

Towards indicators for assessing land-use change in planning: Case study of the peri-urban zone of Thessaloniki.

N. Bessa

University of Thessaly, Greece

ABSTRACT

Expanding urban areas face growing land use conflicts particularly in the peri-urban zone, which is defined as a zone outside the city, occupied both by 'classical' rural land uses, and construction of road infrastructure and commercial shopping centers, which result as rapid changes. These changes of the peri-urban zone lead to complex patterns of land uses as evidenced in terms of the intensity and structure. To the extent that modern societies need to understand such patterns in order to formulate appropriate guidance policies, it is interesting to develop a relevant framework of analysis. It is necessary to assess land-use change in order to assist urban planning and related decision-making. The proposed approach explores an analytical framework combining GIS and a system of PSI (pressure-state-impact) indicators aimed at the analysis of urban growth and land use change in the peri-urban zone of Thessaloniki. Thessaloniki is the second largest city of Greece which is located in the Northern part of the country and has approximately one million inhabitants.

SIGNIFICANCE OF LAND USE AND LAND USE CHANGE

Land use is being formed under the influence of two broad sets of forces (i) humans needs and (ii) environmental features and processes, and thus why land use actually is the human use of land. The different types of land use are formulated from the bio-physical characteristics of land itself and the use that humans try to service (food production, residence...).

The scientific study of the factors that contribute to the land use change and of the impacts of land use change involves a wide research field. The diversity of those factors involves inevitably the mixture of different and disparate sciences (social, economic sciences.). The approaches taken for the analysis of land use change are decided by the analyst's objectives. Thus the definitions of land use, land use change land use change classification systems used, the theoretical schemata adopted and the models employed all depend on the aim of the research.

Defining Land Use and Land Use Change

In the various studies of the land use and land use change are not adopted usually similar definitions. The definitions and the descriptions of these terms vary depending on the aim and the framework of the study. It is, consequently, essential to report some alternative definitions. (Briassoulis, 2000)

- Land use involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation – the purpose for which the land is used (Turner et al. 1995, 20). Meyer (1995),
- land use is the way in which, and the purpose for which, human beings employ the land and its resources (Meyer 1995, 25),
- land use denotes the human employment of land (Turner and Meyer 1994, 5).

- land use itself is the human employment of a land-cover type, the means by which human activity appropriates the results of net primary production (NPP) as determined by a complex of socio-economic factors (Skole 1994, 438).
- land use concerns the function or purpose for which the land is used by the local human population and can be defined as the human activities which are directly related to land, making use of its resources or having an impact on them (FAO 1995, 21). (Briassoulis, 2000)

The above definitions of land use refer mostly to larger scales, at the urban scale, interest focuses on other aspects of the term. In the words of Chapin and Kaiser (1979): "At territorial scales involving large land areas, there is a strong predisposition to think of land in terms of yields of raw materials required to sustain people and their activities. At these scales, 'land' is a resource and 'land use' means 'resource use'. In contrast, at the urban scale, instead of characterizing land in terms of the production potential of its soils and its submineral content, the emphasis is more on the use potential of the land's surface for the location of various activities" (Briassoulis, 2000).

It is essential to note the differences between land use and land cover, because it is certain that sometimes those terms are confused. Land cover has been defined from Turner et al. 1995, as the biophysical state of the earth's surface and immediate subsurface". (Briassoulis, 2000). Additional Moser (1996) remarks that: "The term originally referred to the type of vegetation that covered the land surface, but has broadened subsequently to include human structures, such as buildings or pavement, and other aspects of the physical environment, such as soils, biodiversity, and surfaces and groundwater". (Briassoulis, 2000)

The description of land use, which is depended from the definition that is employed at a specific analysis, should specify for a given spatial level and for a given area the followings: (Bourne 1982, Skole 1994)

1. the mix of land use types,
2. the pattern of these land use types,

3. the areal extent,
4. the intensity of use associated with each type,
5. and the land tenure status. (Briassoulis, 2000)

Considering the above description of land use, for a given spatial level and for a given area it is simple to conceptualize the meaning of change. It is important to underline that the detection and measurement of change depends on the spatial scale.

Land use change may entail either (a) conversion from one type of use to another or (b) modification of a certain type of land use. On the one hand conversion it is easier to be observed, for example it is obvious that an agricultural area becomes residence or a change on the specific pattern. On the other hand modification, it is not so easy, because for example the change in the intensity of a use, as well as alterations of its characteristic qualities/attributes is not so noticeable.

The land use change involves also land cover change, as Meyer and Turner (1996) suggest that land use alters land cover in three ways: (a) converting the land cover, (b) modifying it, or quantitatively changing its condition without full conversion, and (c) maintaining it in its condition against natural agents of change" (Briassoulis, 2000).

Thus, their analysis requires the examination of the ways in which land use relates to land cover change. It is crucial to specify the spatial and temporal levels of the analysis as: first of all it is the guide for the selection of the types of land use and land cover that will be analyzed. Secondly, is the determinant of the drivers and processes of change that can be detected and, thus, it affects the recognition and explanation of the linkages between land use and land cover within particular spatio-temporal frames.

However, the analysis of land use change depends on the chosen system of land use and land cover classification. The size and quality of land use change is expressed in terms of specific land use or land use/cover types.

Defining Land Use classification system

A vital dilemma for a classification system is the choice between representing "what is" and "what should be". According to Wolman (1987) the "what is" encompasses the land available on earth and its characteristics as described by a given technology at a given point in time. While the "what should be" relates to values placed on the land and its characteristics and the resulting choices made by people about uses for land (Briassoulis, 2000).

Classification systems are distinguished in terms of the spatial scale of analysis for which they are developed and the purpose of their development. The spatial scale determines the level of environmental and socio-economic detail contained in the classification system while the purpose of the study determines the particular attributes of the land use types that will be considered. In addition, available technology for data collection is a significant determinant of their structure and content (Briassoulis, 2000).

Moreover, the classification systems have to deal the existence or not level in the land uses and also the number of categories of types of land uses that is used, the usual solution can be grouped in three types, as it appears diagrammatic in following table: (Oikonomou, 1994)

Monodimensional systems	Systems of two levels		Multidimensional systems				
	General uses	Special uses	I	I.I	I.I.I	I.I.I.I	
1 Agricultural land	Residence	Unmixed residence	1	Industry			
2 Irrigated agricultural land	Central functions	Trade		1.1 Heavy industry			
3 Unmixed residence	Industry	Leisure facilities			1.1.1 Steel		
4 Seasonal residence	Industry			1.1.2 Oil		
.....		Transportation		1.2 Agricultural industry			
				1.2.1 Food		
					1.2.2 Drink		
				2 Trade			
			2.1 Retail				

Table 1: The diagrammatic appearance of different classification system.

Source: Oikonomou, (1994)

LITERATURE REVIEW

Economic Theories of Land Use and Location

Historically city growth in Europe has been closely linked to economic structural change. Rural to urban migration was parallel with the reduction in agricultural and the growth in industrial employment for the duration of the first industrial revolution. (Wegener, M. & Fürst, F., 1999)

Location theory is based on Von Thünen's (1826) classic work, which studied the relationship between agricultural land allocation, distance to commodities markets, and prices of agricultural goods. Von Thünen was among the most well known pioneers who establish a connection between land price and distance from a commercial center. He argued that the cost of transporting commodities to markets defines the rents that farmers and other producers can afford to pay, and how far from a market the farmer can afford to purchase land.

