



# A Spatial Decision Support System for Tourism Land Use Planning.

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## Abstract

One of the most complex challenges the tourism industry faces is keeping up to date with information technology developments caused by the globalisation of information and advances in technology. The development of robust decision support systems for tourism land use planning is a way to address this challenge.

This paper demonstrates how a spatial decision support system (SDSS), called the Land Use Decision Support System (LUDUS), can contribute in allocating complex forms of tourism. The system combines an artificial intelligence technique, called ontologies, with Geographic Information Systems and object-oriented programming to support decision-making in spatial planning. The system consists of two subsystems: the Insert Data Subsystem and the Graphic Imaging and Decision Support Subsystem. The core of the system is an ontology that is aligned to a standard of the Open Geospatial Consortium, called Geosparql.

The case study of this paper is the Mastichochoria area of Chios Island, Greece. Therefore, the structure of the ontology was modelled according to the provisions of Greek legislation. The results produced confirmed the correct coding and application of the system's criteria. The validity, accuracy and reliability of the results were also confirmed.

The adopted approach facilitates the identification of alternative options for allocating, among other land use types, complex forms of tourism development in suburban areas, by examining the provisions of the legal framework as well as their geology and terrain.

**Keywords:** Land use planning; Ontologies; Tourism; Decision-support; Knowledge-management

## 1. Introduction

The European Union (EU), according to the European Tourism Policy, must develop tourism in a sustainable manner and better position itself as the number one provider of quality tourism (Iunius et al., 2015). Consequently, the EU must find ways and means to accomplish the following (EC, 2018): (i) enhance competitiveness in the tourism sector; (ii) promote the development of sustainable, responsible and high-quality tourism; (iii) consolidate the image and profile of Europe as a collection of sustainable and high-quality destinations; (iv) maximise the potential of EU financial policies and instruments for developing tourism.

Tourism land use planning must follow the priorities, directions and principles that sustainable development promotes, but it must also respect the environment and promote balanced economic development while minimising social inequalities. Furthermore, tourism land use planning must ensure that the local population is

“conformed as an important engine from the social and economic point of view” (Morales et al., 2018). It is obvious that a shift in tourism policies is required to assess the “complex socio-ecological systems and the accommodation of global environmental forces” (Higham and Miller, 2018). Otherwise, significant economic benefits may occur, but pollution, unbalanced development, landscape degradation and social exclusion issues are likely to become even more severe.

Keeping up to date with the advances in technology caused by the globalisation of information is a crucial and complex challenge the tourism industry faces nowadays (Yoo et al., 2017). A way to address this challenge is to develop robust decision support systems for tourism land use planning. This paper demonstrates the way such a system, called the LUDUS, can contribute in allocating complex forms of tourism in sub-urban areas.

Section 2 describes the main characteristics of the developed system, such as its architecture, database and functions. Furthermore, the legal framework related to complex tourism land use types, according to the Greek legal framework, is analysed. Then, Section 3 presents randomly selected examples that were used to evaluate the system’s performance. Finally, Section 4 presents the conclusions produced by this paper.

## 2. Proposed approach

### 2.1. Architecture

The developed system comprises the Insert Data Subsystem (IDS) and the Graphic Imaging and Decision Support Subsystem (GIDSS) (Fig. 1).

