CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Forestry and Wood Sciences

Department of Applied Ecology

“Analysis of landscape structure change on the level of land use and land cover” due to construction of dam, comparative study from Greece and Czech Republic

M.Sc. DIPLOMA THESIS

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DIPLOMA THESIS ASSIGNMENT

Panagiotidis Dimitrios

Thesis title

Analysis of landscape structure change (on the level land use and land cover) due to construction of dam, comparative study from Greece and Czech Republic

Objectives of thesis

The Aim of the Thesis is to evaluate landscape structure changes due to realization important hydrological facilities. Meaning of work is formed by comparison two similar areas, one from Greece and second one from Czech Republic, where the important hydrological facility were builded (Greece) and area where the important hydrological facility will be probably builded in the future time period of 20 - 50 years. The output of the thesis going to be comparison of landscape structure development and evaluation of human impact on landscape.

Methodology

- Projection of the land use structure changes in area of Lake Plastiras (Greece) using aerial photo and GIS analysis
- Projection of development land use changes at hydrological important area (Czech Republic) using aerial photo and GIS analysis
- Comparison of two studies areas
- Prediction of future landscape structure development in the hydrological important area in Czech Republic.

Schedule for processing

2013

Analysis and reconnaissance two places of interest, literature Review on relevant field of Environmental studies gis analysis and experimental part of the research, characteristics of the study area, methodology, the current state in the field of research.

2014

Results

Discussion

Conclusion

The proposed extent of the thesis
approximately 50 pages text and 10 pages of maps annexes

Keywords
GIS, aerial photo, Strategic Environmental Assessment, landscape pattern

Recommended information sources

Forman, R.T.T., Godron, M.: Landscape Ecology. John Wiley & Sons NY, 1986.
Forman, R.T.T.: Land Mosaics, The Ecology of landscape and regions. Cambridge University Press, 1995.
Bissonette, J. A., Storch, I.: Landicape Ecology and Resouice Management. Island Press, 2003.

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Declaration

I hereby declare that this thesis is a presentation of my research study, which I wrote independently. This study was done under the guidance of my supervisor Ing. Zdeněk Keken, who provided me with other information. I have listed all literature and publications from which I have acquired ideas.

Whenever contributors of others are involved is made to indicate this research clearly.

In Prague, date …………….. …..………………………

Signature

Acknowledgments

I would foremost like to thank my supervisor Mr. Zdeněk Keken for his guidance, criticism, and unending support. This project is dedicated to God, my parents my brother and to my grandmother for giving me life, love, support and encouragement to go on in my life.

I would also like to thank all of my professors for supporting me and challenging me to strive for increased knowledge for the past two years of my life in this country at this University.

Abstract

This study evaluates the physical landscape structure changes due to realization of important hydrological facilities before and after the construction of the dam in the autumn of 1959 in central Greece. Meaning of the work is formed by comparison of landscape characteristics, which emerged after treatment of aerial photos in two different time periods. The spatial landscape dynamics from 1945 until 1996 in the study area are monitored and changes analysis, together with the effects that the dam could have on the surrounding environment, lend insight to this research. This study tries to provide a significant level of information which could affect the current and future decisions-making, from the ecological point of view, concerning the possibility of such a hydraulic construction to take place in 20 to 30 years from now in Kočov region in the Czech Republic. Additional analyses of landscape changes in the microstructure period were examined from 1945 to 1996 using vector-based landscape analysis tools extension (V-LATE) software, were a number of landscape characteristics were evaluated. All data were processed using Arc-map GIS by environmental systems research institute (ESRI). During the monitoring period, results have shown that arable areas together with grasslands were found significantly decreased because they were mostly located in the lower elevations flat areas and therefore were flooded, showing the level of influence brought by the construction. Concerning the forest areas overall, only a small decrease of total area was recorded from 1945–1996. On the other hand, residential areas and other constructions like communication network were found significantly higher as expected due to the economic value gained by the region after the implementation of the dam. Generally, indicators from diversity analysis in the results, showed significant changes in landscape structure over a time period of 50 years. Through the comparison of the landscape structure development, the output of the thesis defines the main driving forces behind these changes and tries to emphasize valuable results concerning planning, decision-making processes and changes in cultural landscapes from the point of view of nature conservation throughout a land record geodatabase.

Keywords: GIS, aerial photo, Strategic Environmental Assessment, landscape pattern.

Abstrakt

Tato práce zkoumá změny fyzické struktury krajiny ovlivněné realizací podstatných hydrologických zařízení před a po konstrukci přehrady v centrálním Řecku na podzim roku 1959. Základním smyslem práce je povorovnání krajinných charakteristik, které se objevily po zpracování leteckých snímků ze dvou různých časových období. V práci je monitorována prostorová krajinná dynamika místa v letech 1945 až 1996 a jsou analyzovány zpozorované změny a efekt, který vystavěná přehrada mohla mít na okolní prostředí. Tato práce se snaží poskytnou významné množství informací, které by mohly ovlivnit současné a budoucí rozhodování z ekologického úhlu pohledu, zahrnující také možnost výstavby podobné hydraulické konstrukce za 20 až 30 let od teď v oblasti Kočova v České republice. Dodatečné změny krajiny v letech 1945–1966 byly analyzovány pomocí vektorově založeného softwaru, který slouží jako rozšířený nástroj pro analýzu krajiny – tzv. V-LATE – díky němuž mohla být hodnocena řada krajinných charakteristik. Všechna data byla zprocesována za použití systému Arc-map GIS vytvořeného Institutem pro výzkum environmentálních systémů (ESRI). Výsledky analýzy monitororvaného období ukázaly, že množství orných a travnatých ploch bylo výrazně sníženo a to z toho důvodu, že tyto plochy se nacházely zejména v nižších polohách dané oblasti a byly tedy zaplaveny, což ukazuje stupeň vlivu, který konstrukce přinesla. Když vezmeme v úvahu lesní plochy, v období let 1945–1996 byl u nich zaznamenán jen malý úbytek. Na druhé straně se však objevilo více obytných oblastí a jiných konstrukcí, jako například komunikační sítě, než se původně očekávalo, a to hlavně díky ekonomické hodnotě, kterou región získal po implementaci přehrady. Obecně tedy během zkoumaného 50letého období indikátory diverzity ve výsledku ukázaly zásadní změny v krajinné struktuře. Pomocí porovnání vývoje krajinné struktury výsledek této diplomové práce definuje hlavní hnací síly, které stojí za těmito změnami, a snaží se zdůraznit hodnotné výsledky obsahující plánování, rozhodovací procesy a změny v kulturní krajině z pohledu ochrany přírody prostřednictvím geodatabáze monitorující pevninu.

Klíčová slova: GIS, letecké snímky, strategické posuzování vlivů na životní prostředí, reliéf.

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1. INTRODUCTION

1.1 Landscape ecology

The term “landscape ecology” first appeared a half century ago (Schreiber, 1990). Landscape ecology plays a significant role in facing today's major conservation and also land use issues responding to a number of serious problems arising as a result of global change. This arises due to the increasing recognition that many conservation and land use issues can only be tackled in a sensible way within a landscape framework (Saunders et al. 1991; Franklin, 1993). Landscape has been defined variously during the past (Urban et al. 1987; Pickett and Cadenasso, 1995). However, from all of these, definitions have been given particular importance to spatial heterogeneity for ecological processes. Moreover, often but not always, landscape ecology is also characterized by a focus on spatial extents larger than those typically and traditionally studied in ecology. The scale independent of landscape ecology on the causes and consequences of spatial heterogeneity is distinct from how landscape ecology is sometimes defined by humans (Bastian, 2001; Opdam et al. 2001).

1.1.1 Temporal analysis of habitat fragmentation

Land is transformed usually from more to less suitable habitat in a small number of basic mosaic sequences, through several spatial processes, including attrition, perforation and fragmentation, resulting increases of isolation and habitat loss. However, progressive parallel strips from edges seem that can lead to an ecologically optimum sequence. Mechanisms such as logging, desertification and wildfires transform land from one type to another, while each land transformation is effectively a mosaic sequence.

Habitat fragmentation, is nothing but a phase in a wider sequence of spatial processes transforming land, considering human or nature as the main culpable for this alternation from one type to another, hence other spatial processes in landscape change, which his ecologically significant (Forman, 1995).

1.1.2 Landscapes and regions

Landscape and region are both human scales, which are forming land mosaics; a mixture of land use types repeated over the land, forming a landscape composed of spatial elements. Those at the regional scale are landscapes and those at the landscape scale are commonly called landscape elements (Forman, 1995). The boundary between landscapes can be easily determined by recording the landscape elements present along transects or in randomly or regularly distributed plots. Ecological conditions differ in the center and edge of a landscape (Liu et al. 1994). Boundaries can be considered as an evident from the contrasting composition of spatial elements in the plots, and also can be precisely delineated at this scale by using various statistical analyses (Forman and Godron, 1986). Region on the other hand, is an extended usually geographical area with a common macroclimate, human interest and activity (Burke et al. 1991). It is relatively strong related with communication and culture, but often it is extremely diversified ecologically. In conclusion, the distinct boundary of landscapes, and additionally with the sharp difference in appearance of adjustment landscapes, it provides a high contrast pattern to a region.

1.1.3 Future landscapes and the future of landscape ecology

Landscape ecology points out the ecological effects of broad spatial scale patterning of ecosystems and it is strongly related and integrated into land use decision-making process with emphasis on ecology. Specifically, takes into account the dynamics of spatial heterogeneity, as well as interactions and influences across heterogeneous landscape areas on the level of biotic and abiotic processes. Landscape ecology studies biosphere disorders throughout information collection, which gained and arose mainly from European traditions of regional geography and vegetation science research. Landscape ecology has this broad objective, which is relevant to the problems that mankind faces and needs to deal with at the end of twentieth century (Golley, 1987).

From many people future sometimes associate with fate. In fact it is something we form according to our daily needs. One choice is to simply allow future to roll over us. Scientist need to take a decision, whether they wish to participate in the process by recognizing and admitting that humanity is an active and integrated part, which participates in the most of natural processes.

Another matter of a great significance is that all people need to decide what is left so far from the point of view of i.e. natural resources and where we are planning to go. To be realistic is a very difficult question to be answered. In terms of function and structure, landscape ecologists have to have clear and integrated ideas about what we want from our landscapes, always driven by our necessities. There are still several territories out there that are not developed yet in terms of landscape ecology, which could be a base for plenty of new opportunities and strategies for substantial progress. It becomes clear and crucial at the same time that the understanding of how landscape can change over the time, including the long term legacies of past disturbances, that can caused either from natural or human causes, is an important line of inquiry in contemporary landscape ecology (Turner, 2005).

Scientists need to wisely decide and answer an important question, if modeling and so far used methodologies are relevant to real world applications and how effective they are. One solution could be including policy makers and managers in the process of developing the science of landscape ecology. Someone who cares about landscape ecology can play a part in putting these suggestions into action. If we do, landscape ecology really does have a future as a vibrant and useful science (Hobbs, 1997).

1.1.4 The effect of pattern on process

The distribution of the entire temporal evolution of succession stages has been described as a pattern of patches across a landscape over time. The complex spatial pattern across the landscape was constant, but this constancy in the pattern was maintained by the temporal changes at each point. Thus, space and time were linked for the first time at the broader scale that is now termed the landscape (Watt, 1947). The effects on spatial mosaic, which have been caused by natural disturbances, have received considerable study and research in a variety of terrestrial and aquatic systems (Pickett and White, 1985). The spread of disturbance across landscape is an important ecological process that is influenced by spatial heterogeneity. We can observe landscape from many aspects, where ecological processes in landscapes can be studied at various spatial and temporal scales (Risser, 1987).

Primary object of ecological research on landscapes is the clarification of the relationship between landscape pattern and ecological processes. However, the broad-spatial temporal scales involved make experimentation and hypothesis, testing of results obtained from small-scale experiments to broad scales (Turner, 1987). Species living and interconnected in various and sometimes complex ways together with other species, in a landscape which can be considered as a habitat mosaic comprising of patches, where landscape connectivity is quite crucial for species persistence; hence size, shape and diversity of patches also can significantly influence species abundance. Landscape position can also affect redistribution processes. Landslide areas for instance, affects the spatial and temporal patterns of sediment fluxes carried across landscapes by surface water (Swanson et al. 1988).

1.1.5 Ecological network conventions

The ecological network is nothing but a model that has been developed over the past 30 years, aiming to maintain environmental processes. In terms of conservation approach, ecological networks are characterized by two generic objectives.

A. To maintain the ecosystem functionality as a means of facilitating the conservation of species and habitats.

B. To promote the sustainable use of natural resources in order to reduce the impacts of human activities on biodiversity and/or to increase the biodiversity value of man-managed landscapes (Bennett and Wit, 2001).

In achieving these objects, a number of elements can be discerned and together they characterize all ecological networks. These are:

- Conserving and rehabilitate of degraded ecosystems by enhancing biodiversity at the landscape.
- Emphasis on maintaining ecological coherence, primarily through providing for connectivity (Bio-corridors).

- Proper use of buffer zones around the endangered areas from the external effects of potential damaging.
- Promoting the sustainable use of natural resources in areas of importance to biodiversity conservation.

Ecological networks having the ability of sharing the information about, how a model should be applied on the ground, respect to the allocation of specific functions to different areas depending on their ecological value and their natural resource potential (Bennett, 2004).

"Natura 2000" is considered as the best-developed network system of protecting core areas across the European Union. Nevertheless, additional work should be done in order to strengthen its ecological character against the incoming challenges which European landscapes are facing; concerning vital matters of habitat loss and fragmentation. Therefore, European Commission has recognized and has been trying to face this important issue by developing a concept of ecologically coherent green infrastructure, for the sake of people and nature (Sundseth and Sylwester, 2009).

In comparison with North and South America, most of the ecological network programs in Europe are being designed and implemented through government programs, whether international, national or regional level. Remarkable is the fact that only a relatively small number of the programs are driven by non-governmental organizations (NGOs) (Bonnin et al. 2007).

1.2 Analysis, techniques and methods to assess landscape structure and landscape change

Generally, landscapes are very dynamic in structure and functions, while landscape changes are running on different time scales. Therefore, they differ in the magnitude and extents of changes. Assessment of changes in the landscape implies evaluation whether and how the changes comply with natural processes, whether they affect the landscape ecological stability and biodiversity negatively (Lipský, 2000). Both landscape ecology and geography have elaborated methodological approaches to landscape changes, monitoring and assessment. Landscape ecology in its dynamic concept is basically focused on three large topics:

1) Structure; 2) functions and processes; 3) changes and developments. Usually, rapid changes actually expressed by changes in LULC are a characteristic feature of the present cultural landscape. Landscape ecology in correlation with geography focused on monitoring of landscape changes. However, each science have its own methodology in order to investigate and assess changes in horizontal landscape structure because complex questions such as how energy flows and in which rate, species movement etc. can be answered. Depending on existing data, like scale, size and topology of the area, different methods can be used each time. To investigate changes and developments in landscape macrostructure, we are using summary statistical data. Additionally, research methods focusing on monitoring of changes in landscape microstructure are based on data derived from maps, aerial and satellite images (Gong et al. 1992).

1.2.1 Methods of monitoring and assessment of landscape macrostructure

Taking into account criteria concerning the landscape structure and extend dynamics of some of the main "classes" of land use like agriculture, forestry or construction areas, led to plenty of studies, which divided into separate objects of interest in order to examine these changes more detailed. There is a common method to follow up potential changes in landscape macrostructure by using statistical data concerning the land use which are usually available per district areas, cadastral areas etc. This approach is widely practiced by human geography (Bičík et al. 1996) and is suitable in case of large territories. Hence, administrative boundaries looking from the ecological point of view are not the best and that is because they do not correspond with natural boundaries of catchments or any other landscape units. Recently, some new statistical data from the "CORINE" land cover database derived from satellite images used to determine landscape changes on large areas, optionally on the scale of the whole countries and regions in Europe (Feranec et al. 2004). Statistical and cartographic methods have been elaborated to use database so to demonstrate historical changes, which have occurred at arable lands, forests, built-up areas, grasslands and plenty of other different land use categories. In the Czech Republic land use changes as a whole as well as in landscape units, landscape protected areas and biosphere reserves have been evaluated by this way (Bičík et al. 1996).

In smaller areas different development models have been applied according to different landscape types from lowlands to mountains areas and from core areas to periphery. Statistical data are combined with methods, using field mapping techniques, and aerial photographs. To evaluate the ecological stability of the cultural landscape, most of the attempts are based on the proportion of different land use categories. Generally, uses of ecological stability coefficient of the landscape are formulated as the proportion of ecologically relatively stable areas like forests, waters, grasslands and ecologically relatively unstable areas like built-up areas, arable lands, etc. The simplest coefficient of ecological stability is counted as:

$$Kes = \frac{S}{L}$$

Where (S) expresses the total area of all ecologically stable land use categories and (L) is the total area of all ecologically unstable land use categories (Míchal, 1992). Researchers attempting to reduce the shortages mentioned above by using partial coefficients; one of those partial coefficients for example is the coefficient of ecological importance for different types of land cover (Miklos, 1986). Bičík and Kupková in order to evaluate the coefficient of anthropogenic transformation (Kac) of the landscape have used similar but opposite approach (Bičík and Kupkova, in 2005). Both types of coefficients, Kes as well as Kac, had been also used to assess historical temporal changes in ecological stability of the landscape. Unfortunately using those coefficients, scientists are not able to quantitate the ecological quality of classes such as: arable lands, grasslands and other land use categories in different historical periods. Original statistical data on land use (landscape macrostructure) are not able to respect landscape microstructure, which is extremely important for landscape processes, its biodiversity and ecological stability. That is the reason why the coefficients are not suitable and feasible to use them in historical comparison (Lipský, 2000).

1.2.2 Methods of monitoring and assessment of landscape microstructure

There are hundreds of both statistical and analytical methods of how to evaluate changes in landscape microstructure based on measuring and calculation of landscape metrics and indices. Landscape ecological research oriented at landscape microstructure has been influenced by Forman´s concept of landscape structure and his definition of a landscape as a heterogeneous land area composed of a cluster of interacting ecosystems (Forman, 1995). The rapid development of computer systems in the last decades has enabled the possibility of using other modern and more reliable quantitative methods (Turner and Gardner, 1990). For instance, some metrics are used to describe only some individual characteristics of landscape elements, while others try to describe the whole pattern of a landscape structure. Assessment of landscape microstructure applies different statistical and analytical methods of landscape pattern analysis (like index of heterogeneity, Shannon´s diversity index, edge and boundary characteristics and patch characteristics). However, description of a landscape pattern isn't an easy object with the use of a single index, so a set of metrics is necessary to be used. Even more remarkable is that plenty of the metrics can be evaluated just from a limited number of primary parameters (e.g. patch size, shape, edge length, perimeter-area ratio, etc.). Practical application of landscape pattern quantification with landscape metrics includes description of temporal land use changes, future predictions regarding landscape change and evaluating differences in landscape pattern between landscapes (Pixová, 2005). Landscape structure changes are increasingly used to monitor changes of different landscape types. Remote sensing (RS) is one of the techniques with a remarkable potential to record temporal landscape changes. Moreover, remote sensors are providing multispectral and multiple spatial domain data, making it the ideal tool suited for integration into a geographic information system. RS attributes like for example measurement of spatial properties, are successfully applied so far to analyze landscape ecological spatial characteristics (Quattrochi and Pelletier, 1991).

1.2.3 Thematic maps as a tool to encode information

The whole process of multispectral mapping of the landscape consists of delineated boundaries around geographically located classes that are homogeneous in a consistent and logical manner. In any landscape, there is a possibility to record a huge amount of attributes that can be used each time depending on the purpose for any description or classification assessment.

Nowadays, the widely use of multispectral data has become an integral component of contemporary land use studies for mapping LULC. Different types of thematic maps like forestry, soil maps, as well as plenty of others have not always been readily available to extract in a digital format. In fact, at many localities there is still great demand and necessity for data in digital form. Therefore, LULC mapping techniques often rely on the differences of spectral characteristics of the landscape in order to distinguish meaningful LULC classes (Robinove, 1981).

1.2.4 Picture postcards as a tool to decode information

The cards generally can be considered as a mean of describing landscape images. Picture postcards began to develop during the beginning of the last century, in a time period were development of camera technology was blowing, allowing photographs to be printed onto a postcard combined with the changing of laws permitting writing on the back of the postcards (Staff, 1966). An important issue although, when applying picture postcards in order to pump information, is the distortion of specific elements of the landscape, that could be caused by many factors, such as enhancement or even colorization sometimes. This phenomenon often leads to an incorrect depiction of the environment. It is also likely that postcard publishers usually, for different reasons each time, modify the original scene by enhancing different aspects of the view, which leads to a false representation of the landscape (Sawyer et al. 2006). Therefore, when attempting to pump any kind of information we should be aware of this fact. In conclusion, displayed image on the postcard just laid the infrastructure to the past and even now with new approaches for estimation when trying to describe landscape structure and definitely shouldn’t be considered as representative of a landscape in reality.

1.2.5 Repeat photography of geomorphic landscape change

Methodology in case of repeat photography, provides first the site detection of an earlier time period, followed by estimation of the original place of the camera and finally reshooting the same image, usually without regard to season period. However, some other researchers are looking for more precision in their work, by taking into account other parameters as well, of the original image that could enhance the result. The technique of repeat photography in the field has been a very simple and practical interpretive tool to express geomorphic modifications in the physical landscape (Veatch, 1969; Harrison, 1974; Ives and Jack, 1987).