Weber (1929) developed the classical model of industrial location, which requires a minimization of transport costs for both inputs and outputs, given an optimal level of production. Weber's model assumes that transport costs are linearly related to distance, and uses simple geometry to define the location of a production facility.

Then Christaller (1933) and Lösch (1940) adopted different approaches in order to explain the geometric and hierarchical arrangement of market areas with their central place theories. Based on these theories is the conclusion that transportation infrastructure defines the market area of an activity center and the uses of the land surrounding the center.

Alonso (1964) analyzed the economics of land use in a modern urban area and probably proposed the most influential example of the urban land market. The basic assumption of the Alonso model is that firms and households choose that location at

which their bid rent equals the asking rent of the landlord, so that the land market is in equilibrium. He argued that the travel time, travel cost, and accessibility are not the only determinants of land rent and other noneconomic factors may have equal or greater influences on land values. Therefore he proposed these noneconomic factors (satisfaction factors) to be included in an analysis of the effects of transportation improvements on land values. (Kockelman et al, 2000)

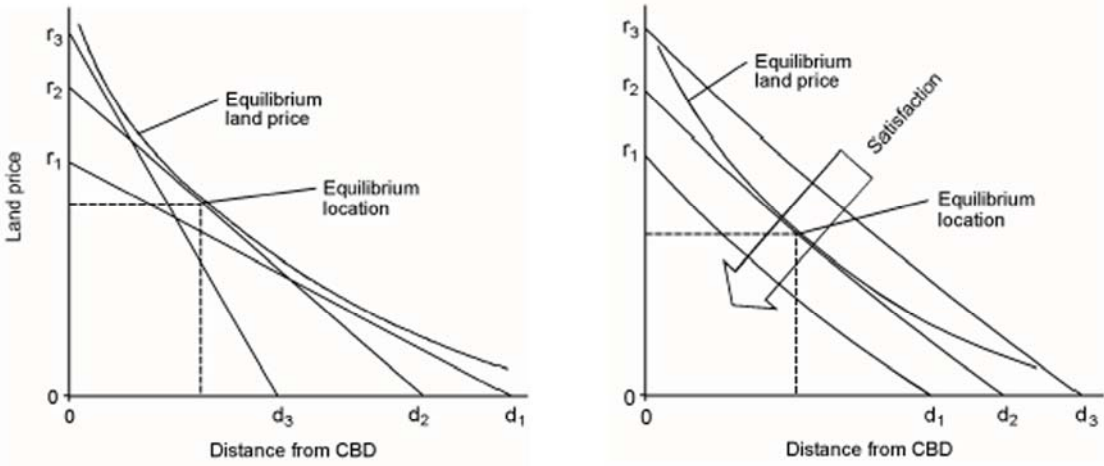


Figure1: The model of urban land markets by Alonso (1964).

Source: Wegener, M. & Fürst F. (1999)

Figure 1 shows the principles of the Alonso model for firms and households. Under the simplifying assumption that all goods are sold in the city centre, the bid rents of different types of firms follow curves sloping outward from the centre with different degrees of slope; their envelope curve is the equilibrium asking rent (Figure 1, left). The optimum location for a firm is where its bid rent curve is tangential to that curve. As households have no cost functions like firms, it is necessary in their case to use indifference curves indicating their trade-off between land consumption and distance to the centre (Figure 2.3, right). Each household type has a linear budget restriction, i.e. has to divide its expenditure between land and transport costs. The optimum trade-off between land consumption and accessibility for a household is where its budget line

and indifference curve are tangential; its optimum location is where its resulting bid-rent curve is tangential to that of the equilibrium asking rent. (Wegener, M. & Fürst F., 1999)

Alonso's model has become a byword for a multitude of urban economics model approaches. Afterwards followed several variations of the model, where restrictive assumptions such as perfect competition and complete information or the monocentric city have been relaxed (e.g. Anas, 1982). Other extensions comprise models to deal with land speculation (Seo, 1989) or the behaviour of landlords in neighbourhoods undergoing gentrification (Smith and Williams, 1986) or the incorporation of intersectoral and interregional factor and commodity flows into the model (Williams and Echenique, 1978). (Wegener, M. & Fürst F., 1999)

Kondratieff (1926) and Schumpeter (1939) proposed the theory of long waves, which notes that economic history is a succession of growth phases triggered by 'basic innovations' such as the steam engine, the railway or the automobile. (Wegener, M. & Fürst F., 1999)

Giuliano (1986) commented the development of employment subcenters in suburban areas. Improvements to radial highways made possible for commuters to live further from work as the travel time remained the same, thus promoting the low density housing common to suburban areas. In the meantime, firms and employers have followed the flow of residents and employees from the central business district to the suburbs. Consequently transportation improvements enlarged market areas and accelerated the process of decentralization, nevertheless instead of allowing everlasting decentralization; they have encouraged the development of multi-centered regions. Employment and retail subcenters have developed at major intersections in the suburban highway network. This centralization of businesses as a result created the attraction of relatively high-density residential development to the immediate vicinity of the subcenters. (Kockelman et al., 2000)

Transportation costs and customer access do not have the same significance for certain types of businesses. For example, for manufacturing firms transport costs are only a small component (less than five percent) of overall production costs (Button 1993), therefore for manufacturers it isn't a crucial decision the location choice. On the contrary, for service-oriented firms transport costs are ten percent or more of total costs (Button, 1993). Therefore, firms in the service sector are expected to consider location choice more carefully and respond to transportation improvements. High-technology firms give transportation networks careful consideration (Button, 1993), given their need to retain scarce skilled labor and ship their products to international markets; this is particularly relevant to places like Silicon Valley, California, and Austin, Texas. (Kockelman et al, 2000)

Social Theories

In social sciences theories of urban development the spatial development of cities is the result of individual or collective appropriation of space. Since Durkheim and Simmel the city is a fundamental dimension of human existence. Bahrtdt (1969) defined the city as the interface between public and private society, Goffman (1959) as the stage for social interaction and selfexpression, Lefebvre (1968) as the medium for the world of daily life or Harvey (1973) and Castells (1977) as the field of action of social movements. However, these approaches remained essentially social theories and failed to deal explicitly with the spatial and temporal dimensions of urban development. (Wegener, M. & Fürst F., 1999).

The study of the urban past remained the domain of urban historians, their method was essentially hermeneutic. However, the Chicago school of urban sociologists looked more closely into processes of social change on the neighbourhood and urban levels. They interpreted the city as a multi-species ecosystem, in which social and economic groups fight for 'ecological positions', based on an adaptation of evolutionist thoughts from philosophy and biology.

As a result, several qualitative theories of urban development were presented to explain the spatial expansion of American cities, such as the concentric (Burgess, 1925), sector (Hoyt, 1939), or polycentric (Harris and Ullman, 1945) theories of city growth. However, despite their effort to include space, these theories, were essentially social theories. Space and time were included in them only in categorical terms, since analytical methods for treating intervals in space and time were only rudimentarily developed (Wegener, M. & Fürst F., 1999).