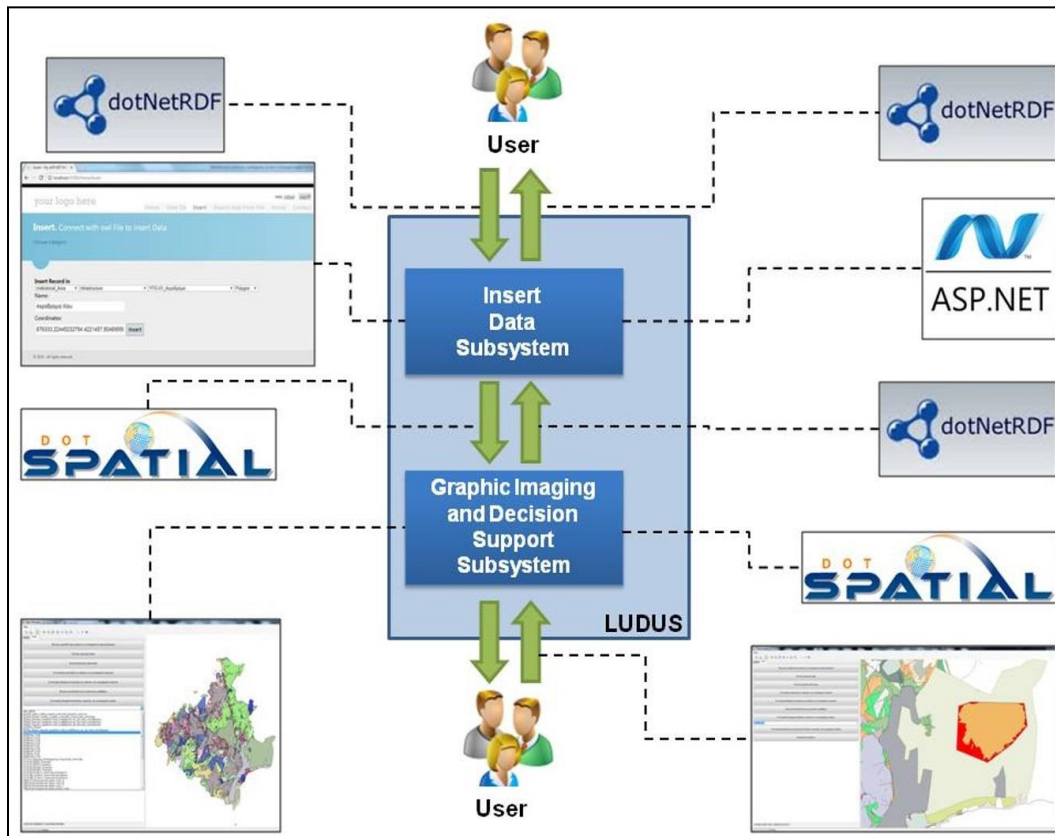


Figure 1: Architecture of the developed system.

The IDS is a web application that supports all actions related to the database of the system (i.e. user authentication, data input and data search) and allow the users to update and manage the system’s database. The GIDSS was designed in the .NET environment using the C# programming language. It supports all the reasoning functions the system provides and the typical GIS functions related to system’s data representation as well.

## 2.2 Tools and techniques

The DotSpatial and DotNetRDF .NET libraries were used to develop the system. The DotSpatial library is a GIS library that allows its users to integrate a variety of GIS related features into applications, while the DotNetRDF library support processing data (i.e. searching, finding, inserting, and saving data) to RDF, RDFS, and OWL files via .NET-based applications. The operation of the system is based on managing coordinates; thus it supports managing two types of templates for the serial representation of coordinates (WKT or GML) and three types of records: points, linestrings and polygons.

## 2.3 Structure of the ontology

The database of the system is an ontology which is aligned to a standard of the Open Geospatial Consortium (OGC), called Geosparql (Perry and Herring, 2012). The GeoSPARQL standard supports “representing and querying geospatial data on the Semantic Web,... defines a vocabulary for representing geospatial data in RDF, ...defines an extension to the SPARQL query language for processing geospatial data, ...is designed to accommodate systems based on qualitative spatial reasoning and systems based on quantitative spatial computations” (Perry and Herring, 2012). The ontology was designed using the Protégé ontology editor software.

The ontology’s main classes are the “Attributes”, “Criteria”, “Items”, “Item”, “Spatial Object”, “Restrictions”, “Type” and “Types” classes (Fig. 2). The “+” symbol indicates classes that can be analysed in additional subclasses.

