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Determination of land use/cover changes and land use potentials of Sivas city and its surroundings using Geographical Information Systems (GIS) and Remote Sensing (RS)

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Abstract

Land cover/use change information is a very important and useful source for planners in land use studies. Moreover, determination of land use potential by considering capability of the land and other characteristics provides an important data source for regional planning studies. Remote Sensing (RS) and Geographical Information Systems (GIS) are widely used for this purpose. This study aims to determine land use/cover changes in the Sivas city and its surroundings using Remote Sensing and Geographical Information Systems, and to create the land use potential map that shows the optimal land usage of the study area. Landsat satellite images from 1987 and 2002 were used to determine the changes and to follow the development of residential areas in the Sivas city. By revealing the existing environmental characteristics of the study area (topography, geology, soil, climate, hydrology), optimal land usage (settlement, agriculture, forest and meadow-range) was determined according to the data. The land use potential map of the study area was created using suitability maps for the optimal land usages. By assessing the land use/cover change information and optimal land usage together, it was determined that the city was developed in the northeast, south and southwest direction. The settlements were founded on the most appropriate areas from the agricultural point. As a result, suggestions for the appropriate land use in the Sivas city and surroundings were made for the future.

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Keywords: Sivas; geographic information system; remote sensing (RS); land use/cover information; land use potential.

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Introduction

Stress on natural resources has been increasing daily due to steady population increase. In particular, misuse of lands constitutes a significant potential threat. Effective planning strategies have been developed in order to reduce stress on productive agricultural lands. Remote sensing (RS) and geographic information systems (GIS) play an important role in the development of this policy (Karakus et al., 2013). Previous case studies have provided a wealth of useful information, which has allowed us to rethink the adverse consequences of land use/cover change and rapid urbanization and therefore to help the decision-makers to develop and execute rational land use policies (Zhang et al., 2013). Land use/cover changes have been given increasing attention from both environmental and socioeconomic points the view. The changes are spreading rapidly involving large areas, especially in developing countries and their influence on the environment is getting immense. One of the relatively inexpensive methods of dealing with land cover changes is the use of remotely sensed data (Wondrade et al., 2014). With the invention of remote sensing and GIS techniques land use/cover mapping is a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial purpose (Rawat and Kumar, 2015). The application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy in association with GIS that provides suitable platform for data analysis, update and retrieval. Digital change detection techniques based on multi-temporal and multi-spectral remotely sensed data have demonstrated a great potential as a mean of understanding landscape dynamics. These techniques can detect, identify, map, and monitor differences in land use/cover patterns over time, irrespective of the causal factors (Rawat et al., 2013). Satellite images together with geographic information system are important data resources for use in regional planning studies (Tapiador and Casanova, 2003). Urban land use models can be easily developed using GIS and RS data. These models prove that arranging and managing urban growth based on environmental carrying capacities may be practically useful through definition of fundamental urban growth vectors and general land use tendencies, which will ultimately pave the way to application for appropriate regional planning authorization (Almeida and Monteiro, 2005). The two most significant characteristics of this technology is their application to the existing challenges of physical and human geography. Furthermore, these technologies have often been used by the executives and planners at both regional and national levels. (Kent et al., 1993).

A land use/cover database has a strategic importance for any country and can supply required spatial information of national and regional scope. Updated and systematic information together with dated sources of reference are required for coordination of land use planning, making of policy decisions and monitoring. Monitoring of land use variations utilising updated data, pre-configuration of future settlement areas and estimating amounts of change and development by means of forward-looking strategies are important for urban planners (Mundia and Aniya, 2005). Temporal Landsat images are widely used data sources for analyzing and mapping land cover variations, land planning administration and policy decision-making (Yuan et al., 2005).

The stage of data collection and analysis is very important in the processes of land use planning. Care must be taken for the data to be as updated as possible. Especially the maps and principal information used should be detailed in a level to constitute a substructure for the preparation of land capability maps (Yilmaz, 2008).

Land information is used in order to assess the feasibility of the lands by land use types. The land use planning around the city is an important concept for the conformity assessment carried out for development. For example, topographical properties are one of the most important factors affecting the conformity of a specific area. Slope values between 2 and 6% are sufficient in order to ensure a good surface drainage and appropriate settlement areas. Important problems may be faced in areas that are not sufficiently even in terms of the development of settlement areas (Lillesand and Kiefer, 1994).

