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Investigation Of Conformity Of Land Use/Land Cover Changes Obtained From Remote Sensing Data To Master Plans

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Abstract: In urban planning studies, it is very important to consider the changes in land use/cover over the years and to consider the development plans prepared in the past years which will guide the planning studies. Remote Sensing (RS) and Geographic Information Systems (GIS) are widely used to produce such information. The purpose of this study is to evaluate the appropriateness of land use changes for a certain period of time for the city center and its immediate surroundings in Sivas to zoning plans and to develop suggestions on these areas. Within this scope; as RS data, Landsat-4 TM dated 27.08.1989 and Landsat-8 OLI satellite images dated 11.08.2015 and aerial photographs of 1973 and 2005 were used. In order to reveal the zoning status information of the study area, the zoning plans of 1982 were used. Changes in land use over satellite images were determined by controlled classification method, and aerial photographs and land use patterns at zoning plan points were obtained by digitization. When the changes in land use obtained from satellite images and aerial photographs are evaluated together with the land use patterns in the existing zoning plan, It has been observed that residential areas and other land uses of Sivas city have generally developed in accordance with the zoning plan. The importance of the need to evaluate zoning plans in conjunction with land use/cover changes in zoning plans production and improvement is emphasized.

Keywords: Aerial Photograph, Landsat, Development Plans, Land Use/Cover, Sivas

I. Introduction

Large and underdeveloped rural areas have been rapidly developing into urban land use. Such land use dynamics pose a serious challenge in acquiring or maintaining updated land cover and land use information during master planning. There has been a growing awareness among local, regional and international planning agencies towards the need of RS information for formulizing the related policies and providing information related to future change patterns and tendencies [1]. There is a growing need for in-depth analysis of the changes in land use/land cover and their impacts by local and regional land administrators for taking conscious decisions with a balanced approach to the positive and negative aspects of urban development in preservation of environmental resources and improvement of socio-economic welfare [2].

Land use/land cover of a region involves the spatial and temporal use by humans as a result of natural and socio-economic factors. There is an increasing need for information related to the selection, planning and implementation of land use plans, in addition to the potentials for their optimal use, to meet basic human needs and welfare. Such information will be also useful in monitoring land use dynamics that originate from the ever-evolving demands of increasing population [3].

In addition to its position as the fundamental focus of a sustainable development [4], land use/land cover changes is known to be a crucial concept in natural resources management and monitoring [5]. In this regard, monitoring land use/land cover changes by use of prospective strategies and updated data holds great importance for urban planners [6]. As a cutting edge-technology, RS uses a combination of high resolution images and image processing techniques that effectively reveal land use changes [7,8]. UA has been used in land use/land cover mapping and change analysis through application of a variety of techniques [9,10]. RS data analysis provides the thematic mapping of land use/land cover changes for urban planning for a period that covers a wide span [11,12]. Landsat satellite images are highly efficient for analysis of land use/land cover changes and urban region analysis [12,13,14]. Recently released Landsat 8 multispectral sensor enables improvements in such studies through use of time series analysis for monitoring urban sprawl [15]. GIS provides a flexible media for displaying, storing and analysis of digital data required for monitoring land use/land cover changes [16]. Combined use of RS and GIS proved to be a powerful and cost-effective approach for monitoring land use/land cover changes [17]. Land use/land cover mapping via RS and GIS techniques is quite useful for identifying the areas for agricultural, urban and/or industrial use [18]. Development of high spatial resolution satellite images and improved image processing and GIS technologies enabled monitoring and modeling land use/land cover models in a more routine and stable way [3]. Intensive use of such technologies

stems from their ability to provide land use/land cover data with high accuracy through their user-friendly interfaces [19].

RS data provided by satellite imaging and air photographs are commonly used to identify the changes in land use/land cover. Air photo interpretation is a fundamental process in land use/land cover mapping. The advantage of air photos is their ability to provide an accurate interpretation in a complex area by use of high spatial resolution and to make a distinction between the different types of land use. Air photographs' disadvantages are their being costly and time-consuming Also, human related errors are unavoidable during their interpretation [20]. On the other hand, the use of satellite images is advantageous for allowing more frequent data collection and analysis with specified intervals and requiring less subjective interpretation owing to the higher information content of multi-band data as compared to air photographs. Challenges in performing an accurate classification of land use/land cover approaches by use of simple categorization approaches due to the low spatial resolution of easily accessible satellite data sets and resulting pixel confusion on urban areas is a drawback of satellite images [21].

Conformity of land use/land cover change data obtained from RS with the master plans prepared in accordance with specific regulations and laws holds particular importance for planners. Regulation on Preparation of Spatial Plans [23] prepared in accordance with Law no 3194 on Land Development Planning and Control [22] prescribes the application of master plans under the title of "Spatial Strategic Plan". As per the 11th article of the mentioned regulation, the minimum standards and acreage requirements specified within the regulation should be complied in consideration of the conditions of the area or region planned during the preparation or amendment of master plans for urban, social and technical infrastructures. Also, in the 19th article of the same regulation, particular emphasis has been placed upon the need for establishment of an updateable and inquirable digital data-base by use of GIS and RS techniques during environmental plan preparation process. Establishment and improvement of residential areas in an orderly, healthy and aesthetical fashion so as to meet the present and future need of inhabitants is defined as "master planning". The use of master plans constitutes the primary step for development of urban areas that meet the minimum requirements for social welfare and establishment of a social order. Master planning defines the determination of the future objectives for residential areas based on their present condition to enable the development of related infra and superstructures in accordance with the requirements of human life [24].