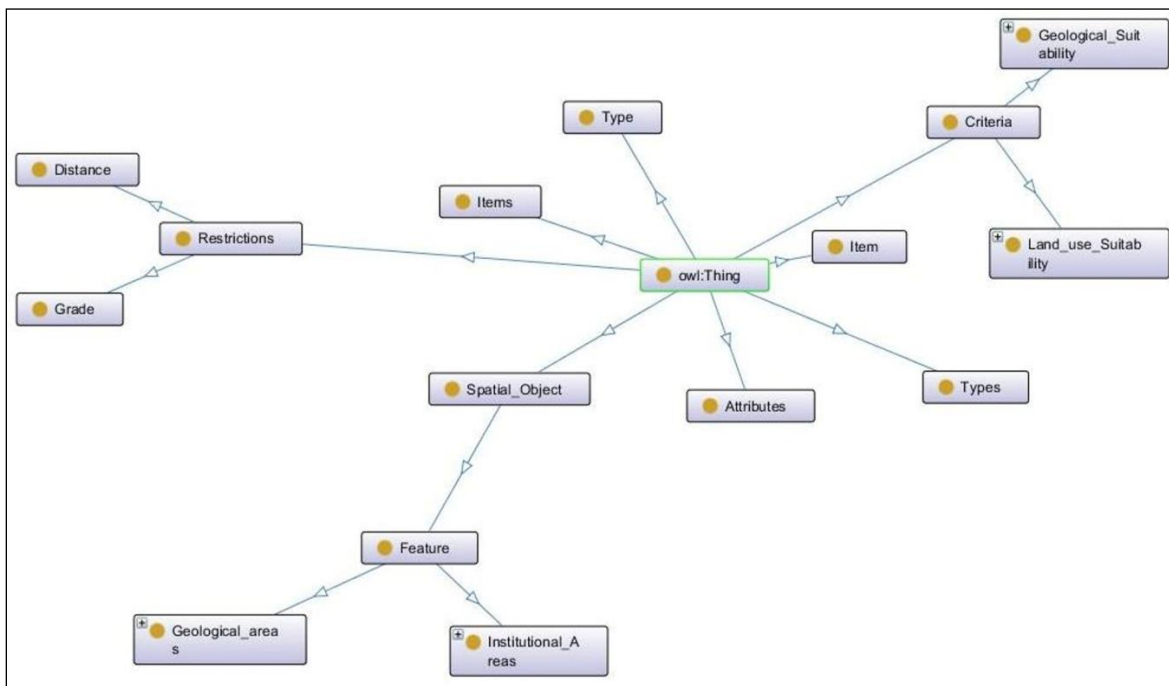


Figure 2: Structure of the ontology.

The types of geological and institutional areas are stored in the “Geological Areas” and “Institutional Areas” classes that belong to the “Feature” class. The “Feature” class belongs to the “Spatial object” class which is directly connected to the “Thing” class, which the fundamental class of the ontology. The “Institutional Areas” and “Geological Areas” classes include the coordinates of the existing land use types and the geological areas of a given study area. The “Criteria” class contains the classes “Geological Suitability” and “Land-use Suitability” in which are stored the criteria related to either the “Geological Areas” or the “Institutional Areas”. The types of geological areas for which the various reasoning functions are performed are stored in the “Items” class. The geological areas used during a reasoning function are stored in the “Item” class along with the parameters each geologic criterion contains. The legal criteria are stored in the “Attributes” class. The “Types” class contains the land use types included in each reasoning function. Each land use type related to the various reasoning functions is characterised as a “Type”.

## 2.4 Institutional Areas

Case study of this paper is the Mastichochoria area, thus the types of institutional areas included in the system’s ontology follow the provisions of Greek legislation. The Mastichochoria area of Chios Island, Greece, is well-known around the world for the production of mastic. Within the Mastichochoria area exist among others semi-mountainous areas, Natura 2000 network areas, coastal zones, streams, forests, agricultural land of high and medium productivity, as well as archaeological and historical sites.