Cultural change can be also expressed through the use of repeat photography by looking variations of population growth at the land use pattern and through irrigated fields (Nüsser, 2001). A series of particular problems appears when trying to orient the camera to the exact position range from the removal of the original site (Butler and DeChano, 2001), quite often there is found the alteration of the location due to geomorphic agents (Graf and William, 1987).

Moreover, a series of other concerns like scale and perspective may arise when trying to recapture a scene (Hall Frederick, 2001). There are a few parameters such as time and season period that should be considered seriously when reshooting images, because they may cause negative affects concerning the scale. While other parameters such as the tree crown shape, foliage or even the angle of the sun can significantly alter the way of how landscape looks like in reality.

1.2.6 Remote sensing technology

It is one of the most prevalent techniques for data acquisition, about an object without making any physical contact with the object. Growing awareness of an environmental conservation, as well as contribution to other services which daily concerns humans has caused the need to improve such capable tools, in order to better understand the functionality of landscape. Geographers for instance are widely using the technique of (RM) to monitor and measure phenomena found in the Earth's biosphere (Pidwirny, 2006). Acquisition of data with this technique in recent years has proved significantly to be of great importance and effective tool in the hands of scientists for effective natural resources management, while could also be applied to environment monitoring and management applications (Ramachandran et al. 1997). Some of the methods of acquisition data are:

- Aerial photos
- Satellite images
- Laser scanning

Furthermore, remote sensing of the environment is usually implemented with the help of special mechanical devices known as remote sensors. These sensors have a great ability to receive and store information about an object without any physical contact with high resolution and detail. Usually, they are placed on helicopters, planes, satellites and even on air balloons, away from the object of interest, however lately other kind of gadgets are used as well like professional flying RC models. Most of the sensing devices record information about an object by measuring an object's transmission of electromagnetic energy from reflecting and radiating surfaces (Pidwirny, 2006). The technique of (RM) is considered as being a powerful method for researchers to quickly generate thematic maps (cartography), rather than field based sampling methods, which are more time and effort consuming. In particular, aerial photos can be considered as the best way to detect changes in the landscape over the time, since they are available from 1930s (Casson et al. 2003). Terrestrial photos enable the assessment of parts of the landscape often in a small scale (e.g. single species), while aerial photos allow an extent landscape view (Innes and Koch, 1998). This kind of technology provides the basis for developing landscape composition and structure indices and sensitive measures of large-scale environmental change and represents a quite simple management tool (Kepner et al. 2000). It is improved by Geographic Information Systems (GIS) that opened many new possibilities in this field research (Baltsavias, 1996).

Although, the full potential of RS technology for applications change detection has to be completely realized yet. Planning administrations at local, regional and international levels now recognize the need for RM information to help to derive and formulate policy so to provide insight into future changes trends (Jensen and Cowen, 1999). RS information, together 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 (Franklin et al. 2000). Clearly however, the fast developmental nature of (RM) technology often overlooks the needs of users as it continues to outpace the accumulation of understanding (Franklin, 2001). As a result, effective real world operational examples of land cover and land use change remain relatively rare (Loveland et al. 2002; Rogan et al. 2003). It is expected that in the near future, (RM) will change dramatically with the projected increase in number of satellites of all types (Glackin, 1998).

1.2.7 Using satellite data analysis

Satellite images can be considered a very convenient tool and simply applicable in order to measure landscape patterns, since they are able to provide a digital mosaic of the spatial arrangement. The main advantage of a satellite image is that it includes both spectral and spatial information, while they can be used from many different sciences like forestry, meteorology, agriculture etc., in order to extract useful information. Spatial information, such as texture and context, has been used to solve confusion when discriminating some thematic categories, which may show spectral overlapping (Gastellu-Etchegorry and Ducros-Gambart, 1991; Cohen and Spies, 1992). Remotely sensed images can provide significant information on landscape pattern, which involves portraying the spatial framework of landscape elements as well as their spatial relationships (connectivity, size, shape, local diversity, etc.), (Forman and Godron, 1986). Spatial attributes of a satellite image have been measured both with two different ways:

1. Interval scale data and
2. Nominal scale data.

The former approach has been frequently based on a moving window (3 x 3 or 5 x 5 pixels, which are the most common sizes), where various indices measure spatial contrast is computed. From the co-occurrence matrices, several texture measures have been proposed, such as contrast and correlation (Haralick, 1979). Several other measures of texture have been defined, based on the concept of a textures spectrum that shows a histogram of the so called texture unit numbers which are created from local differences in grey level values within n x n windows (Wang and He, 1990). Textural images have been frequently used for urban land cover mapping (Gong et al. 1992).

The other approach his based on nominal-scale classifies maps. These maps can also be analyzed by using quantitative indices, which mainly measure the heterogeneity of classes. Diversity and dominance are well known examples of those indices (O'Neill et al. 1988; Baker and Cai, 1992). They are ordinarily computed from polygons of homogeneous cover type, size, shape, perimeter, connectivity, orientation, diversity of patches, which are variables critical for describing the landscape mosaic. In conclusion, not much work has been devoted so far to the measurement of these variables from satellite images, although satellite data have been extensively used for land cover mapping (Delbaere and Gulinck, 1995).

1.2.8 The use of intelligent systems to land use

Multi-agent systems (MAS) (Franklin and Graesser, 1996), consist of a number of interacting autonomous entities, which have defined agents, as anything that with the help of special sensors can perceive and record any kind of environmental functions and to act upon environment through effectors (Russell and Norvig, 1995). Accordingly, agents may be:

- Persons
- Computer programs
- Even thermostats

There are two main fields of applications: a) operations research and b) systems analysis. A number of techniques have been developed on the basis of MAS to solve complex optimization problems, like artificial neural nets and genetic algorithms. MAS are increasingly used nowadays as simulation tools to explore the complex relationships between environmental change, human actions, and policy interventions. The advantage of these models lays in their ability to combine spatial modeling techniques, such as cellular automata (CA) or GIS, with biophysical and socioeconomic models at a fine resolution (Parker et al. 2003). Another significant advantage is the flexibility, which they have in their representation of human decisions, concerning natural resources with a great background in sciences such as environmental, geography and economics. The behavior of individual actors can be modeled one to one with computational agents, which allows direct observation and interpretation of simulation results. Even more remarkable is the fact that MAS are autonomous decision-makers who communicate and interact to alter the environment in the best possible way, that's why they have been applied in a wide range of settings so far with very good results. It is clear that those systems programmed by humans act instead of them with high flexibility and speed, by using and combining numerous and very simple rules of action at the same time. Most of MAS applications have been implemented with software packages such as, Cormas, NetLog, RePast, and Swarm (Railsback et al. 2006). Empirical evidence has shown that people use simple heuristics to make decisions (Parker et al. 2003). In land use simulation, optimizing agents have been implemented in MAS using a variety of optimization techniques. For instance, Balmann, and Happe used mathematical programming (Balmann, 1997; Happe, 2006), while Manson used genetic programming to optimize agent land use decisions (Manson, 2005).

1.2.9 Agent-based models - ABM/LULCC

Agent-based models like ABM/LULCC have a possibility to focus on a hypothetical representation of reality through the study of social interaction between the public collaborators related with the phenomenon of changes in land use. Essentially, those models are trying to simulate the social behavior in space and to predict the decisions about future land use that will be chosen by the actors in that space (Parker and Meretsky, 2004). Those models usually consist of two components. The first part is a cellular model, which study the development of land use and therefore represents the spatial unity. Here we can also include a variety of other spatial processes related to land use changes and the technical construction which draws similarities from the construction and function of cellular automata. The second part represents actors who make relevant land uses. This part works in order to simulate heterogeneous entities of decision-making, i.e. interactions among people and organisms with other entities, as well as with the physical environment. It comprises specific rules, which are delimiting the relation between entities and their environment, and rules which determine the course and the order things into the simulated environment (Castle and Crooks, 2006).

One of the most important dimensions of ABM/LULCC is that they do consist of modules, which result in easier control and upgrade of the module. Additionally there are two other important dimensions that should be mentioned as well. The first one concerns the social and natural space which behavior and development are trying to simulate the processes of spatial formations. The other dimension concerns the environment of programming which adopts the construction of simulation model of the spatial phenomenon. A common adopt environment is that of object oriented programming (Castle and Crooks, 2006).

1.2.10 Artificial neural networks

Huge strides have been made so far in another dimension with the wide use of technology, which opened new horizons for the development of more sophisticated approaches concerning decision-making and design. The reason is the so called artificial neural networks (ANNs), which were originally designed as pattern recognition and data analysis tools that can mimic the neural storage and analytical operations of the brain. The main advantage of this approach over classical statistical classification methods is that they are non-parametric and also the almost negligible amount of knowledge that they require as input data in order to operate (Benediktsson and Sveinsson, 1997). Nowadays, a large portion of scientists believe even more that this technology can offer a new alternative approach to the study and understanding of the phenomenon of land changes with plenty of promising possibilities. ANNs approaches have been widely used for image classification in RS since the 1990s (Babu et al. 1997; Bischof and Leonardis, 1998). While various (ANNs) approaches have been applied to many LULC classification applications using remotely sensed data (Benediktsson and Sveinsson, 1997; Carpenter et al. 1997), the two most frequently used neural networks are the supervised Multilayer Perceptron (MLP) (Rumelhart et al. 1986) and the unsupervised Self-Organizing Mapping (SOM) (Babu, 1997). The MLP neural network is a supervised model that uses single or multilayer perceptrons to approximate the inherent input-output relationships is the most commonly used network model for image classification in RS (Kanellopoulos and Wilkinson, 1997). MLP networks are typically trained with the supervised back propagation (BP) algorithm (Rumelhart et al. 1986) and consist of one input layer, one or more hidden layers, and one output layer.

SOM networks were found to be capable of analyzing complex multivariate data from natural systems (Weller et al. 2006). The standard (SOM) algorithm is summarized by Lippmann and Chen (Lippmann, 1987; Chen, 1999). This approach is ideal in case where class labels for training patterns are very expensive to obtain. For example: heterogeneous landscape SOM has operational advantages over supervised methods in terms of reduced interaction time by the analyst; however, it offers less control over the resulting classes (Thomson et al. 1998).

1.2.11 Cellular automata

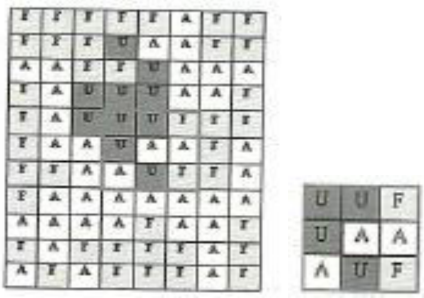
Models of cellular automata (CA) are widely used in the field of study concerning changes in land use, particularly when trying to be considered future land uses at one place. Despite the fact that those models are having complex structure, they require specialized software and powerful computer systems. Land use of the study area at a particular time (t + 1) results in the future in taking into account a combination of subjects, such as land use that do exist in the area at the time (t), the neighboring land use of each pitch, the use of which his studied as well as a number of other information. The crucial characteristics of which are consist are four:

- Cell space, which synthesized from many individual cells, usually having a square shape and are arranged to form grid.
- Cell states, which in the case of the study of changes in land use usually, represent the different uses.
- Time steps, regards the temporal unit basis, which begins the calculation of changes in land use of the study area.
- Transition rules are the most important part of the model. Under these rules changes made statements of the cells (White and Engelen, 1994).

Rules of transition could be:

- Cell <A> stays <A> if 3 or 4 of the neighbors are also <A>
- Cell <A> change in <U> if 2 or 3 of the neighbors are <U>
- Cell <A> change in <F> if 5 or 6 of the neighbors are <F>

Cells can be found at 3 possible situations: (U) Urban use, (A) Agriculture use, (F) Forestry use.



Neighbor of (A) which is ready to change

Figure 2. Cellular space and land use

Source: (White & Engelen, 1994)

Rules of transition could be a combination of commands of qualitative and quantitative character. Models of CA have the advantage that they can provide a detail study of changes in a land use at the same time at all territorial levels and in various time scales. Additionally, CA obeys in three general rules. The first one is known as "rule of parallelism" and it means that changes in land use of each cell are dependent one to each other. The second rule is well known as "rule of homogeneity" and it means that cells are changing their status base on common rules of transition. Finally, the third rule calls "rule of locality" concerns the new land use that is occupied by cells. According to that law the new land use of a cell based on the old land use of that cell and the uses of the closest neighboring cells, there is observed phenomenon called "neighborhood effect" and reflects the attraction and repulsion forces of land uses which exist in side a specific territory (White and Engelen, 1994).

1.2.12 Special issues about the analysis of land use

In recent years the range of spatial and temporal scales at which ecological problems are posed has expanded dramatically, and the need to consider scale in ecological analyses has often been noted (Allen and Starr, 1982; Delcourt et al. 1983; Addicott et al. 1987; Morris, 1987). Processes and parameters important at one scale are frequently not important and usually information is often lost as spatial data, which are considered at coarser scales of resolution (Henderson-Sellers et al. 1985). Additionally, ecological problems often require the extrapolation of fine scale measurements for the analysis of broad-scale phenomena. Therefore, the development of methods that will preserve information across scales or quantify the loss of information with changing scales has become a critical task.

1.2.13 Scale

We can define scale as the spatial, temporal, quantitative or analytical dimension used by scientists to measure and study objects and processes (Gibson et al. 1998).

The meaning of scale is crucial and concerns:

- The spatial resolution, which adopts quantitate exemplary and the area of spatial extent.
- Temporal resolution or time step as the time duration of the exemplary.
- The unit analysis, which associated with the human decision-making resolution and the level of social organization that covers the exemplary (Agarwal et al. 2005).

Scale is an essential concept in both natural and social sciences, and has been defined in several ways (Gibson et al. 1998; Marceau, 1999; Jenerette and Wu, 2000). In landscape ecology, scale refers primarily to resolution and extent in space or/and time. Scale can be distinguished in absolute (measured in spatial or time units) or relative (denoted as a ratio). Dealing with scale in ecological research and applications, there are three major spots that need to be clarified and pointed out. An important matter is the size of affection of the results including their interpretation, usually in case of changing the scale. Much work has been done in this area either in the name of "scale effects" where scale can be extent in space or time (Jelinski and Wu, 1996; Marceau, 1999). However, due to improper use of analysis methods sometimes there is possibility of the fact that it is not always clear whether the effect of changing scale is an indication of the scale multiplicity of ecological systems. Additionally, models and procedures for extrapolating information across scales need to be developed for understanding and managing heterogeneous landscapes. Although simple "scaling laws" do exist in ecology and visualize information over a wide range of scales may often require a hierarchical approach (Wu, 1999).

1.2.14 Spatial data analysis

Spatial data location attributes are expressed by means of the geometric features of points, lines or polygons in a plane. This spatial referencing of observations is also the extension feature of a GIS, as a tool for the analysis of spatial data. The significance of location for spatial data, both in an absolute sense (coordinates) and in a relative sense (spatial arrangement, distance) has major implications for the way in which they should be treated in statistical analysis, as discussed in detail by Anselin (Anselin, 1990a). Indeed, location gives rise to two classes, which are called spatial effects: a) spatial dependence and b) spatial heterogeneity. The first one sometimes refers to a spatial association (Tobler's, 1979). Cressie, recently suggested a useful taxonomy for spatial data analysis. He distinguishes and determines between three broad classes of spatial data and identifies a set of specialized techniques for each. Cressie's taxonomy consists of lattice data (discrete variation over space, with observations associated with regular or irregular areal units), geo-statistical data, and point patterns; occurrences of events at locations in space (Cressie, 1991).

1.3 Next possibilities in landscape change analysis tools

As human population gradually increases in some countries over the world, pressure of humans on landscape continues to be more and more intense, in order to cover its daily greater demands for natural resources, but which are at the same time strongly associated with problems concerning the water quality, wildlife habitat, and ecosystem biological processes. Nowadays, scientists apply integrating concepts derived from landscape ecology, hydrologic sciences and other sciences as well together with the wide use of algorithms in order to promote sustainability through support of local regional and trans-boundary decision-making and planning now and in the future, by the use of models and as well as by the application of Policies, Plans and Programs (PPPs) of all levels (Sadler and Verheem, 1996). In this direction, characteristics the wide use of technology mainly of the electronic computers devices and software in combination with various mathematical models and theories, to better understanding of landscape change and to assist in decision-making and support. Some of these tools are going to be submitted and analyzed below.

1.3.1 Assessing landscape changes and dynamics using patch analysis and GIS modeling

In Germany for instance, the concept of landscape change analysis is not something new, but it has been developed through different geographical research, which indicates that it has been a scientific object of study for a long time with a relatively significant historical background. Historic Geographical Land Survey by Denecke comes to confirm the above assertion (Denecke, 1972). Particular knowledge of historical landscape conditions and of landscape change over time could facilitate and furthermore improve predictions about the current and future state of the landscape (Marcucci, 2000). Process and analyses of cultural landscapes demand operation with the help of GIS in order to assess and successfully manage the huge source of attribute data information, which are stored in digital form.

The conceptual model for the GIS is, therefore, determined by land-register data. Cadastral landscape models and geodetic survey maps provide information of different types of land use, information about the ownership status and plenty of other attributes as well. Thus, using older land plot records can form such a database; therefore, incorporation of additional information to the current data can enrich the availability and accessibility of such an important geo-database for better decision-making. Nevertheless, in a diachronic comparison and in specifications of the land-register data, the terminology for the basic category "type of use" needs to be adapted, for the reason it may sometimes vary and change over the time (Ziegler, 1987).

In order to determine the extent of landscape changes, land use categories must be actively plan mattered. This visual representation of data, processed through GIS in form of thematic maps, offers a better and simpler interpretation and allocation of the data in geographical space, because this geo-relational approach permits an assessment of development trends (Krettinger et al. 2001).

1.3.2 ES4LUCC: A GIS-tool for remotely monitoring landscape dynamics

ES4LUCC is semi-automatic software for change detection and classification of LULC. The tool is based on image processing techniques applied on multi-temporal remotely sensed spectral and surface model data. Synergies of RS and GIS have been demonstrated to be very powerful tools enabling a wide range of users to easily deal with complex multi-task environmental monitoring issues (Shalaby and Tateishi, 2007). Expert systems based on a priori knowledge through predefined rules with multiple data sets and management options represent valuable alternatives to cope with the afore mentioned problems and to model landscape (Aitkenhead and Alders, 2011). The performances of ES4LUCC largely depend on the quality of the input files. Future developments of ES4LUCC should focus on implementing more automatic and flexible training procedures to allow an easier applicability of the proposed method. Recent advances in sensor technology and planned future satellite missions (e.g., GeoEye, OrbView, Hyper- ion, ICESat, DESDynI) provide increasing RS datasets, represent new opportunities for detailed land cover mapping and are then potentially useful input sources for ES4LUCC (Forzieri and Catani, 2011).

1.3.3 LUCAS (LUcifer Cellular Automata Simulator)

LUcifer Cellular Automata Simulator (LUCAS) is software developed within the framework of the Lucifer project. The main purpose of this program is to simulate and to predict spatial changes by means of cellular automata (CA) models; lumped models described by a set of differential equations or a few models, which combine the two approaches. Even if LUCAS is a general package, in this section we focus our attention on the situation where an extended GAP model describes the local dynamics and the distributed dynamics is governed by dispersal CA rules. These two models can be automatically generated in this program (Shugart, 1984).

1.3.4 Landscape metrics

Landscape metrics have been used to compare ecological quality across landscapes, scales and to track changes in landscape pattern through time (Henebry and Goodin, 2002). The landscape structural approach has been influenced and supported by tools, methods and concepts from geographical information science and digital image analysis. Nowadays, the toolbox of ‘landscape metrics’ with a huge variety provides a set of tools available for the quantitative spatial analysis of landscape structure. Since the development of landscape metrics in the 1980s and 1990s, in which conceptual considerations were of primary concern (Blaschke, 2000; Gustafson, 1998; O'Neill et al. 1988), today the approach is established in various workflows and utilized in decision-making and planning by describing and evaluating patterns, aiming to explain the processes that occur (Botequilha Leitão and Ahern, 2002).

On the landscape level, we have landscape aggregated metrics and landscape-specific ones. The latter comprise measures for assessing the overall spatial distribution of patches, either spatially implicit. Statistically, many metrics are correlated and there have been attempts to de-correlate them and identify factors through e.g. principal component analysis (Lausch and Herzog, 2002; Riitters et al. 1995; Walz, 2001).

Today, because of the widespread recognition that landscape is a dynamic entity, one of greatest challenge is to confront landscape pattern analysis by quantifying temporal variations in landscape pattern metrics (Cushman and McGarigal, 2008). Landscape metrics or spatial metrics are one of the key factors of modern landscape planning and ecological research (Uuemaa et al. 2009). The spatial metrics, which have been used to quantify spatial patterning of land cover (LC) patches and LC classes of the study area, can be defined as quantitative and aggregate measurements showing spatial heterogeneity at a specific scale and resolution (Herold et al. 2003). Spatial metrics, apart from their capability to describe and evaluate the spatial arrangement of the LC types, are also able to estimate the composition in a landscape. When applying spatial metrics, the spatial unit used is called patch, defined as a relatively homogeneous area that differs from its surroundings (Forman, 1995). The approach pursued combines (RS) and landscape metrics to understand spatial-temporal patterns of LC, like urban-rural gradient analysis (Luck and Wu, 2002).