Notwithstanding these shortcomings, concepts from social ecology continue to be useful for understanding the mechanisms of social change in cities, which also shape the pattern of land use, beyond the economic processes on the land market.

Technical Theories

Cities appeared in human history when technological innovation required the division of labour. The concentration of specialised skills in larger settlements released a 'tremendous expansion of human capabilities' and then there was the demand for protection and exchange: the citadel and the market were the primeval urban functions (Wegener, M. & Fürst F., 1999).

Andersson (1986) presents 'four logistical revolutions' that have shaped the European urban system. First in the Middle Ages, safe highways made possible long-distance trade, afterwards safe money exchange facilitated international trade, later on was the industrial revolution which brought the railways and finally today, the integration of transport and telecommunications (the 'real' logistical revolution) is creating the 'global' city and, in the European context.

The technical paradigm of urban development is at the base of many theories of why some cities grow and some stagnate or decline. Törnqvist (1968, 1970) developed the idea of city systems built on contact networks describing interactions of people and information between cities (Wegener, M. & Fürst F., 1999).

URBAN SYSTEM AND PERI-URBAN ZONE

Understanding the concept of a city and the processes that take place in it was, is and will be always a main concern. According to Bourne (1982), it consists of three elements: urban form, urban interaction and a set of organising principles that define the relationship between the two. Specifically, urban form is defined as the spatial pattern of fixed elements within a metropolitan area and urban interaction refers to the flows of people, goods and information among different locations in the city. The determinant is that urban form exerts a profound influence on the transportation flows within the city, but does not determine them completely. In reality, within a complex urban system several organising principles work concurrently.

The urban system is also a dynamic entity, its spatial structure evolving over time and responsible for this evolution is a variety of factors. Concisely, can be reported here some factors such as: (a) behaviour of the actors that operate in the system because with their locational decisions shape urban form and their trips decisions formulate urban interaction, consequently is closely related to the organising principles. (b) natural and man-made processes can shape the urban environment, (c) national, regional and even local state of the economy and a number of policies can affect the urban environment.

Transportation—Land Use Interactions

In the 1950s first efforts were made in the USA to study systematically the interrelationship between transport and the spatial development of cities. The recognition that trip and location decisions co-determine each other and that therefore transport and land-use planning needed to be co-ordinated, quickly spread among American planners, and the 'land-use transport feedback cycle' became a commonplace (Wegener, M. & Fürst F., 1999). (see Figure 2)

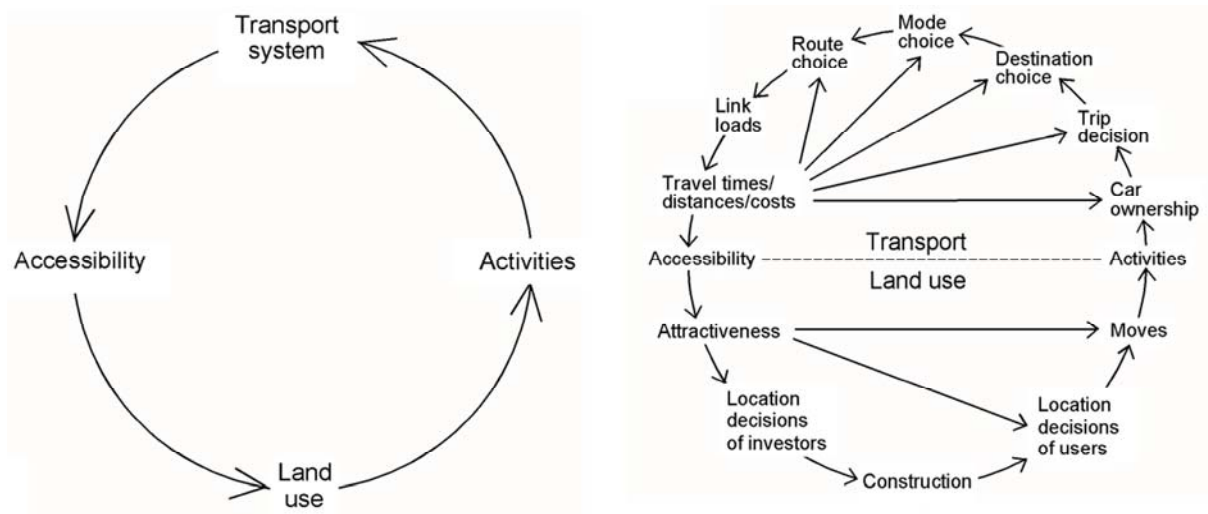


Figure 2: The 'land-use transport feedback cycle'.
Source: Wegener, M. & Fürst F. (1999)

To sum up the set of relationships implied by this term it can be said the following:

- The distribution of land uses, over the urban area determines the locations of human activities and shapes the land use pattern.
- The distribution of human activities in space requires spatial interactions or trips in the transport system in order to overcome the distance between the locations of activities.
- The distribution of infrastructure in the transport system creates opportunities for spatial interactions and can be measured as accessibility.
- The distribution of accessibility in space co-determines location decisions and so results in changes of the land-use system (Wegener, M. & Fürst F., 1999).

Transportation and land use are inextricably linked. The spatial pattern of human activities creates the need for travel and goods transport is the principle of transport analysis and forecasting. Based on this principal, it is obvious that the suburbanisation of cities is connected with increasing spatial division of labour, and hence with ever increasing mobility. On the other hand, the reverse impact from transport to land use, is less obvious and well known. It is not clearly understood exactly how the development of the transport system influences the location decisions of landlords, investors, firms and households.

Miller, Kriger and Hunt (1999), made four main observations, in their effort to explain how urban form affects travel behavior; however, transit systems also affect urban form:

1. Fixed, Permanent Transit Systems Have the Most Significant Effect. Only major fixed guideway infrastructure can have a discernable effect on urban form development. Flexible systems such as bus systems, relatively ubiquitous systems can provide reasonably high levels of accessibility, which, influence location and travel choices, but can not stimulate major land development decisions.
2. Transit's Effects Are Measurable Only in the Long Term. Urban form evolves on a time scale of decades. Short-term effects are inevitably negligible and shortterm responses are not necessarily indicative of longterm effects.
3. Transit's Effects on Land and Development Markets— Not Land Values—Must Be Considered. Most of the empirical evidence relates to the effects of transportation on land values.
4. Transportation Facilitates Development But Does Not Cause Development. In particular, transportation facilitates is a "necessary but not sufficient condition" for development to occur. Knight and Trygg (1977) build a compelling case that transit investment is "one piece of the puzzle" and local land use policies, other government policies, and so forth, all must interact in a mutually reinforcing way in order to succeed positive land development (TRB, 1999).

Paulley and Pedler (2000) in their final report for project TRANSLAND, present in brief, the theoretically expected impacts of transport to land use as well as findings in empirical studies. On the one hand the impact of transport on land use is mediated by a change in the accessibility of a location. As a consequence higher accessibility increases the attractiveness of a location for all types of land uses thus influencing the direction of new urban development. If, though, accessibility in an entire city is increased, it will result in a more dispersed land use pattern. On the other hand in empirical studies it was reported that accessibility has different importance for different types of land uses. It is a vital location factor for retail, office and residential uses.