The types of institutional areas included in the ontology are (Fig. 2): (i) Residential areas which “are areas existing within approved Local Spatial Plans (LSPs), or settlements established before 1923, or settlements with fewer than 2.000 residents, or areas appropriate for urbanisation” (Law 4269/14); (ii) Land use control areas which “are out-of-plan and out-of-settlement areas mainly located around residential areas, or areas of production and business activities” (Law 4269/14); (iii) Protection areas which “are areas belonging to protection regimes (e.g. wildlife refuges, archaeological sites, world heritage sites etc.) (Law 4269/14); (iv) Production and business areas which “are areas possessing characteristics that allows them to host production and business activities” (Law 4269/14); (v) Integrated Tourism Areas which are described in detail in the next Session; (vi) Infrastructure areas which host the infrastructure of a study area; (vii) Zones of Residential Control established in a study area (Law 1337/1983); (viii) Special land use areas that comprise specific types of land uses (Law 4269/14); (ix) “Out-of-plan areas” that comprise areas not included in any of the previous categories. A thorough analysis of the legal provisions about the types of institutional areas has been performed in a previous study (Lazoglou and Angelides, 2016).

## 2.5 Complex forms of tourism and legal provisions in Greece

According to the Greek legislation (Law 4179/13) as complex forms of tourism are identified (Fig. 3): (i) Integrated Tourism Development Areas (POTAs), previewed in article 29 of Law 2545/1997, (ii) Special Plans for the Spatial Development of Public Real Estate (ESXADAs), previewed in Article 12 of Law 3986/2011, (iii) Special Plans for the Spatial Development of Strategic Investments (ESXASEs), previewed in Article 24 of Law 3894/2010, (iv) Tourist accommodation complexes previewed in Laws 2160/93 and 4002/11. The main legal provisions related to their allocation are presented below.

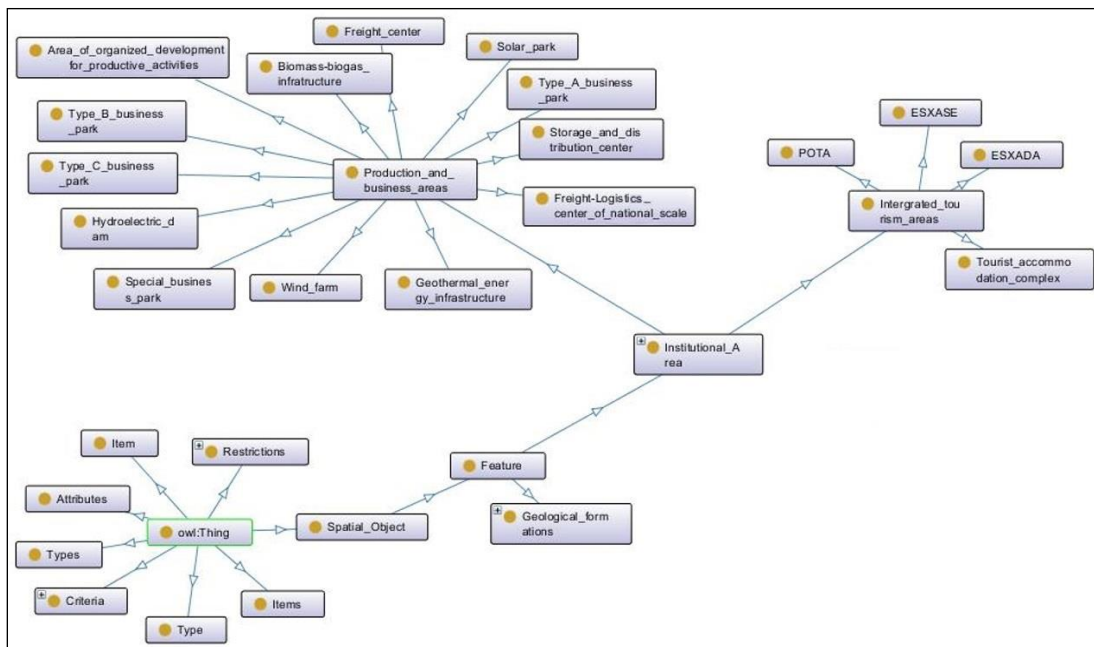
### 2.5.1 Integrated Tourism Development Areas

This land use type can be allocated to either private or public land that exists within or without approved LSP or urban control zones. A Presidential Decree (PD) defines and approves various elements: (i) the necessary technical works needed to restore the functional integration of the area; (ii) the permitted land use types as well as any additional prohibitions or obligations; (iii) any restrictions designed to control the intensity of each land use type; (iv) the sitting of facilities and infrastructure; (v) the necessary public utility areas; (vi) the building restrictions; and

(vii) the founding body of the POTA (Law 2545/97). Roads, streams and related natural or artificial barriers do not constitute fragmentation of the POTA’s area (Article 4, Law 4179/2013), although it is possible for POTAs to include areas that are subject to special protection regimes. The specific terms and building provisions of a POTA are defined in an urban study.

