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Diachronic Land Uses Changes in Semi Mountainous Areas Next to Urban and Tourist Areas

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Abstract*— Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types. Water types include wetlands or open water. Land use shows how people use the landscape – whether for development, conservation, or mixed uses. The relationship between the land ownership status and the rate of coverage by trees or shrubs do the unconscious people to put fires. The timeless control of changes and land use maps prevent fires aimed at creating plots. In the context of this research, land cover maps of previous years and recent ones were compared, with the help of aerial photographs and analytical and digital photogrammetric stations in representative regions of Greece. Generally we observe that where intense coastal tourist traffic (Toroni) is existed, the forest land is reduced in order to increase housing, while where there is not exist tourist traffic (all the other research areas such as Sarakina, Petrokerasa, Panorama and Pelion), the forest land is increased everywhere with parallel abandonment of agricultural land.

***Index Terms*—Forestry, land cover, land use, photogrammetry.**

I. INTRODUCTION

The use of the land, through the years, passed through various stages, so that the present form is the result of historical, social, economic and cultural developments.The concept of land use concerns in the form of exploitation of man to satisfy various needs, which needs are food, housing, recreation, coverage of economic activities, cultural, educational, religious and other purposes [2]. The land use depends on except from the satisfaction of human needs, the quality of the soil and access to it [3]. Although there is a sharp distinction between the two terms "land use" and "land cover", often used with the same sense. It may arise land use from land cover and instead, but the link is not always so obvious. In contrast to land cover, land use is difficult to "observe". For example, it is often hard to know whether or not pastures used for agricultural purposes. Thereafter land use and land cover are called "land use".

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A timely and accurate change detection of various distinctive features on the surface of the Earth is extremely important for understanding the relationships and interactions between human and natural phenomena to manage and better utilize of natural resources [12]. Land use, land-use change and forestry (LULUCF) is defined by the United Nations Climate Change Secretariat as "A greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities" [7].

The Greek landscape, as in all Mediterranean countries, has undergone a significant change. Of particular concern is deforestation, where logging or burning is followed by the conversion of the land to agriculture or other land uses. Even if some forests are left standing, the resulting fragmented landscape typically fails to support many species that previously existed there. This land-use dynamic makes it difficult for planners to obtain or maintain up-to-date land-cover and land-use information, where typical updating processes are on an interval scale of 5 or 10 years [4]. Although the full potential of remote sensing technology for change detection applications has yet to be completely realized, planning agencies at local, regional and international levels now recognize the need for remote sensing information to help formulate policy and provide insight into future change patterns and trends [10]. Remote sensing information, in concert with available enabling technologies such as GPS and GIS, can form the information base upon which sound planning decisions can be made, while remaining cost-effective [8]. The economic studies often affect the policy decision-making on the land use, but rather to a lesser extent in the more developed economies than in the less developed [9]. Typical is that the way of land use is not decided primarily by those who can use it most effectively, but by an administrative process that often excludes some land users, in the name of public interest [14; 13]. Therefore is necessary to demarcate the uses and take administrative and organizational measures for unification of activities of a coordinating body, so finding the right balance of uses for rural development with rational planning. Therefore it is very important the role of land use maps. Specifically, the primary objective of rational spatial land use planning of forest areas should be to ensure, within the framework of an organic rubber and land use plans, the living space:

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a. productive land.
b. hydrologic network.
c. forests and woodlands.
d. traditional - cultural heritage.
e. development of the area within the conservation of compatibility with the natural environment [5].

The present study deals with the diachronic landscape change in woodlands of high and low plot value by exploiting modern technology of digital photogrammetry and Geographic Information Systems (GIS).

For this purpose, by comparing land uses data and maps over a period of time, forest managers can document land use trends and changes. The problem of recording the land uses of past years are solved only by the use of photogrammetry and old aerial photos.

II. Materials and Methods

A. Research areas

In order to achieve the objective that has been set in the context of this paper were selected as research areas 7 (seven) semi mountainous regions separated into two different categories (Fig. 1). The first four of them are semi mountainous regions nearby the second big city of Greece, Thessaloniki, at a road distance from 55 to 14 km. The second three of them are semi mountainous regions close in tourist areas with low or heavy tourist traffic.