Locations with high accessibility tend to be developed faster than other areas. The value of accessibility for industry varies considerably, depending mainly on the goods produced.

Comprehensively, for residential locations the theoretically expected impacts are that locations with better accessibility to workplaces, shops, education and leisure facilities will be more attractive for residential development. As a result they tend to have higher land prices and be developed faster. Also, in empirical studies it was reported that more accessible locations are developed faster. If accessibility in the whole region grows, residential development will be more dispersed. Similarly, for industrial locations the theoretically expected impacts are that locations with better accessibility to motorways will be more attractive for industrial development and be developed faster. However, in empirical studies it was reported that there is little evidence of impacts of accessibility on location of manufacturing, but ample evidence of the importance of accessibility for high-tech and service firms. In the same way, for office locations expected that locations with better accessibility to transport infrastructures will be more attractive for office development, have higher land prices. Even so, in empirical studies it was reported that office locations are predominantly at highly accessible inner-city locations or in office parks or 'edge cities' at the urban periphery with good motorway access. Finally, for retail location the theoretically expected impacts are that locations with better accessibility to customers and competing retail firms will be more attractive for retail development, have higher land prices and be faster developed. As expected in empirical studies it was reported that retail locations are at highly accessible inner-city locations or on peripheral sites with ample parking and good road accessibility (Paulley, N. & Pedler A., 2000).

Defining peri-urban zone

The peri-urban zone is known as an alternative pattern of urban development. It has been observed in many European countries (Caruso, 2002) as well as in the US (Nelson and Sanchez, 1997). The definition and the attributes of peri-urban zone

constitute a complex problem of urban theory, as it is shaped depending on the wider economy, social and cultural development of the city.

As populations and economies grow, the demand for land increases, also adding pressure on traditional land uses for change. Rising opportunity costs of land, influenced by a wider choice of options for land use and the rising market value of land, often lead to heightened conflicts particularly when some land uses are seen as incompatible with community expectations. Demand for land is affected by complex interactions between different objectives of land use—including conservation, and the nature of land available across locations (Mallawaarachchi et al.,2000).

Hence, the peri-urban area may be viewed either as a rural area in the sense that the vast majority of its land is used for farming, or as an urban area with most of its working population commuting to the city where jobs are concentrated. There has also been a *specialisation* of land use in peri-urban zone. Traffic concentrates along routes and trade in nodes of routes where urbanisation had its starting points. Desired and undesired land-use changes should be identified.

These changes of the peri-urban zone lead to complex patterns of land uses as evidenced in terms of the intensity and structure. The most appropriate method to understand such patterns in order to formulate appropriate guidance policies is to identify the patterns of the processes that cause land-use pressure.

MODELS OF LAND USE CHANGE

Models of land use change are used to **describe** the spatial and temporal relationships between the drivers and the resulting patterns of land uses and their changes and also to **explain** the observed relationships. There are also practical situations, where models are used to **predict** future configurations of land use patterns under various scenarios of bio-physical and socio-economic change. In some cases models of land use change are used as an instrument in impact **assessment** of past or future activities in the environmental and/or the socio-economic spheres. While in other cases models of land use change are used to **prescribe "optimum"** patterns of land use for sustainable use of land resources and development. Finally, models of land use change are used to **evaluate**, which actually is achieved with a set of alternatives - based on prediction, impact assessment and prescription - which have to be evaluated on the basis of specific criteria.

The literature contains a considerable number and variety of models of land use change. Thus, the modeling literature suggests several model classification schemes. For example the classification scheme, which is used in Briassoulis web book (Analysis of Land Use Change: Theoretical and Modeling Approaches, 2000), based on an aggregate, composite criterion, the modeling tradition to which a model belongs. This criterion is governed by the dominant feature of model design and solution technique which is more relevant for model building and discriminates among various model types. Moreover, model design is usually associated with particular model purposes, underlying theories and types of land use modeled (and, usually, the discipline where models originate), and spatial and temporal levels of analysis. Based on this criterion, four main categories of models were distinguished: 1. statistical and econometric models, 2. spatial interaction models, 3. optimization models, 4. integrated models, and 5. a fifth category has been added which contains those models for which classification is not straightforward as they reflect a variety of modeling traditions, which includes (a) natural-sciences-oriented approaches, (b) Markov modeling of land use change and (c) GIS-based approaches.

GIS-based modeling approaches

Exploring the types of GIS-based modeling approaches for the analysis of land use change, it is necessary to look over the issues of spatial data, the functions of GIS for the analysis of these data, and the broad field of spatial analysis.

Spatial data sets have two distinctive traits. On the one hand they describe the locations of objects in space (and their topological relationships) and on the other hand they describe non-spatial attributes of the objects recorded (Fischer et al. 1996).

GIS have four main functions related to spatial data: 1. Data input, 2. Data storage, retrieval, and database management, 3. Data analysis (data manipulation, exploration, and confirmation), and 4. Output (display and product generation) (Fischer et al. 1996).

Spatial analysis offers a multitude and diversity of procedures for the analysis of spatial phenomena. There can be distinguished two main directions: 1. **Statistical spatial data analysis** – which makes possible the appropriate analysis of spatial data, and 2. **Spatial modeling** – which provides a variety of models for the study of spatial phenomena (process, policy, location-allocation, spatial interaction, regional economic, spatial choice models) (Fischer et al. 1996).

The analysis of land use change, based on available sets of geo-referenced (spatial) data, in a GIS environment involves the coupling (of spatial analytic models with a GIS. This coupling may take two forms, in general: tight or loose coupling. Tight coupling may be either full or close. Full coupling has not been achieved yet; close coupling has been achieved but there are several issues related to the interfacing yet to be resolved. At last, loose coupling is the widespread practice in which spatially-explicit models are linked to a GIS either to retrieve input spatial data and/or to display graphically the model results in map form. Many older models, especially those which are rule-based, like the CLUE models, the USTED models and IIASA's LUC model, among others,

have already developed or are developing linkages with GIS. Aspinall (1994) distinguishes four types of modeling approaches which are capable of being incorporated into GIS: 1. rule-based, 2. knowledge-based 3. inductive - spatial and 4. geographic. Of the four approaches, rule-based modeling is perhaps the most widely used GIS-based approach in the form of map overlay analysis which has many applications in planning contexts. Data pertaining to several attributes of a study area (elevation, slope, climate, hydrology, land uses) are stored in layers in a GIS. Different layers are overlain to generate maps showing "unique conditions" in McHarg's (1969) tradition. Overlay analysis is used also to predict a new map as a function of the distribution of observed attributes (Unwin 1996). However, the restrictions of the map overlay technique which Hopkins (1977) has so succinctly analyzed should be taken under consideration in a GIS (Briassoulis, 2000).

The analysis of land use change, (rule-based approaches) contributes to three purposes of analysis: **description**, **prediction** (and conditional prediction), and **evaluation**. Description of land use change can be performed by overlaying land use maps from different time periods, in order to identify the location and assess the magnitude of change. Prediction of land use change can be performed by combining various characteristics which are assumed to determine the kinds of changes that are researched under a number of scenarios to define future values. Finally, evaluation of proposed or expected future patterns of land use change is a function which can be undertaken in the context of a GIS.