1.4 Tools of the sustainable development

The United Nations Conference on the Environment in Stockholm in 1972 and subsequent conventions formalized environmental impact assessment (EIA). At present, all developed countries have environmental laws whereas most of the developing countries are still adopting it (Lee, 1995). EIA and Strategic environmental assessment (SEA) are structured approaches for evaluating and obtaining environmental information prior to its use in decision-making in the development process (UNEP, 2004).

EIA is a process to improve decision-making, in other words we can say that is an assessment of possible impacts that a proposed project may have on the environment to ensure that the development options under consideration are environmental friendly and socially sustainable (Donelly et al. 1998). It is important to understand and recognize that EIA intention is not only to ensure legal compliance, but more significantly, is to make sure that infrastructure development projects are approved with sustainable development principles. While SEA is used exclusively for assessments of policies, plans and programs and term "environmental assessment" is used for assessments of specific projects (Sadler and Verheem, 1996). Over the years, many forms of SEA have been founded mostly on project's EIA based approaches, others on policy science and decision-making systems or on spatial planning approaches (Dalal et al. 1998). Environment conservation was the beginning for enhancing alternative tools that eventually would compete with SEA. Unfortunately, even nowadays there is limited understanding of the term "environment" and what's the meaning really hiding behind this word, when associated only to earth issues, integrated impact assessment (UNEP, 2005; UNEP, 2009) as well as sustainability assessments (Pope et al. 2004) have evolved as instruments that aim to ensure the inter-linkages between the social, physical-ecological and economic systems. EIA and SEA, as integrated assessments nowadays, are currently used at any scale worldwide at the level of policy project analysis as major decision-making tools. Additionally, EIA should definitely not be replaced by SEA, because there are mutual interconnections between them and also due to the fact that EIA will benefit by having a better context for improved performance if SEA is in place.

1.4.1 Historical review of the construction of a dam

The remote history of dams is not well known, since most dates of events earlier than 1000 B.C. can be only estimated. Ancient Egypt engineers managed to construct in 2950-2750 B.C. the first known dam to exist so far. The ruins of ancient works in parts of Asia like India and Sri Lanka offer some proves of how water reservoirs were created by people in ancient years (Jansen, 1980). A common used method of construction, which were used by ancient people, involved the placement of earth barriers across streams construction of dams started as far as 3,000 years ago in the fertile Crescent (WCD, 2000), with the primary objective of serving as water storages, but for another important reason as well, such as controlling floods, irrigating croplands, and also allowing navigation though the rivers. Since the industrial revolution, humans were able to start experiment and construct even larger dams usually to obtain energy for primary purposes. Until recently, large dams were considered as a milestone on the development plans of nations and they were often viewed as a symbol of modernity and economic progress (McCormack, 2001).

China is another example of a country which has a long history of hydraulic technology projects and which can be traced back to 598 B.C., when Qebei dam was built in Anhui Province. Also the famous Dujiangyan Dam and its innovative irrigation system were built three centuries later, around 256 B.C. and it is quite remarkable that it has been still operating until nowadays (Fuggle and Smith, 2000).

However, according to relatively recent studies from many places around the world, there were recorded significant effects from such a constructions, both on the environment and society. In addition to the increasing uncertainties about their economic viability and adverse environmental impacts, some developed countries such as France, United States and others as well, were forced to interrupt their construction and even to start their demolition in some areas (WCD, 2000; McCormack, 2001).

1.4.2 Feasibility of dam construction

Worldwide, by the year 2000, over 45,000 large dams have been constructed, generated 19% of the world's electricity supply, while irrigated over 30% of the 271 million hectares irrigated worldwide. The view, which prevails nowadays concerning the possibility of large dam constructions, to increase hydroelectricity production, irrigation of large agriculture areas and water quality, could result development. Therefore, has led developing countries to adopt this ideology and to start investing in dam constructions. However, these dams also displaced over 40 million people, altered cropping patterns, and significantly increased salination and waterlogging of arable land (World Commission on Dams, 2000a). Dams provide a particularly good chance to study the potential disjunction between the distributional and productivity implications of a public policy. On the other hand however, a serious drawback arise with those who live downstream from a dam stand to benefit, while those who live upstream from a dam stand to lose. There are plenty of views, which are trying to approach this conflict by giving a satisfactory solution. Some people believe that one way is to try to compensate the upstream citizens, while others argue though that despite the fact that downstream populations may favor by these benefits, the increased economic activity around the reservoir, should also favor the upstream populations. Definitely it is a controversial topic, which demands intensive research to be completely answered. It has been mentioned by McCully that they potentially suffer by large losses without compensation; flooding reduces agricultural and forestland, increased salinity and water logging reduces the productivity of land in the vicinity of the reservoir as a result of succession (McCully, 2001).

Low river gradient areas are most suitable for irrigation dams, while very steep river gradient areas are suitable for hydroelectric dams. Regions, where the river gradient is somehow steep, are the least likely to receive dams.

US Department of Agriculture states, “dam canals should be designed to develop velocities, which are non-erosive for the soil materials through which the canal passes”, (US Department of Agriculture, 1971). In contrast, slower water velocities with higher river gradient in the river channel can lead finally to a total reduction of the cost of producing hydroelectricity (Warnick, 1984). To quote Cech dams for hydroelectric power generation should be located at a site where the deference in elevations between the surface of the new reservoir so that the outlet to the downstream river is adequate to power electrical-generating turbines. Moreover, dams for irrigation purpose are generally constructed at a high elevation so to be able to deliver irrigation water to cropland entirely by the force of gravity (Cech, 2003).

1.4.3 Types of the dams

The most common classification of operational characteristics divides dams into two basic groups:

- Storage
- Run of river

For example, a storage dam typically has a large hydraulic head and storage volume, long hydraulic residence time and control over the rate at which water is released from the impoundment. By contrast, a run of river dam usually has a small hydraulic head and storage volume, short residence time, and little or no control over the water-release rate (EPA, 2001).

1.4.4 Life-span of storage dams

Dams are hydraulic structures that generally serve the primary purpose of retaining water in order to meet basic daily needs. Designed by humans to modify the magnitude and timing of its movement downstream. Moreover, dams have a finite life span and so dam age is a crucial factor affecting removal decisions. Two of the major factors influencing the aging process are:

- The deterioration of construction materials increasing time to time.
- The accumulation of sediment within the dam's impoundment.

Of course, continuous maintenance could be substantially increasing the life span of the dam, but on the other hand this is associated with high costs. For example, the cost of repairing a small dam can be as much as three times greater than the cost of removing it (Born et al. 1998).

Sediment capture of dams is often limiting factor of a dam's functionality, by reducing reservoir storage ability and capacity. Nowadays, the importance of sedimentation is widely well known recognized, but sedimentation rates were not consistently taking into account as criteria for a dam design until the 1960s and many dams are expected to fill in with sediment at rates exceeding design expectations (Morris and Fan, 1998).

1.4.5 Role of the EIA and SEA in decision-making process

EIA is simply a decision tool created with a specific purpose, to identify and evaluate the possible environmental impacts and consequences of a certain proposed infrastructure in order to facilitate decision-making. Furthermore, EIA governed under certain sustainable development limitations and effectiveness, but still it has the potential ability to promote sustainable development in multiple ways and that's the reason this tool is functional (Cashmore et al. 2004). Additionally, it has the capacity potential to support the development of policy and above all, it can play a fundamental role in promoting sustainable principles helping to implement sustainable development (Fischer, 1999; Partidário, 2000). The SEA framework has the potential to permit the principles and practices of sustainability to be carried down from the policies to individual projects if the following conditions are met (Partidário, 1999). More recently, Sadler spoke about the shortcomings of EIA and SEA, as a new framework for assessing and evaluating the sustainability of development trends and proposals was developed (Sadler, 1999).

The increasing complexity in a global scale proved that EIA was unable to respond to sustainability and decision-making. Therefore, most of the scientists are convinced that something is missing, a supplement tool perhaps. While, later on determined the need for SEA in its early days (Lee and Walsh, 1992; Wood and Djeddour, 1992). The reasons are various and can be summarized as:

- The nature of decisions: often its incremental nature, through small and iterative decisions that challenge systematic processes, was seen as a significant constraint to the operation of a pragmatic and a new impact assessment tool, more strategic.
- The level of information: at the policy and planning level often there are important limitations in the availability of information. This impeded the satisfaction of project EIA needs in terms of required detailed levels of information.
- The timing of decisions, which is established at a stage when it is too late to consider the effects of policy and planning critical decisions;

Under these circumstances, SEA must definitely play a key role to the kind of decision-making process in place (Partidário, 1998). Different levels within strategic decision-making and integration of environmental concerns should take place at all levels.

1.4.6 Interaction and linkage between EIA and SEA

According to UNEP, EIA and SEA are two processes that move toward the same goal, demonstrate the same level of significance of informing decision-makers and produce the same effect, which is the promotion of sustainable development with just only minimal differences concerning the different level of decision-making they are providing separately (UNEP, 2002). However, the relationship between them is not straightforward. The common understanding is that SEA relates to environmental assessment for "initiatives other than projects" (Annendale et al. 2001). Two major views on SEA related to the tie ring concept can be seen:

- First of all, SEA is considered as a simple extension of the EIA project and
- Second, works as a mean for policy development and an instrument for 'trickling down' sustainability ideas (Annendale et al. 2001).

The following figure correlates the interaction between EIA and SEA concerning programs, plans and policies.

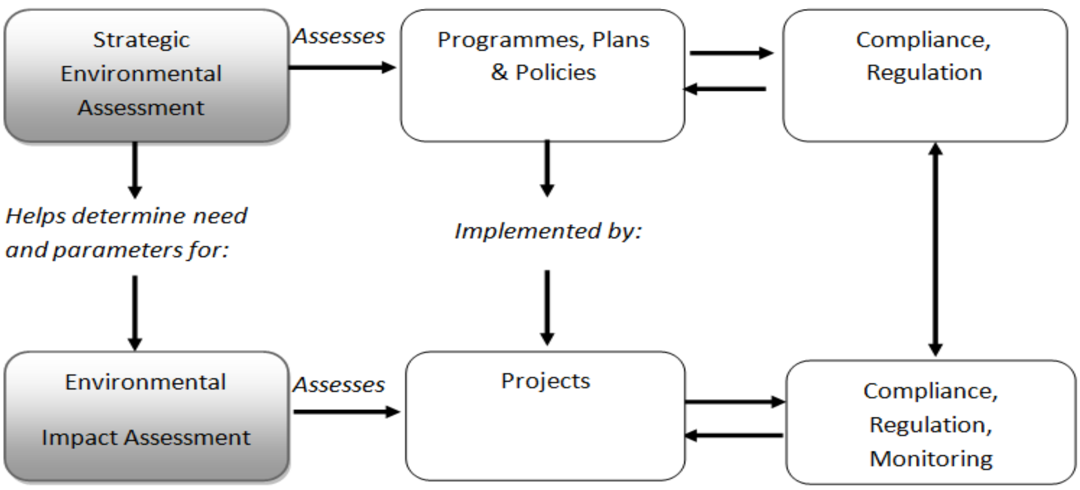


Figure 3. Interaction between EIA and SEA

Source: (De Groot Rudolf et al. 2006, Ramsar Technical Report No. 3)

1.4.7 Advantages and disadvantages of Cost Benefit Analysis (CBA)

Among the tools of the economic trade, cost-benefit analysis (CBA) is one of the major concepts of economy science with great significance and that is why considered being the most widely used in policy circles. CBA can be beneficial, but on the other hand it can lead to adverse impacts as well in case of improper handle. The problem mainly lies in the fact that, management of water resources, comprising their services, belongs in nonmarket values. Therefore, climate change is just one version of negative externalities globally with no market prices (Chichilnisky, 1996b). Simple rule says that when the number for costs is larger than the number for benefits, then the project is turned down. But it also creates a few legitimate questions: a) where do these prices come from? b) How much do they influence the outcome of the cost-benefit analysis? c) How reliable are they in fact? The answer is that prices usually come from markets and depend on their fluctuations and inflation. Inflation occurs when market basket of goods and services gets more expensive. How to price their services? Actually there is no clear and straight answer in such a complex issue, because we definitely cannot use market prices, for the simple reason that water is not traded in markets. The issue is actually very delicate because an error in prices can completely change the results: It is even likely, that a project can turn from positive to negative at once when the wrong prices are applied. International markets in resources do not improve the problem; they can make it worse (Chichilnisky, 1994). Problems usually emerge in case of projects spanning a long period of time, such as construction of dams. Developing strict economic tools, updates cost-benefit analysis, so it reflects a fair treatment for the present and the future. This is so called sustainable cost-benefit analysis (Chichilnisky, 1996a). The example of global warming illustrates the weaknesses of cost-benefit analysis for dealing with global problems in the best way.

1.4.8 Effect of a dam construction on spatial-temporal change of land use

LULC play a pivotal role in environmental and ecological changes, therefore they affect human survival (Bloomfield and Pearson, 2000). Changes of land use pattern are basic for LULC (Veldkamp and Lambin, 2001). Although the social benefits gained from dams are huge, there always exists a risk, particularly in the downstream, that needs to be addressed for public safety. On the other hand there is a group of people who consider (and prove by using mighty arguments) that dam construction nowadays lies in a phase where risks from such a constructional most don't exist anymore. However, there are still studies demonstrating through their researches that failures related to extreme hydrologic events still exist (Saxena, 2005). Hydropower development is the most sensitive influence of human social activities on LULC. This brings the chain reaction like the forestland area reduction and the agriculture land area unceasing increase. Due to reduced risk of floods, the downstream areas of dams become safer places to settle and expand development, hence accelerating "urban sprawl" (Seto et al. 2011). Such a change leads to a detectable change in the surface properties of urban areas by increasing its roughness as compared to the prior undeveloped area (Shepherd, 2005). Furthermore, artificial reservoirs have some serious direct influences on the surrounding ecosystem; one main impact relies on the phenomenon of open water evaporation modifying the microclimate of the locality, which additionally causes enhancement of moisture supply, which manifests itself in the form of precipitation. Recently, there have appeared other studies reporting that the origins of heavy precipitation have traced through the tracking of evaporated moisture (Kunstmann and Knoche, 2011). Therefore, we can count numerous reasons, which are responsible for changes in landscape structure and which take their place continuously after the post-dam era.

Various modeling approaches in the past have been implemented to investigate the effect of LULC changes. For instance, regional models like Regional Atmospheric Modeling System (RAMS) have been used to model the effect of land use heterogeneities on the local climate, vegetation and stream flows in and near the impact areas (Schneider et al. 2004). In conclusion we can claim that people understand the impact of the local-regional LULC change scenarios, but their effects on climate implications are not understood very well so far.

1.5 Driving forces and linkage socio-economic factors, land cover and its changes

LULC changes mainly caused by human activities and natural ecological processes and therefore researchers require an interdisciplinary approach (Petit and Lambin, 2002). To be able to understand the long-term changes, human environment interactions first need to be analyzed, based on the reconstruction of past LULC changes (Ramankutty and Foley, 1999). Nevertheless, some main problems emerge in analyzing socio-economic and environmental factors are that of the differences in spatial resolution (Irwin and Geoghegan, 2001; Van der Veen and Otter, 2001). Most of the socio-economic data available in public statistics are measured at a broad scale. While on the other hand, land cover and environmental data, are available only at small scales. Global environmental changes include nature society interactions, the search for natural resources to an adequate nutrition, population growth, connections between land use and climatic change and many other pressing issues (Turner II et al. 1990). The growth of a place and the development of its economic or political power depended in a large extent on its geographical situation and its accessibility (Taaffe et al. 1996).

Analyzing changes in cultural landscapes require considering, and if possible quantifying, the human impact (Dale et al. 2000; Riera et al. 2001). In some regions, land use changes appear to be closely related to the physical attributes of the landscape (Pan et al. 1990; Paquette and Domon, 1997), in other regions patterns appear to be poorly correlated with such characteristics and the connection between landscape patterns and environmental conditions may be weakened if human activities remove or reduce some of the constraints set by the abiotic template (Iverson, 1988).

European landscapes are increasingly threatened by an intensity of agricultural activities mainly and secondly by forestry (Stoate et al. 2001), as well as urban development, tourism, and plenty of other uncontrolled recreational purposes. For better understanding landscape changes required knowledge of the processes and mechanisms that can cause them. Three main driving forces can be recognized: (1) accessibility related to transportation mode and infrastructure; (2) urbanization and (3) globalization. It is crucial though, for the scientists, trying to pay more attention, when examine the landscape history, because through this way, the past can reveal and explain current ecological structure and functions of landscape, based on land cover as a condition for developing sustainable landscape management systems (Thomson et al. 1998).

1.5.1 Conceptual framework between the growth of population and LULC

Without any doubt the twentieth century can be characterized as a time period when mankind has been facing a series of important problems such as the uncontrolled population growth rate, especially in some areas of the world with all the ripple effects that this implies. On the one is the economic fluctuation and from the other environmental change scenarios with respect to the global warming. A human population growth influences long-term pattern of land use, which is considered as one of the major driving force behind environmental, changes globally (Jolly and Torrey, 1993). Hence aggregate-level studies all over the world have generated important insights, like the one, which says that population size or population growth, is not enough, because changes in population structure (e.g., age) are also important to the understanding of land use and environmental changes (Moran et al. 1994; Geoghegan et al. 2001; Perz, 2001; Fox et al. 2003). Population and environment are both closely related and interconnected in a complex and dynamic manner where this relationship is mediated by number of socioeconomic, cultural, political, and developmental aspects whose role varies considerably). Another approach is based on the idea that population affects the environment mainly through changes in land use and industrial metabolism. It becomes clear that to be able to understand these processes concerning environmental change, developing countries primarily, we should be able to analyze land use changes and the factors underlying those (Richards, 1986).

Land cover indicates the physical land type such as forest for instance while land use states how people are using the land. Moreover, land cover comprise subject of study and research for social scientists while land use for environmental scientists. Together they are proximate sources of natural environmental change that may ultimately feedback the land use affect, usually guiding under the human influence as main driving forces (Turner and Meyer, 1991).

1.5.2 Impacts of human activity on landscapes by analysis of spatial structure

GIS and environmental modeling together, provide a useful and yet practical way of describing landscapes both temporally and spatially. They are also proved to be particularly significant for understanding changing pattern in landscapes all over the world. To better comprehend changes in diversity and spatial heterogeneity in the landscape, series of measures of landscape pattern and diversity have been devised. A comprehensive review of some of these indices can be seen in the work of Haines (Haines et al. 1996). Most of these measures are based on patch theory, using three basic landscape features - patches, matrix and corridors (Forman, 1995), in order to set some pattern of land classification. Many of these indicators are now available and often contained within software packages which are fully integrated with GIS such as V-LATE or FRAGSTATS*Arc (Innovative GIS Solutions Inc. 1999) and Patch Analyst (Elkie et al. 1999). Since traditional approaches to landscape ecology have tended to be based on the identification of patch-matrix corridor features (Forman and Godron, 1981), this means, that the landscape is partitioned into homogeneous units with distinct boundaries.

1.5.3 The role of land abandonment in landscape dynamics

It is widely acceptable nowadays that there are no landscapes, which can remain static and unchanged through time. Land use has changed dramatically over the last 30–40 years with various proportions, since these changes vary in space and time. Much of these changes have been driven by shifts in agricultural and socio-economic policy. In fact, these changes are quite significant as drivers of ecological processes, including biodiversity issues as well. The acquiring knowledge on landscape changes and factors of such changes is an important question for the understanding and the management of our environment (Baudry and Tatoni, 1993).

From the majority of scientist, there is general agreement, which claims that agricultural intensification produces land degradation, by reducing the quantity and deteriorates the quality of the services and functions, that ecosystems provide to humankind (Weiss and Fox, 2003), declining populations of particular species (Gregory et al. 2005) and increased erosion (Hendrickson, 2003; Maertens et al. 2006). However, the abandonment of agriculture land has not only negative but positive consequences as well. The effects of these changes are usually externalized having a greater impact on society than on the farms on which they take place (Stoate et al. 2001). Agricultural land represents open spaces under secondary succession that are colonized by pioneer vegetation if abandoned. When abandonment is simultaneous for large extensions of farmland, it leads to vegetation homogenization (Lasanta Martineza et al. 2005) and a reduction in landscape heterogeneity, while reduced landscape heterogeneity increases the spread of disturbances (Loret and Mari, 2001).

1.5.4 The concept of traditional landscapes as a base for landscape evaluation and planning

In Flanders at 1985, it was first given the idea of what a traditional landscape is, aiming to actualize the classical horology of the geographical regions. Geographical regions in plenty of countries had been already mapped on small scales such a traditional areas in order to give a general framework of the territorial diversity (Brulard et al. 1969). Unfortunately, in general most of the traditional rural landscapes suffered in the past due to the increased urbanization phenomena and dense road infrastructure development. Because of the continuous human pressure upon the rural land, in correlation with the structural disruption, which undergoes an incentive given to the necessity of mapping the characteristics of the traditional landscapes, many places or elements in the landscape received a symbolic value, which was later called traditional landscape (Antrop, 1997). In particular, it contains the complex history of a region, which still can be read and set so from its unique structure and composition.