### 2.5.2 Special Plans for the Spatial Development of Public Real Estate

This land use type constitutes a way to develop public property. It has to follow all regional development and fiscal policies (Law 3986/11). ESXADAs may include areas located outside of any approved plans, in settlements designated as legally existing before 1923 or at the boundaries of settlements housing fewer than 2 000 residents. They may also be located within new LSPs. Moreover, ESXADAs may include areas that are subject to special regimes. A relevant study analyses the existing regulatory regimes for the designation of an ESXADA and previews the guidelines that must be followed (Art. 3, Law 4092/12). The final approval of an ESXADA is performed by a PD. If necessary, this PD may introduce modifications in any already existing regulatory plan (e.g. LSP). The specific terms and building provisions of an ESXADA are defined in an urban study.



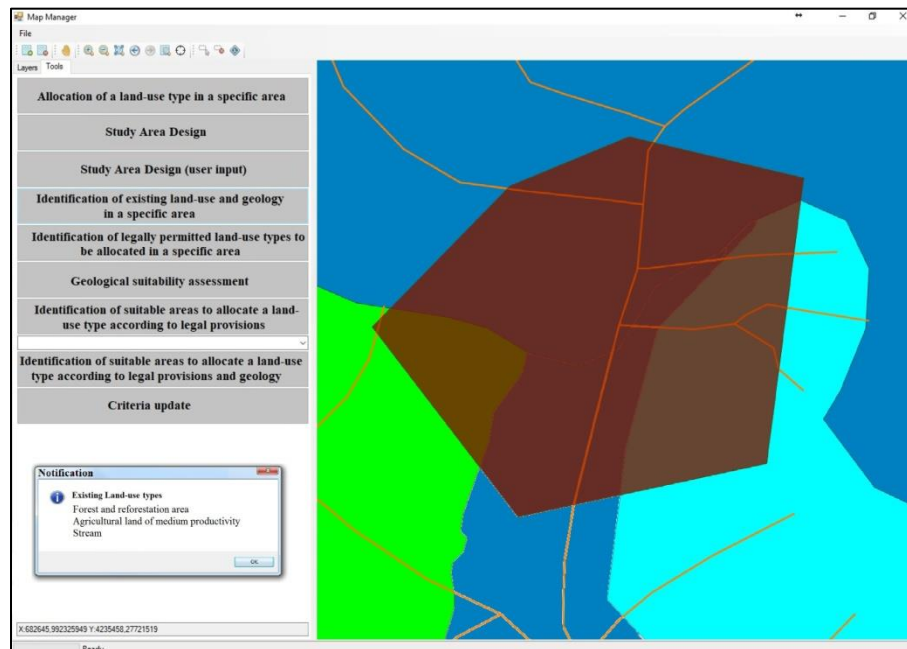
**Figure 3:** Structure of the “Integrated Tourism Development Areas” class along with the main classes of the ontology.

### 2.5.3 Special Plans for the Spatial Development of Strategic Investments

This land use type may include areas outside approved LSPs or settlements designated as legally existing before 1923, or may be developed at the boundaries of settlements housing fewer than 2 000 residents. They may also be located within new LSPs. The building conditions and restrictions for the implementation of ESXASEs are issued by a PD. According to Art. 2 of Law 4072/12, deviations from the terms and limitations are permitted in areas included in ESXASEs for reasons of public interest or due to related provisions of the current National Spatial Plan. These deviations are issued by a PD and in a proposal of the Minister of Environment and Energy. The allocation criteria for ESXASEs and ESXADAs are the same (Art. 24, Law 3894/10).