It is important also to note that within the trend of integration GIS with spatial analysis and modeling techniques, knowledge-based approaches have a great potential to contribute to the design of meaningful integrated systems for spatial analysis and decision making which are known as spatial decision support systems (SDSS).

Indicators as decision support instruments

Indicators are powerful tools to simplify, quantify and communicate information on processes such as society–nature interaction that are too complex to be measured and perceived directly (Hammond et al., 1995). Experience with indicators over the past years allow for the identification of a number of other success factors related to the use of indicators. More specifically these include:

- (a) To be effective, indicators should report progress over time and should be accompanied with an assessment of the reasons explaining their development;
- (b) They should be few in number, and users should get used to their presentation;
- (c) They become more powerful when linked with formal targets or informal or indicative (sustainable) reference values. Linked with targets, indicators become tools for management and to make policy makers accountable;
- (d) With or without targets, using indicators to compare or benchmark individual sectors or companies with each other is another way to make decision makers accountable and to foster progress as both failure and success stories become evident. (European Environment Agency (EEA), 2001)

In planning, they may support decisions in four main functions. Firstly, in the description/explanation of the state of spatial systems and its deviation from some reference state, secondly as instrument of impact assessment/evaluation of the effect of particular actions on the state of spatial systems and its deviation from some reference state, thirdly in the prediction of future conditions of spatial systems under various scenarios of socio-economic and environmental change and finally in the monitoring to keep track of changes in the state of spatial systems and to support appropriate corrective actions (Briassoulis, 2001).

The discussion on indicators of land-use pressure needs an intellectual debate on the central concepts. Otherwise, a high or increasing level of land use (intensity) may too easily be defined as a problematic ‘pressure’, without much attention to evaluative standards and disregarding problems of ‘underuse’. Aspects of economy and

demography, motivating land use, should be balanced against ecology and culture, defining the sustainability of land use. Since it is defined such a context, it is simple to concentrate on impacts of land use on natural and cultural values. Spatial differentiation in intensity as well as promoting multiple use may be strategies of land-use planning. The existing causal linkages between land-use pressure and land-use planning are illustrated in a pressure-state-impact-response chain (see Figure 3). (Getimis P. and Spanidis N.,1999)

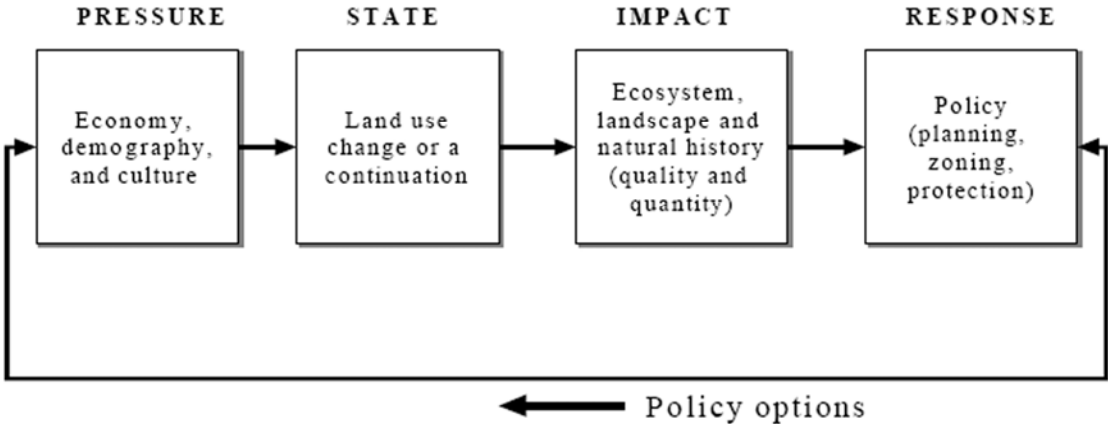
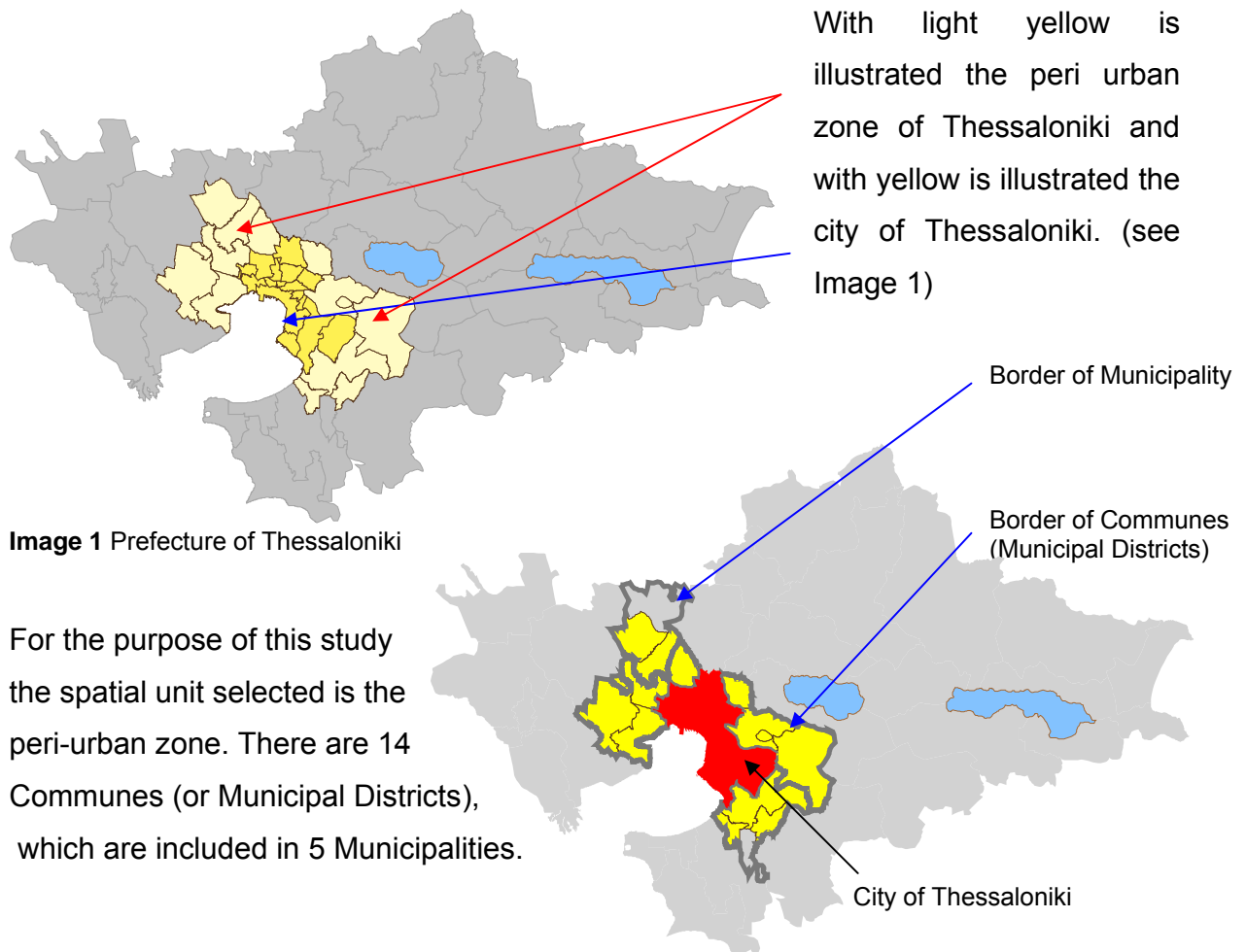