In this regard, this research aims to evaluate the compliance of land use changes detected in the provincial center and vicinity of Sivas province by use of remote sensing data of specified years via RS and GIS methods, with related master plans, and propose recommendations for prospective planning works.

II. Material and Method

This study was conducted in the provincial center and vicinity of Sivas province which is located on 323000-337000 (West-East)/4397000-4407000 (South-North) UTM coordinates (ED50 datum/37N zone). The study area covers approximately 206 km2 (Figure 1).

The main research materials consist of the air photographs of the study area, Landsat satellite images and zoning sheets (Table 1). 35 (analogue) air photographs with 1/35.000 scale from year 1973, and 70 (digital) air photographs with 1/5000 scale from year 2005 were generated by General Command of Mapping. Landsat-4 TM images dated 27.08.1989 and Landsat-8 OLI satellite images dated 11.08.2015 was received from USGS (US Geological Survey Agency) website (http://www.earthexplorer.usgs.gov). The air photographs and satellite images were used in determination of the changes in land use/land cover within the time period specified for this work. As the other main research material, the zoning sheets from year 1982 were obtained from Sivas Municipality Directorate of Reconstruction and Urbanization and these sheets were used for the recent zoning status of the study area. The other research materials consist of 1972 Environment Plan of Sivas Province, Master Development Plan Report of year 1982 [25], 1/25000 scaled digital topographical maps that show the general characteristics of the study area [26], 1/25000 scaled digital geological maps [27] and 1/25000 scaled digital soil maps [28].

Table 1. Data used in the Study

Technicial Specifications	Data Type				
	Aerial Photos		Landsat TM/OLI Satellite İmages		Zoning Plan Maps
	1973 Year	2005 Year	1989 Year	2015 Year	1982 Year
Source	Cumhuriyet University	GDM	USGS	USGS	Municipality of Sivas
Product Environment	Photo (35 pieces)	Digital	Digital	Digital	Analogue
Scale / Resolution	1/35000	1/5000	30 m	30 m	1/25000
Production / Display Date	1973	2005	27.08.1989	11.08.2015	1982

GDM: General Directorate of Mapping
USGS: United States Geological Survey

The first Zoning Plan of Sivas province was prepared in a contest organized by Provincial Bank in year 1967. 1/5000 scaled Master Development Plan and 1/1000 scaled Implementary Development Plan were prepared in accordance with 1/20.000 scaled Environment Plan and approved on 14.03.1972. Upon the application of the municipality, a revision and appendices were made on the development plan after the municipalities are entitled to make their development plans by virtue of the law no 3194 on Land Development Planning and Control as a result of migration induced growth of the province [29]. The Master Development Plan of 1982 was prepared in 1/25000 scale in line with the conditions of the period and in accordance with the Environment Plan [30]. As a result of comparison of the digitalized [31] 1/20000 scaled 1972 Environment plan consisting of a single sheet, and 1/25000 scaled 1982 Master Plan with 7 sheets, settlement boundaries were found to have increased by 2 folds, and municipal adjacent areas were found to have increased by 15 folds. The comparison of the plans from two different years also revealed that, the percentage of zoning areas and settlement areas within the adjacent areas were found to have decreased as compared to year 1972, despite the significant increase in these areas. Settlement areas were reported as 13.27 km2 in the Envionment Plan of year 1972, whereas these areas were reported to be 76.88 km2 in the Master Development Plan of year 1982 [32].

The majority of the study area is located at 1250-1300 m elevation which covers the provincial center of Sivas. Also, the majority of lands on which Sivas city center and its close vicinity are located, is of a very low slope grade between 0-2% (34.36%) and 2-6% (19.63%) [26]. A major part of the study area consists of pebble-stone-sandstone-mudstone (35.16%), gypsum (18.08%) which is not favored for settlement areas, and alluvium (18.66%) [27]. Particularly alluvial units have been regarded as very inconvenient landforms considering the basic settlement conditions of the province. The majority of the study area consists of III. (15.18%), IV. (12.96%) and VII. (33.73%) grade lands. Kızılırmak River, passing through the middle of the study area, its southern tributaries Fadlım and Tecer Rivers and Mıslımırmak River constitute the important surface water sources of Sivas Province and its vicinity [26].

The study was carried out in 3 stages. During the first stage, methods for determination of land use changes between specific time intervals were determined to reveal the current zoning status from the zoning map by use of remote sensing data. In the second stage, the specified methods were implemented to obtain research data, and in the third stage an overall evaluation was performed to check the compliance of the land use changes obtained from remote sensing data with the zoning plans.

Within the scope of this research, Erdas 9.1 software was used to determine the land use changes detected via satellite images, and for rectification and tiling of the air photographs from year 1973 in accordance with the specified projection and datum. Also, ArcGIS 10.1 software was used for digitalization of mosaic air photos from years 1973 and 2005 and preparation of the digital master plan of year 1982. In line with the purpose of the research, all research data were converted to the same coordinate system (UTM/ED50).

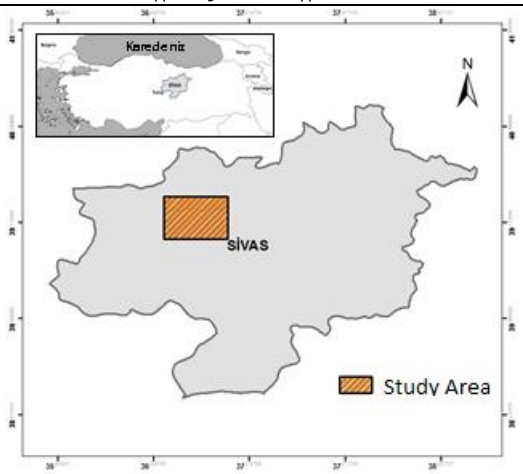

Figure 1. Site location map of the study area

Determination of Land Use/Land Cover Changes Using Air Photographs

Air photographs from 1973 and 2005 were used to determine the land use/land cover changes within the specified time interval. All of the air photos from 1973 were scanned at 600 dpi resolution and saved as raster data in TIFF image format. Digital orthophoto map from year 2005 was used as reference data for rectification of each air photograph in accordance with a specified coordinate system. Raster data from year 1973, defined on the basis of a specified coordinate system in TIFF image format were tiled to obtain a single mosaic photo of the research area from year 1973.