Fig. 1, Research areas.

A. Next to urban centers (Thessaloniki)

In the first category the research deals with four areas next to Thessaloniki, the following:

First study area is the wider area of both sides concerning a part of road axis of Panorama - Hortiati. The proximity to the city of Thessaloniki and Hortiati is the main cause of land use changes.

As the second research area was chosen the Municipal District of Galatista. Galatista located 40 kilometers southeast of Thessaloniki, and 28 kilometers northwest of Polygyros. It lies between the geographical longitudes 23° 16′ and 23° 18′ and latitudes 40° 27′ and 40° 29′. It is built at an altitude of 500 meters, at the foot of the Saint Elias of Kissos (Ivy) Mountain.

The area around the village of Galatista are: a) barren lands, b) agriculturally cultivated lands, c) olive groves d) fruit orchards and areas with scattered fruit trees and ornamental trees (walnut, almond, fig, chestnut, mulberry, pear, apple), e) areas with low herbaceous vegetation f) cultivated fields with wheat. Throughout the area surrounding the village are woodlands covered by evergreen broadleaf forest vegetation (mainly oaks) and is forest with canopy cover from 0.5 to 0.7 and 0.7 to 0.9. Near the streams there is broadleaf evergreen forest vegetation, aquatic riparian vegetation and in positions with Poplars and stubble with degree of canopy cover from 0.4 to 0.8 and individual fruiting trees.

The third research area is the forest of Sarakina that lies between geographic coordinates: north latitude 40° 32′ 0′′ to 40° 37′ 30′′ and west longitude 23° 10′ 0′′ to 23° 14′ 50′′. It is about 40.52 km road away from Thessaloniki. The height above the sea level ranges between 320 m and 520 m at “Kedra”. The forest is public. The predominant species are oak, as well as forest beech, sweet chestnut and kermes oak, while appearing sporadically between them in the minimum rate of mixing the European Hop-hornbeam, hornbeam, sycamore maple, Cornelian cherry, etc.

The fourth area is the forest of Petrokerasa that lies between the geographical coordinates: north latitude 40° 25′ to 40° 41′ and west longitude 23° 15′ to 23° 23′. It is about 54.70 km road away from Thessaloniki. The height above the sea level ranges from 590 m to the stream “Manas Lakkos” to 1.009 m at the top of Avrianos or Omvrianos. The forest is public and community. The predominant species are oak, as well as forest beech and sweet chestnut, and sporadically between them in a minimum rate of mixing the European Hop-hornbeam, hornbeam, sycamore maple, Cornelian cherry, the holly, hazel, kermes oak etc. are appeared.

B. Close in tourist regions

In the second category the research deals with three areas, with heavy, medium and low tourist traffic, the following:

The first area is the forest of Toroni - Chalkidiki that lies between geographic coordinates: north latitude 40° 2′ 0′′ to 40° 17′ 30′′ west longitude and 23° 36′ 0′′ to 23° 55′ 15′′. The height above the sea level ranges from 10 m to 753 m. The forest is public. The predominant species are and the Aleppo and Calabrian pine with oaks and the lentisks (*pistacia sp.*) etc.

The second area is the Pinakates - Milies - Vyzitsa of Pelion of Magnesia Prefecture. It lies between 370-1070 meters. Showing almost all aspects on the horizon, with the predominant S - SW, N - NW and E and the altitude ranges from 0-1466 meters (top Tsakos). The slopes are on average between 10-70%. The predominant species are sweet chestnut, common walnut tree, forest beech and downy oak.
The third research area is Maroneia - Rodopi west longitude 25° 25′ to 25° 38′ and north latitude 40° 51′ to 41° 01′. The area is crossed by rather low mountains (Ismaros 678 m) and is in a relatively short distance from the sea (Thracian Sea). The height above the sea level of the area ranges from about 10 meters at the lowest point and 678 m to the highest point thus showing elevation difference of about 660 m. All forest land owned by the Greek public “rights of war” as a new state.