Potential land use assessment is likelyto be theprediction of land potential for productive land usetypes. This case is great important in guiding decisions on land uses in terms of potential and conserving natural resources for future generations. Therefore, careful planning of the use of land resources is based on land evaluation, which is the process of assessing the suitability of land for alternative land uses (Bolca et al., 2013).

Land evaluation is concerned with the assessment of land performance when used for a specified purpose (FAO, 1977). In other words, land evaluation is likely to be the prediction of land potential for productive land use types, and then generally a comparison or match of the requirements of each potential land use with the characteristics of each kind of land.

In this study, the land use/land cover changes of Sivas province and its vicinity were detected using Remote Sensing and Geographic Information Systems, and a usage potential map showing the most appropriate land use of the area of study was created. It was aimed to create the most appropriate usage model for the future for the purposes of planning, developing and managing the natural resources of the area for Sivas province and its vicinity in a sustainable way in order by assessing the changes of land use/land cover changes and area usage potentials together.

2. Materials and methods

2.1. Study Area

The study area is within the limits of the city of Sivas (UTM coordinates 4415000-319000, 4415000-339000, 4389000-319000, and 4389000-339000, datum ED50, zone number 37N). 1/25000-scale quadrangles i37-b3, i38-a4, i37-c2 and i38-d1 covering the Sivas city center and environs were thoroughly examined in this study (Figure 1). Sivas is located in the upper reaches of the Kızılırmak River within the central Anatolian region. In Turkey, the province of Sivas is ranked second in terms of surface area (28,488 km2) after the province of Konya, and is located between 36˚ and 39˚E longitude and 38˚ and 41˚N latitude.

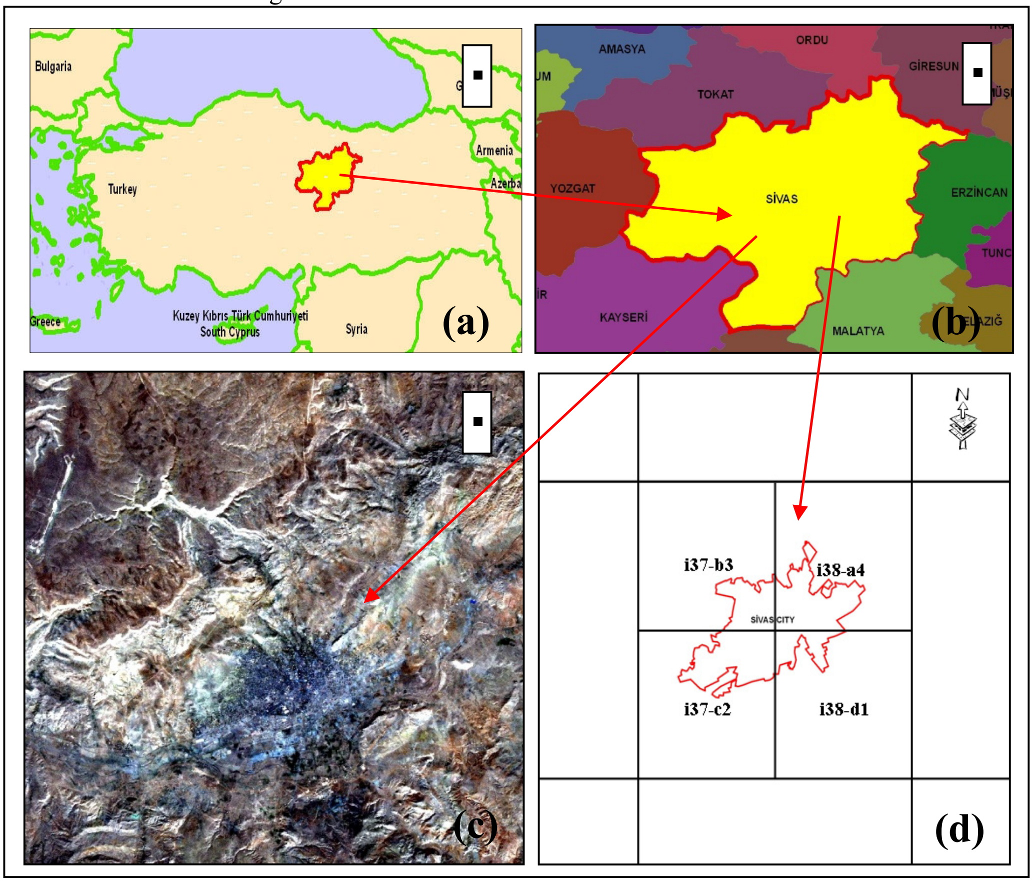

Figure 1. a) Location map of the study area b) Border provinces of the city of Sivas c) Landsat TM satellite image of the city center of Sivas d) Layout index of the study area.