As also shown in the land use/land cover classification in Table 2, land use classes were categorized into four groups, namely agricultural areas, water surfaces, settlement areas and non-agricultural lands, and digitalization process was performed accordingly on the basis of land use boundaries to determine the land use/land cover changes in the study area using the digitalized and tiled air photographs from years 1973 and 2005.

Determination of Land Use/Land Cover Changes from Satellite Images

RS method has been used to reveal the land use/land cover changes and categorize and map varying landscape components by aid of land-sat images [33]. Numerous methods have been developed to monitor land use/land cover changes. The most precise way of monitoring changes is the comparative analysis of the categorization spectrally made for times t_1 ve t_2. The type of comparison made after categorization has been known to be the most common way of monitoring changes [34]. The technique used for monitoring land use/land cover changes is a way of identifying and detecting the changes in land use and land cover characteristics on the basis of multiple-time remote sensing data. The main principle underlying the use of remotely sensed data to monitor changes is identification of the change between two or more dates as a means to reveal the uncertainty of the normal change [35].

In this research, Landsat-4 TM images dated 27.08.1989 (path 174, row 032) and Landsat-8 OLI images dated 11.08.2015 (path 174, row 032) were used to detect the land use/land cover changes for a specified time interval. Both images were obtained as full frame, in band form and with their radiometric corrections made, and both images were in orthorectified image form. All bands in the images were used to obtain a single 7-band data set for Landsat-4 TM dated 1989, and a single 11-band data-set for Landsat-8 OLI dated 2015. The study area with 206 km^2 acreage was cropped from the full frame Landsat-4 TM (1989) and Landsat-8 TM OLI (2015) images that cover an approximate area of 185 km x 185 km. False color images (5-4-3 band combination) of each image were generated to perform a precise categorization for determination of the land use changes and for visual interpretation purposes. Visual interpretation gives an idea about the land use/land cover changes that occur throughout a specific period [35]. The purpose of image enhancement is to improve the image's interpretability [36].

In this research "Anderson Land Cover Classification System" developed by Anderson et al. [37] was used. This system involves only generalized level 1 and level 2 land use types. "Level 1" involves urban areas, agricultural areas, pasture areas, forests, water surfaces, wetlands, badlands, tundra and snow or ice sheets. In this study, five land use categories namely agricultural areas, vegetation cover, settlement arras, water surfaces and uncovered terrains were defined to determine land use/land cover changes from satellite images (Table 2). A controlled classification was performed by use of high resolution IKONOS satellite image that cover the study

area, air photographs with dates close to specified periods, data obtained from the lands (100 training data) and auxiliary data such as topographic maps. As the controlled classification method, Maximum Likelihood algorithm was employed to perform controlled classification of 5 land classes using all bands (except thermal bands). Maximum likelihood algorithm is a classification technique based upon the maximum probability decision rule and is dependent on the quality of training samples which are generally characterized with land cover maps and field information. Owing to its high applicability, objectivity and capability to make distinction between land classes, this classification technique has been widely used on various remote sensing data to classify land covers throughout the world [38].

Table 2. Land use/cover classes defined for the study area

Land use/cover classes	Definition
Agricultural areas	Cultivated areas
Vegetation	Trees covered with natural forests, small herbs, natural vegetation
Residential areas	All residential, commercial and industrial areas, villages, settlements, transportation infrastructure
Water surfaces	All open water areas, including lakes, rivers and pools
Bare land/Non-agricultural areas	Non-vegetated, mostly inefficient land covered with sandy and bare rocks

Acquisition of Land Use Classes from Zoning Maps

7 Master Development Plan sheets from year 1982 with 1/25000 scale were obtained from Sivas Municipality and saved in TIFF image format after being scanned. The scanned sheets were rectified with ArcGIS 10.1 software using 59 ground control points taken from standard topographic maps, and the rectified sheets were combined to generate the tiled digital zoning plan land use categories map of the study area.

The land classes located on the digital zoning plan land use classes map were digitalized on the basis of land use boundaries, thus the land use classes of year 1982 were obtained, and then the study area having an approximate acreage of 206 km^2 was cropped from this image (Figure 4).

III. Findings

Land Use Changes between Years 1973 and 2005

The digitalization process results based on the visual interpretation of tiled air photographs from year 1973 show that revealed that the non-agricultural areas (grassland-pastureland, rocky lands, etc.) have the highest percentage with 112.49 km^2, while settlement areas cover an area of 6,78 km^2 (Table 3). In the image, the city center lies at nearly 3 km north of River Kızılırmak. The settlement area in the west of study area is identified as Sivas Cement Plant which was established in 1943. Agricultural areas are mostly observed to be located in the vicinity of River Kızılırmak and in the northeast of the study area. Also, agricultural activities are identified within Sivas city center and along River Kızılırmak (Figure 2a).