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The predominant species are kermes oak, cedar and other evergreen broadleaved, mixed with deciduous broadleaf (forb and downy oak, common bearberry, etc.). Also, several areas have been reforested with various pine species.

B. Methodology

For the diachronic analysis of land uses changes are used aerial photos because have much longer history and generally higher spatial resolution than satellite images. Greece, the whole country, has been photographed from the air by the Hellenic Military Geographical Service (HMGS) that is the Greek military mapping agency since the 1945's. Historical aerial photographs, which recorded the whole history of land use dynamics, are therefore the main source of data for this study. The available photographs, which cover the study areas, were taken in 1945 and 2007. 1945 black and white photographs are at scale a scale of 1:42,000. Although aerial photographs may have potential drawbacks, like doubtful quality and problems with registration and distortion [6], they remain a valuable data source in land uses changes research. These photos were scanned to convert them to digital format for digital photogrammetric processing.

Determining land use changes in the study areas were performed using digital photogrammetric methods. The hard-copies of the aerial photographs (A / P), taken in 1945, which after digitization (scanning) in special photogrammetric scanner, processed with the software Leica Photogrammetry Suite (LPS 9) company Leica Geosystems.

The relative orientation as well as the automated production of Digital Terrain Model (DTM) made by the implementation of automatic correlation homologous pixel using as standard windows of radiometric values of the pixels (area based matching). Also software LPS 9 enables the production and use of digital images pyramids which improve the final results as they are an auxiliary means for finding appropriate initial values used for determining the optimum solution to the problem of the digital correlation [11] (Fig. 2).

The final products of the photogrammetric processing of A / P of the study areas are digital orthophotos for the comparison year 1945, resulting from the differential reduction of A / P by eliminating position errors they contain because of the terrain relief. The 2007 colour orthophotos are at a nominal scale of 1:20,000 to 1:30,000, with spatial resolution 0.5 m, represent the most up-to-date cartographical data. The import of orthophotos, for the comparison years 1945 and 2007, in GIS was followed which was based on ArcGIS 9 software company ESRI. Geographic vector data (polygons and lines) were created based on photo-interpretation of the study area for the two periods of comparison, which were associated with descriptive data in the geographic database of ArcGIS. After defining the topology, held the area measurement of the polygons and calculated the total area for each land use, such as recording of the road net in the area. Follow the mapping performance efficiency and production of the final orthophotomaps.

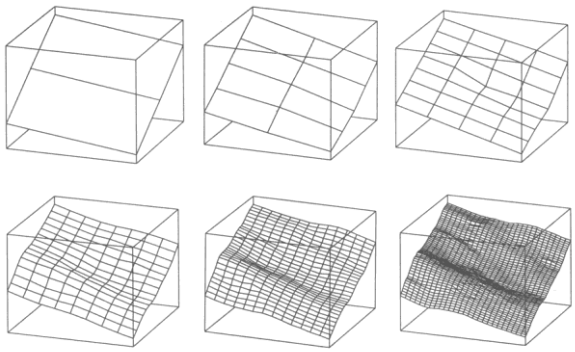

Fig. 2, Automated production of DTM by use of pyramids (Source: [1]).

III. RESULTS

After the drawing and comparison of land use orthophotomaps of 1945 and recent orthophotomaps the followings resulted:

A. Next to urban centers (Thessaloniki)

- Regarding the study area of Panorama – Hortiati road axis:

Figure 3 depicts the percentages of area per land cover category for the two study periods (see Table I).