2. AIM OF WORK

2.1 Vision of diploma thesis

The vision of my diploma thesis mainly focuses on providing a significant level of information which could affect the current and future decisions-making, from the ecological point of view, concerning the possibility of such a hydraulic construction to take place in 20 to 30 years from now in Kočov region in the Czech Republic. By taking into account the outputs of this study research in Greece, which concerns the long-term dynamics that forced landscape structure to change during a time period of over 50 years, we are hoping in more detail re-evaluation of the criteria, which initially comprises the necessities of people to cover their future needs, in both local and larger scale. However, in order to succeed, it is also crucial to understand the nature of landscape in broad terms, in order to upgrade the living standards of people with the less ecological impacts.

2.2 Purpose of diploma thesis

This study focuses on to evaluate landscape structure changes, due to the realization of important hydrological facilities, and more specifically to:

- To evaluate those landscape structure changes.
- Analyze landscape changes in the microstructure during the monitoring period.
- Compare the development of landscape characteristics in both areas during the reporting time period.
- Provide information for further decision-making, concerning the possibility and probability of future important hydrological facility construction in Kočov region in the Czech Republic.
- Evaluate the level of nature and human impact on the landscape as a driving force.

2.3 Design of the research

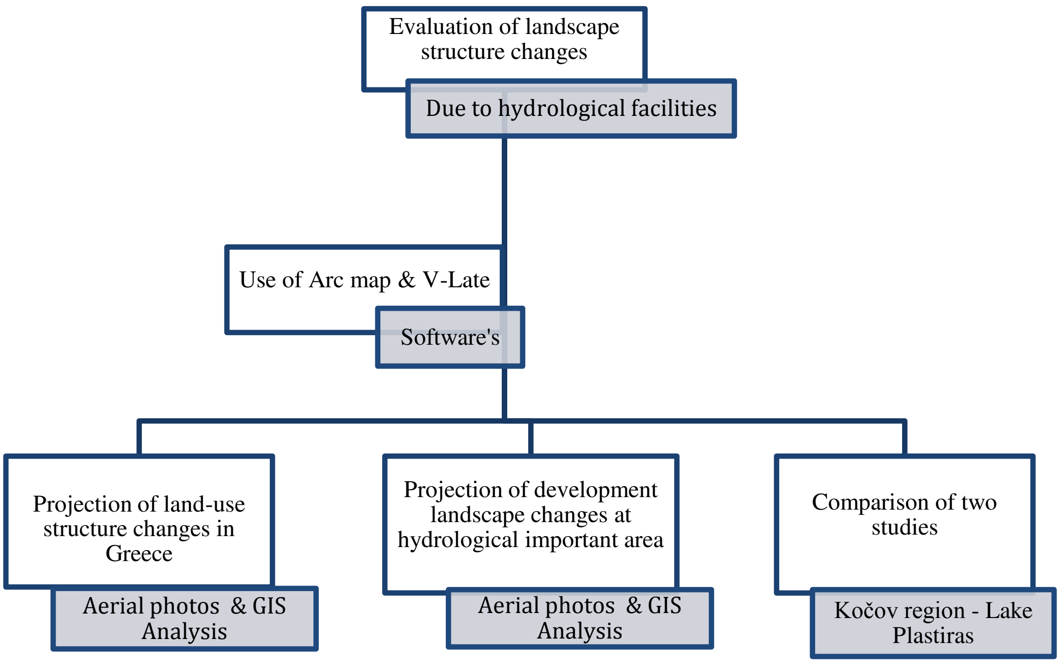


Figure 3. Chart of research

3. CHARACTERISTICS OF THE STUDY AREA

The area examined in the study is the Plastiras artificial reservoir and its surroundings, built in central Greece toward the end of the 1950s. The lake is 30 kilometers from the city of Karditsa. The reservoir has a total capacity of 40,000,000 m^3, while its stage ranges from +776 to +792 m and maximum depth 60m. The total draining area is 161.3 km^2, where 24.7 km^2 is the maximum area captured by the lake. The mean annual runoff during 1960–2009 is 160.4 hm^3. The average annual temperature is 16-17^oC. The average annual rain height is 700 mm, ranging from 400–600 mm at the central plains to 600–1,000 mm on the eastern parts, and to over 1,200 mm on the mountains. Rain frequency is 100–130 days per year. The total precipitation is 10,426 hm^3/year and the mean annual relative humidity is 67–72%. Snowfall is very frequent in the mountains. When the level of the lake drops, a piece of land is revealed between the trees and the water, and this affects the unity of the landscape. Concerning the geology transformations, thin layers of limestone in a ratio of 23% are composing the area presenting sufficient strength and little permeability. Additionally, 61% comprises impermeable metamorphic rocks and the rest 16% granular and alluvial deposits (EL.KE.THE, 2009). At the north part of the lake, where the slopes are small, large dry areas appear; at the south, where the landscape is rugged, a yellowish brown narrow strip shows. Covering an area of 24 km^2, the surrounding is covered by natural beauty of vast forest, which consists of mixed coniferous and broadleaf species. Fauna and flora in the area appears a great variety, which depend on the altitude and the microclimate of each area. We can distinguish in the following vegetation zones:

- Up to 700 m, there are bushes with main species; Horse chestnut '*Aesculus hippocastanum',* kermes oak *'Quercus coccifera',* European ash *'Fraxinus excelsior',* Judas tree *'Cercis siliquastrum'* and from animals mainly, Red squirrel *'Sciurus vulgaris'* etc.
- From 700 up to 900 m, i.e. around the lake, spread extensive forests of mainly Italian oak '*Quercus frainetto'* and from animal's European roe deer '*Capreous capreolus'*.

- From 900 to 1600 m, forests of European beech '*Fagus sylvatica'*, Scotch pine '*Pinus sylvestris'* and animals like Wild boar '*Sus scrofa'*.

Additionally, in the area we can meet remarkable plants such as: a) '*Centaurea chrysocephala'* and b) '*Viola alba scotophylla'*.

Most of the settlements are scattered around the reservoir, each one preserving the history and natural beauty of this land. Thanks to this unique ecosystem and the incomparable beauty of the surrounding nature, the wetland was inscribed on the "Natura 2000" European Map of protected natural areas.

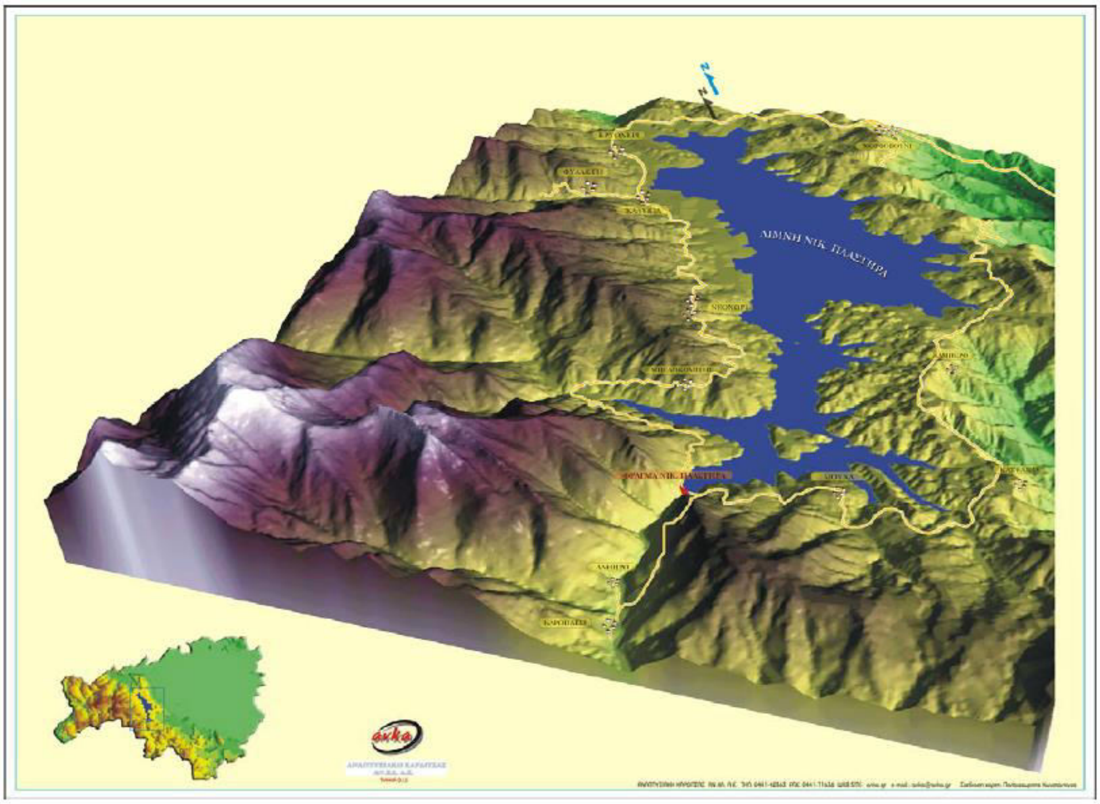


Figure 4. Digital elevation model of Lake Plastiras
Source: (Karditsa development 2002)

3.1 Delineation of localities in Greece and in the Czech Republic

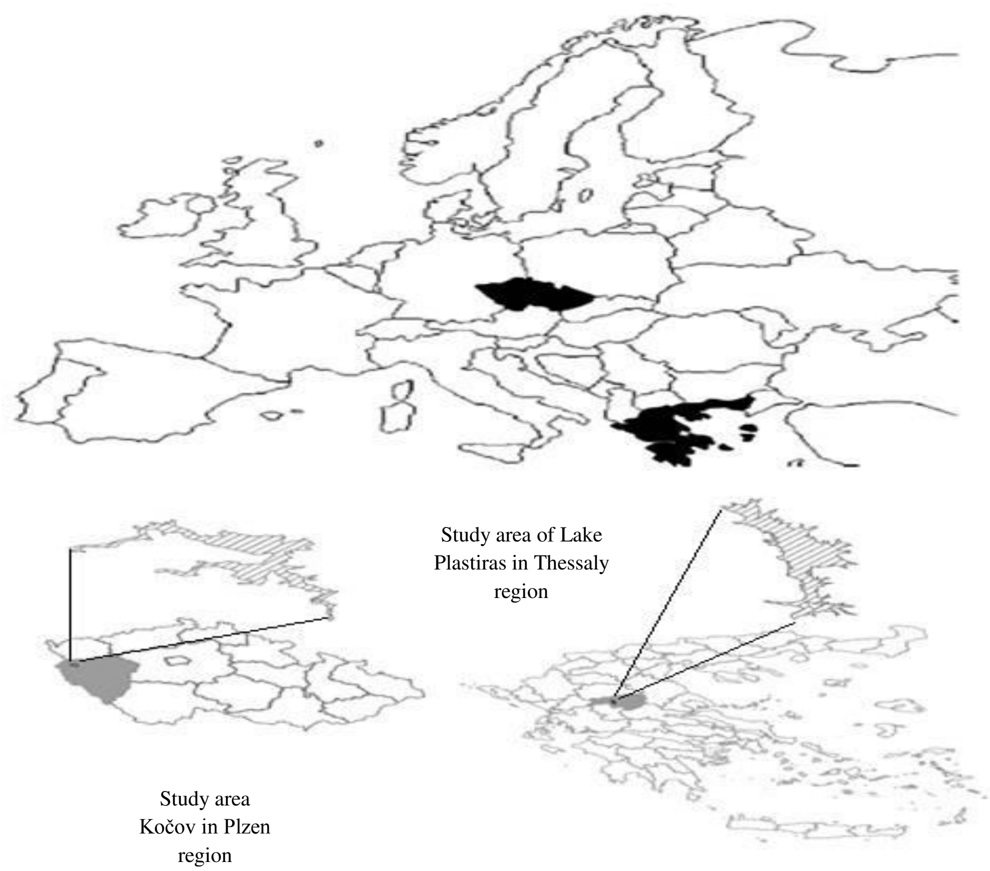


Figure 5. Location of the study area in Greece and in the Czech Republic as well as the position of the two countries in Europe

4. METHODOLOGY

4.1 Range, capacity of interest area

The use of the buffers in larger size areas, allows the detection of meaningful land cover changes at this scale, for that reason a buffer zone of 0.5 km was applied. Moreover, buffer zone was applied not only in the map of 1996 but also in 1945 aerial photo, expressing the LULC in the nowadays-flooded area. Such a kind of approach has been chosen to better compare data from different sources, dates and formats: one of the advantages is to make directly available the tables containing the spatial information of each class (area, perimeter, etc.) and the information about amount, location, and nature of change.

4.2 Data source

The analysis of land cover change plays a key role in understanding a great variety of phenomena in several research fields. Also aerial photos represent the main existent database providing evidence of landscape changes with a high detail. However, the extraction of information from aerial photos can be really harsh especially when dealing with historical photos and/or when involving areas with a complex topography. Twelve Black and white aerial photographs taken in year 1945, at a scale of 1:42,000 and 1:40,000 in year 1996 respectively. Historical aerial photographs of 1945 and positive transparency reproductions were obtained from Hellenic Mapping and Cadastral Organisation (H.E.M.C.O.), through license of the Hellenic Military Geographical Service photography coverage of Greece acquired by the U.S. Air Force in 1945. However, for military confidential reasons a few problems appeared during the data collection mainly with one additional set of aerial photos, concerning the both chronicles periods, which finally led me to exclude them from the study. Because of the limited sources detailing pre-1950s conditions and because of the poor resolution of aerial photographs, most of the comparisons between the historic landscape and year 1996 are a bit more general than the recent one. Additionally, to fulfill the objectives of the study, data from a similar research in Kočov region, have already been used and preceded in this case study, in order to be able to compare the two areas, one in Greece and other in the Czech Republic. For that reason, black and white panchromatic aerial photos from two different time periods 1950 and 2012 respectively, were analyzed and proceeded by redefining the primary buffer zone of 2 km to 0.5 km around the study area, in order to make the results comparable and more representative.

4.3 Processing the data

The process of digital change detection developed, has allowed determining and describing changes in land cover, by means of classification procedures and photo-interpretation tasks between two fundamental dates: 1945 and 1996. This work presents a semi-automated object-oriented procedure for the long-term analysis of Greek landscape, dynamics on the applications of RS on a multi land form boundary changes and land use patterns. The approach, which has been followed, is based on the following processing procedure. The 1945 and 1996 datasets of aerial photographs were first scanned and they were merged as one mosaic and geo-referenced so to project them in a GIS. This process requires a selection of ground-control points that are defined in the software with specific coordinates. To ensure highest accuracy during the process of vectorization and interpretation of aerial photographs, use of other documents were taken into account as well. All aerial photos, layers and maps produced have been projected to the national Greek grid. This local geodetic datum is using a transverse Mercator projection, which is conformal and therefore local shapes are well preserved. While, is widely used in national and international mapping systems around the world. To determine the changes in land cover in different years, the 1945 aerial photos have been compared with the 1996 ones, by means of the "Spatial Analyst Tools" of Arc-map developed by ESRI. During the process, aerial photos were converted into vector model through the process of digitizing, creating series of polylines and polygons, which were recorded parallelyin the attribute table, determining the land cover category. Subsequently, new fields, such as center of centroid area (m^2) and perimeter (m) of each facet were created and evaluated. These characteristics have been subsequently utilized for analyzes, tables, graphs and visual map outputs (layout) to better describe the shape and the area of each class feature respectively.

4.4 Typology of land cover

For the classification of land cover, aerial photo interpretation was carried out using standard photographic keys such as:

- Difference of tone
- Texture, which can be classified into:
  a. Glossy
  b. Windpipe
  c. Thin, linear
  d. Corrugated and mottled
- Pattern and correlation with the surrounding environment

- Shape and size

The texture is the result of the combination of tone, size, shape and shade of small objects. Based on these principles, we can distinguish the following categories with the specific characteristics:

- Arable land can be distinguished due to its geometrical shape; a linear organization and discrimination mainly in polygonal shapes consist of more or less similar areas. By observing differences in tone we can extract useful information concerning the field when it has been cultivated and if not, how long it is left uncultivated.
- Grassland is a category, which can be distinguished from the “soft texture”.
- Orchards present a regular arrangement of tree crops.
- Forests is a category where a lot of parameters could be evaluated, depending on the intended purpose each time and can comprise, species composition, degree of infestation, type of vegetation etc.
- Swamps appear with a characteristic spotted tone.
- Sparse tree vegetation mainly can be distinguished by evaluating the degree of canopy cover.
- Scrublands present a thin texture, which can be easier distinguished and evaluated when we observe the data in large scales and where there can be even significant differences in shadow and depth, comparing the neighboring tree vegetation cover.
- Mixture of shrubs & grasses represents a mixture of different percentages of land cover of both shrubs and grasses.
- Stream net is typical for its dark color, because water has the ability to absorb higher amount of the incident radiation from the one, which reflects.
- Water bodies in case of lakes, are characterized by its unique circular shape and the dark color that they reflect.
- A built-up territory appears uniquely corner shaped and they are also imparted with a white tone, due to the constructed material, which is usually made of cement.

- Erosion surfaces area is usually imparted with open white color.
- Finally, communication network can be recognized thanks to its linear shape, width of the planar pavement and the white color (Karteris, 2002).

4.5 Spatial analysis

Landscape metrics can be calculated for landscape as a whole or for individual soles with the same attributes. Nowadays, the toolbox of landscape metrics provides various sets of techniques for the quantitative spatial analysis of landscape structure**.** By analyzing landscape pattern characteristics, the results obtained are extremely useful for the government to optimize landscape pattern and manage land utilization in a sustainable way. Analytic tools have been used to evaluate geometric intersection, using Arc-map 10.1 software. More specifically, it allows the user to locate and quantify the temporal and spatial changes in the observed patches that have not changed over a monitoring period of over 50 years (between 1945 and 1996).

4.5.1 Monitoring of landscape microstructure

Landscape microstructure provides information about the internal structure of landscape components and interactions between them. In this study there will be characterized the properties of the surfaces of various categories of land use.

For the calculation of selected statistical indices and characteristics of the soles, V-LATE plug-in has been used. Moreover, V-LATE toolbox provides a selected set of the most common metrics to cover basic ecological and structure-related investigations. Area and perimeter were first calculated with V-LATE for each patch for every feature class, which was added to all attribute tables. Additionally, the selected class field was set to “TYPE” and all classes were further selected for analysis. They are organized according to the main aspects of structural pattern analysis and therefore employ metrics of different categories (area analysis, edge analysis and form analysis, where each of these categories contain sub categories to evaluate indices such as NP, MPS, MPE, MSI, MPAR, MFRACT etc.). In conclusion, V-LATE is an expansion tool, with many promising opportunities, which is fully compatible with the latest versions of Arc-map 10.1 & 10.2 designed by ESRI; this module was developed within the SPIN project at the University of Salzburg in Geo-informatics Center (V-LATE 2004).

4.5.2 Landscape metrics in order to quantify landscape structure

Number of Patches (NP) are mosaic elements usually of polygon shape, which make up a landscape according to the analysis of fragmentation and a measure of fragmentation of a given class within a landscape since the landscape size is constant. Total NP specifies the number of facets that each category shows in the study area. This characteristic actually has a significant importance for landscape ecology, expressed by the possibility of organisms that live in as specific type of land cover, to move in the landscape (Balej, 2006; Romportl and Chuman, 2009).

Average size of the patches (MPS - Mean Patch Size) for arable land partially affects the level of intensity utilization and fragmentation of natural habitats (Romportl and Chuman, 2009). However, it is the most valuable piece of information, which comprises a landscape mosaic. When the value of MPS is small and NP is high respectively, it can indicate a fragmented landscape (Botequilha Leitão and Ahern, 2002).

Index average length of the edges of each class of land use (MPE - Mean Patch Edge) is expressed in meters (m) (Balej, 2006).

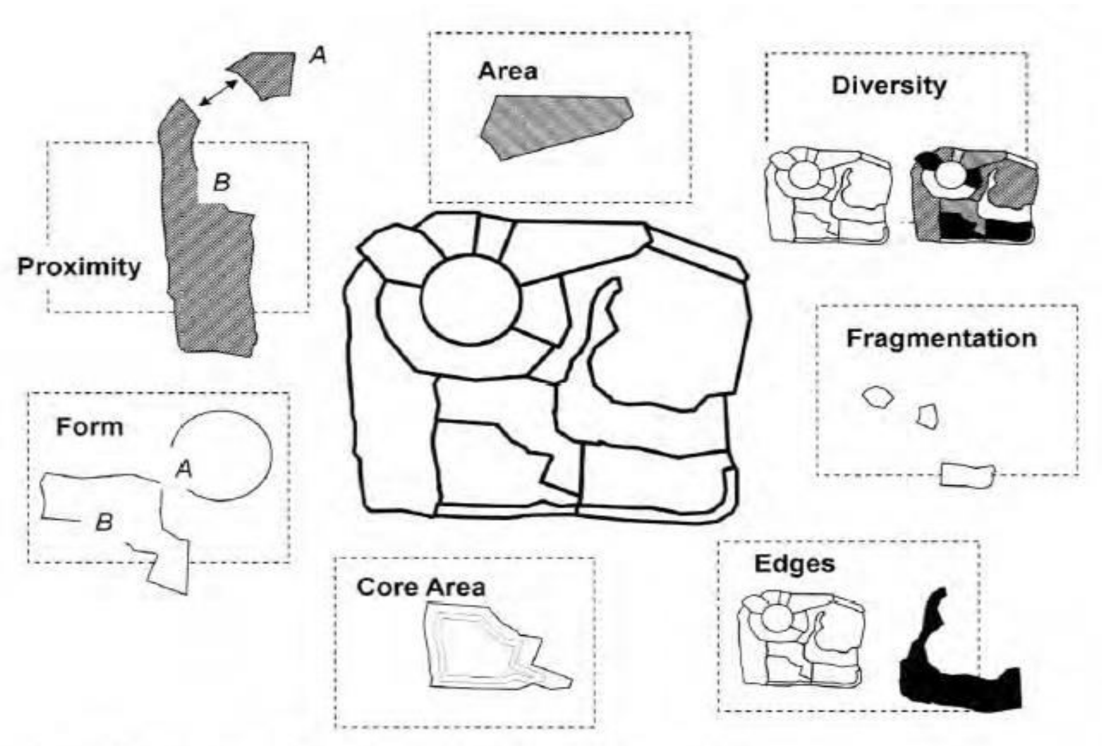


Figure 6. Facets of landscape structure analysis

Source: Land & Blaschke, 2007, (modified)

4.5.3 Statistical Indexes

Landscape metrics are numerous and exist at a patch, class and last in the landscape level. Usually, at the level of landscape and class, some of the metrics specifically evaluate the landscape composition while others quantify the landscape configuration. The use of structural indicators, which are based on landscape metrics, can provide a researcher a series of information concerning the shape, size and neighborhood relations (Lang and Klug, 2006). Speaking in mathematical terms, they do simply express the arrangement and configuration of landscape elements in a specific area, while characterizing different spatial properties of landscape units by using basic statistical values (mean, standard deviation, etc.)