### 2.5.4 Tourist accommodation complexes

Tourist accommodation complexes include hotel accommodations which may be built in combination with furnished residences and facilities of special tourist infrastructure, such as conference centres, thalassotherapy centres, thematic parks, spa–healing centres, diving centres, etc. Tourist accommodation complexes may include areas located outside of the approved plans, in settlements designated as legally existing before 1923, or at the boundaries of settlements housing fewer than 2 000 residents. They may also be located within new LSPs. The specifications, terms and conditions for designating tourist accommodation complexes are defined by the Joint Ministerial Decisions 177/12 and 9347/14.



**Figure 4:** The results of the “Identification of existing land uses in a specific area” function in a randomly user-defined area.

The development area of tourist accommodation complexes is permitted to areas of at least 150 km<sup>2</sup>; however, in case they include an already-existing hotel, their minimum development area must be at least 50 km<sup>2</sup> (Law 4002/11).

Tourist accommodation complexes can be designated in areas which are not subject to disturbing land uses such as those that are sources of noise or environmental pollution. Roads, streams and related natural or artificial barriers do not constitute fragmentation of an area used to develop a tourist accommodation complex (Article 4, Law 4179/2013).

### 2.6 Criteria

The reasoning functions the system supports follow the provisions of the existing Greek legal framework regarding various types of land uses, terrain and geology; they were coded using C# programming language. In all, 144 criteria were designated. The parameters each land use criterion may include are (i) the distance a land use type must maintain from another; (ii) the land use types that must be included, or excluded, in an area for another land use type to be allocated; (iii) the land use types which must neighbour another land use type; (iv) the land use type

within which another land use type is permitted to be allocated; (v) the limits of a terrain's slope in relation to the geology of an area, to calculate whether a land use type is permitted to be allocated in that location.

### 2.7 Supported functions

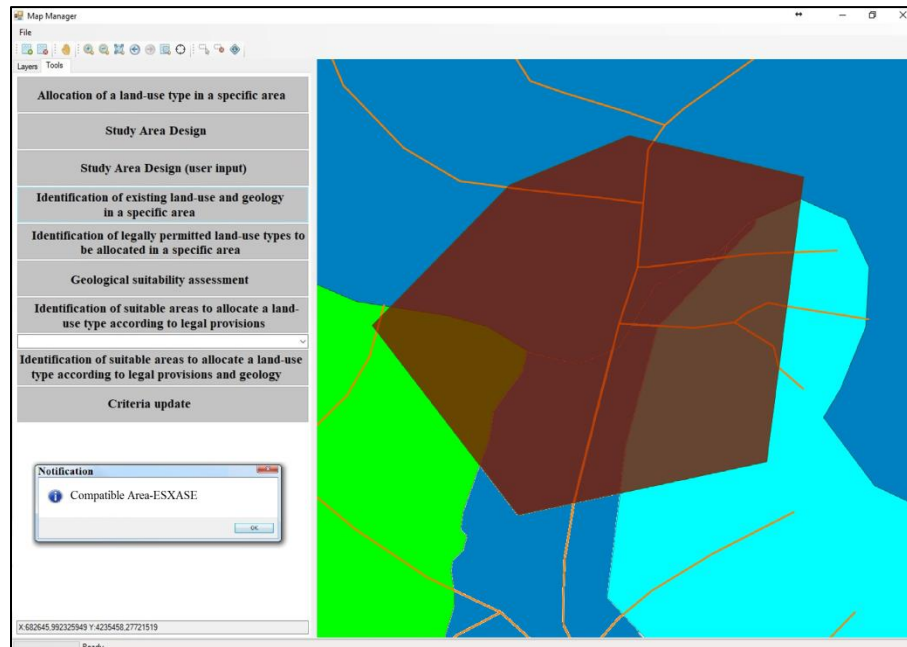
The developed system: (i) allows users to design a study area using the mouse pad ("Study Area Design" function), (ii) allows users to design a study area by typing in the coordinates of successive points ("Study Area Design (user input)" function), (iii) supports the identification of legal restrictions to which a study area is subject ("Identification of existing land use and geology types in a specific area" function), (iv) examines whether the provisions of the legal framework permit allocating a specific land use type within a study area ("Allocation of a land use type in a specific area" function), (v) identifies the land use types that can be allocated in a study area according to the current legal framework ("Identification of legally permitted land use types to be allocated in a specific area" function), (vi) allows the investigation of whether the geology and terrain of an area allow for any kind of development according to relative legislation ("Geological suitability assessment" function), (vii) finds an area located within a larger study area, in which the allocation of a particular land use type is permitted according to the current legal framework, the geology and the terrain of the study area ("Identification of suitable areas to allocate a land use type according to legal provisions and geology" function), (viii) permits its users to insert, modify or remove the criteria existing in its database without requiring any programming knowledge ("Criteria update" function).