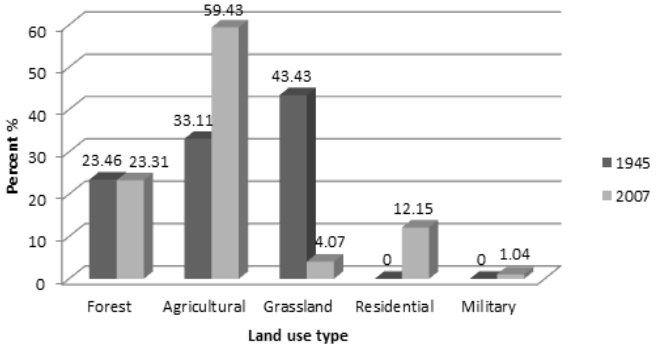

Fig. 3, Land use percentages in Panorama-Hortiati road axis.

Table I. Land use changes in Panorama-Hortiati road axis

Land use type	1945	2007	Changes in ha	Percent of changes (%)
	Area in ha			
Forest	92.68	92.09	-0.58	-0.64
Agricultural	130.85	234.80	+103.96	+79.45
Grassland	171.57	16.08	-155.50	-90.63
Residential	0.00	48.02	+48.02	-[a]
Military	0.00	4.11	+4.11	-[a]

[a] This value cannot be calculated due to the division by zero.

The proximity to the city of Thessaloniki and Hortiati is the main cause of land use change. There is a reduction of grasslands at the expense of rural and mainly of residential land use. - Regarding the study area of Galatista Chalkidikis:

The land cover map of 1945 and 2007 of the sample area is shown in figure 4, while figure 5 depicts the percentages of area per land cover class for the two study periods (see Table II).

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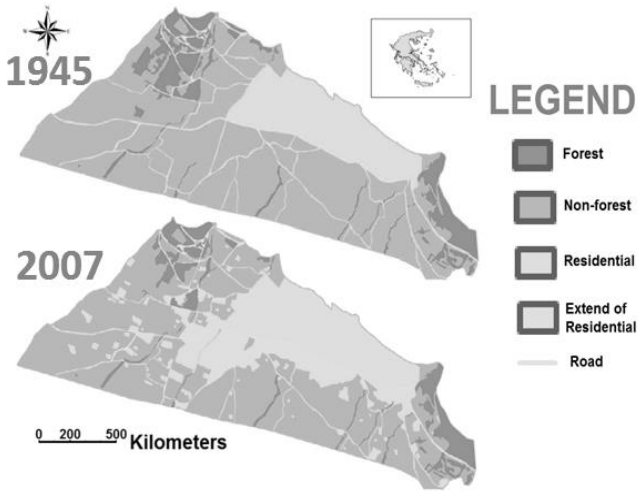

Fig. 4, Land use maps of Galatista Chalkidikis of 1945 and 2007.

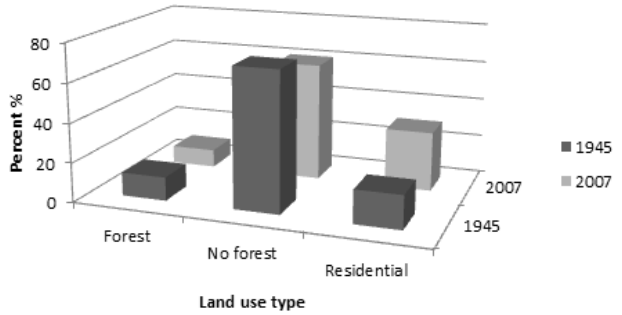

Fig. 5, Land use percentages in Galatista Chalkidiki.

Table II. Land use changes in Galatista Chalkidiki

Land use type	1945	2007	Changes in ha	Percent of changes (%)
	Area in ha			
Forest	26.13	20.02	-6.11	-23.4
No forest	154.63	131.89	-22.74	-14.7
Residential	37.17	66.02	+28.85	+77.6

In Galatista is observed that forest and non-forest (agricultural, grasslands) were converted into residential areas.

- Regarding the study area of Sarakina – Thessaloniki (320 - 520 m):

In figure 6 is shown the percentages of area per land cover class for the two study periods (Table III).