Evaluation of shape complexity (MSI - Mean Shape Index) is based on the ratio of the total girth and area of facets for each category (classes). MSI is taking the value one when all patches are circular and increases as the patches become more irregular.

Index of average ratio perimeter - area (MPAR - Mean Perimeter -Area Ratio) reflects small facets in the landscape and also provides information about the shape complexity soles.

The average fractal dimension soles (MFRACT - Mean Patch Fractal Dimension) allow describing the average shape complexity soles. The index value is close to one if the surface is a simple circuit with a close circle or square. While we get closer to two, the boundary shapes are getting more complex, e.g. elongated and irregular, like communication networks (Balej, 2006). Last landscape metric, which was used, is Shannon's Evenness Index (SEI).

$$SHDI = -\sum_{i=1}^{m}(Pi * lnPi)$$

- m = number of patch types
- P_i = proportion of area covered by patch type (land cover class) i

SEI increases as the number of different classes increase and/or the proportional distribution of the area among patch types (classes) becomes more equitable. Finally, evenness usually refers to the area distribution of classes (structural component). However, accurate estimation of landscape diversity from obtained results is rather complicated procedure. All these changes occurred apparently for the period between 1945 and 1996, and they have remained almost in a steady state up to the present time (Dramstad et al. 2006). All V-LATE analyses were exported to .txt format and then processed in spreadsheets, with graphs and tables in order to express the degree of changes in the study area over a 50 year time period.

5. RESULTS

5.1 Study area in Greece, land cover distribution during 1945–1996

Results suggest that landscape structure after the flooding has changed considerably, by converting the shape and structure of the distribution of land uses in the study area during the period 1945–1996. Specifically in 1945, the most prevalent land types was grassland 1667.00 ha or 33.67% of total area, followed by arable land occupying 823.31 ha or relative area 16.63%, forest areas 884.33 ha or 17.86% and sparse tree vegetation 847.53ha or 17.12%. On the other hand, other forms of land cover were present, but the percentage of cover can be considered very low relative to the size of all study area. Analysis has showed that residential areas were 2.55 ha or 0.05% of the total area, roads 24.03 ha or 0.49%, streams 79.57 ha or 1.61% and finally swamps 13.49 ha or 0.27%. In 1996 arable land covered 51.62 ha or 1.04%. Forests covered 1511.93 ha or 30.54%, grassland 531.81 ha or 10.74%, residential areas 12.79 ha or 0.26%. Concerning the roads, they occupied 90.34 ha or 1.82%, followed by scrublands 278.47 ha or 5.62% and sparse tree vegetation 85.09 ha or 1.72%. Moreover, additional land type categories, which weren't in the past, have been recorded after the flooding with main one - the water bodies, occupying the most of the area. Nevertheless, the percentages of other types distributed in the area are quite low, in compare with the size of the whole study area and that for can be considered more or less negligible. Indicative analysis showed following changes: lake 2134.64 ha, 43.12%, followed by mixture of scrubs and grasses 152.35 ha, 3.08%, erosion surface 66.54 ha, 1.34%, facilities 8.92 ha, 0.18%, orchards 11.98 ha, 0.24% and other types 5.49 ha, 0.11%.

	1945		1996	
	Area (ha)	**%**	**Area (ha)**	**%**
Arable Land	823.31	16.63	51.62	1.04
Erosion Surface	-	-	66.54	1.34
Facilities	-	-	8.92	0.18
Forest Area	884.33	17.86	1511.93	30.54
Grassland	1667.00	33.67	531.81	10.74
Lake	-	-	2134.64	43.12
Mixture of Scrubs & Grasses	-	-	152.35	3.08
Orchard	-	-	11.98	0.24
Others	-	-	5.49	0.11
Roads	24.03	0.49	90.34	1.82
Scrublands	609.17	12.30	278.47	5.62
Sparse Tree Vegetation	847.53	17.12	85.09	1.72
Streams	79.57	1.61	0.00	0.00
Swamp Area	13.49	0.27	9.01	0.18
Residential Area	2.55	0.05	12.79	0.26

Table 1. Changes in different land cover types

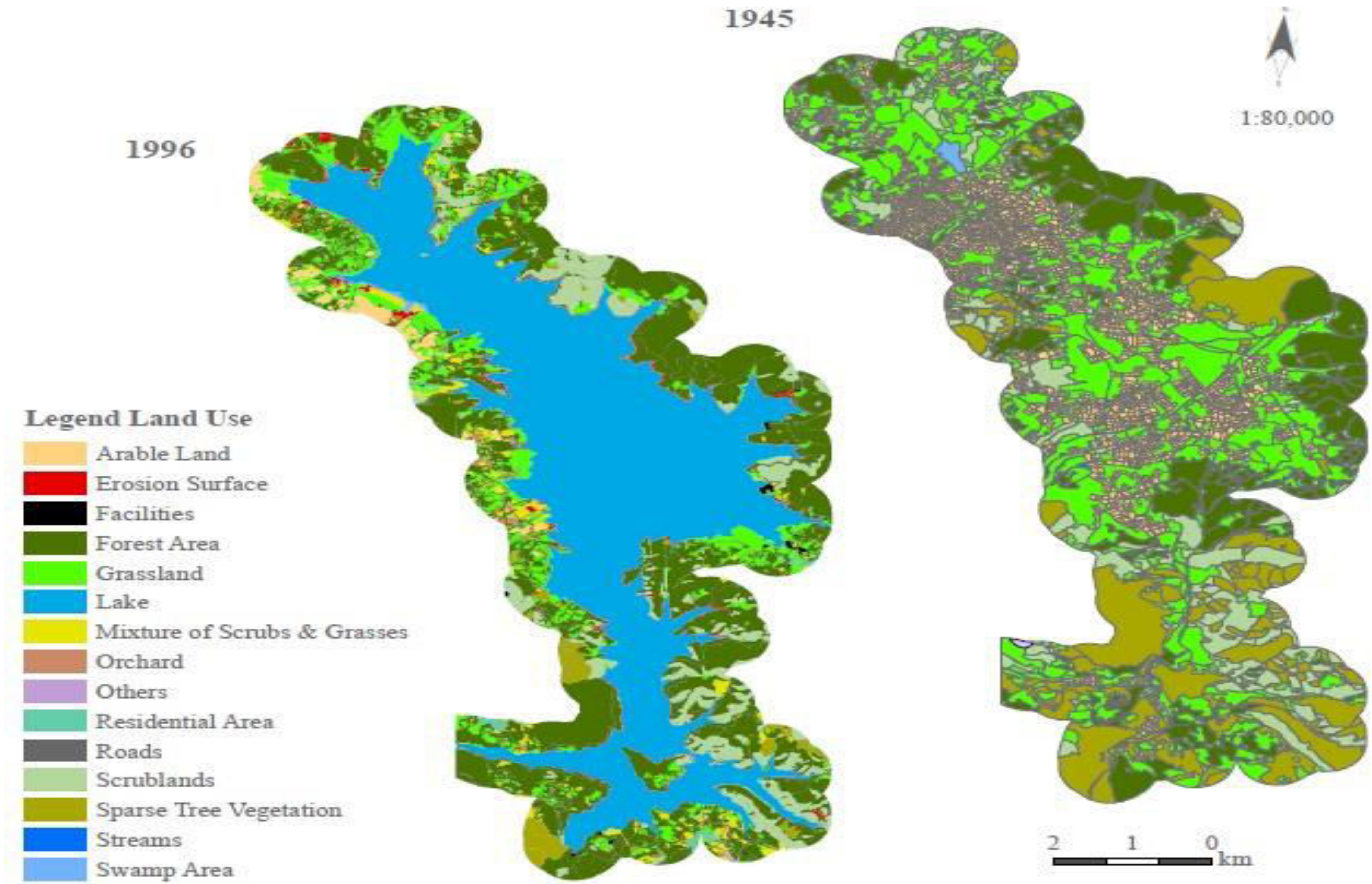


Figure 7. Land cover distribution between 1945 and 1996

5.1.1 Conversion of LULC inside the floodplain area

Most of the anthropogenic changes around dams are illustrious once a dam becomes functional. Hence, it is essential first to investigate the conditions after the dam implementation post-dam era and then to compare it with the initial undisturbed conditions pre-dam era in terms of LULC changes. Mainly affected was the grassland area with 45.50% of the total study area, followed by arable land 30.67% of total area, less affected were the forest area 5.31%, scrublands 7.17%, sparse tree vegetation 7.23% and the lowest representation had roads 0.70%, streams 2.78% and swamp areas 0.63% respectively.

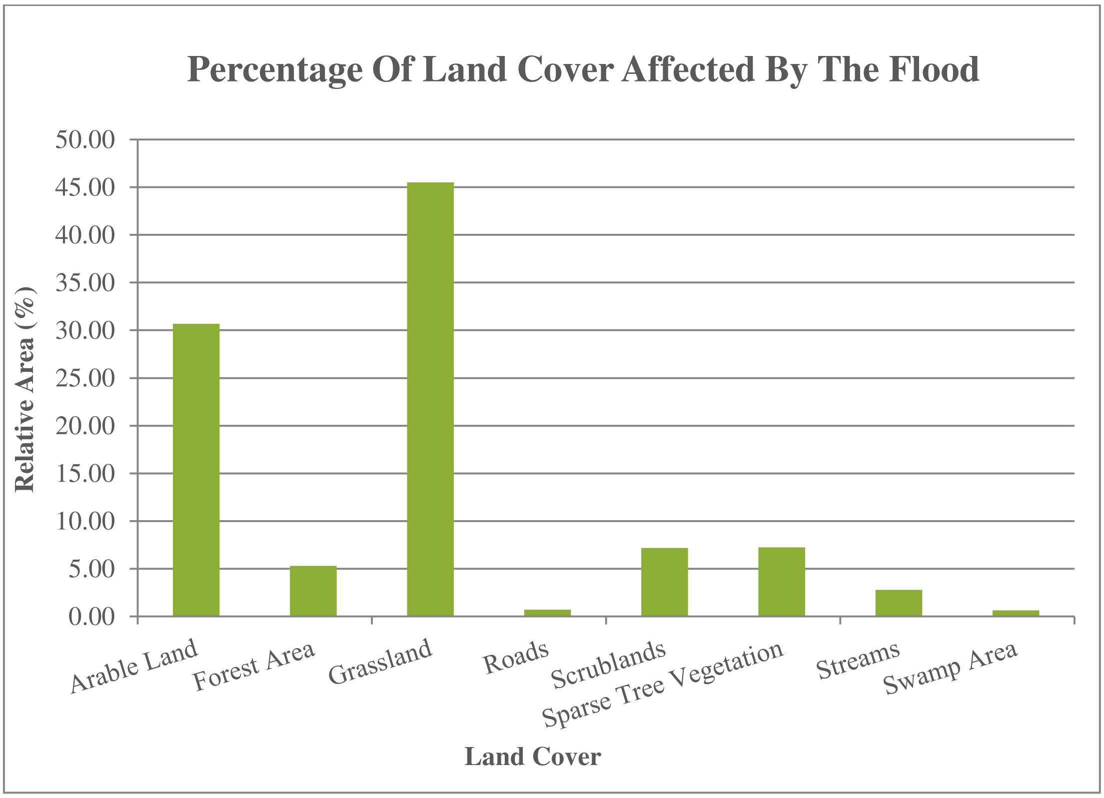


Figure 8. Representing percentages of LULC, affected after the flooding

5.1.2 Calculation of the statistical index

The number of patches (NP) in each classification helped to interpret the data (Table 2). Changes in patch numbers were important to note as it relates to both composition and formation of the reservoir. The statistical indices showed that the number of patches of arable land have been significantly reduced from 1945 until today almost 13 times. The number of facets of the forest area in 1996 has been increased almost 4 times comparing to the state in 1945. However, the number of patches for sparse vegetation was found almost 3 times higher in 1945 in contrast to the present time. Another case in land cover development observed the rate of increase of residential areas, which were found 35 times higher, compared to the situation in 1945. The numbers of patches of road construction have been enormously increased, almost 18 times; the area around the lake, as well as the number of patches of swamp areas, has been almost quadrupled since 1945. However, no significant changes were noted concerning the number of patches of scrublands over the time period of 50 years. MSI is used to estimate the shape complexity, while MPE index tracks the development of average patch areas through time. In contrast, classes such as forests, arable land, sparse tree vegetation and water bodies (Table 2) have lower values, as their shapes resemble more to squares or circles respectively.

Land use	Time period	NP	MSI	MPAR	MFRACT	MPE (m)	MPS (a)
Swamp Area	1945	2	13.22	3.75	2.54	1127.60	674.50
	1996	9	21.81	11.54	3.36	746.46	100.05
Grassland	1945	628	15.33	6.80	2.91	777.42	265.45
	1996	871	15.62	11.76	3.83	381.75	61.16
Roads	1945	9	85.44	22.22	3.29	5488.86	266.96
	1996	158	48.40	31.61	4.32	1440.59	57.17
Forest Area	1945	216	17.00	8.35	2.91	934.19	409.41
	1996	933	18.51	23.19	3.89	630.86	163.12
Sparse Tree Vegetation	1945	112	16.02	3.80	2.48	1297.34	756.72
	1996	40	15.20	6.60	2.88	647.09	212.73
Arable Land	1945	2970	12.16	9.61	3.69	216.10	27.72
	1996	227	12.22	11.28	3.89	194.25	22.74
Scrublands	1945	231	15.91	5.78	2.78	796.25	263.71
	1996	215	16.57	8.60	3.21	590.49	130.49
Residential Area	1945	1	12.48	2.77	2.37	706.15	254.90
	1996	35	14.10	25.51	8.41	236.00	36.54

NP Number of Patches
MSI Mean Shape Index
MPAR Mean Perimeter Area Ratio
MFRACT Mean Patch Fractal Dimension
MPE Mean perimeter of the edges
MPS Mean patch size

Table 2. Statistical indices of landscape metrics calculated for each class of land use in the areas of interest in two different time periods

Land use	Time period	NP	MSI	MPAR	MFRACT	MPE (m)	MPS (a)
Streams	1945	28	71.76	17.85	3.14	4498.48	284.17
Orchard	1996	30	12.252	7.717	3.19	264.11	39.93
Erosion Surface	1996	306	21.79	26.13	6.62	341.79	22.4
Mixture Of Scrubs & Grasses	1996	225	16.142	9.53	3.34	437.11	67.71
Others	1996	20	13.58	13.34	14.87	234.15	27.44
Water bodies	1996	1	58.03	0.45	1.868	95125.41	213800.47
Facilities	1996	28	13.75	16.48	13.95	232.72	31.84

NP Number of Patches
MSI Mean Shape Index
MPAR Mean Perimeter Area Ratio
MFRACT Mean Patch Fractal Dimension
MPE Mean perimeter of the edges
MPS Mean patch size

Table 3. Statistical indices of landscape metrics calculated for each category of land use in one monitoring period in the area of interest

YEAR	SEI
1945	0.75
1996	0.58

SEI Shannon’s Evenness Index

Table 4. Shannon’s Evenness Index for each year of the study

5.1.3 Stability of the land types during the monitoring period 1945–1996

Analysis of unaltered land cover with the use of GIS, has showed that between 1945 and 1996 most stable category with 50.64% or absolute area of 582.89 ha of total area are forests. Second most stable category is grasslands with 30.65%, i.e. an area of 352.82 ha, followed by scrublands in an area of 129.30 ha (11.23%). Furthermore, sparse tree vegetation remained preserved as well during the monitoring period 1945 and 1996 with relative area of 4.89% or 56.31 ha. Finally, the least stable category appears to be croplands of only 29.74 ha (2.58%).

Land Cover	Count Class	Area (ha)	Relative Area (%)
Arable Land	579	29.74	2.58
Forest Area	725	582.89	50.64
Grassland	951	352.82	30.65
Scrublands	182	129.30	11.23
Sparse Tree Vegetation	23	56.31	4.89

Table 5. Unaltered percentage of land use between 1945 and 1996

5.1.4 Changes in land cover area during the monitoring period

Analysis of changed land cover with the use of GIS, has showed that the most unstable category is lake with 43.02%, but it is important to highlight that the high percentage of this category is caused by the fact that the lake didn't actually exist at 1945. So if we drop the lake category for its low relevance, the most unstable category is grassland, which found reduced at 22.93% or -163.90 ha of its total area. Second most unstable category is arable lands reduced at 15.59%, or -116.98 ha, followed by sparse tree vegetation 15.41% or -608.06 ha. Forest area was found increased from 1945 to 1996 at 12.68% or absolute area of 741.00 ha. Other categories like erosion surface, facilities, scrubs & grasses, orchards and others, where found increasing after the implementation of the dam, since they weren't present previously. Roads and residential areas have showed an increased tension of 1.33% or 81.24 ha and 0.21% respectively expressing an absolute area of 10.24 ha. While scrublands and swamps were found decreased with 6.68% or -177.70 ha and 0.09% or -9.01 ha respectively. Finally, streams were found decreased, 1.61% or -20.12 ha.

	Changed Land Cover During the Monitoring Period 1945-1996	
	Area (ha)	**%**
Arable Land	-116.98	-15.99
Erosion Surface	66.54	1.34
Facilities	8.92	0.18
Forest Area	741.00	12.68
Grassland	-163.90	-22.93
Lake	2134.64	43.12
Mixture of Scrubs & Grasses	152.35	3.08
Orchard	11.98	0.24
Others	5.49	0.11
Roads	81.24	1.33
Scrublands	-177.70	-6.68
Sparse Tree Vegetation	-608.06	-15.41
Streams	-20.12	-1.61
Swamp Area	-9.01	-0.09
Residential Area	10.24	0.21

Table 6. Representation of land cover changes in percentages and absolute area

5.2 Study area in the Czech Republic

5.2.1 Changes in land cover structure between the time period of 1950–2012

According to the results, until 1950, arable land occupied 1221.74 ha or 52.10%. The second most prevalent category was sparse tree vegetation with an absolute area of 686.24 ha or 29.26%, followed by grassland occupied an absolute area of 266.25 ha or 11.35%. Mixture of scrubs & grasslands occupied 94.43 ha or 4.03%, followed by water bodies with 26.28 ha or 1.12%. Concerning the category of roads & facilities, an absolute area of 23.83ha or 1.02%, forest areas occupied 18.12 ha or 0.77%. Final category is swamp areas, present only in 1950 covering a small area of 8.16 ha or 0.35% and absent in present time. In 2012 arable land covered 534.69 ha or relative area of 22.80%, sparse tree vegetation with 69.05 ha or 2.94%, grasslands occupied 596.86 ha or 25.45%. Mixture of scrubs and grasses 119.64 ha or 5.10%, followed by water bodies, occupied 23.83 ha or 1.02% of the total area, roads & facilities 106.98 ha or 4.56% and final category, forest areas with 894.07 ha or 38.12%.