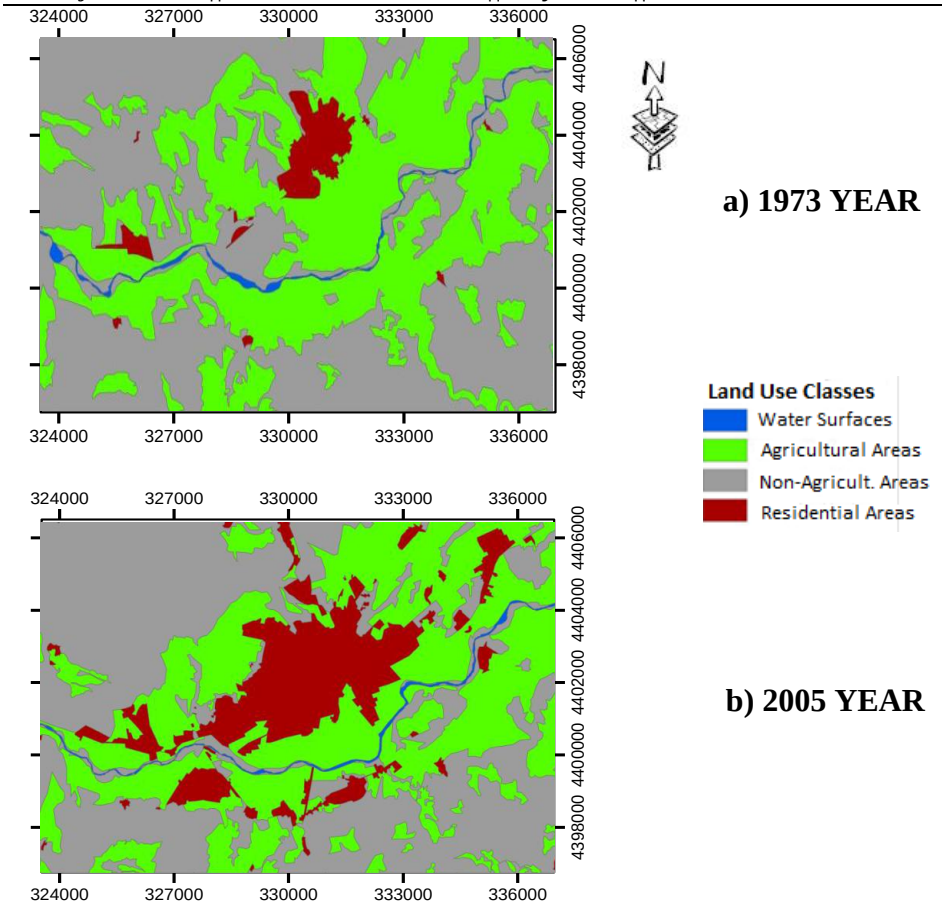

Figure 2. Land use distributions obtained from air photographs

As indicated by 2005 land use distribution (Figure 2b); non-agricultural areas (grassland-pastureland, rocky areas, etc.) cover the highest acreage with 74.45 km^2, whereas settlement areas cover 38.95 km^2 (Table 3). Sivas city center lies in nearly 2 km north of River Kızılırmak. Also, other settlements (Karşıyaka Neighborhood and University Campus Area) are detected in the South of River Kızılırmak. Agricultural areas show a dispersed distribution in the vicinity of River Kızılırmak and settlement areas of Sivas Province (Figure 2b).

Table 3. Land use/cover changes obtained from aerial photographs

Land use/cover classes	Land use changes				Changes in land use between 1973 and 2005 (%)
	1973		2005		
	km^2	%	km^2	%	
Agricultural areas	84.68	41.2	90.26	43.6	+2.4
Residential areas	6.78	3.2	38.95	18.8	+15.6
Water surfaces	2.75	1.2	3.04	1.4	+0.2
Non- Agricultural areas	112.49	54.4	74.45	36.2	-18.2
Total	206.7	100	206.7	100	0

In a comparative analysis of the tiled images from 1973 and 2005, 2.4% and 15.6% increase is observed respectively in agricultural and settlement areas. On the other hand, a 18.2% decrease is observed in uncovered land usage class. These results show that, the majority of developing settlement areas have developed on uncovered lands.

Land Use Changes between years 1989 and 2015

The classification results based on the land use class definitions in Table 2 indicate that, 12.35% and 2.48% increase occurred in settlement areas and agricultural areas respectively. In addition, a 15.65% decrease is observed in uncovered land class (Table 4). 1% increase in vegetation cover class is detected for the

specified time interval. This increase is mainly attributable to the afforestation works conducted by the related institutions and organizations in Sivas city center and its close vicinity. An overview of the land use changes between years 1989 and 2015 shows that; urban settlement areas (particularly the organized industrial zone) are mostly established on the agricultural areas which are located in the northeast of the study area. Settlement areas are also observed to have developed near River Kızılırmak which lies in the south of the study area (Figure 3b).

Table 4. Land use / cover changes obtained from Landsat TM / OLI satellite images

Land use/cover classes	Land use changes				Changes in land use between 1989 and 2015 (%)
	1989		2015		
	km^2	%	km^2	%	
Agricultural areas	54.72	26.47	59.83	28.95	+2,48
Vegetation	18.66	9.03	20.73	10.03	+1
Residential areas	27.63	13.37	53.17	25.72	+12,35
Water surfaces	2.07	1.00	1.69	0.82	-0,18
Bare land	103.62	50.13	71.28	34.48	-15,65
Total	206.7	100	206.7	100	0

The classification results also reveal that, the dominant land use classes in 1989-2015 period are agricultural areas and uncovered lands. Accordingly, the majority of uncovered lands (nearly 12.35%) turned into urban settlement areas. The transition from rural settlement to urban settlement, which has been encountered for a long period in Sivas province, also fostered the increase in agricultural and settlement areas.