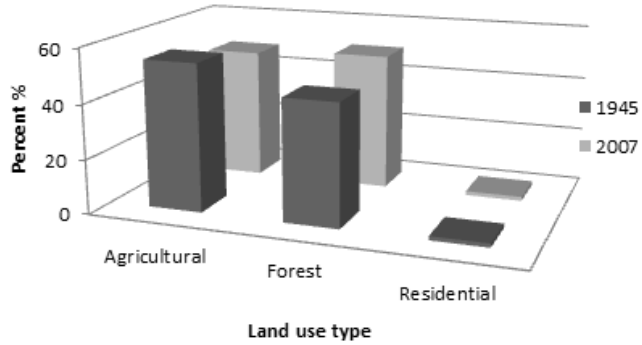

Fig. 6, Land use percentages in Sarakina Thessalonikis.

Table III. Land use changes in Sarakina Thessalonikis

Land use type	1945	2007	Changes in ha	Percent of changes (%)
	Area in ha			
Agricultural	264.73	236.52	-28.21	-10.66
Forest[a]	217.87	246.08	+28.21	+12.95
Residential	7.255	7.255	0.00	0.00

The area is hilly to semi-mountainous and natural conditions leave little opportunities for a significant agricultural production. This is depicted by the high percentage of abandoned farmland (about 6%). Unlike is observed corresponding increase in forest area while the residential areas have remained unchanged.

- Regarding the study area of Petrokerasa – Thessaloniki (590 - 1.009 m):

In figure 7 is shown the percentages of area per land cover class for the two study periods (Table IV).

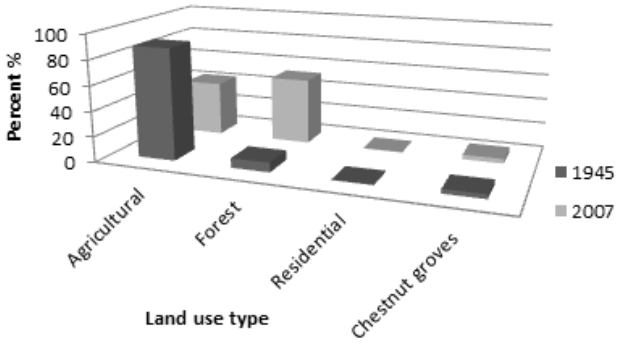

Fig. 7, Land use percentages in Petrokerasa Thessaloniki.

Table IV. Land use changes in Petrokerasa Thessaloniki

Land use type	1945	2007	Changes in ha	Percent of changes (%)
	Area in ha			
Agricultural	2,355.83	1,154.74	-1,201.09	-50.98
Chestnut groves	93.21	98.32	+5.11	+5.48
Forest[a]	202.76	1,398.74	+1,195.98	+589.86
Residential	12.95	12.95	0.00	0.00

[a] This includes and scrublands, pastures and grasslands.

The area is hilly to semi mountainous. Due to the varied terrain relief of the region, with many ravines, narrow gorge with steep sides and because of the steep slopes of the ground, which increased from moderate to strong in the side slopes of the numerous streams unsuitable for valuable agricultural production. So there is a large percentage of abandoned farmland with marginal production (approximately 50% of the total area of agricultural lands). In contrast was observed corresponding increase in forest area while the residential areas have remained unchanged.

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B. Close in tourist regions

- Regarding the area Maroneia - Rodopi (10 - 678 m): In figure 8 is shown the percentages of area per land cover class for the two study periods (Table V).

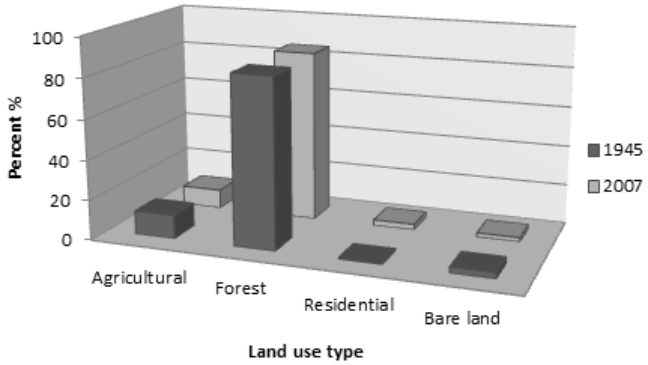

Fig. 8, Land use percentages in Maroneia – Rodopi.