	1950		**2012**	
	Area (ha)	**%**	**Area (ha)**	**%**
Arable Land	1221.74	52.10	534.69	22.80
Forest Area	18.12	0.77	894.07	38.12
Water Bodies	26.28	1.12	23.83	1.02
Grassland	266.25	11.35	596.86	25.45
Roads & Facilities	23.83	1.02	106.98	4.56
Sparse Tree Vegetation	686.24	29.26	69.05	2.94
Mixture of Scrubs & Grasses	94.43	4.03	119.64	5.10
Swamp Areas	8.16	0.35	-	-

Table 7. Changes in different types of land cover

Figure 9. Land cover distribution in 1950

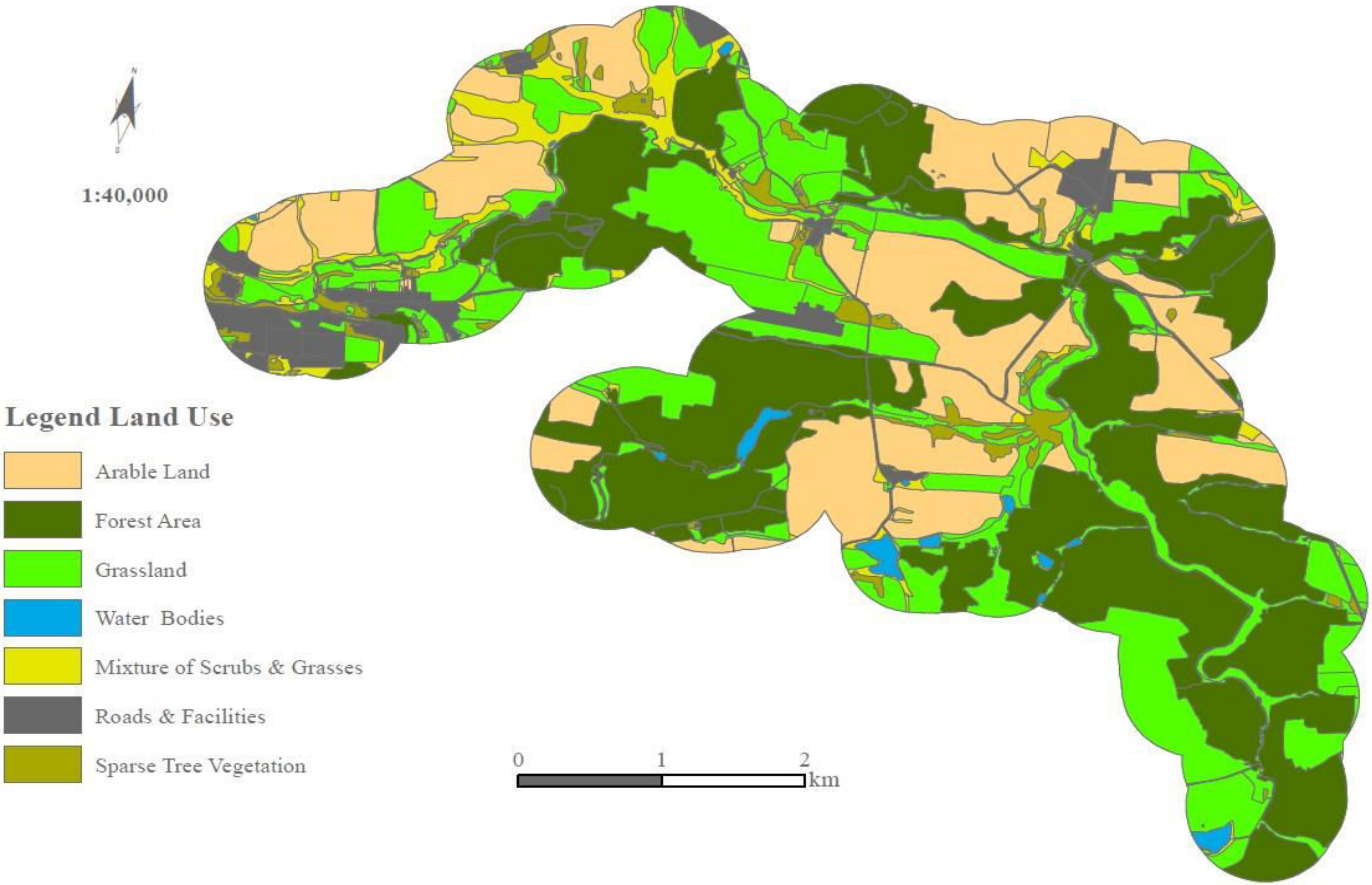


Figure 10. Land cover distribution in 2012

5.2.2 Monitoring of landscape microstructure

The statistical indices show that NP of arable land has diminished significantly, almost 33 times than it used to be in 1950. In the case of forest area, no changes have been recorded. Concerning grasslands, there was almost 50% decrease. The NP from the communication (roads etc.) & facilities relatively decreases from 150 to 112. Water bodies (lakes, rivers) had balanced out at almost the same level. In the case of sparse tree vegetation, a relatively small increase has been noticed - from 68 to 84. Finally, for the category of mix scrubs & grasslands there was noticed a decrease of a bit more than 50%, while swamp areas were present only in the past with 29 patches. MSI showed high values, again confirming the irregular shape structure of the patches, especially higher during the time period of 2012 at most of the patch types. The MPE index tracks the development of average patch areas through time. For MPAR and MFRACT index show values, which are approaching two patches with substantially complex perimeters and therefore possess higher values. Finally, from the evaluation of Shannon's Evenness Index, comparing the SEI between 1950 and 2012, we notice that for each year of monitoring period, values relatively differs (Table 9), confirming that for a given number of classes the maximum value (one) of the Shannon Index is reached when all classes have more or less the same area or the proportional distribution of the area among patch types (classes) becomes more equitable.

Land use	Time period	NP	MSI	MPAR	MFRACT	MPE (m)	MPS (a)
Swamp Area	1950	29	1.48	0.17	1.47	254.36	28.13
	2012	-	-	-	-	-	-
Grassland	1950	301	3.12	0.32	1.62	859.85	88.45
	2012	165	17.96	8.73	3.05	962.79	361.73
Mix of Scrubs & Grasses	1950	260	1.91	0.25	1.54	388.40	36.32
	2012	108	36.83	23.94	4.00	1096.72	110.78
Forest Area	1950	45	7.61	1.73	2.17	1068.73	40.28
	2012	46	22.57	10.80	2.73	2649.63	1943.63
Sparse Tree Vegetation	1950	68	1.75	0.06	1.36	1679.91	1009.17
	2012	84	18.19	12.42	3.70	523.81	82.20
Arable Land	1950	1401	1.63	0.24	1.43	447.01	87.20
	2012	43	14.34	4.30	2.59	1531.75	1243.46
Water bodies	1950	55	1.30	0.17	1.44	259.39	47.79
	2012	63	66.10	165.67	11.99	791.32	37.83
Roads & Facilities	1950	150	6.48	0.81	1.94	970.94	15.89
	2012	112	38.55	37.53	6.57	911.31	95.52

NP Number of Patches
MSI Mean Shape Index
MPAR Mean Perimeter Area Ratio
MFRACT Mean Patch Fractal Dimension
MPE Mean perimeter of the edges
MPS Mean patch size

Table 8. Statistical indices of landscape metrics calculated for each class of land use in areas of interest in two different time periods

Year	SEI
1950	0.59
2012	0.77

SEI Shannon’s Evenness Index

Table 9. Shannon’s Evenness Index for each year of study

5.2.3 Possible change scenario of LULC inside the hypothetical floodplain area in the present time

In order to more illustrated comprehending of the degree of possible impact, that a dam construction could have the in the future (20-30 years from now) in Kočov region, it's necessary to identify first the areas with the lowest elevation. In the meanwhile, we can detect those places relatively easy by the use of a digital elevation model (DEM) of the research area, which is able to show those places in Arc-map, by forming a corresponding layer with high accuracy. The analytical research showed that mainly the categories of land cover, which are likely to affect by the possibility of flooding are: Forest areas, with a percentage of 35.37% or absolute area 205.15 ha of the total study area, the second most affected are grasslands with a percentage of 24.62% or absolute area of 142.79 ha, followed by arable land with 22.44% or absolute area of 130.14 ha. Finally, other types of category were recorded as well, but their land cover percentage appears relatively small in contrast to the previous mentioned land types. Indicatively I mention mixture of scrubs & grasslands 7.79% or absolute area of 45.21 ha, sparse tree vegetation 5.96% or 34.56 ha, water bodies (lakes, rivers) with 2.05% or 11.89 ha and last communication & facilities infrastructures 1.78% or 10.30 ha respectively.

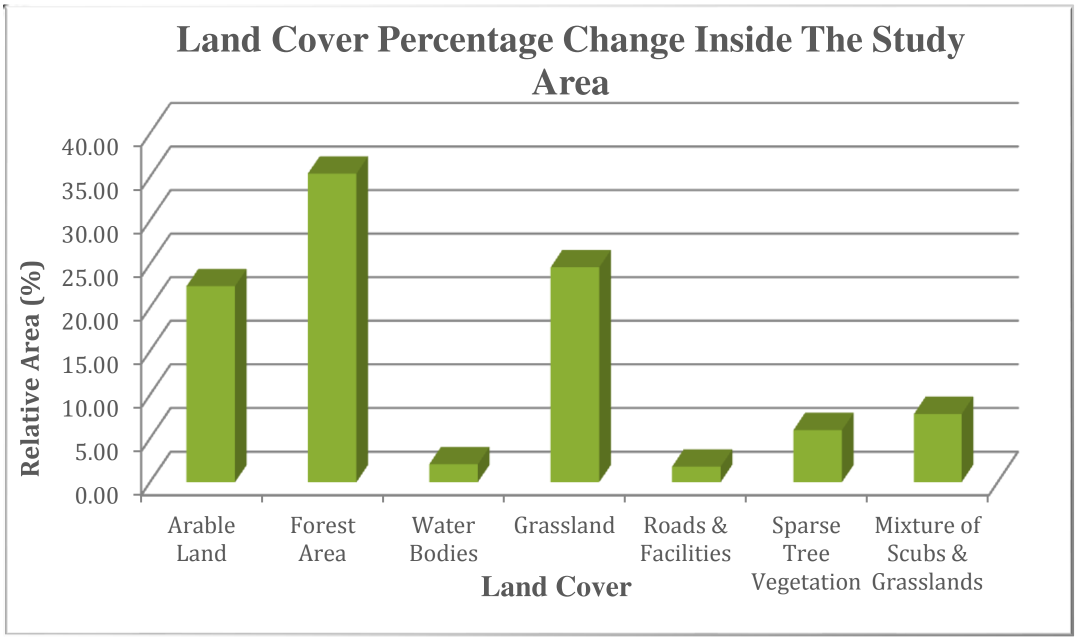


Figure 11. Representing percentages of land cover affection in case of flooding

5.2.4 Changes in land cover area during the monitoring period

Through the results of the analysis, it is clear that the most unstable category is forest area, which was found increased comparing to the past 37.35% or 875.95 ha of its total area. Second most unstable category is arable land was found reduced of 29.30%, or an absolute area of -687.05 ha, followed by sparse vegetation 26.32%, absolute area of -617.19 ha. Grasslands, increased from 1945 to 1996 at 14.10% or absolute area of 330.61 ha. Communications & facilities were found increased with 3.54% or absolute area 83.15. While other categories like water bodies and swamp areas showed decrease with 0.10% or -2.45 ha and 0.35% or -8.16 ha respectively, however, this difference can be considered as negligible and therefore they are less stable. Final category is mixture of scrubs & grasses, which were found increasing with 1.07% or 25.21 ha.

	Changed land cover during the period 1950–2012	
	Area (ha)	**%**
Arable Land	-687.05	-29.30
Forest Area	875.95	37.35
Grassland	330.61	14.10
Water bodies	-2.45	-0.10
Mixture of Scrubs & Grasses	25.21	1.07
Communication & Facilities	83.15	3.54
Sparse Tree Vegetation	-617.19	-26.32
Swamp Areas	-8.16	-0.35

Table 10. Land cover change in percentages and absolute area

6. DISCUSSION

6.1 Discussion on methodology

The integration synthesis of RS technique with the use of GIS systems for measuring and monitoring landscape structure changes through time series images is quite useful and with great results. As land cover is often indicative of land use in different chronologies, it is rational and useful composition at the same time that has been the focus of considerable critical review and applied research (Trotter, 1991; Michalak, 1993). It has been proven thought, through a series of temporal surveys, that using aerial photographs becomes difficult to obtain information from the past, due to the lack of data of the study area. But on the other hand, aerial photographs were used long before multi spectral satellite imagery technology was invented. Meaning that one of the main advantages lies in the fact that they can provide historic information with high spatial resolution, which is valuable for the LULC change detection study analysis. However, the negative of this case lies in those images, which were shot in the past and exist only in the form of black and white, which implies a series of negative effects during the procedure of photo interpretation.

Land cover and especially vegetation mapping, is important information for any scientist, who needs to comprehend natural or man-made caused environmental changes. This can be done through evaluation of vegetation coveratany scale (local or global) and at any given time or continued period. Also many RS studies usually focus on a specific purpose during the process of defining the cover types in order to obtain better classification accuracy. Focusing on one purpose is of great importance in decision-making, according to the source of available data (Egbert et al. 2002). However, computer pattern-recognition capabilities still have long way ahead in order to approach those human interpreters (Hay and Niemann, 1994).

Mainly two basic methods are adopted for change detection analysis. The first one using raw images in order to detect changes and it is so called (pixel-to-pixel comparison) and the second one originates from the comparison of two panchromatic classified images (Green et al. 1994). The greatest contribution of the second method lies in the fact that the bi-temporal images are separately classified; therefore the problem of radiometric calibration between the dates is minimized (Coppin et al. 2004).

6.2 Driving forces behind landscape transformation

This study has analyzed the dynamics of landscape structure development of over the time period of 50 years. The development of this structure during the monitoring period, as in the most of the landscapes elsewhere in the world, has been influenced by anthropogenic impacts while the resulting mosaic is nothing but a mixture of natural and human-managed patches that vary in size, shape and arrangement (Turner, 1989). Extends of land use changes should be used for better comprehension of the trend of land use change and its driving forces (Chen et al. 1996). Evaluation of relative area which originates from indices analysis, for instance the rate of land which is used for buildup areas (area build-up/total area), enables scientists to evaluate this extension of land use with relatively high accuracy (Tables 1 & 7), representing those fluctuations in different time periods. Therefore, quantifying the vegetation cover and generally the LULC change is significant for assessing the influence of land management policies and decision-making. Hydropower construction and operation is associated with a number of serious environmental problems like interruption of fish migration, bank erosion, water diversion, reservoir flushing and inundation of landscapes, resulting in natural alternation of landscape structure (Truffer et al. 2003). Sediment storage can result to a) increase the capacity of reservoir and b) bank erosion. Table 3 illustrates the increasing amount of erosion patches in the post-dam area, which is probably caused by annually or seasonally fluctuating levels. Usually, areas are not easily accessible to humans and are often characterized as stable and natural. Development of the transport infrastructure as a supplementary project to enhance further the functionality of the study area (Tables 1 & 2), confirms that these areas begin to change rapidly (Lipský, 2001).

Predominant purpose of a dam construction, for example in the Mekong River in Southeast Asia basin, is hydropower energy production and mainly focuses on the improvement of the socio-economic status (Campbell, 2007). In this study case it can be explained by the necessity for rapid decisions in the past, that could enhance the economic growth and reduce poverty in Greece, while it led in a high decrease of arable land inside the floodplain areas as result of the dam construction, making it one of the most affected and unstable LULC areas during 1945–1996 (Figure 8, Table 6). This was a huge bet between the government and the local citizens, while it was a price, which people accepted to pay. In the meanwhile, government is willing to compensate the cropland owners for their land or even to provide them new areas in plain of Thessaly, so to be able to continue their activities. This move demonstrated the seriousness of the project, while agricultural production was (and still is) one of the main occupations for the local society. Additionally, around 850,000 ha are given to exploitation to 150,000 refugee families and additional 673,000 ha to 130,000 rural families especially in Thessaly Campus (Svoronos, 1976). At the same time, a huge part of population was pushed to internal migration for survival (Stathakis, 2004). This fact is strengthening the argument that lakes are important ecosystems contributing to the national and local economies by producing a wide range of opportunities in forms of goods and services (Turner et. al. 2000) and which have resulted to the reshape of landscape. Moreover, the identification of the significance and the wide range of all type of benefits, from any natural or artificial wetland ecosystem, provide to humans (Turner, 1999), increased interest for new wetland ecosystems for supporting human life (Hammer and Bastian, 1989). The construction of artificial lakes additionally may provide a range of services beyond the primary reason of its construction, like support of recreational activities or aesthetic services (Benyamine et al. 2004; Knight et al. 2001). Water ecosystems can be valued from several perspectives that lead to at least four different types of value: owner, user, regional, and social (Leitch and Hovde, 1996). Values are of significant importance because they influence decision-making attitudes and behavior (Stern and Dietz, 1994).

6.3 Indicators and management links

In the literature, a large number of landscape metrics have been used to measure and monitor landscape change (Lausch and Herzog, 2002), to quantify ecological processes (Tischendorf, 2001; Bender et al. 2003), to study the effects of society on landscape (Saura and Carballal, 2004) and to assist in landscape designing (Gustafson and Parker, 1994). Focusing on the percentage of forest area cover for Lake Plastiras in overall, including the category of sparse tree vegetation (Tables 1

& 7) we found a small decrease of 2.64%, while for Kočov region, including the forest and sparse tree vegetation area categories, we found an increase of 11.03%. Recent studies however, demonstrated that detail observation on vegetation fluctuations is essential for land use and landscape changes and they significantly affect biodiversity and therefore are essential for ecological perspectives in general (Gachet et al. 2007). Although Kadıoğulları in his study research in Turkey states that the increase of total forested area does not always lead to enhancement of landscape functionality (Kadıoğulları, 2013). Such metrics can be used as well to observe, capture and evaluate changes in patterns through time, so to determine the long-term impacts of previous land use (Burgi, 1999; Griffith, 2003). NP index was chosen because it is commonly applied in landscape monitoring and it is relatively simple to use and to interpret (Dramstad et al. 2006). Furthermore, NP is the most valuable indicator, as it serves as the basis for computing other, more interpretable metrics (McGarigal and Marks, 1995). A matter of great significance, mainly from the ecological point of view, is to examine the level of fragmentation, which can be derived through counting NP from the statistical index. Comparing the Tables 2 & 3 with Table 8, we can see the difference, where higher values of NP, at almost all classes of Table 8, indicate a more fragmented landscape in the past in Kočov region, in contrast with Tables 2 & 3 from the Lake Plastiras. Observing the classes in Lake Plastiras in general, we can conclude that the level of fragmentation is higher in nowadays comparing to the past. However, arable lands were found as the most fragmented category in both study cases.

Evaluating the MSI from the Greek region, we observe high values at all classes, expressing the fact that patches consists of irregular shapes in both time periods 1945–1996 (Tables 2 & 3). While for the Kočov region patches of 1950 are more circular at 6 of the 8 classes therefore we have values closes to one, expressing that way the regularity of the patches (Table 8).

Shannon Index is used by most of researches recently, because it is relatively simple to use and to interpret (Dramstad et al. 2006). Additionally, as an estimator of landscape structure highlights the rare cover types and richness component. The observed SEI is divided by the maximum Shannon's diversity index for that number of patch types (McGarigal and Marks, 1995). The Shannon diversity index takes into account the abundance of classes and it increases as the number of classes increases or the equitability of distribution of land amongst the various classes increases, ranging from 0 to infinity (Nagendra, 2002). By comparing SEI in case of Lake Plastiras between 1945 and 1996, results have showed that for each year there was expressed different value (Table 4). Indicator, which proves that diversity, has changed relatively significantly over the 50 year of monitoring period. This can be explained by the fact that although the number of classes for 1945 was lower than those of 1996. It expresses that we should expect higher value of SEI in 1945 but the proportional distribution of the area in 1996 among patches due to the flooding resulted a high increase of water volume, which affected the proportion of area distribution significantly. That for Shannon's index found higher in 1945 (Table 4). In Kočov region, SEI values between 1950–2012, showed almost the same values, but inverted (Table 9), demonstrating equal number of classes for both time periods but more equitable area distribution in 2012 in contrast to 1950 (Table 7).

It is crucial to consider conflicts between the intensity of land use and arable land abandonment, in case of analyzing the significance of any kind of environmental, economic or socio-economic management design. In fact, this action is leading for instance the landscape vegetation to overgrowing trees as a successional procedure, more dynamically in riparian vegetation (Šlezingr, 2003). Generally speaking, it can be said that understanding the past is necessary for understanding the present and for correct actions in the present (Bloch, 1952) and obviously this is most apparent in case of landscape changes.

7. CONCLUSION

This study explored the impact of dam implementation on landscape structure through analysis of LULC change. The aim of the work focused on understanding the implications for dam design of such size on the level of LULC. The results of this study may further help to understand the long-term dynamics of the landscape structure change through time and to reveal the driving forces behind those changes. Primary operations of the reservoir such as irrigation of agricultural land, supply of drinking water, water quality, hydroelectric energy production as well as secondary functions like recreation have been controversial issues for many years.

Also, some researchers recently showed that irregular water release has resulted in a significant annual fluctuation of the reservoir water level, which implies usually negative impacts on the ecosystem in general. Daily demands of people for electricity and irrigation are partially competing to each other and that is because of different optimal time schedules of releases. Apparently, the higher release of water (from the reservoir), the higher energy production and therefore larger amount of arable lands can be irrigated. On the other hand, higher water release means lower water level in the reservoir and that implies with its turn impacts resulting in weakening of the beauty scenery of the landscape and also in deterioration of the trophic state of the lake.

Concerning the development of the area and the landscape structure modification since the implementation of the dam, the results showed that the study has significantly changed during the 1945–1996 for a few reasons:

- The dam construction occupied a relatively big area of arable land and forced/allowed local residents to take the advantage of other economic opportunities as well, and start to invest, resulting gradually the landscape development by increasing the share of residential areas around the lake.
- After the completion of the project gradually and in short relatively time of period, similar infrastructure developments such as road net establishment began to perform, so to impart a multivariable role, i.e. recreation.

Comparisons of the development of landscape characteristics have shown that the main driving forces that caused those changes are mainly:

a) Political and socio-economic factors, especially after the end of the Second World War, an age milestone for the development at all levels in human mankind all over the world.

b) Naturally, as a result of succession.