## 3. Results

The "Identification of suitable areas to allocate a land use type according to legal provisions" function and the "Identification of legally permitted land use types to be allocated in a specific area" function are two of the most important functions that the developed system supports; therefore, these functions are examined in detail.

In this example, the system was asked to identify areas within a randomly selected polygon, in which the "ESXASE" land use type could be developed. A polygon within the boundaries of the Mastichochoria area was randomly selected by the user by enabling the "Study Area Design" function. Then, using the "Identification of existing land use types in a specific area" function, the system calculated (Fig. 4) that within the polygon (brown polygon) existed "Forest and reforestation areas" (green polygon), "Agricultural land of medium productivity" (light blue polygon) and "Stream" (orange linestring). The areas that are not protected are depicted in blue.

When the "Identification of legally permitted land use types to be allocated in a specific area" function is enabled, the system randomly chooses a pentagon (polygon) within the user-defined study area. If the designated area follows the institutional criteria for the selected land use type, the points inside the pentagon are added to a new layer that is designed automatically and added to the system's layers. After multiple iterations, one or more polygons are created in the new layer, within the user-defined study area. A more detailed description about the operation of this function is available in our previous papers (Lazoglou and Angelides, 2018). In this specific example, the system correctly calculated the whole user-defined area as appropriate for allocating ESXASE (Fig. 5) because according to the applicable law (Law 4092/12), ESXASEs may include areas that are subject to special regimes such as "Forest and reforestation areas", "Agricultural land of medium productivity" and "Stream" land use types.



**Figure 5:** The results of the “Identification of legally permitted land use types to be allocated in a specific area” function in a randomly user-defined area.

In the next example, another polygon within the boundaries of the Mastichochoria area was randomly selected by the user by enabling the “Study area design” function.

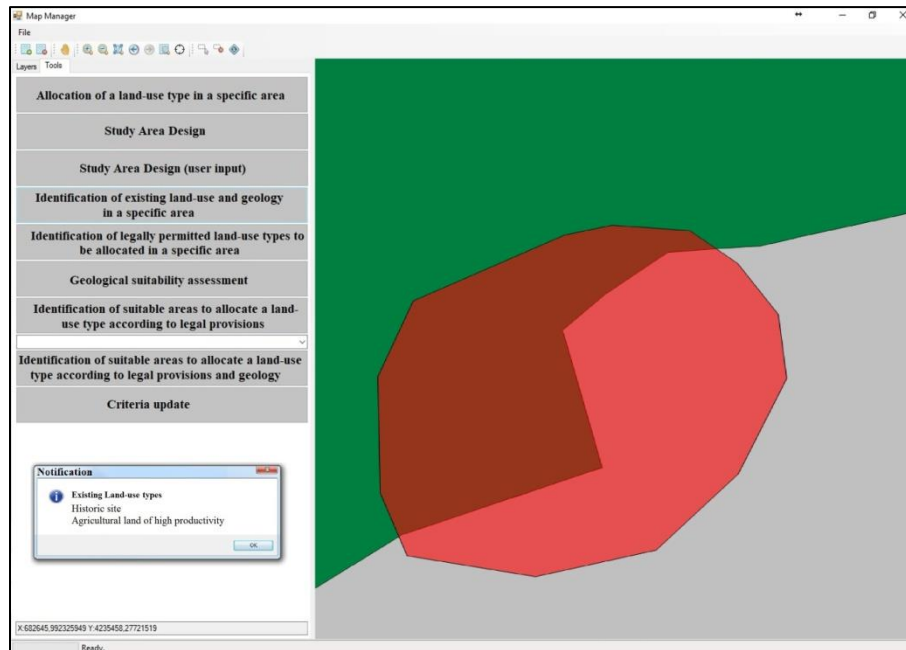
Then, using the “Identification of existing land use and geology types in a specific area” function, the system calculated that within the user-defined area existed the “Historic site” and “Agricultural land of high productivity” land use types (Fig. 6).