Figure 3: Pressure-State-Impact-Response chain.
Source: Getimis P. and Spanidis N. (1999)

CASE STUDY

In an attempt to analyse the urban growth and land use change in the peri-urban zone of Thessaloniki, which is located in the Northern part of the country and is the second largest city of Greece, it was firstly necessary to define the area that is considered as peri-urban area. The first report on the existence of peri-urban zone round Thessaloniki city occurs with the Law 1561 in 1985. According to this Law 'the part of the wider area of Thessaloniki, where are located urban activities, is defined as peri-urban zone of Thessaloniki and includes the following communities Asvestoxori, Diavata, Exohi, Thermi, Kaloxori, Nea Magnisia, Nea Raideostos, Neo Rusio, Neoxorouda, Pentalofos, Sindos, Filuro, Hortiatis and Oraiokastro.



At this stage of the analysis have been used data from national censuses for the years 1971, 1981, 1991 and 2001 and also data from national census of buildings for the year 2000, both from General Secretariat of National Statistical Service of Greece. More specifically two indicators were used from the national censuses population, population growth and nine indicators from national census of buildings which are the proposed uses of the buildings (1. Residence, 2. Religious Buildings (Churches – Monasteries), 3. Hotels, 4. Industrial Buildings (Factories – Laboratories), 5. School buildings, 6. Retail and Services (Retail Shops – Offices), 7. Parking, 8. Health Services Buildings (Hospitals, Clinics ...), 9. Other uses of buildings). The national census of buildings has also one more information about buildings, which was used, the information about exclusive use of the building or mixed use (where classification have been based on the main use). Also as it was possible to find the year of construction in national census of buildings combined with the uses of them but only at urban and rural level. In Greece the discrimination of regions in urban, semi-urban as well as rural regions becomes based on the population of each settlement, up to 2000 residents is considered '*rural region*', between 2000 up to 10000 residents is considered '*semi-urban region*' and above 10000 is considered '*urban region*'. (see image 3)

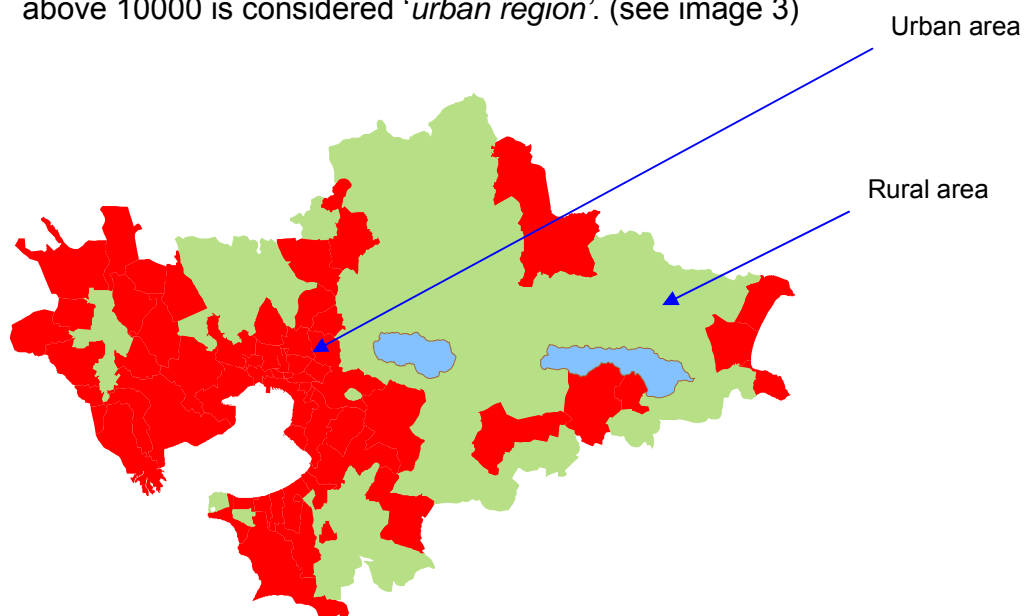


Image 3 Rural and Urban area of the Prefecture of Thessaloniki

Using these data it was possible to attempt the first analysis of the area. Yet, assessing the state of the environment for any given situation has proven to be a very difficult task because of there are limitations such as the lack of data etc.

Preliminary Results

First of all and before mentioning the preliminary results it is important to note the reason that Thessaloniki was elected as the case study. The new political and economic figures in Europe and internationally, created new developmental possibilities, and under the new circumstances Thessaloniki tends to exceed its regional operation and to be included in wider networks of policies, economic and cultural activities. In this frame it is recognized that the prospects of city growth compose different scenarios, core of which is ***the extended international role of Thessaloniki***. As the aim of this study is to formulate appropriate guidance policies based on the need of modern societies a city as Thessaloniki is particular interesting.

In the beginning of the analysis, population and population growth were compared, in order to examine the hypotheses that peri-urban of Thessaloniki is under dynamic development. As it appears at table 1 until 1981 the population growth of the city area was higher but after that peri-urban area has a dramatic growth, not only comparing with the city but also with the data from the Country and the Prefecture.

Area	Population 1971	Population Growth 71-81	Population 1981	Population Growth 81-91	Population 1991	Population Growth 91-01	Population 2001
Total of peri-urban area	32.528	19,2%	38.784	38,0%	53.535	84,4%	98.713
Total of the city	557.360	26,7 %	706.180	6,1 %	749.048	6,9%	800.764
Total of Prefecture	710.352	22,7 %	871.580	8,6 %	946.864	11,7%	1.057.825
Total of Greece	8.768.641	11,1 %	9.740.417	5,3 %	10.259.900	6,9%	10.964.020

Table 1: Population of characteristic geographic areas

Continuing, it is appeared the percentage of exclusive and mix use buildings, in order to find out if the phenomenon of mix use buildings is the same all the years and if it has

the same image at urban and rural areas. First of all, there is a noticeable decline after 1981 for constructing buildings with mix uses. Secondly as it was expected it was found that buildings with mix uses are located in urban areas, and final that the percentage of rural areas is stable. (see table 2)

	total	unlti 1960	1961 until 1970	1971 until 1980	1981 until 1990	1991 until 2000	Under Construction	It was not declared
Prefecture Thessaloniki								
Exclusive use	82.53	87.96	80.43	75.20	84.40	86.23	89.79	93.40
Mixed use (Based on the main use)	17.47	12.04	19.57	24.80	15.60	13.77	10.21	6.60
Urban areas								
Exclusive use	79.74	86.17	76.20	70.97	82.61	84.74	88.87	92.62
Mixed use (Based on the main use)	20.26	13.83	23.80	29.03	17.39	15.26	11.13	7.38
Rural areas								
Exclusive use	92.71	92.66	93.73	91.38	92.09	93.87	94.55	95.78
Mixed use (Based on the main use)	5.35	5.29	4.23	6.34	6.17	4.81	4.27	3.38

Table 2: The distinguish of the buildings based on their exclusive or mixed use

Next, it is presented the percentage of each use based on the period of the construction. First, for the Prefecture (see Table 3) were it is found that particularly the religious buildings, retail buildings and health services buildings are old, whether school buildings are quiet new. Also it is appeared that a great number of industrial buildings were constructed from 1971 until 1991. Finally, it is impressive the percentage of mix use hotels buildings from 1971 until 1991.