Its topography is generally rugged with elevations 1200-1500 m above sea level. In accordance with the topographic structure of Turkey, Sivas generally increases in elevation from west to east, and most of its eastern parts are of higher elevation. The province has the general appearance of a plateau that, in fact, has been shaped by valleys along mountain ranges, or comprises individual mountains and plains in graben and terrace areas. The city centre of Sivas as a settlement area descends from north to south, and this descending slope generally does not exceed 5%. Sivas is the coldest city of the central Anatolian region; its temperature may reach 40˚C in summer and can drop to -33˚C in winter. The mean annual precipitation is 420 mm, comprising precipitation of 22% in autumn, 36 % in spring, 32 % in winter, and 10% in summer.

2.2. Determination of Land Use/Cover Changes

Landsat TM images dated 08.10.1987 (-path 175, row 032-), and Landsat ETM+ images dated 18.10.2002 (-path 174, row 032-) have been used to determine land use/cover variations for the city of Sivas and environs over a particular time period (Table 1). Er Mapper 7.0 software are used to determine the land use/cover variations and field type hand-held GPS were also used to identify ground control points.

Table 1. Data types and technical properties of the aerial photographs and satellite images used in this study.

Technical Properties	Data Type Landsat TM satellite images	
	Year 1987	Year 2002
Source	USGS	USGS
Spatial Resolution	28.5 m	28.5 m
Radiometric Resolution	8 bit	8 bit
Year Produced	1987	2002
Projection	NUTM37	NUTM37
Datum	WGS84	WGS84

Note: GCM - General Command of Mapping of Turkey

The types of data (below) used in this study served as reference data to determine the land use/cover variation, aided by the use of satellite images:

a) Topographic maps at the scale of 1/25000
b) Aerial photographs at the scale of 1/35000 from the year 1973 and
c) aerial photographs at the scale 1/5000 from the year 2005
d) Urban Planning Drawings for the year 1982
e) Point reference data obtained by GPS during fieldwork.

In this study, stages indicated below have been followed up by using the satellite images of the study area from the years 1987 and 2002, and the land use/cover variations in the study area have been ascertained.

Image Processing

Each image has been supplied as a whole frame and in the form of seven bands; each Landsat TM image has rectifying image characteristics and each Landsat ETM+ image has orthorectifying image characteristics. Radiometric rectification has not been applied insofar as radiometric rectification was done previously. Satellite images from both years have been developed by using all bands of each image and with the help of the Er Mapper 7.0 software. A study area covering approximately 420 km2 has been extracted as a subset from the Landsat ETM+ whole-frame images dated 2002, and Landsat TM images dated 1987, covering an area of 185 km x 185 km.

Image Enhancement and Visual Interpretation

Visual interpretation can give an idea concerning land cover variation over a particular time period (Shalaby and Tateishi, 2007). The goal of image enhancement is the refinement of image interpretability via increasing differentiability among objects. The image interpretation process that is, images whose quality has been enhanced digitally- is the best way to benefit from the complementary capabilities of the human mind and computer technology. Bands 7, 4 and 1 were combined to produce false-color images for visual interpretation.

Image Classification

Remote-sensing data may be analysed in order to obtain needed thematic information. One of the most useful methods for obtaining this information is image classification. Image classification is the conversion process that is applied to converting raw image data to thematic information. This information is gathered by identifying and measuring certain intervals of the electromagnetic energy spectrum spreading or reflecting from the earth's surface, and by saving these measurements into spectral bands (Jensen, 1996).