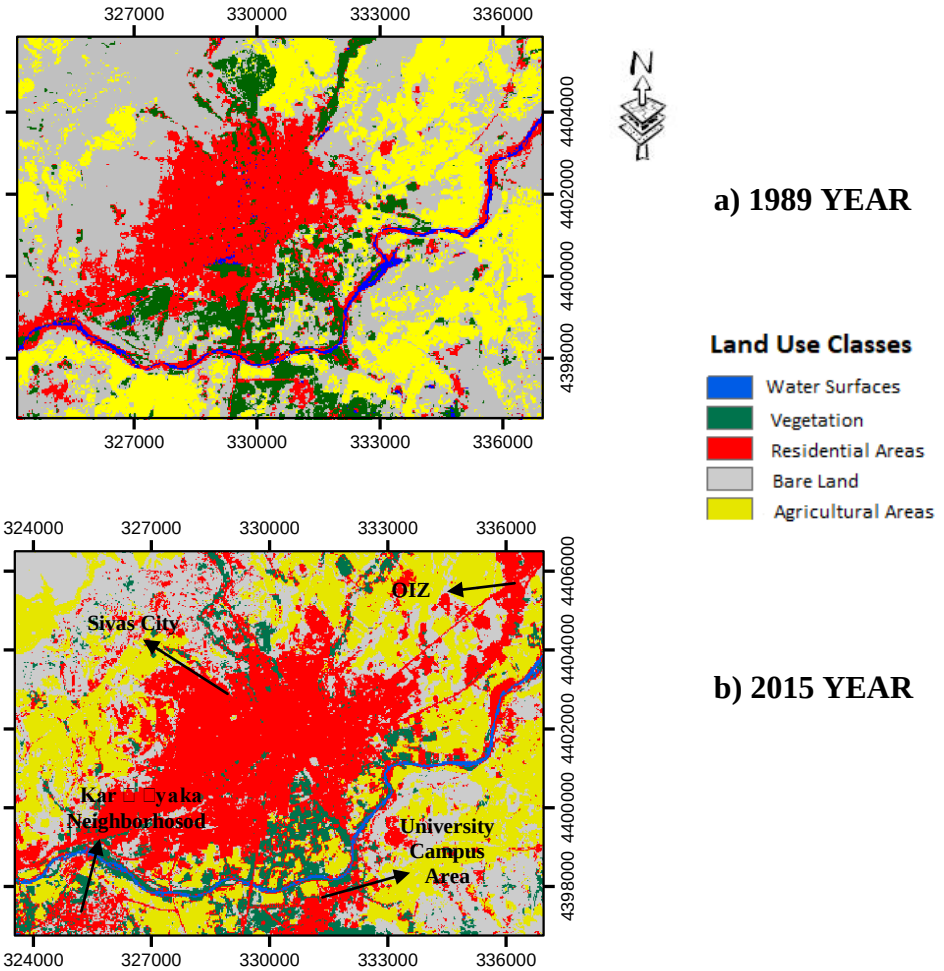

Figure 3. Land use distribution data obtained from Landsat-4 TM and Landsat-8 OLI images

Accuracy Assessment

The accuracy assessment of the classification made using satellite images was performed using Congalton's [39] accuracy assessment procedure [40]. The accuracy assessment of the classification results belonging to the satellite images from years 1989 and 2015 was performed using Erdas 9.1 software. For this purpose, error matrices were obtained to verify the accuracy of land use/land cover maps (Table 5). The training maps of the subject land and auxiliary reference data (air photograph, IKONOS image) were used for accuracy assessment. Reference points were chosen on the basis of the conformation of the randomly selected points on the images and the real data. The air photograph from 1990 was used for accuracy assessment of 1989's satellite image, and IKONOS satellite image from year 2015 was used for accuracy assessment of the satellite image from year 2015. The number of reference points obtained from the study area for years 1989 and 2015 were respectively determined as 551 and 526 using Simple Random Sampling method. The general accuracy values of land use/land cover maps of 1989 and 2015 were found as 84.39% and 94.11% respectively. Kappa coefficients were found to be 0.79 for year 1989 and 0.92 for year 2015. The accuracy assessment results for year 2015 show that, water surfaces land use class is 100% producer, and vegetation cover land use class is 100% consumer (Table 5). Kappa values higher than 0.75 and/or 0.80 indicate that classification and reference data are in agreement [41]. As reported by Anderson et al. [37], the minimum required value for accuracy assessment in land use/land cover mapping with Landsat satellite images is 85%, as recommended by USGS (US Geological Survey Institution). The accuracy assessment results obtained from this study are clearly in agreement with those reported in the literature.

Table 5. Error matrices for classification results

1989		Reference Data						
	Land use classes	Agricultural areas	Vegetation	Residential areas	Water surfaces	Barren land	Row sum	UA (%)
Classified data	Agricultural areas	**87**	2	0	0	18	107	81.31
	Vegetation	3	**72**	0	0	4	79	91.14
	Residential areas	0	0	**121**	1	20	142	85.21
	Water surfaces	0	0	1	**45**	3	49	91.84
	Bare land	21	0	13	0	**140**	174	80.46
	Column sum	111	74	135	46	185	**551**	
	MA (%)	78.38	97.30	89.63	97.83	75.68		
	GA (%)	84.39						
	Kappa	0.79						
2015		Reference Data						
	Land use classes	Agricultural areas	Vegetation	Residential areas	Water surfaces	Barren land	Row sum	UA (%)
Classified data	Agricultural areas	**137**	0	3	0	10	150	91.33
	Vegetation	0	**74**	0	0	0	74	100.00
	Residential areas	2	2	**138**	0	9	151	91.39
	Water surfaces	0	0	0	**50**	0	50	100.00
	Bare land	0	0	5	0	**96**	101	95.05
	Column sum	139	76	146	50	115	**526**	
	MA (%)	98.56	97.37	94.52	100	83.48		
	GA (%)	94.11						
	Kappa	0.92						