Prefecture Thessaloniki	unlti 1960	1961 until 1970	1971 until 1980	1981 until 1990	1991 until 2000	Under Construction	It was not declared
Exclusive use	18.52	20.72	20.24	22.44	16.07	1.45	0.56
1. Residences	17.67	19.80	19.99	23.37	17.24	1.67	0.25
2. Religious Buildings (Churches – Monasteries)	37.54	15.79	14.91	12.81	12.81	1.40	4.74
3. Hotels	16.56	24.20	16.56	18.47	20.38	2.55	1.27
4. Industrial Buildings (Factories – Laboratories)	9.40	14.72	24.97	32.12	16.74	0.44	1.61
5. School buildings	19.95	13.90	13.54	26.25	24.23	1.31	0.83
6. Retail and Services (Retail Shops – Offices)	21.43	20.16	19.17	19.68	16.97	0.99	1.59
7. Parking	16.67	25.00	20.83	16.67	20.83	0.00	0.00
8. Health Services Buildings (Hospitals, Clinics ...)	25.61	12.20	22.56	15.24	19.51	0.61	4.27
9. Other uses of buildings	23.57	27.38	21.44	16.41	8.95	0.50	1.75
Mixed use (Based on the main use)	11.97	23.82	31.53	19.59	12.12	0.78	0.19
1. Residences	10.76	24.15	32.70	19.29	12.18	0.73	0.18
2. Religious Buildings (Churches – Monasteries)	38.71	11.29	17.74	24.19	8.06	0.00	0.00
3. Hotels	5.79	7.44	33.06	41.32	11.57	0.00	0.83
4. Industrial Buildings (Factories – Laboratories)	13.96	17.36	26.98	27.74	13.40	0.57	0.00
5. School buildings	25.00	20.59	16.18	26.47	10.29	0.00	1.47
6. Retail and Services (Retail Shops – Offices)	20.41	21.46	21.11	21.11	14.66	1.19	0.07
7. Parking	14.29	7.14	21.43	28.57	14.29	0.00	14.29
8. Health Services Buildings (Hospitals, Clinics ...)	15.79	26.32	31.58	10.53	10.53	0.00	5.26
9. Other uses of buildings	25.74	23.78	21.19	19.17	8.48	1.45	0.19

Table 3: The uses of the buildings of the Prefecture Thessaloniki

Then, it follows the table for urban area of the Prefecture (see Table 4) were it is showed that particularly the religious buildings, retail buildings and health services buildings are old, whether school buildings and hotels are quiet new. As it is appeared that a great number of industrial buildings were constructed from 1981 until 1991 and industrial buildings with mix uses. It is remarkable the percentage of mix use hotels buildings from 1971 until 1991.

Urban areas	unlti 1960	1961 until 1970	1971 until 1980	1981 until 1990	1991 until 2000	Under Construction	It was not declared
A. Exclusive use	17.34	19.65	19.97	23.48	17.42	1.58	0.55
1. Residences	16.48	19.32	19.70	24.10	18.41	1.73	0.26
2. Religious Buildings (Churches – Monasteries)	36.91	14.33	14.60	12.95	15.70	1.65	3.86
3. Hotels	17.29	27.07	17.29	18.05	17.29	1.50	1.50
4. Industrial Buildings (Factories – Laboratories)	11.59	17.36	25.75	27.82	15.11	0.54	1.82
5. School buildings	17.11	14.14	14.57	28.01	23.90	1.41	0.85
6. Retail and Services (Retail Shops – Offices)	22.26	19.18	19.42	19.35	17.07	1.06	1.66
7. Parking	16.67	25.00	20.83	16.67	20.83	0.00	0.00
8. Health Services Buildings (Hospitals, Clinics ...)	28.93	11.57	19.83	14.05	20.66	0.00	4.96
9. Other uses of buildings	23.45	23.56	21.67	18.95	9.40	0.78	2.18
Mixed use (Based on the main use)	10.95	24.15	32.15	19.46	12.35	0.78	0.17
1. Residences	9.87	24.57	33.29	19.05	12.32	0.73	0.17
2. Religious Buildings (Churches – Monasteries)	33.33	11.11	20.00	26.67	8.89	0.00	0.00
3. Hotels	5.79	7.44	33.06	41.32	11.57	0.00	0.83
4. Industrial Buildings (Factories – Laboratories)	15.73	18.65	26.07	26.52	12.81	0.22	0.00
5. School buildings	16.95	23.73	16.95	28.81	11.86	0.00	1.69
6. Retail and Services (Retail Shops – Offices)	20.73	21.53	20.33	21.45	14.54	1.35	0.08
7. Parking	16.67	8.33	25.00	33.33	8.33	0.00	8.33
8. Health Services Buildings (Hospitals, Clinics ...)	12.50	31.25	31.25	6.25	12.50	0.00	6.25
9. Other uses of buildings	25.33	20.76	19.62	21.62	10.57	1.90	0.19

Table 4: The uses of the buildings of the urban areas of Thessaloniki's Prefecture

Finally, it is presented the percentage of each use based on the period of the construction for the rural areas. As it is appeared the religious buildings, the residences and the school buildings are old, whether hotels, industrial buildings are quiet new. Also it is noticeable that the majority of the buildings is constructed until 1981.

Rural areas	unlti 1960	1961 until 1970	1971 until 1980	1981 until 1990	1991 until 2000	Under Construction	It was not declared
A. Exclusive use	22.22	24.09	21.08	19.17	11.83	1.02	0.58
1. Residences	22.36	21.71	21.15	20.51	12.65	1.42	0.21
2. Religious Buildings (Churches – Monasteries)	38.65	18.36	15.46	12.56	7.73	0.97	6.28
3. Hotels	12.50	8.33	12.50	20.83	37.50	8.33	0.00
4. Industrial Buildings (Factories – Laboratories)	3.97	8.13	23.04	42.82	20.78	0.18	1.08
5. School buildings	34.81	12.59	8.15	17.04	25.93	0.74	0.74
6. Retail and Services (Retail Shops – Offices)	17.11	25.28	17.86	21.38	16.48	0.63	1.26
8. Health Services Buildings (Hospitals, Clinics ...)	16.28	13.95	30.23	18.60	16.28	2.33	2.33
9. Other uses of buildings	23.71	31.67	21.19	13.55	8.45	0.18	1.26
Mixed use (Based on the main use)	22.38	20.49	25.29	20.95	9.82	0.75	0.33
1. Residences	21.95	18.84	25.32	22.26	10.48	0.80	0.36
2. Religious Buildings (Churches – Monasteries)	52.94	11.76	11.76	17.65	5.88	0.00	0.00
3. Hotels	4.71	10.59	31.76	34.12	16.47	2.35	0.00
4. Industrial Buildings (Factories – Laboratories)	77.78	0.00	11.11	11.11	0.00	0.00	0.00
5. School buildings	17.96	20.96	26.95	18.56	15.57	0.00	0.00
6. Retail and Services (Retail Shops – Offices)	0.00	0.00	0.00	0.00	50.00	0.00	50.00
8. Health Services Buildings (Hospitals, Clinics ...)	33.33	0.00	33.33	33.33	0.00	0.00	0.00
9. Other uses of buildings	26.55	29.76	24.29	14.31	4.33	0.56	0.19