Initially, an unsupervised classification process for both images was followed in order to obtain preliminary information regarding the land use/land cover for the study area. A classification process for 10 types of land class was then applied by using the ISODATA algorithm in an unsupervised classification process. Data from the training areas have been gathered from the field. Subsequently, with the resultant map in hand, supervised classification was carried out using aerial photographs (with closely spaced dates), auxiliary reference data (topographic maps, zoning sheets, etc.), and data gathered in the field. A supervised classification process involving eight land classes has been applied with the help of the Maximum Likelihood Algorithm, using all the spectral bands except the 6th spectrum (band), which has thermal characteristics. Kernel filter 3x3 was employed in order to decrease the number of faulty pixels in the classified images, and land use/cover variations for the study area were established by comparing classified images.

2.3. Determination of Land Use Potentials

For generating the usage potential map for Sivas province and its vicinity; 1/25.000 scale topographic maps with the section numbers of i37-b3, i38-a4, i37-c2 and i38-d1 (for altitude), numerical soil maps and digital geological maps were used. Arc GIS 9.3.1 programme was used for the analyses necessary to carry out on these GIS data. Considering the logic of the map overlay technique during the studies; the projection of all numerical data was corrected as UTM and the datum as ED50 for the analyses to be carried out in the advanced stages of the study, as all numerical data require a common projection and datum variable.

In the first stage, thematic maps showing the properties topographical structure (altitude, slope, aspect), geological structure (type of rock) and soil structure (LUC=Land Use Capability, soil depth, slope, erosion, limiting soil properties).

In the second stage, natural factors that can be determinant for the relevant sectors within the scope of "Analysis Method on the Value of Conformity of the Natural Potential to Sectoral Uses" developed using the "Landscape Assessment Method" of Mc Harg (1969) and "Analysis of the Value of Use in Planning" of Kiemstedt (1972), and their sub-units were determined. Then, the factors that were expediently determined were graded by their effectiveness in determining the usage potential of the area in question (Mc Harg, 1969; Köseoglu, 1982). After this weighting process, each factor was put through a separate numerical evaluation in itself. This assessment was carried out on the chosen sub-units of the factor in question by giving positive (+) numerical values varying between 1 and 4 considering their effectiveness in terms of the land use in question.

After these factor weights, sub-units and the values pertaining to those units were determined, reclassification was applied on the determined natural factors of thematic maps created using the Spatial Analyst module (Multi-Criteria Decision Analysis Module) of ArcGIS 9.3.1 programme, their sub-units and the factor weights.

The weighted overlay technique was applied for detecting the areas that best suit the natural structure of the study area. Weighted overlay is a technique that is used to assess inputs that have different values, in other words, different units in order to be able to make an integrated analysis. The solution of spatial problems requires the analysis of many different factors (Cabuk, 2006).

In the next stage, the weighted overlay of reclassified maps was conducted using the "Weighted Overlay" module of ArcGIS 9.3.1 programme. At the end of the weighted overlay, conformity maps on the relevant land uses divided into four classes were generated (Cabuk, 2001). Because of the weighted overlay, it was indicated that the most appropriate fields in the 4-degree conformity maps are the fields shown with the term "1st Degree Appropriate". The 4-degree conformity maps generated in the area of study for determining the appropriate areas for the relevant sectors were applied weighted overlay and the area usage potential map (Figure 2) of the area of study showing the most appropriate way of land use was generated.

3. Results

When determination of Land Use / Land Cover Variations via Satellite Images 10-class unsupervised classification algorithm has been applied using all of the bands except the thermal band in the Landsat ETM+ satellite images, from the year 2002 and the Landsat 5 TM images from the year 1987. Two hundred and sixty three training data elements gathered from the area from the year 1987, existing land use categories on Urban Planning Drawings from the year 1982 (used as reference data because of their dates being closest to those of the images from the year 1987), unsupervised classification results map from the year 1987, and 741 RGB false-colour images have been assessed collectively and their training scopes determined. In the same manner, 263 training data elements gathered from the area in the year 2002, orthophoto aerial phototographs from the year 2005 (used as reference data because of having the date closest to the year 2002), unsupervised classification results map from the year 2002, and 741 RGB false-colour images were assessed collectively and their training scopes determined for the same year. Training data which were gathered from the area have been taken into consideration via a supervised classification process for the years 1987 and 2002, and land use/cover variations have been determined and recorded (Table 2) as eight land use categories with corresponding definitions (Table 3).

Table 2. Land use categories and their definitions.