The system was asked to identify the complex tourism land uses that could be allocated within the user-defined area. It correctly identified that the user-defined area was permitted to allocate all four of land use types (i.e. POTA, ESXADA, ESXASE, and Tourist accommodation complex) (Fig. 7) as the current legal provisions analysed in Sections 5.2.1 to 5.2.4 preview.

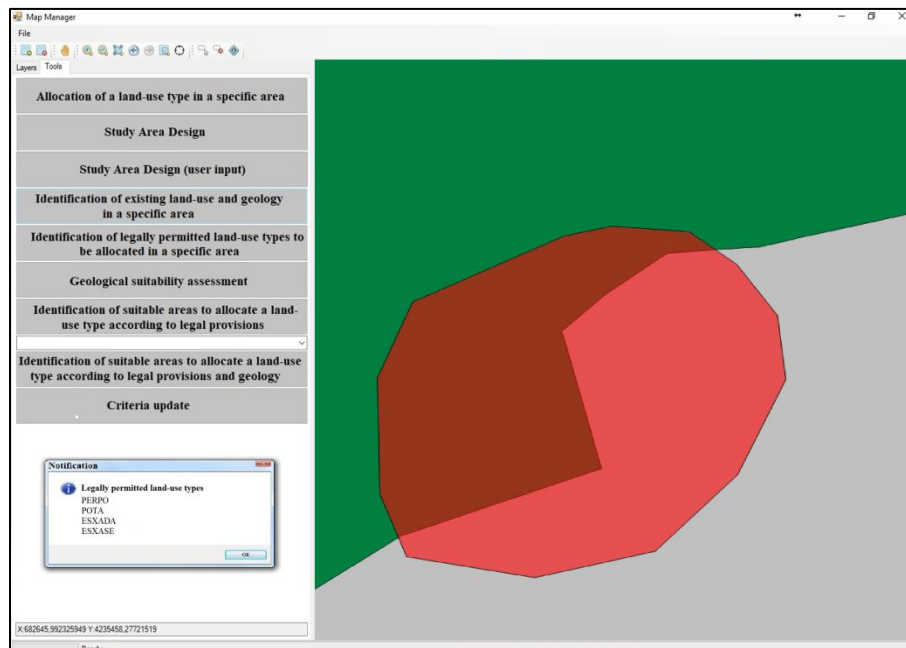
#### 4. Conclusions

This paper presents an effective SDSS, called LUDUS. The results produced reveal that the developed system helps the stakeholders involved in spatial planning to form their views within the provisions of the legal framework and in accordance with the geology and terrain of a study area, and also provides analysis adapted to the requirements of each examined problem. The adopted approach facilitates the identification of alternative options for allocating, among other land use types, complex forms of tourism development in suburban areas.





**Figure 6:** The results of the “Identification of existing land uses in a specific area” function in a randomly user-defined area.



**Figure 7:** The results of the “Identification of legally permitted land use types to be allocated in a specific area” function in a randomly user-defined area.

The above examples verify the correct coding and application of the LUDUS criteria as well as the validity, accuracy and reliability of the system’s results using the “Identification of suitable areas to allocate a land use type

according to legal provisions” and the “Identification of legally permitted land use types to be allocated in a specific area” functions.

The paper’s approach reveals that incorporating an SDSS into spatial planning is a research field that can improve the efficiency and effectiveness of the tourism land use planning policies. The developed system reduces costs and time by assessing alternative options according to the existing legal framework. It also facilitates the exploration of various scenarios for tourism land use planning. This is a crucial contribution that helps to narrow down the examined problem, an approach that reassures the applicability of the proposed policies’ priorities.

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