Those pressures resulted in gradually uncontrolled changes in land cover, with various environmental impacts. But nevertheless, in contrast with the main concept of the economic usefulness of reservoirs in general and their negative impacts they usually have on the landscape (depending on size, scale) and generally on the environment, it is feasible such a project, under a proper design, extensive knowledge of surrounding ecosystems and supervision of a rational and primarily environmental friendly management plan (EIA and SEA), can provide useful information so to improve the environmental quality and stability and eventually to become more competitive and attractive for new investments, contributing significantly to a further development of the neighboring regions. We can also realize the significance of landscape structure, which can either mitigate the negative impacts of the reservoir on nature ecosystems and human health, or it can favor it. In conclusion, a good management plan would require a multi-criteria decision-making, so to achieve equilibrium between the functions of a reservoir, environmental development and safeguard of financial needs of the citizens.

After the operation of the dam, the lower elevation sites flooded and consequently the structure and shape of the landscape altered quickly, transforming that way the previously heterogeneous area to homogenous one covered by water. Hence, these phenomena could have negative impacts on the biology of some species, i.e. a population of a species could gradually extinguish, but on the other hand, they can support the introduction of new species (fauna and flora) as well.

The database of landscape state changes, which was recorded between 1945 and 1996, contains statistical and also quantitative information. This information constitutes a very good example of a continuously monitoring program and, the most important, with comparable measure values. Moreover, the research identified subset of metrics, which basically proposed to determine trends in landscape patterns on the level of LULC and their consequences as well. Thus possible future problems of impacts in LULC like fragmentation of landscape patches can be counteracted.

Moreover, the geospatial technology, which was used in this work, has showed the ambidexterity of GIS for quantifying historic changes in LULC with respect to the precise location where the changes occurred. The advantage of this method lies in the ability to detect changes in the landscape for long time periods. The availability of the data at relatively affordable prices in correlation with the wide use of electronic computer provides the ability to analyze the data in various ways in a short time. Additionally, it is providing a great ability to the users to trace back history, using a wide range of aerial photos from different time periods to detect landscape changes, while this information can help to understand the magnitude of historical changes and to detect the precise percent of land use that have been converted to another category or either eliminated. Unfortunately, this method has some weak points as well. Most important, is the fact that it is a time consuming method, especially when digitizing large areas, while aerial photographs are available in better resolution, approximately during the period of Second World War, where we have several improvements in this field, mainly for military purposes. The results of this retrospective study may be an important regulating factor in future trends setting in landscape development for various forms of landscape planning management. In order to detect those landscape changes, it is necessary to understand the historical context and the driving forces involved in its development.

8. REFERENCES

ADDICOTT J.F., AHO J.M., ANTOLIN M.F., PADILLA D.K., RICHARDSON J.S. and SOLUN D.A., 1987: Ecological neighborhoods. Scaling environmental patterns. Oikos 49: 340-346.

AGARWAL C., GREEN M.G., GROVE M.J., EVANS T.P. and SCHWEIK M.C., 2005: A Review and Assessment of Land use Change Models Dynamics of space, Time and Human Choice. Collaborative Report Series No. 1 (Center for the study of Institutions Population and Environmental Change Indiana University).

AITKENHEAD M.J. and ALDERS I.H., 2011: Automating land cover mapping of Scotland using expert system and knowledge integration methods. Remote Sensing of Environment. 115(5): 1285-1295.

ALLEN T.F.H. and STARR T.B., 1982: Hierarchy: Perspectives for ecological complexity. University of Chicago Press. Chicago.

ANTROP M., 1997: The concept of traditional landscapes as a base for landscape evaluation and planning: The example of Flanders Region Lands. Urban Plan. 38: pp. 105–117.

ANNENDALE D.J., BAULEY E., OUANO W. and EVANS KING P., 2001: The potential role of strategic environmental assessment in the activities of multi-lateral development banks. Environmental Impact Assessment Review, Vol. 21: pp. 407-429.

ANSELIN L., 1990a: What is special about spatial data? Alternative perspectives on spatial data analysis in DA. Griffith (Ed.): Spatial Statistics, Past Present and Future: pp. 63-77.

BABU G.P., 1997: Self-organizing neural networks for spatial data. Patt. Recogn., Lett., 18: pp. 133-142.

BAKER W.L. and CAI Y., 1992: Programs for multi-scale analysis of landscape structure using the GRASS geographical information system. Landscape Ecology 7: pp. 29-302.

BALEJ M., 2006: Krajinné metric jako indicatory udržitelné krajiny. Univerzita J.E. Purkyně, Online: http://gacr.geograf.cz/projekt_s/pdf/budejovice_balej.pdf, accessed 29.3.2011.

BALMANN A., 1997: Farm-based Modeling of Regional Structural Change. European Review of Agricultural Economics 25 (1): pp. 85-108.

BALTSIAVAS E.P., 1996: Digital Ortho-images: A powerful tool for the extraction of spatial geo-information. ISPRS Journal of Photogrammetry and Remote Sensing, 51: pp. 63-77.

BASTIAN O., 2001: Landscape ecology towards a unified discipline. Landscape Ecology 16: 757-766.

BAUDRY J. and TATONI T., 1993: Changes in landscape patterns and vegetation dynamics in province France. Landscape and urban planning 24: pp. 153-159.

BENDER D.J., TISCHENDORF L. and FAHRIG L., 2003: Using patch isolation metrics to predict animal movement in binary landscapes. Landscape Ecology 18: pp. 17-39.

BENEDIKTSSON J.A. and SVEINSSON J.R., 1997: Feature extraction for multisource data classification with artificial neural networks. Int. J. Remote Sens. 18: 727-740.

BENNETT G. and WIT P., 2001: The Development and Application of Ecological Networks. A Review of Proposals Plans and Programmes. Amsterdam: AID Environment.

BENNETT G., 2004: Integrating Biodiversity Conservation and Sustainable Use. Lessons Learned From Ecological Networks. Gland/Cambridge: IUCN.

BENYAMINE M., BACKSTROM M. and SANDEN P., 2004: Multi-objective environmental management in constructed wetlands. Environmental Monitoring and Assessment 90: pp. 171-185.

BERGER T., 2000: Agentenbasierte räumliche: Simulations modelle in der Landwirtschaft. Dissertation, Göttingen, 2000.

BIČÍK I. and KUPKOVÁ L., 2005: Dlouho dobé změny vevy užívání krajiny v Česku. Historickág eografie, 33: 346-366.

BIČÍK I., JANČAK V., JELEČEK L., MEJSNAROVA L. and ŠTEPÁNEK V., 1996: Land Use/Land Cover Change in the Czech Republic 1845-1995. Journal of the Czech Geographical Society, 101, 2: pp. 92-109.

BISCHOF H. and LEONARDIS A., 1998: Finding optimal neural networks for land use classification. Geosci. Remote Sens. 36: pp. 337-341.

BLASCHKE T., 2000: Landscape Metrics: Konzepteeinesjungen Ansatzes der Landschaftsökologie und Anwendungen in Naturschutz und Landschaftsforschung. In Archivfür Naturschutz und Landschaftsforschung 39: 267–299.

BLOCH M., 2009: Apologie pourl 'histoireu Métier d'historien. Paris: Armand Colin.

BONNIN M., BRUSZIK A., DELBAERE B., LETHIER H., RICHARD D., RIENTJES S., VAN UDEN G. and TERRY A., 2007: The Pan-European Ecological Network. Nature and Environment, No. 146: Council of Europe: Strasbourg.

BORN S., GENSKOW K., FILBERT T., HERNANDEZ-MORA N., KEEFER M. and WHITE K., 1998: Socioeconomic and institutional dimensions of dam removals. Environmental Management 22: 359-370.

BOTEQUILHA LEITAO A. and AHERN J., 2002: Applying landscapes ecological concepts and metrics in sustainable landscape planning. In Landscape and Urban Planning 59: pp. 65–93.

BRULARD T., DUSSART F., NICOLAI H. and SNACKEN F., 1969: Regionaleindelingen. Nationaal Comittvoore Geografie, Brussel.

BURGI M., 1999: A case study of forest change in the Swiss lowlands. Landscape Ecology 14: 567-575.

BURKE I.C., KITTEL T.G.F., LAUENROTH W.K., SNOOK P. and YONKER C.M., 1991: Regional analysis of the central Great Plains: Sensitivity to climate variability. Bioscience 41: 685-692.

BUTLER DAVID R. and LISA DECHANO M., 2001: Environmental change in Glacier National Park, Montana. An assessment through repeat photography from fire look outs. Physical Geography 22(4): 291-304.

CAMPBELL I.C., 2007: Perceptions, data and river management. Lessons from the Mekong River. Water Res., 43, W0240.

CARPENTER G.A., GJAJA M.N. and GOPAL S., 1997: ART neural networks for remote sensing. Vegetation classification from Landsat TM and terrain data. Geosci. Rem. Sens. 35: pp. 308-325.

CASHMORE M., GWILLIAM R., MORGAN R., COBB D. and BOND A., 2004: The interminable issue of effectiveness, substantive purposes, outcomes and research challenges in the advancement of environmental impact assessment theory. Impact Assessment and Project Appraisal, volume 22, No. 4: Beech Tree Publishing: pp. 95–310.

CASSON B., DELACOURT C., BARATOUX D. and ALLEMAND P., 2003: Seventeen years of the “La Clapiere” landslide evolution analyzed from Ortho-rectified aerial photographs. Engineering Geology, 68: pp. 123-139.

CASTLE C. and Crooks A., 2006: Principles and concepts of Agent-based Modelling for Developing Geospatial Simulations. Working paper series, paper 110: pp. 1-31.

CECH THOMAS V., 2003: Principles of Water Resources. History Development, Management and Policy (John Wiley and Sons 2003).

CHEN Z., 1999: Texture segmentation based on Wavelet and Kohonen network for remotely sensed images. IEEE SMC’99 Conference Proceedings, Tokyo, Japan, Oct. 12-15, 1999; Vol. 6: pp. 816-821.

CHEN J., FRANKLIN J.F. and LOWE J.S., 1996: Comparison of abiotic and structurally defined patch patterns in a hypothetical forest landscape. Conservation. Biol.10: 854–862.

CHICHILNISKY G., 1996b: The economic value of the earth's resources. Trends in Ecology and Evolution, 11: pp. 135-139.

CHICHILNISKY G., 1994: North-South trade and the global environment. American Economic Review 84: pp. 851-874.

COHEN W.B. and SPIES T.A., 1992: Estimating structural attributes of Douglas fir/Western Hemlock forest stands from Landsat and SPOT imagery. Remote Sensing of Environment, 41: pp. 1- 17.

COPPIN P., JONCKHEERE I., NACKAERTS K., MUYS B. and LAMBIN E., 2004: Digital change detection methods in ecosystem monitoring. International Journal of Remote Sensing, 25(9): 1565–1596.

CRESSIE N., 1991: Statistics for Spatial Data (New York, Wiley).

CUSHMAN S.A. and McGARIGAL K., 2008: Parsimony in landscape metrics. Strength universality and consistency. Ecological Indicators 8: 691-703.

DALE V.H., BROWN S., HAEUBER R., HOBBS N.T., HUNTLY N., NAIMAN R.J., RIEBSAME W.E., TURNER M.G. and VALONE T., 2000: Ecological principles and guidelines for managing the use of land. Ecol. Appl. 10: 639-70.

DE GROOT R., STUIP M., FINLAYSON M. and DAVIDSON N., 2006: Valuing wetlands: Guidance for valuing the benefits derived from wetland ecosystem services. Ramsar technical report No. 3, CBD Technical series No. 27.

DELBAERE B. and GUILINCK H., 1995: A review of landscape ecological research with specific interest to landscape ecological mapping. In Remote Sensing in Landscape Ecological Mapping, edited by Delbaere B. and Gulinck H., (Luxembourg: Publications of the European Communities): pp. 3-28.

DELCOURT H.R., DELCOURT P.A. and WEBB T., 1983: Dynamic plant ecology: The spectrum of vegetation change in space and time. Quat. Sci. Rev. 1: pp. 153-175.

DENECKE D., 1972: Die historisch-geographische Landesaufnahme. Aufgaben, Methoden und Ergebnisse, dargestellt am Beispiel des mittleren und südlichen Leineberglandes. Göttinger Geographische Abhandlungen 60: 401–436.

DONELLY A., DALAL-CLAYTON B. and HUGHES R. [eds], 1998: A Directory of Impact Assessment Guidelines. Second Edition. Russel Press, Nottingham. A Directory of Impact Assessment Guidelines, Online: http://www.iied.org/docs/spa/dir_impassess.pdf, accessed 14.11.2013.

DRAMSTAD W.E., SUNDLI TVEIT M., FJELLSTAD W.J. and FRY G.L.A., 2006: Relationships between visual landscape preferences and map-based indicators of landscape structure. Landscape and Urban Planning 78: 465-474.

EGBERT S.L., PARK S. and PRICE K.P., 2002: Using conservation reserve program maps derived from satellite imagery to characterize landscape structure. Comput. Electron Agric., 2002; 37: 141-56.

EL.KE.THE, 2009: Environmental monitoring of artificial reservoir N.Plastiras.

ELKIE P.C., REMPEL R.S. and CARR A.P., 1999: Patch Analyst User Manual: A tool for quantifying landscape structure. NWST Technical Manual TM-002. Ontario.

EPA, 2001: US Environmental Protection Agency. Dams management measures. EPA Office of Water, Online: http://www.epa.gov/nps/MMGI/Chapter6/ch6-3a, accessed 10.09.2013.

EPSTEIN J. and AXTELL R., 1996: Growing Artificial Societies. Social Science from the Bottom Up, MIT Press/Brookings, MA. 1996.

FERANEC J., OT´AHEL´ J. and CEBECAUER T., 2004: Krajinná pokrývka ako zdroj informácií o krajinnej dynamike. Geografický časopis, 56: pp. 33.

FISCHER T., 1999: Benefits arising from SEA application, a comparative review of North West England. EIA Review 19(2): pp. 143-173.

FORMAN R.T.T. and GORDON M., 1981: Patches and Structural Components for Landscape Ecology. Bioscience 31,10: 733-739.

FORMAN R.T.T. and GORDON M., 1986: Landscape ecology. John Wiley, New York.

FORMAN R.T.T., 1995: Land Mosaics: The Ecology of Landscapes and Regions. Cambridge University Press, Cambridge, UK.

FORZIERI G. and CATANI F., 2011: Scale dependent relations in land cover biophysical dynamics. Ecological Modeling 222(17): 3285-3290.

FRANKLIN J., 1993: Preserving biodiversity species, ecosystems or landscapes. Ecol. Appl., 3: pp. 202-205.

FRANKLIN S. and GRAESSER A., 1996: Is it an Agent, or just a Program? A taxonomy for Autonomous Agents, in Proceedings of the Third International Workshop on Agent Theories, Architectures, and Languages, Berlin, Springer, 1996.

FRANKLIN J., WOODCOCK C.E. and WARBINGTON R., 2000: Digital vegetation maps of forestlands in California. Integrating satellite imagery, GIS modeling, and field data in support of resource management. Photogrammetric Engineering and Remote Sensing 66: 1209-1217.

FRANKLIN S.E., 2001: Remote Sensing for Sustainable Forest Management. Lewis Publishers, Boca Raton, FL: 407.

FUGGLE R. and SMITH W.T., 2000: Experience with dams in water and energy resource development in the People's Republic of China, Cape Town (South Africa). Secretariat of the World Commission on Dams, 2000.

GACHET S., LEDUCA BERGERON Y., NGUYEN-XUAN T. and TREMBLAY F., 2007: Understory vegetation of boreal tree plantations, differences in relation to previous land use and natural forests. Forest Ecology Management 242: pp. 49-57.

GASTELLU-ETCHEGORRY J.P. and DUCROS-GAMBART D., 1991: Computer assisted land cover mapping with SPOT in Indonesia. International Journal of Remote Sensing, 12: 1493-1507.

GEOGHEGAN J., VILLAR S.C., KLEPEIS P., MENDOZA P.M., OGNEVA-HIMMELBERGER Y., CHOWDDURY R.R., TURNER B.L. and VANCE C., 2001: Modeling tropical deforestation in the southern Yucatan peninsula region. Comparing survey and satellite data. Agriculture Ecosystems and Environment 85: pp. 25-46.

GETIS A. and FRANKLIN J., 1987: Second order analysis of mapped point pattern. Ecology 68: 473-475.

GIBSON C., OSTROM E. and AHN T.K., 1998: Scaling Issues in the Social Sciences. A Report for the International Human Dimensions Programme on Global Environmental Change. IHDP Working Paper No.1. Bonn: International Human Dimensions Programme.

GLACKIN D.L., 1998: International space-based remote sensing overview 1980 - 2007. Canadian Journal of Remote Sensing 24: 307-314.

GOLLEY F., 1987: Introducing landscapes ecology. Landscape Ecol.1: pp.1-3.

GONCALVES M.L., 1998: A neural architecture for the classification of remote sensing imagery with advanced learning algorithms. Proceedings of IEEE Signal Processing Society Workshop, Cambridge, UK, Aug. 31- Sep. 2, 1998: 577-586.

GONG P., MARCEAU O.J. and HOWARTH P.J., 1992: A comparison of spatial feature extraction algorithms for land use classification with SPOT-HRV data. Remote Sensing of Environment, 40: pp. 13-151.

GREEN K., KEMPKA D. and LACKEY L., 1994: Using remote sensing to detect and monitoring land cover and land use change. Photogrammetric Engineering and Remote Sensing, 60: pp. 331-337.

GREGORY R.D., VAN STRIEN A., VORISEK P., MEYLING A.W.G., NOBLE D.G., and FOPPEN R.P.B., 2005: Developing indicators for European birds. Philosophical Transactions of the Royal Society of London. (S.B), Biological Sciences 360: pp. 269-88.

GRIFFITH J.A., STEHMAN S.V. and LOVELAND T.R., 2003: Landscape trends in mid-Atlantic and southeastern U.S. eco-regions. Environmental Management 32: 572-588.

GUSTAFSON E.J. and PARKER G.R., 1994: Using an index of habitat patch proximity for landscape design. Landscape Urban Planning 29: pp. 117-130.

GUSTAFSON E.L., 1998: Quantifying Landscape Spatial Pattern. What is the state of the art? In Ecosystems 1: pp. 143-156.

HAINES-YOUNG R. and CHOPPING M., 1996: Quantifying Landscape Structure: A Review of Landscape Indices and their Application to Forested Landscapes. Progress in Physical Geography. 20, 4: 418-445.

HALL FREDERICK C., 2001: Ground-Based Photographic Monitoring. General Technical Reports of the U.S. Department of Agriculture, Forest Service, PNW-GTR-503. Portland, OR: Pacific Northwest Research Station.

HAPPE K., KELLERMANN K. and BALMANN A., 2006: Agent-based analysis of agricultural policies: An Illustration of the Agricultural Policy Simulator AgriPolis, its adaptation and behavior. Ecology and Society 11(1): pp. 49.

HARALICK R.M., 1979: Statistical image texture analysis. In Handbook of Pattern

Recognition and Image Processing, edited by T. Y. Young and K. S. Fu (New York: Academic): pp. 247-280.

HARRISON A.E., 1974: Reoccupying unmarked camera stations for geological observations. Geology 2: 469-471.

HAY G.J. and NIEMANN K.O., 1994: Visualizing 3-D texture: A three dimensional structural approach to model forest texture. Can. J. Rem. Sens. 20(2): pp. 90 101.

HENDERSON - SELLERS A., WILSON M.F. and THOMAS G., 1985: The effects of spatial resolution on archives of land cover type. Climatic Change 7: 391 402.

HENDRICKSON O., 2003: Influences of global change on carbon sequestration by agricultural and forest soils. Environmental Reviews 11: pp. 161-92.

HENEBRY G.M. and GOODIN D.G., 2002: Landscape trajectory analysis: Toward spatio-temporal models of bio geophysical fields for ecological forecasting. Paper presented at Workshop on spatio-temporal Data Models for Bio geophysical Fields, La Jolla, CA, April 8-10, 2002, Online: http://www.calmit.unl.edu/BDEI/papers/henebry_goodin_position.pdf, accessed 23.10.2013.

HEROLD M., GOLDSTEIN N.C. and CLARKE K.C., 2003: The spatio temporal form of urban growth: measurement, analysis and modeling. Remote Sensing of Environment 86: pp. 286-302.

HOBBS R., 1997: Division of Wildlife and Ecology. PO Midland. W.A. 6056. Australia.

INNES J.L. and KOCH B., 1998: Forest biodiversity and its assessment by remote sensing. Global Ecology and Biogeography Letters, 7: 397-419.

IRWIN E.G. and GEOGHEGAN J., 2001: Theory, data, methods: developing spatially explicit economic models of land use change. Agriculture Ecosystems and Environment 85: pp. 7-23.

IVERSON L.R., 1988: Land use changes in Illinois, USA: The influence of landscape attributes on current and historic land use. Landscape Ecology, 2: pp. 45-61.

IVES JACK D., 1987: Repeat photography of debris flows and agricultural terraces in the Middle Mountains. Nepal. Mountain Research and Development 7(1): pp. 82-86.

JELINSKI D.E. and WU J., 1996: The modifiable areal unit problem and implications for landscape ecology. Landscape Ecology 11: pp. 129-140.

JENERETTE G.D. and WU J., 2000: On the definitions of scale. Bulletin of the Ecological Society of America 81: pp. 104-105.

JENSEN J.R. and COWEN D.J., 1999: Remote sensing of urban/suburban infrastructure and socio-economic attributes. Photogrammetric Engineering and Remote Sensing 65: 611-622.