Land Use Categories	**Definition**
Surface Waters	Rivers, lakes
Natural Vegetation	Steppe, weed, etc.
Bare Soil	Badlands
Settlements	Buildings, roads, industrial centres
Agricultural Land	Arable rich soil land
Forest Land	Trees
Rockies1	Stone, rock
Rockies2	Limestone

Table 3. Classification results of the land use/cover for the years 1987 and 2002.

	1987		2002		1987-2002
	Land Use /Land Cover		Land Use / Land Cover		Areal Variation
Categories	km^2	(%)	km^2	(%)	(km^2)
Settlements	27.15	6.45	33.02	7.87	+5.87
Agricultural Land	186.93	44.44	152.95	36.46	-33.98
Natural Vegetation	156.93	37.30	184.51	43.99	+27.58
Surface Waters	1.97	0.47	7.22	1.72	+5.25
Forest Land	4.85	1.15	6.50	1.55	+1.65
Bare Soil	31.77	7.55	29.29	6.98	-2.48
Rocky Place 1	8.14	1.93	3.44	0.82	-4.70
Rocky Place 2	2.94	0.70	2.55	0.61	-0.39

When areal distribution values (Table 3) for land cover use for the year 1987 are examined, it is seen that agricultural lands of the study area occupy the greatest area. When the land use categories map for the year 1987 is examined, it is observed that agricultural land is haphazardly distributed. Natural vegetation within the study area is located mainly in the north-western part of the area. Moreover, there is infertile land with no agricultural activity, which we term bare soil, mainly to the west and north-east of the city centre.

These lands, which we describe as Rockies 2, are the areas, which have high slopes and where limestone is abundant. This type of land is mainly seen in the Tavra Valley, which is in the northern part of the study area, and is present in the western part of the study area. Stony areas and rocky fields, with higher elevations, are defined by us as Rockies 1 and are mainly present in the south-eastern part of the study area. Forestlands cover little ground in the study area and are close to the city centre; forests are located in the southern, northern and north-eastern parts of the city. Settlement areas are located north of the Kızılırmak River and cover an area of 27.15 km^2. Attention is drawn to the availability of settlement areas south of the Kızılırmak River.