Table V. Land use changes in Maroneia – Rodopi

Land use type	1945	2007	Changes in ha	Percent of changes (%)
	Area in ha			
Agricultural	509.7	412.7	-97.0	-19.03
Forest[a]	3,629.5	3,679.5	+50.0	+1.38
Residential	28.5	120.5	+92.0	+322.81
Bare lands	134.8	89.8	-45.0	-33.38

[a] This includes and scrublands, pastures and grasslands.

The area is hilly seaside-but is not well tourist developed. It is shown an increase of settlement areas due to population growth and also observed increase in forest area over agricultural abandonment because of burned from time to time olive groves (approximately 1%).

- Regarding Toroni - Halkidiki (10 - 753 m):

In figure 9 is shown the percentages of area per land cover class for the two study periods (Table VI).

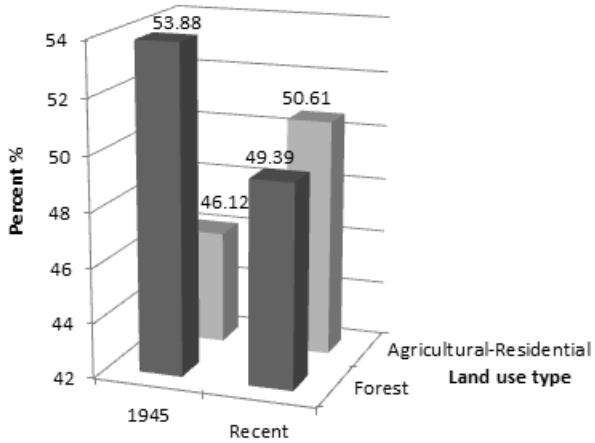

Fig. 9, Land use percentages in Toroni – Chalkidiki.

Table VI. Land use changes in Toroni - Chalkidiki

Land use type	1945	2007	Changes in ha	Percent of changes (%)
	Area in ha			
Forest[a]	230.278	211.088	-19.19	-8.33
Agricultural - Residential	197.082	216.2,72	+19.19	+9.74

[a] This includes and scrublands, pastures and grasslands.

The under study area is coastal to semi-mountainous with heavy tourist pressure. It shows a reduction of the forest area (about 8%) and correspondingly increasing of residential.

- Regarding the study area of Pinakates - Milies - Vyzitsa of Pelion:

In figure 10 is shown the percentages of area per land cover class for the two study periods (Table VII).

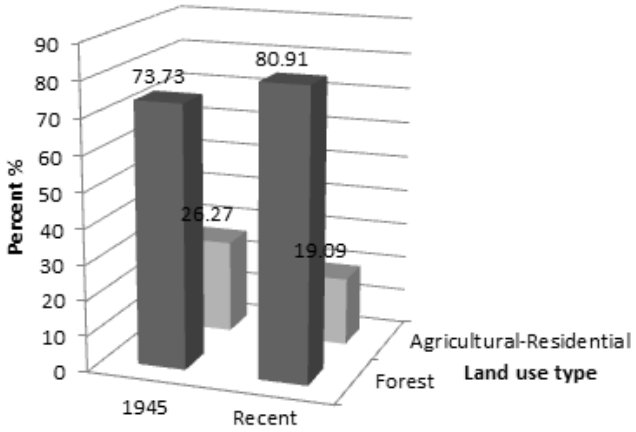

Fig. 10, Land use percentages in Pinakates - Milies - Vyzitsa of Pelion.

Table VII. Land use changes in Pinakates - Milies - Vyzitsa of Pelion

Land use type	1945	2007	Changes in ha	Percent of changes (%)
	Area in ha			
Forest[a]	697.32	765.19	+67.87	+9.73
Agricultural - Residential	248.42	180.55	-67.87	-27.32

[a] There are no scrublands, grasslands, bare lands and grasslands.