MA: Manufacturer's Accuracy
UA: User Accuracy
GA: General Accuracy

Distribution of 1982 Zoning Plan Land Use Classes

The evaluation made in consideration of Sivas city center shows that, settlement points are generally located in the north of River Kızılırmak, whereas agricultural areas are mostly located in the north and southeast of the city and along River Kızılırmak which is close to the city center. The lands allocated for afforestation are located in the north and northeast of the city (Figure 4). The total acreage of industrial sites which are located near the city center in the zoning plan is 14,74 km^2, whereas Tüdemsaş Factory established in 1939 was located on an area of 1,03 km^2 between the southern region of city center and River Kızılırmak in the zoning plan of year 1982. In the zoning plan, 4 Eylül Industrial Site is planned as 0,68 km^2 in the southeast of Tüdemsaş Factory and in parallel to the state highway. An industrial site (0,38 km^2) lies in the east of the city center near Mımılırmak river which is adjacent to the city. The total area of industrial sites which were planned as Organized Industrial Zone in the northeast of the study area have a total area of 2,20 km^2. The industrial regions lying in the west of the study area (Sivas Cement Plant and Concrete Sleeper Facility) were planned as 2 km^2 in the zoning plan of year 1982. The ratios of settlement and agricultural areas planned in the zoning plan of 1982 are % 14.90 and % 15.93 respectively (Table 6).

Table 6. Land use classes included in the digital construction plan of 1982

Land use classes	Area (km^2)	% Distribution
Areas to be Forested	30.54	14.77
State Road	6.23	3.15
Kızılırmak	6.17	2.98
Forest	1.53	0.70
Industrial Areas	23.5	11.30
Large Urban Green Areas	11.33	5.48
Farming areas	32.94	15.93
Non-agricultural areas	63.66	30.79
Settlement Areas	30.80	14.90
Total	206.7	100

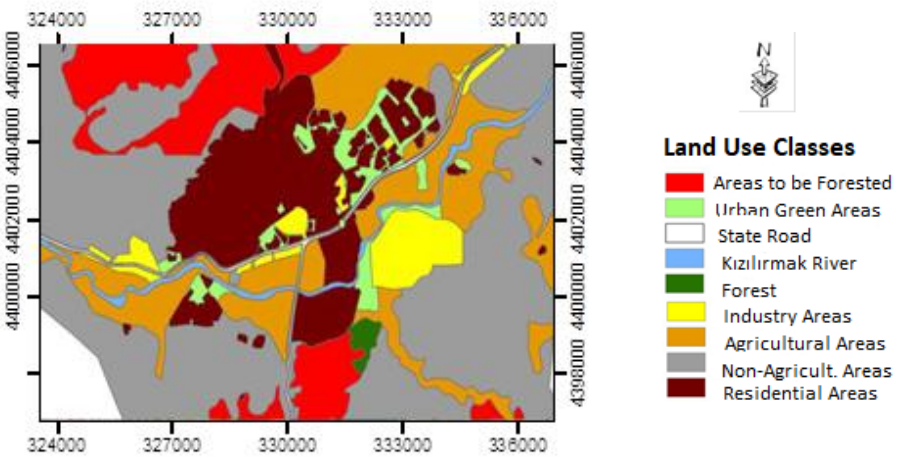

Figure 4. Distribution of land use classes in digital zoning plan of 1982

IV. Conclusion and Recommendations

This research was carried out to evaluate the consistency of land use/land cover changes, obtained by UA and CBS methods for a specified period, with the zoning plan. An area of 30.80 km^2 was planned as settlement area in the zoning map of year 1982 (Figure 4). The settlement areas determined on the land use distribution map of 2005 amount to acreage of 38.95 km^2. During the evaluation of land use/land cover changes in Sivas city center and its close vicinity, the settlement areas detected as of year 2005 were found to exceed the planned acreage by approximately 8 km^2. Also, the settlement areas detected from 2015 satellite image were found to exceed the planned settlement areas by nearly 23 km^2. It can be inferred from both UA data (air photographs and satellite images) that, the development of settlement areas is generally consistent with the zoning plan, and the regions planned as settlement areas (Figure 4, Figure 2b and Figure 3b) in the

south of River Kızılırmak also developed in accordance with the zoning plan (Karşıyaka Neighborhood and University Campus Area). The distribution of agricultural areas identified in Figures 2b and 3b are also in agreement with those shown in Figure 4. As shown in the zoning map (Figure 4), agricultural areas are observed in the northwest of the study area although no agricultural area was planned in this region (Figures 2b,3b).

The agricultural areas detected from UA data were found to display a wider distribution than the planned agricultural areas. As inferred from the land use/land cover changes, agricultural activities have been carried out on the region planned as settlement area in the south of River Kızılırmak. According to the tiled air photograph from year 2005, Organized Industrial Zone covers an area of nearly 1.81 km^2 which exceeds 2.20 km^2 as the planned acreage for industrial sites in 1982 zoning plan. From the viewpoint of vegetation cover and green zones, the amount of vegetation cover (forests, green areas) land use class (Figure 3b) determined from land use/land cover changes is not in agreement with the value planned for urban green zones and forestlands.