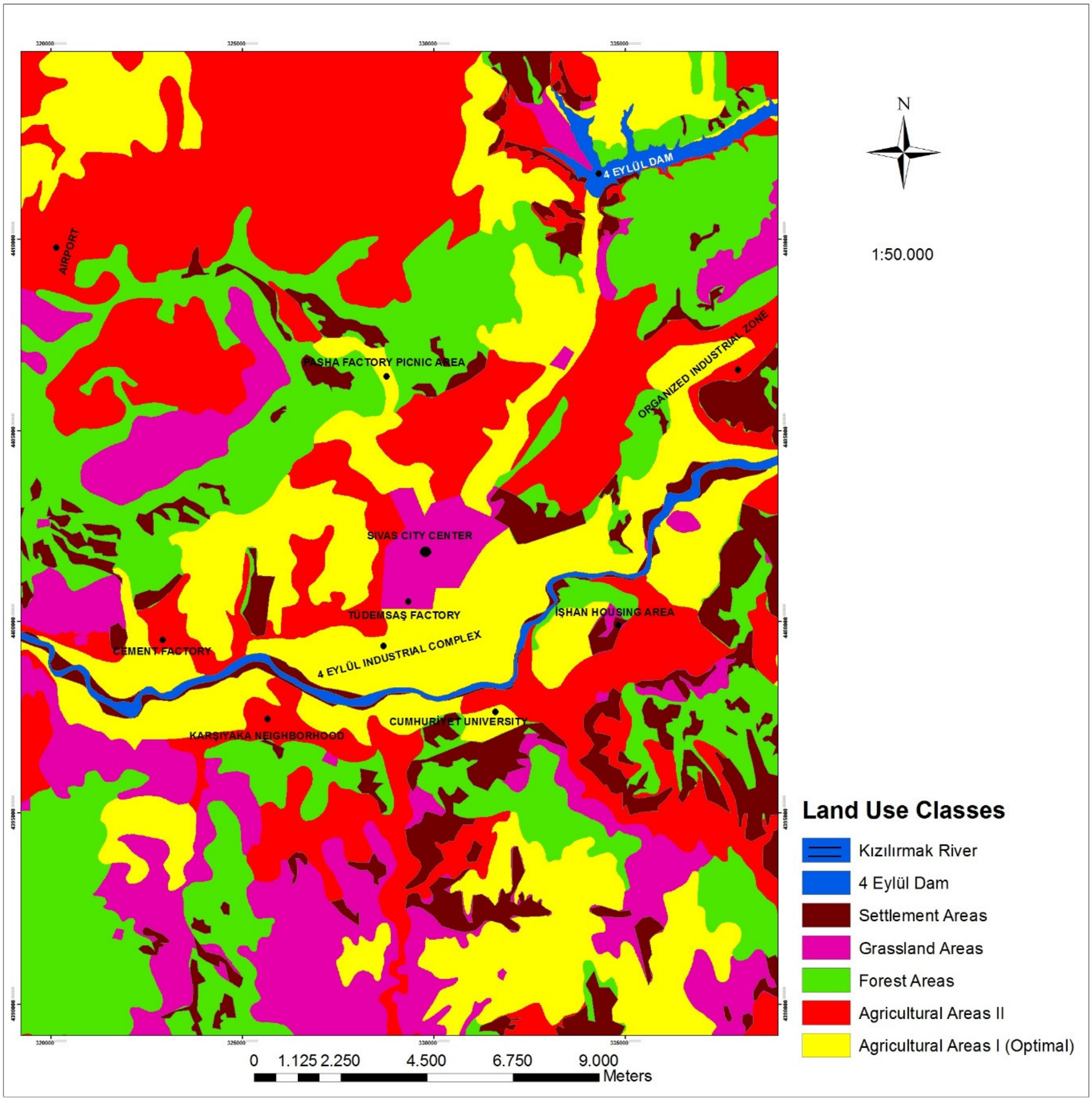

Figure 2. Land use potential map of the area of investigation.

4. Conclusions

Recognition and mapping of land use/cover are important in resource management and planning studies. Current information about land cover and use, and their variation over specific periods, are helpful in avoiding the wrong utilisation of land, in accurate strategy development aimed at conservation, and in planned development. Monitoring of urban sprawl and the conversion of fertile land for different uses is possible through studies that ascertain and effectively track variation. By determining changes in the amounts of rural countryside and urban areas caused by migration, urban managers and planners can predict the potential growth vector(s) of a city and thus make informed

decisions about urban planning and encourage the well-balanced development of fertile agricultural lands in concert with urban development in a way that responsibly protects them and also facilitates the monitoring of at-risk land.
It should not be overlooked that there was a possibility of confusion of some categories during the supervised classification process carried out on satellite images from the years 1987 and 2002. Insofar as reinforced concrete structures in settlement areas and rocky parts of mountainous areas have similar spectral reflections, such settlement and rocky areas possess similar characteristics and may cause confusion during classification. The same situation has been valid for rocky areas and the Kızılırmak River. In order to avoid such confusion, the assignment of categories through field work and the importance of accurate satellite-image interpretation have been stressed. Settlement areas have increased 1.42% and agricultural land has been encroached upon as is clear through examination of land use change in the period 1987-2002.
When the land use/land cover changes of the area of study were assessed with the area use potentials, it was determined that settlement areas determined from the land use changes do not exhibit any development according to the land use potential map (Figure 2). As is seen in the land use/land cover changes, it was concluded that the settlement areas where Sivas city is located should be used as areas of meadow-pasture according to the land use potential map. It is seen that the Cement Factory in the west of the area of study is established on the lands that are most suitable in terms of agricultural lands (Agriculture I). It is observed that Karşıyaka Neighbourhood and University Campus Site in the South of the area of study, 4 Eylül Industrial Site in the South of the city, and Organized Industrial Site in the northeast of the area of study are located on the lands that are suitable for the use as agricultural lands (Agriculture I, II). It was detected that the settlement areas developing in the northeast of the area of study, and South and southeast of the city are founded on agricultural lands (Figure 2).
Consequently; it is required to detect the land use/land cover changes and current environmental features and considering these features for each land use class in terms of revealing the feasibility of the land use potentials in Sivas province. It is necessary not to build the areas to be newly opened for settlement on productive agricultural lands, and considering water resources, agricultural lands and settlement areas when planning industrial areas. Natural structural features of the area of study and conformity maps for each sector should be considered especially by local governments for the areas to be opened for settlement in the future.

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