Table 5: The uses of the buildings of the rural areas of Thessaloniki's Prefecture

Conclusions

The aim of this study is an attempt to analyse the urban growth and land use change in the peri-urban zone and particularly of the case study area the peri – urban of Thessaloniki. First come the effort to define the peri – urban area, and the best solution was to adopt the Law 1561 in 1985. The problem arise from this definition is that the Law should probably be reconsider, in order to include the actual or the near future peri –urban area because there have past more than 20 years from the definition. This underlines that with the new definition probably should be determined the time period of the peri – urban zone as it is a dynamic zone which change.

The indicators that are used give the first impression and formulate a plan of peri – urban zone but should be expanded. It is clear that this is a preliminary analysis which was able to show the dynamic of peri – urban zone. But there was not such good representation of land use conflicts. Probably some indicators should be added like the agricultural area and its rate of growth or decline, or the structure of the employment data for the area. Also should be added some data about the road infrastructure, the location of the airport in order to emerge the conflicts of land use. Finally, it would be very useful to add data for the actual land uses ("what is") and the expected land uses ("what should be").

Last but not least it is important to mention that this method of analysis, which is preliminary, can and should be extended to incorporate more spatial characteristics as the topography of the area and more features such as synthesis of the demographic data of the specific area. Also there should be added some historical data for the wider region in order to explain some noticeable observations. Furthermore it can be incorporated in more complex decision making tools such as a spatial decision support system.

References

- Briassoulis, H. (2000) *Analysis of Land Use Change: Theoretical and Modeling Approaches*, The Web Book of Regional Science, Regional Research Institute, West Virginia University, www.rri.wvu.edu/WebBook/Briassoulis/Contents.htm
- Briassoulis, H. (2001), Sustainable Development and its Indicators: Through a (Planner's) Glass Darkly *Journal of Environmental Planning and Management*, 44(3), 409–427.
- Caruso, G., 2002. La diversité des formes de la périurbanisation en Europe. In: Perrier-Cornet, P.H. (Ed.), *Repenser les Campagnes*, pp. 67– 99 L'Aube-Datar, Paris.
- Chapin, F., S. Jr. and E.J. Kaiser. 1979. *Urban Land Use Planning*. Urbana: University of Illinois Press.
- Coccosis, H. (1991) "Historical Land Use Changes: Mediterranean Regions of Europe." In *Land Use Changes in Europe: Processes of Change, Environmental Transformations and Future Patterns*, eds. F.M. Brouwer, A.J. Thomas and M.J. Chadwick, 441-462. Dordrecht: Kluwer Academic Publishers.
- FAO/IIASA. (1995). *Agro-Ecological Assessments for National Planning: The Example of Kenya*. FAO Soils Bulletin 67, Rome: FAO.
- Fischer, M., H.J. Scholten, and D. Unwin. eds. (1996) "Geographic Information Systems, Spatial Data Analysis, and Spatial Modeling: An Introduction." In *Spatial Analytical Perspectives on GIS*, eds. M. Fischer, H.J. Scholten, and D. Unwin, 3-19. London: Taylor and Francis.
- Getimis P., Spanidis N. (1999) LAND USE PRESSURE INDICATORS Background Report for Spatial Organisation of European Territory
- Hammond, A., Adriaanse, A., Rodenburg, E., Bryant, D., Woodward, R. (1995) Environmental Indicators, a Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development. World Resources Institute, Washington, DC.
- Kanargolou, P.S. & Scott, D. (1999) 'Integrated Urban Transportation and Land-use Models for Policy Analysis' at *Cities on the Move*, London: Ashgate.
- Kockelman, K., Siethoff, B., Walton, M. and Mahmassani, H (2000) The Effects of Highway Capacity Expansion on Land Development, RESEARCH ON RELATIONSHIPS BETWEEN TRANSPORTATION INFRASTRUCTURE & INCREASES IN VEHICLE MILES TRAVELED: THE EFFECTS OF HIGHWAY CAPACITY EXPANSION ON LAND DEVELOPMENT by Center for Transportation Research, The University of Texas at Austin
- Mallawaarachchi, T., Quiggin, J., Ebert, S. (2000) Integrated assessment methods for land-use planning: combining economic, environmental and social objectives. Unpublished paper presented to ISEE 2000 People and Nature: Operationalising

Ecological Economics, Congress 2000 of the International Society of Ecological Economics, 5–8 July, Canberra, Australia.

Meyer, W.B. and B.L. Turner, II (1996) "Land-Use/Land-Cover Change: Challenges for Geographers." *Geojournal* 39(3): 237-240.

Meyer, W.B. and B.L. Turner, II, eds. (1994) *Changes in Land Use and Land Cover: A Global Perspective*. Cambridge: Cambridge University Press.

Nelson, A.C., Sanchez, T.W. (1997) Exurban and suburban households: a departure from traditional location theory. *Journal of Housing Research* 8, 249–276.

Oikonomou, D., Beriatos, I. & Purgiotis, G. (1994) CODING AND MECHANISMS OF CONTROL OF USES OF GROUND IN THE SPACE OUT OF THE TOWN Comparative investigation of experience of other countries, Proposal for Greece. (in Greek)

Paulley, N. & Pedler A., (2000) TRANSLAND, Integration of Transport and Land Use Planning, Final Report for Publication, Transport Research Laboratory.

Skole, D.L. (1994) "Data on Global Land-Cover Change: Acquisition, Assessment, and Analysis." In *Changes in Land Use and Land Cover: A Global Perspective*, eds. W.B. Meyer and B.L. Turner II, 437-471. Cambridge: Cambridge University Press.

TRB (1999), *Integrated Urban Models for Simulation of Transit and Land Use Policies: Guidelines for Implementation and Use*, TCRP Report 48, Transportation Research Board, Washington, D.C., United States of America.

Turner, B.L. II, D. Skole, S. Sanderson, G. Fischer, L. Fresco, and R. Leemans. (1995) *Land-Use and Land-Cover Change; Science/Research Plan*. IGBP Report No.35, HDP Report No.7. IGBP and HDP, Stockholm and Geneva.

U.S. EPA, 2000. Projecting Land-Use Change: A Summary of Models for Assessing the Effects of Community Growth and Change on Land-Use Patterns. EPA/600/R-00/098. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH. 260 pp.

Wegener, M. & Fürst F. (1999), Land-Use Transport Interaction: State of the Art, TRANSLAND Integration of Transport and Land Use Planning Deliverable D2a, University of Dortmund, Dortmund, Germany.