The Master Development Plan of year 1982 was prepared for year 2000 as the horizon year and for estimated population of 500.000. The city is observed to develop in northeast, west and northwest directions [42]. The urban development regions detected with air photographs and satellite images show consistency with the urban development areas planned in the Master Development Plan of year 1982. In general, the settlement areas and other land use classes in Sivas city center showed a consistent development with the zoning plan; while in the regions which were planned as "Industrial Sites" in the southeast of the city, agricultural areas and uncovered/non-agricultural areas are detected from the air photographs and satellite images (Figures 2b,3b,4). The possible adverse effects of industrial sites initially planned in the city center and located on River Kızılırmak and settlement areas, as well as the possible threat that will be posed by the development of settlement areas near River Kızılırmak and other natural resources are some of the main considerations that should not be overlooked. These situations are likely to pose an unavoidable threat to the health of citizens living in urban areas and to the water resources of the region. These areas should be strictly banned for settlement and industrial purposes. To avert such adverse consequences, development regions should be determined and specified in the new planning works and implementary development plans should be prepared in these areas before urban development takes place. As also stated in the 19th article of the Legislation on the Design and Construction of Spatial Structures [23], urban planners are required to use CBS and UA techniques to establish updateable digital databases in their planning works.

The available zoning plans provides guidance as to the planning of land use classifications, whereas the direction of the land use changes for a specified time period can be detected using UA data. By use of the data received from both sources, urban planners can avoid negative consequences through evaluating the consistency of land use changes for a specific period with the available zoning plans by taking required precautions. Thematic maps for land use generated using UA data can provide preliminary data in preparation and implementation of zoning plans.

Consequently, as the authorities responsible for preparation, revision and implementation of zoning plans, municipalities are required to reveal the direction and size of urban development and the changes in land use between specified periods, and they should conduct their zoning revisions accordingly as a means for proper implementation of urban development works in terms of environment management and urban planning. Urban planners should also use updated UA and CBS data for planned settlement areas, detect the land use/land cover changes for subject regions and consider the updated land use/land cover changes while preparing or revising zoning maps.

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References

[1]. J. Rogan, D. Chen, Remote sensing technology for mapping and monitoring land-cover and land-use change, *Progress in Planning*, vol. 61, 2004, pp. 301–325.

[2]. F. Yuan, K.E. Sawaya, B.C. Loeffelholz, M.E. Bauer, Land cover classification and change analysis of the twin cities (Minnesota) metropolitan area by multitemporal landsat remote sensing, *Remote Sens. Environ.*, vol. 98, 2005, pp. 317–328.

[3]. J.S. Rawat, M. Kumar, Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh Block, District Almora, Uttarakhand, India, *The Egyptian Journal of Remote Sensing and Space Sciences*, vol. 18, 2015, pp. 77-84.

[4]. E.F. Lambin, M.D.A. Rounsevell, H.J. Geist, Are agricultural land-use models able to predict changes in land-use intensity? *Agriculture, Ecosystems and Environment*, vol. 82, 2000, pp. 321–331.
[5]. S. Sinha, L.K. Sharma, M.S. Nathawat, , Improved land-use/land-cover classification of semi-arid deciduous forest landscape using thermal remote sensing, *The Egyptian Journal of Remote Sensing and Space Sciences*, vol. 18, 2015, pp. 217–233.
[6]. C.N. Mundia, M. Aniya, Analysis of land use/cover changes and urban expansion of Nairobi City using remote sensing and GIS, *International Journal of Remote Sensing*, vol. 26, 2005, pp. 2831-2849.
[7]. M. Herold, N.C. Goldstein, K.C. Clarke, The spatiotemporal form of urban growth: Measurement, analysis and modeling, *Remote Sensing of Environment*, vol. 86, 2003, pp. 286–302.
[8]. G. Chaudhuri, N.B. Mishra, Spatio-temporal dynamics of land cover and land surface temperature in Ganges-Brahmaputra delta: A comparative analysis between India and Bangladesh, *Applied Geography*, vol. 68, 2016, pp. 68-83.
[9]. A. Butt, R. Shabbir, S.S. Ahmad, N. Aziz, Land use change mapping and analysis using Remote Sensing and GIS: A case study of Simly watershed, Islamabad, Pakistan, *The Egyptian Journal of Remote Sensing and Space Sciences*, vol. 18, 2015, pp. 251–259.
[10]. S. Liu, T.X. Yang, Monitoring land changes in an urban area using satellite imagery, GIS and landscape metrics, *Applied Geography*, vol. 56, 2015, pp. 42-54.
[11]. K.M. Morgan, Advances in remote sensing for smart environmental mapping, *Proceedings of the 16th Environmental Communication in the Information Society Wien*, 2002.
[12]. A. Mei, C. Manzo, G. Fontinovo, C. Bassani, A.F. Petracchini, Assessment of land cover changes in Lampedusa Island (Italy) using Landsat TM and OLI data, *Journal of African Earth Sciences*, vol. 122, 2016, pp. 15-24.
[13]. H. Bagan, W. Takeuchi, T. Kinoshita, Y. Bao, Y. Yamagata, Land cover classification and change analysis in the Horqin sandy land from 1975 to 2007, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 3, no. 2, 2010, pp. 168–177.
[14]. H. Bagan, Y. Yamagata, Landsat analysis of urban growth: How Tokyo became the world's largest megacity during the last 40 years, *Remote Sensing of Environment*, vol. 127, 2012, pp. 210–222.
[15]. C. Kamusoko, J.H. Murakami, Monitoring urban spatial growth in Harare Metropolitan Province, Zimbabwe, *Adv. Remote Sens*., vol. 2, 2013, pp. 322-331.
[16]. Q. Wu, H.R. Wang, J. et al. Paulussen, Monitoring and predicting land use change in Beijing using remote sensing and GIS, *Landscape and Urban Planning*, vol. 78, 2006, pp. 322–333.
[17]. P. Phukan, G.R. Saikia, Land use land cover change detection using remote sensing and GIS techniques – a case study of Golaghat District of Assam, India, *Int. Res. J. Earth Sci*., vol. 1, no.1, 2013, pp. 11–15.
[18]. S. Reis, R.U. Nisanci, B.A. Yalcin, H. Inan, T. Yomralioglu, Monitoring land-use changes by GIS and remote sensing techniques: case study of Trabzon", http://www.fig.net/pub/ morocco/proceedings/TS18/TS18_6_reis_el_al.pdf 5, 2003.
[19]. N. Sönmez, I. Onur, M. Sarı, D. Maktav, Monitoring of changes in land use according to CORINE methodology using aerial photographs and IKONOS data: Antalya-Kemer example , *1. Remote Sensing-GIS Workshop and Panel-2006*, Istanbul, 2006.
[20]. E.A. Wentz, W.L. Stefanov, C. Gries, D. Hope, Land use and land cover mapping from diverse data sources for an arid urban environments, *Computers, Environment and Urban Systems*, vol. 30, no.3, 2006, pp. 320-346.
[21]. G.M. Foody, Estimation of sub-pixel land cover composition in the presence of untrained classes, *Computers & Geosciences*, vol. 26, 2000, pp. 469–478.
[22]. Anonymous, Urban Development Law , Official Gazette dated 09.05.1985 and numbered 18749, 1985.
[23]. Anonymous, Regulation on Spatial Plans , Official Gazette dated 14.06.2014 and numbered 29030, 2014.
[24]. N.İ. Çolak, G. Öngören, Zoning plans, zoning applications and cancellation cases, Öngören Law Publications, Publication No: 4, , Beyoğlu, İstanbul, 2014, 179s.
[25]. Sivas Municipality, Sivas city 1972 Year Environment Plan, 1982 Year Oil Master Plan, Sivas Municipality Directorate of Construction and Urban Planning, Sivas, 2009.
[26]. GCM, 1 / 25.000 scale digital topographic map of the study area, Ministry of National Defense, General Command of Mapping, Ankara, 2005.
[27]. MRE, 1 / 25.000 scale digital geology map of the study area, General Directorate Of Mineral Research And Explorations, Ankara, 2005.