In Pinakates - Milies - Vyzitsa of Pelion is observed that agricultural – residential lands were converted into forest areas.

IV. CONCLUSIONS

The comparison between the produced orthophotomaps of 1945 and 2007 indicates the land use changes during a sixty two-years period and wider development of the study areas were determined. Particularly grasslands and forest uses are examined, which are elements of forest ecosystem and usually constitute areas of high trespass danger. Their environmental importance is a subject of national and scientific consideration and their exploitation (built-up, agricultural, reforestation, etc.) should be examined mainly with scientific criteria.

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The research will be continued concerning the processing of recent geographical data derived not only from terrestrial observations, but also from the use of recent up-to date aerial photos (after 2010).

Generally speaking is observed that where there is an intense coastal tourist traffic (Toroni), forest land decreased in order to increase housing, while where there is not intense tourist traffic (all others), the forest land increased, even in Pelion that presents tourist traffic throughout the year but there is not much pressure for the development of tourism accommodation such as in Toroni Chalkidiki. From the above there is a growing trend land use change especially of forest land to residential (Hortiatis) or rural for future real estate development in residential areas with high pressure such as around the second largest city of Greece, Thessaloniki.

The intensity of the pressure on forest areas and non-forest (agricultural, grasslands) areas is reduced with increasing distance from the urban center (Thessaloniki) and increasing the altitude. Wherein there are abandoned agricultural lands with marginal production are converted into forest areas.

Based on the results of the study, it can be said that remotely sensed data like aerial photos can be used as very handy and appropriate tools for monitoring and change detection because they have much longer history and generally higher spatial resolution than satellite images. Land use change or change detection can be analyzed using these data for different dates with the help of an integrated Geographic Information System (GIS). Geographic Information Systems (GIS) can be used to achieve the correct photointerpretation techniques that were developed at detecting and mapping land-use changes in a region with historical aerial photos.

Simulation models on land use changes are tools to assess the causes and impacts of land use changes in order to support land use planning and policy due to the depiction of future land changes under different scenario conditions. These models are useful for monitoring the multiplicative factors such as socio-economic and environmental ones those influence the rate and spatial plan of land use changes and for assessing the impacts of land use changes.

It is of great importance the creation of databases across all regions, in order to monitor closely land-use changes. The purpose of these databases can be twofold; on the one hand in providing land-use information on the country's lands, and on the other hand in becoming a decision "tool box" in sustainability management of the country's lands. Thus the cadastral map is indisputable tool in order to safeguard the forest land from conversion to land plot and a preventive tool for protection against fires.

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AUTHOR PROFILE

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I was given birth in Katerini - Pieria Prefecture in Central Macedonia of Greece. I graduated from the Department of Forestry and Natural Environment of Aristotle University of Thessaloniki in 1990. I am holder of doctoral title with degree "Excellent" from 2000. I elected as Lecturer in the Department of Forestry and Management of the Environment and Natural Resources of Democritus University of Thrace in Orestiada in the cognitive object of Forest Cadastre on 2000. On December of 2005 I elected as Assistant professor in the same Department. I elected as Associate professor on December of 2012 in the cognitive object of Forest Cadastre, Forest Constructions and Forest Opening up. During these years the following courses: Geotechnical Drawing, Technical Mechanics, Topography, Elements of Technical Legislation, Applications of Photogrammetry, Topographic Instruments and Surveying of Forest Regions, Technical Works and Environmental Impact Assessments, Building and Structural Materials, Forest Road Construction, Forest Aerial Photography, Forest Cadastre, Opening up of Forest - Skidding and Transport of Forest Products, Technology of Structural Materials, Science of Engineer, Remote Sensing of Natural Resources, Implementations of Machineries in Forest Technical Works, Forest Constructions, Mapping of Natural Resources and Agricultural Engineering were taught. My research interests are Forest Cadastre, Land Planning, Environmental Impact, Technical Design, Technical Engineering, Surveying, Photogrammetry, Forest Opening Up and Forest Constructions. I am member of FORMEC network. I have above 140 publications in Greek and foreigner magazines and congresses.

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