KADIOGULLARI A.I., 2013: Assessing implications of land-use and land cover changes in forest ecosystems of NE Turkey. Environmental Monitoring and Assessment, 185, 2095-2106, Online: http://dx.doi.org/10.1007/s10661-012-2691-0, accessed 03.10.2013.

KARDITSA DEVELOPMENT, 2002: Rational development of tourism and environmental protection.

KANELLOPOULOS I. and WILKINSON G.G., 1997: Strategies and best practice for neural network image classification. Int. J. Remote Sens. 18: 711-725.

KARTERIS M., 2002: Dasiki aerofotografia. Fotoerminia kai chartografisi, 15: 243 261.

KEPNER W.G., WATTS C.J., EDMONDS C.M., MAINGI J.K., MARSH S.E. and LUNA G., 2000: A landscape approach for detecting and evaluating change in a semi-arid environment. Environmental Monitoring and Assessment, 64: pp. 179-195.

KNIGHT R.L., CLARKE R.A. and BASTIAN R.K., 2001: Surface flow (SF) treatment wetlands as a habitat for wildlife and humans. Water Science & Technology, 44: pp. 27-37.

KRETTINGER B., LUDWIG F., SPEER D., AUFMKOLK G. and ZIESEL S., 2001: Zukunft der Mittelgebirgslandschaften. Szenarienzur Entwicklung des ländlichen Raums am Beispiel der Fränkischen Alb. Bundesamtfür Naturschutz, Bonn-Bad Godesberg.

KUNSTMANN H. and KNOCHE H.R., 2011: Tracing water pathways from the land surface through the atmosphere: A new RCM-based evapotranspiration tagging method and its application to the Lake Volta region in West Africa. Paper presented at the 3rd iLEAPS Science Conference, Garmisch-Partenkirchen, Germany.

LANG S. and KLUG H., 2006: Interactive Metrics Tool (MT) - A didactical suite for teaching and applying landscape metrics. In Ekologia Supplement 25: pp. 131- 140.

LANG S. and BLASCHKE T., 2007: Landschaftsanalyzemit GIS. Stuttgart: Ulmer.

LASANTA-MARTINEZA T., VICENTE-SERRANO S.M. and CUADRAT-PRATS J.M., 2005: Mountain Mediterranean landscape evolution caused by the abandonment of traditional primary activities: a study of the Spanish Central Pyrenees. Applied Geography 25: pp. 47-65.

LAUSCH A. and HERZOG F., 2002: Applicability of landscape metrics for the monitoring of landscape change: issues of scale, resolution and interpretability. In Ecological Indicators 2: pp. 3-15.

LEE N. and WALSH F., 1992: Strategic Environmental Assessment. An overview, Project Appraisal, 7 (3): pp. 126-136.

LEE N., 1995: Environmental Assessment in European Union. A tenth anniversary project appraisal 7: pp. 123-136.

LEITCH J.A. and HOVDE B., 1996: Empirical valuation of prairie potholes: Five case studies. Great Plains Research, 6: pp. 25-39.

LIPPMANN R.P., 1987: An introduction to computing with neural networks. IEEE ASSP Mag. 4: pp. 4-22.

LIPSKÝ Z., 2000: Sledování změn v kulturní krajině. Czech Agricultural University, Prague: pp. 71.

LIPSKÝ Z., 2001: Vývoj české kulturní krajiny. Česká zemědělská univerzita v Praze, Kostelec nad Černými Lesy, 206 s.

LIU J., CUBBAGE F.W. and PULLIAM H.R., 1994: Ecological and economic effects of forest landscape structure and rotation length: simulation studies using ECOLECON. Ecological Economics 10: pp. 249-263.

LORET F. and MARI´ G., 2001: A comparison of the medieval and the current fire regimes in managed pine forests of Catalonia (NE Spain). Forest Ecology and Management 141:155-63.

LOVELAND T.R., SOHL T.L., STEHMAN S.V., GALLANT A.L., SAYLER K.L. and NAPTON D.E., 2002: A strategy for estimating the rates of recent United States land cover changes. Photogrammetric Engineering and Remote Sensing 68: 1091-1099.

LUCK M. and WU J., 2002: A gradient analysis of urban landscape pattern: A case study from the Phoenix metropolitan region, Arizona, USA. Landscape Ecology, 17(4): 327-339.

MAERTENS M., ZELLER M. and BIRNER R., 2006: Sustainable agricultural intensification in forest frontier areas. Agricultural Economics 34: pp. 197-206.

MANSON S.M., 2005: Agent-based modeling and genetic programming for modeling land change in the Southern Yucatan Peninsula Region of Mexico. Agriculture, Ecosystems and Environment 111(1): pp. 47-62.

MARCEAU D.J., 1999: The scale issue in social and natural sciences. Canadian Journal of Remote Sensing 25: 347-356.

MARCUCCI D.J., 2000: Landscape history as a planning tool. Lands. Urban Plan. 49: pp. 67-81.

MCCORMACK G., 2001: Water margins: Competing paradigms in China. Critical Asian Studies, 33, No. 1: pp. 5-30.

MCCULLY P., 2001: Silenced Rivers: The Ecology and Politics of Large Dams (London: Zed Books 2001).

MCGARIGAL K. and MARKS B., FRAGSTATS, 1995: Spatial pattern analysis program for quantifying landscape structure. General Technical Report, PNW GTR-351, U.S. Department of Agriculture, Forest Service, Pacific North west Research Station Portland 1995, Online: http://www.umass.edu/landeco/research/fragstats/fragstats.html, accessed 12.09.2013.

MÍCHAL I., 1992: Ekologická stabilita. Veronica, Brno.

MICHALAK W.Z., 1993: GIS in land use change analysis: Integration of remotely sensed data into GIS. Applied Geography 13: pp. 28-44.

MIKLÓS L., 1986: Spatial arrangements of landscape in landscape ecological planning LANDEP. Ecology (Bratislava), 5: pp. 49-70.

MORAN E.F., BRONDIZIO E., MAUSEL P. and WU Y., 1994: Integrating Amazonian vegetation, land use, and satellite data. Bioscience 44: pp. 329-338.

MORRIS D.W., 1987: Ecological scale and habitat use. Ecology 68: 362-369.

MORRIS G.L. and FAN J., 1998: Reservoir Sedimentation Handbook. McGraw-Hill, New York, U.S.A.

NAGENDRA H., 2002: Opposite trends in response for the Shannon and Simpson indices of landscape diversity. Applied Geography, vol. 27: pp. 175-186.

NUSSER M., 2001: Understanding cultural landscape transformation: A rephotographic survey in Chitral, eastern Hindukush, Pakistan. Landscape and Urban Planning 57: pp. 241-255.

O'NEIL R.V., KRUMMEL J.R., GARDNER R.H., SUGIHARA G. and JACKSON B., 1988: Indices of landscape pattern. Landscape Ecology, 1: pp. 153-162.

OPDAM P., FOPPEN R. and VOS C., 2001: Bridging the gap between ecology and spatial planning in landscape ecology. Landscape Ecology 16: 767-779.

PAN D., DOMON G., DE BLOIS S. and BOUCHARD A., 1990: Temporal (1958 1993) and spatial patterns of land use changes in Haut-Saint-Laurent (Quebec, Canada) and their relation to landscape physical attributes. Landscape Ecology 14: pp. 35-52.

PAQUETTE S. and DOMON G., 1997: The transformation of the agroforestry landscape in the nineteenth century: a case study in southern Quebec (Canada). Landscape Urban Planning, 37: pp. 197-209.

PARKER D.C., MANSON S.M., JANSSEN M.A., HOFFMANN M.J. and DEADMAN P., 2003: Multi-agent systems for the simulation of land -use and land cover change: A review. Annals of the Association of American Geographers 93 (2): 314-337.

PARKER D. and MERETSKY V., 2004: Measuring pattern outcomes in an agent-based model of edge-effect externalities using spatial metrics. Agriculture, Ecosystems & Environment, 101(2-3): 233-50.

PARTIDARIO M.R., 1998: Significance and the Future of Strategic Environmental Assessment. International Workshop on Strategic Environmental Assessment. Japan Environmental Agency: pp. 13-21.

PARTIDARIO M.R., 1999: Strategic Environmental Assessment - principles and potential, chapter 4, in Petts, Judith (Ed.). Handbook on Environmental Impact Assessment, Blackwell, London: pp. 60-73.

PARTIDARIO M.R., 2000: Elements of an SEA framework – improving the added value of SEA. Environmental Impact Assessment Review, 20: 647-663.

PERZ S.G., 2001: Household demographic factors as life cycle determinants of land use in the Amazon. Population Research and Policy Review 20: pp. 159-186.

PETIT C.C. and LAMBIN E.F., 2002: Long-term land cover changes in the Belgian Ardennes (1775–1929): Model-based reconstruction vs. historical maps. Global Change Biology 8: 616-630.

PICHON F.J., 1997: Settler households and land use patterns in the Amazon frontier: Farm-level evidence from Ecuador. World Development 25: pp. 67-91.

PICKETT S.T.A. and WHITE P.S. [eds.], 1985: The Ecology of Natural Disturbance and Patch Dynamics. New York: Academic Press.

PICKETT S.T.A. and CADENASSO M.L., 1995: Landscape ecology: Spatial heterogeneity in ecological systems. Science 269: 331-334.

PIDWIRNY M., 2006: Introduction to Geographic Information Systems. Fundamentals of Physical Geography, 2nd Edition, Online: http://www.physicalgeography.net/fundamentals/2e.html, accessed 19.11.2013.

POPE J., ANNANDALE D. and MORRISON-SAUNDERS A., 2004: Conceptualizing sustainability assessment. Environmental Impact Assessment Review, 24: 595-616.

QUATTROCHI D.A. and PELLETIER R.E., 1991: Remote Sensing for Analysis of Landscapes: An Introduction. In: Turner, M.G., Gardner, R., H., (eds.): Quantitative Methods in Landscape Ecology. The Analysis and Interpretation of Landscape Heterogeneity. Ecological Studies, Vol. 82, Springer-Verlag, New York: pp. 51-76.

RAILSBACK S., LYTINEN S. and JACKSON S., 2006: Agent-based simulation platforms: Review and development recommendations. Simulation 82(9): 609-623.

RAMACHANDRAN S., KRISHNAMOORTHY R., SUNDRAMOORTHY S., PARVIZ Z.F., KALYANAMUTHIAH A. and DHARANIRAJAN K., 1997: Management of Coastal Environments in Tamilnadu and Andaman & Nicobar Islands based on Remote Sensing and GIS approach. Special issue on Coastal Environmental Management. Pune Journal, IV (15 & 16): pp. 129-140.

RAMANKUTTY N. and FOLEY J.A., 1999: Estimating historical changes in global land cover: Croplands from 1700 to 1992. Global Biogeochemical Cycles 13: 997-1027.

RICHARDS JOHN F., 1986: "World Environmental History and Economic Development" in Sustainable Development of the Biosphere, (eds.) W.C. Clark and R. E. Munn. Laxenburg, Austria: International Institute for Applied Systems Analysis.

RIERA J., VOSS P.R., CARPENTER S.R., KRATZ T.K., LILLESAND T.M., SCHNAIBERG J.A., TURNER M.G. and WEGENER M.W., 2001: Nature, society and history in two contrasting landscapes in Wisconsin USA: Interactions between lakes and humans during the twentieth century. Land Use Policy 18: pp. 41–51.

RISSER P.G., 1987: Landscape ecology: State of the art. See Ref. 140: pp. 3-14.

ROBINOVE C.J., 1981: The Logic of Multispectral Classification and Mapping of Land. Remote Sensing of Environment, Vol. 11: pp. 231-244.

ROGAN J., MILLER J., STOW D., FRANKLIN J., LEVIEN L. and FISCHER C., 2003: Land cover change mapping in California using classification trees with Landsat TM and ancillary data. Photogrammetric Engineering and Remote Sensing, 69(7): 793-804.

ROMPORTL D. and CHUMAN T., 2009: Změny struktury krajiny v České republice poroce 1990. Prezentace, přírodo vědecká fakulta, Online:

http://www.cenelc.cz/components/pages/ns/bin/fok03_romportl.pdf, accessed 20.12.2013.

RUMELHART D.E., HINTON G.E., and WILLIAMS R.J., 1986: Parallel Distributed Processing. MIT Press: Cambridge, MA, USA, 1986.

RUSSEL S. and NORVIG P., 1995: Artificial Intelligence: A Modern Approach. Prentice Hall, 1995.

SADLER B. and VERHEEM R., 1996: Strategic Environmental Assessment: Status, Challenges and Future Directions. Report no. 53. Ministry of Housing Spatial Planning and Environment.

SADLER B., 1999: Environmental Sustainability Assessment and Assurance, in Petts (ed.) 1999: pp. 12-32.

SAUNDERS D.A., HOBBS R.J., and MARGULES C.R., 1991: Biological consequences of ecosystem fragmentation: A review. Conservation Biology, 5: pp. 18-32.

SAURA S. and CARBALLAL P., 2004: Discrimination of native and exotic forest patterns through shape irregularity indices: Analysis in the landscapes of Galicia, Spain. Landscape Ecology 19 (2004): 647-662.

SAWYER CAROL F. and DAVID BUTLER R., 2006: The use of historical picture postcards as photographic sources for examining environmental change: Promises and problems. Geocarto, International 21(3): pp. 73-80.

SAXENA K.R., 2005: Dams: Incidents and accidents. A.A. Balkema, Leiden, Netherlands.

SVORONOS N., 1976: Episkopisi Neoellinikis Istorias, Themelio, Athina 1976.

SCHNEIDERN EUGSTER W. and SCHICHLER B., 2004: The impact of historical land use changes on the near-surface atmospheric conditions on the Swiss Plateau. Earth Interact. 8(12): pp. 1–27. Doi: 10.1175/1087-3562(2004) 008<0001: TIOHLC>2.0.CO; 2.

SCHREIBER K.F., 1990: The history of landscape ecology in Europe - In Changing Landscapes. An Ecological Perspective: pp. 21-34.

SETO K.C., FRAGKIAS M., GUNERALP B. and REILLY M.K., 2011: A meta-analysis of global urban land expansion. PLoS ONE, 6(8): e23777, 937. Doi: 10.1371/journal.pone.0023777.

SHALABY A. and TATEISHI R., 2007: Remote sensing and GIS for mapping and monitoring land cover and land use changes in the northwestern coastal zone of Egypt. Applied Geography 27(1): pp. 28-41.

SHEPHERD J.M., 2005: A review of current investigations of urban-induced rainfall and recommendations for the future. Earth Interact., 9: pp. 1-27, 940. Doi: 10.1175/EI156.1.

SHUGART H.H., 1984: A theory of Forest Dynamics: The ecological implications of forest succession models. Springer Verlag, New York.

ŠLEZINGR M., 2003: Applied and landscape ecology. Brno: Akademické nakladatelství CERM.

STAFF F., 1966: The Picture Postcard and its Origins. New York, NY.

STATHAKIS Γ., 2004: To dogma Trouman kai to Sxedio Marshall. Bibliorama, Athina 2004.

STERN P.C. and DIETZ T., 1994: The Value Basis of Environmental Concern. Journal of Social Issues, 50(3): pp. 65-84.

STOATE C., BOATMAN N.D., BORRALHO R.J., RIO CARVALHO C., DESNOO G.R. and EDEN P., 2001: Ecological impacts of arable intensification in Europe. Journal of Environmental Management 63 (2001): 337-65.

SUNDSETH K. and SYLVESTER A., 2009: Towards Green Infrastructure for Europe – Proceedings of the European Commission workshop. Ecosystems LTD, Brussels, Belgium.

SWANSON F.J., KRATZ T.K., CAINE N. and WOODMANSEE R.G., 1988: Land form effects on ecosystem patterns and processes. Bioscience 38: pp. 92-98.

TAAFFE E., GAUTHIER H. and O'KELLY M., 1996: Geography of Transportation. Prentice-Hall, Englewood Cliffs, NJ.

THOMSON A.G., FULLER R.M. and EASTWOODS J.A., 1998: Supervised versus unsupervised methods for classification of coasts and river corridors from airborne remote sensing. Int. J. Remote Sens. 18 (2001): 3423-3431.

TISCHENDORF L., 2001: Can landscape indices predict ecological processes consistently? Landscape Ecology 16 (2001): 235-254.

TOBLER W., 1979: Cellular geography. In S. Gale and G. Olsson (Eds.), Philosophy in Geography: 379-86.

TROTTER C.M., 1991: Remotely sensed data as an information source for geographical information systems in natural resource management: A review. Int. J. GIS 5(2): pp. 225-239.

TRUFFER B., BRATRICH C., MARKARD PETER J.A., WUEST A. and WEHRLI B., 2003: Green Hydropower: The contribution of aquatic science research to the promotion of sustainable electricity. Aquatic Sciences, 65(2): pp. 99 110.

TSAI F., CHOU M.J. and WANG H.H., 2005: Texture Analysis of High Resolution Satellite Imagery for Mapping Invasive Plants. Geoscience and Remote Sensing Symposium, 2005. IGARSS ‘05 Proceedings. 005 IEEE International, vol. 4: 3024-3027. ISBN:0-7803-9050-4.

TURNER M.G. [ed.], 1987: Landscape Heterogeneity and Disturbance. New York. Springer-Verlag.

TURNER M.G., 1989: Landscape ecology: the effect of pattern on process. Annual Review of Ecology and Systematics 20: pp. 171-197.

TURNER M.G. and GARDNER R.H., [Eds.] 1990. Quantitative methods in landscape ecology. Springer, New York.

TURNER B.L. II and MEYER W.B., 1991: Land-use and land cover in global environmental change: Considerations for study. Int. Soc. Sci. J. 130: 669-792.

TURNER, M.G. and GARDNER R.H. [eds.], 1991: Quantitative Methods in Landscape Ecology. The Analysis and Interpretation of Landscape Heterogeneity. Ecological Studies, 82, Springer-Verlag, New York.

TURNER M.G., 2005: Landscape ecology in North America: Past, present and future. Ecology 86: 1967-1974.

UUEMAAE M., ANTROP J., ROOSAARE MARJA R. and MANDER Ü., 2009: Landscape Metrics and Indices: An Overview of Their Use in Landscape Research. Living Rev. Land. Res., 3, 1.

UNEP, 2002: Environmental impact assessment training resource manual. Barry Sadler and Mary McCabe (eds.). Second edition. Geneva, Switzerland.

UNEP, 2004: Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach. Geneva Switzerland.

URBAN D.L., O`NEIL R.V. and SHUGART H.H., 1987: Landscape ecology. Bioscience 37: pp. 119-127.

UNEP, 2009: Integrated Assessment: Guidance for mainstreaming sustainability into policymaking. UNEP.

US Department of Agriculture, 1971: Soil Conservation Service. National Engineering Handbook (World Commission of Dams, 1971).

VAN DER VEEN A. and OTTER H.S., 2001: Land use changes in regional economic theory. Environmental Modeling and Assessment 6: pp. 145-150.

VEATCHFRED M., 1969: Analysis of a 24-year photographic record of Nisqually Glacier, Mount Rainier National Park Washington. U.S. Geological Survey Professional Paper 631: pp. 52.

VELDKAMP A. and LAMBIN E.F., 2001: Predicting land use change. Agriculture, Ecosystems and Environment, 85 (2001): pp. 1-6.

WANG L. and HE D.C., 1990: A new statistical approach for texture analysis. Photogrammetric Engineering and Remote Sensing, 56: pp. 61- 66.

WARNICK C.C., 1984: Hydropower Engineering (Prentice-Hall 1984).

WATT A.S., 1947: Pattern and process in the plant community. J, Ecol. 35: pp. 1-22.

WCD, 2000: World Commission on Dams, Dams and development. A new framework for decision-making (Earth Scan Publications, 2000).

WCD, 2000a: World Commission on Dams, Dams and Development: A new framework for decision-making (Earth Scan Publications, 2000a).

WEISS C.M. and FOX K., 2003: European food supply chains are they sustainable? Executive Outlook 2003; 3: pp. 54-63.

WELLER A.F. HARRIS A.J. and WARE J.A., 2006: Artificial neural networks as potential classification tools for din flagellate cyst images: A case using the self-organizing map clustering algorithm. Rev. Paleobot. Palynol. 141 (2006): 287-302.

WHITE R. and ENGELEN G., 1994: Urban systems dynamics and cellular automata: Fractal structures between order and chaos. Chaos, Solitons & Fractals, 4(4): WOOD C. and DJEDDOUR M., 1992: Strategic Environmental Assessment: EA of Policies, Plans and Programmes. Impact Assessment Bulletin 10 (1): pp. 3-21 563-83.

WU J., 1999: Hierarchy and scaling: Extrapolating information along a scaling ladder. Canadian Journal of Remote Sensing 25: 367-380.

ZIEGLER T., 1987: Einführung in das Automatisierte Liegenschaftsbuch (ALB). Ausbildungsvortrag des Bayerischen Landesvermessungsamtes 19, München.

Used Programs

- ✓ ARCGIS 10.1 2012-13: ArcGIS Desktop. “ESRI”.
- ✓ V-LATE 2004: Vector-based Landscape Analysis Tools Extension. “Geoinformatics Centre”, University of Salzburg, Austria

9. APPENDIX A

Photo 1. Panoramic landscape view of Lake Plastiras

Photo 2. Dam Detail

Photo 3. Historical Picture showing the construction period in late 50's

Source: (http://www.plastiras-lake.gr/)

Photo 4. Bank erosion caused by annually or seasonally fluctuating levels

Source: (http://www.lets-go-earth.blogspot.cz/2013/01/greece-tourism.html)