[28]. GDVS, 1 / 25.000 scale digital soil map of the study area, T.C. Ministry of Food, Agriculture and Livestock, Ankara, 2001.
[29]. Sivas Governorship, Sivas 2023 Strategic Provincial Development Plan, T.C Governorship of Sivas, Provincial Social and Economic Planning Center, Sivas, 2006.
[30]. Sivas Municipality, Directorate of Construction and Urban Planning, Sivas, 2017.
[31]. C.B. Karakuş, Sivas and nearby regional land use and environmental management planning, Doctorate Thesis, Cumhuriyet University Institute of Science and Technology, Sivas, 2009, 116s.
[32]. D. Demiroğlu, C.B. Karakuş, Comparison of the daily plans of Sivas city from the past in terms of space usage, *Inönü University Art and Design Magazine*, vol. 2, no.4, 2012, 1-13.
[33]. S.L. Ozesmi, M.E. Bauer, Satellite remote sensing of wetlands, *Wetlands Ecol. Manage*, vol. 10, 2002, pp. 381–402.
[34]. M. Güler, T. Yomralıoğlu, S. Reis, Using Landsat data to determine land use/land cover changes in Samsun, Turkey, *Environmental Monitoring Assessment*, vol. 127, 2007, pp. 155-167.
[35]. A. Shalaby, R. Tateishi, Remote Sensing and GIS for mapping and monitoring land cover and land use changes in the Nortwestern Coastal Zone of Egypt, *Applied Geography*, vol. 27, 2007, pp. 28-41.
[36]. C.B. Karakus, K.S. Kavak, O.Cerit, Determination of variations in land cover and land use by remote sensing and Geographic Information Systems around the city of Sivas (Turkey), *Fresenius Environmental Bulletin*, vol. 23, no.3, 2014, pp. 667-677.
[37]. J.R. Anderson, E.E. Hardy, J.T. Roach, R.E. Witmer, A land use and land cover classification system for use with remote sensor data. *US Government Printing Office. DC: U.S. Geological Survey. No. Professional Paper 964*, Washington, 1976.
[38]. D. Lu, Q. Weng, A survey of image classification methods and techniques for improving classification performance, *International Journal of Remote Sensing*, vol. 28, no.5, 2007, pp. 823-870.
[39]. R.G. Congalton, A review of assessing the accuracy of classifications of remotely sensed data, *Remote Sensing of Environment*, vol. 37, no. 1, 1991, pp. 35–46.
[40]. H. Saadat, J. Adamowski, R.S. Bonnell, F.M. Namdar, S.A. Ebrahim, Land use and land cover classification over a large area in Iran based on single date analysis of satellite imagery, *ISPRS Journal of Photogrammetry and Remote Sensing*, vol. 66, 2011, pp. 608–619.
[41]. N. Wondrade, Q.B. Dick, H., Tveite, GIS based mapping of land cover changes utilizing multi-temporal remotely sensed image data in Lake Hawassa Watershed, Ethiopia, *Environmental Monitoring and Assessment*, vol. 186, no. 3, 2014, pp. 1765–1780.
[42]. Sivas Municipality, "Sivas City 1/5000 Scale Master Plan Explanation Report", Sivas Municipality, Sivas, 1982, pp. 18.