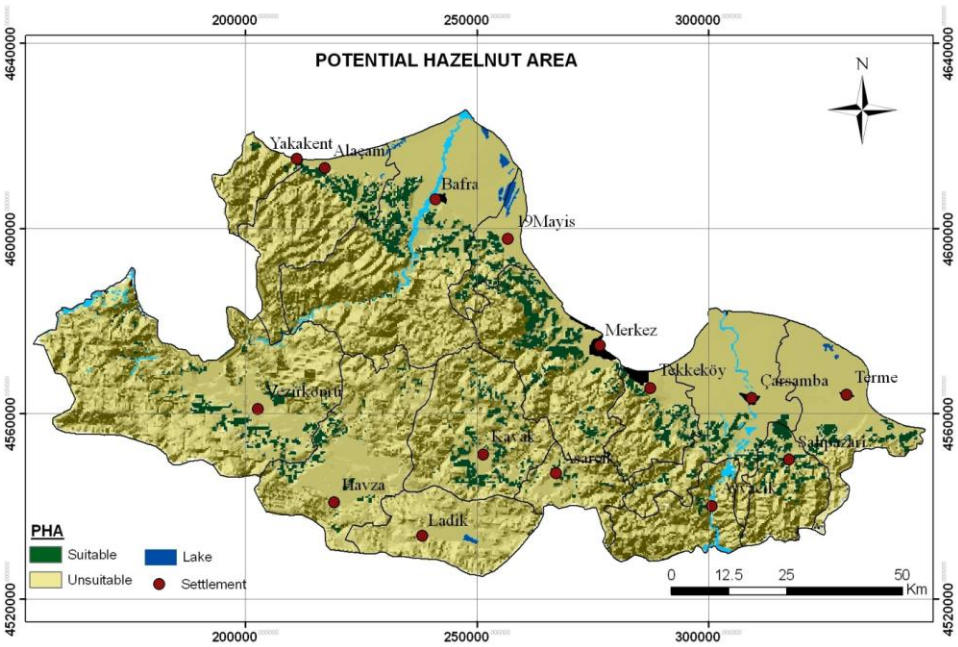

Figure 8. Potential hazelnut area map of the Samsun province

Conclusion

According to the criteria dictated by government regulations, potential hazelnut area in Samsun province was determined and mapped. The GIS technology was used and the criteria including: slope, elevation, LCC, and land use-land cover were used to determine the potential hazelnut areas. Topographic data collection, using traditional land survey methods, requires too much cost and is time-consuming. Today advanced computer programs such as geographic information system (GIS) and remote sensing (RS) contribute to the generation of topographic data in form of digital elevation models (DEM) to study terrain attributes (Bolca et. al 2011). It is also very easy to update or modify data involved in GIS database in the future.

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