Chapter 4

Comparison of the Land Uses and Sustainable Development in Small Islands: The Case of Skiathos Island, Greece

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Additional information is available at the end of the chapter

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Abstract

The Island of Skiathos occupies a total area of 50 km^2, accounting for 1.6% of the area of the prefecture of Magnesia and 0.28% of the Region of Thessaly, Greece. The land is hilly and can be divided into farmland, meadows, woodlands, land covered by water and land occupied by settlements and roads. Also, a large part is occupied by burnt areas that resulted from the fire of 2007. The aim of this chapter is to present the evolution of existing land uses at the Island of Skiathos during the past decades. With the contribution of Geographic Information Systems (GIS) and the orthophotomaps, the spatial planning of the land uses can be evaluated for all these years and the total area can also be calculated. Our results are important for understanding the impacts of land uses on ecosystems in the frame of sustainable development. There has been no other research regarding land uses in Skiathos Island in the past, and, also, this is the first digitization of the area. Finally, two sustainable spatial development scenarios for the Island of Skiathos are proposed. The first scenario relates to the results obtained from a prediction (application of the model of automatic cellular) while the second scenario refers to a more realistic model of development with focus on environmental protection and sustainable development.

Keywords: GIS, land uses, area, island, thematic maps, scenario

1. Introduction

Over the past few decades, European ecosystems have changed substantially as a result of socio-economic and political changes, while future transformations are also expected to occur [9,13].

The European Mediterranean landscapes have undergone many changes over the years due to the relocation of people in coastal areas, forest fires, desertification, logging, the rapid expansion of activities related to tourism and the intensification of agriculture [6,14,20].

Environmental and ecological consequences of landscape transformation are more evident in natural ecosystems where their sustainability, multifunctional role and values are threatened [10,11,15,19].

Sustainable development refers to economic development that is planned and implemented, taking into account environmental protection and sustainability.

The rule of sustainability is the maximum gain of goods from the environment, without interrupting the natural production of these products in sufficient quantities in the future. Sustainable development implies development of the productive structure of the economy while creating infrastructure for a sensitive attitude toward the natural environment and ecological problems (such as defining traditional sciences like geography).

Sustainability implies that natural resources are exploited at a rate lower than that to which renewed, otherwise occurring environmental degradation. In theory, the long-term effects of environmental degradation are the inability of the earth's ecosystem to support human life (ecological crisis).

- The coastal and insular nature of the geography of Greece has a significant impact on local development; it creates geographical areas heavily dependent on the mainland. Although the geographical distances separating the islands from mainland Greece are not large (following the natural-geographic mosaic recommended the Greek area), developmental and political choices are affecting their real integration with criteria of cost, time, frequency of service, availability of interconnection etc., creating, as a consequence, significant dysfunctions in their development completion.

Exploring the development process in the islands and a strategic integrated development model for small islands is on systematic research field and policy in world affairs for decades. The structural problems flowing from the specific natural and socio-economic characteristics distinguish the islands from the mainland and intensified in inverse proportion to the size of the islands, slowing the growth process. Although the need for a differentiated approach to the island territory and particularly small islands has been recognized by the international community in Greece, a few steps in that direction have been made. Given the insular nature of the country, the small size of the majority of the islands and the strong development catching up, exploring the roadblocks and the formation of a strategic model of integrated development of small islands space become necessary.

The purpose of this article is to apply the changes of land uses for the past few decades for the Island of Skiathos and also make a prediction for the land uses change for the year 2020. The comparison of the land uses has been made with the tool of GIS and orthotophotomaps. Moreover, to make the prediction, we used the model of cellular automata and two indicators.

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Our results are important for understanding the impacts of land uses on ecosystems in the frame of sustainable development. There has been no other research regarding land uses in Skiathos Island in the past, and, also, this is the first digitization of the area.

Finally, in the future, these results will be used for making the spatial plan for the Island of Skiathos.

2. Methodology

2.1. Study area

The Island of Skiathos resides in the territorial unity of the northern Sporades and the capital is the city of Skiathos. It is 2.4 miles from the coast of southern Pelion and 4 miles from Skopelos. The surface area is about 49,89 km^2 while the length is 12 km and the width is 9 km. Within the administrative boundaries of Skiathos island lie the smaller islands of Tsougrias, Small Tsougrias, Repio, Aspronisi, Maragos and Arcos. The town of Skiathos is connected with the Island of Skopelos, Alonissos, the town of Volos, Ag. Konstantinos and Euboea, via a (trade—passenger) port. There is also a National Airport located in the northeastern part of the island. Administratively, the Municipality of Skiathos is part of the Magnesia Municipality in Thessaly.

A large part of the island is covered by woodland and the rest of the island is dominated by olive trees. In Skiathos there is one area identified as the Area of Community Interest (Sites of Community Interest) and was included in the European ecological network Natura 2000 (Directive 92/43/EEC). That area is the island of Skiathos (code: GR1430003, 32 ha). Around the island there are about 70 beaches.

The population of the island, in 2011, was 6088 and the density was 122 people/km^2. In Table **1**, the population and the population density, during the past few decades, are presented.

	Population	Population Density (people/km^2)
1991	5096	102.14
2001	6160	123.47
2011	6110	122.45

Table 1. Population.

It can be observed that the difference between the last two decades is very small. The most significant increase in the population took place during the period 1991–2001.

Mediterranean climate prevails in Skiathos with cold winters and pleasant summers. There is almost complete absence of rainfall during the summer months. The temperature during July and August often exceeds 30 degrees Celsius, while in June the weather is somewhat cooler.

As in most islands, from July to mid-August we encounter the phenomenon of Meltemi, quite throwing the night temperature.

In the Island of Skiathos, the month with the maximum daily precipitation amount is January with 155.8 mm while the smallest occurs in July with 25.3 mm. The most humid month of the year is December with a relative humidity of 76.92% while the driest is July with a relative humidity of 60.64%.

2.2. Methodology

The methodology used consisted of data collection (statistics, land register), creation of maps in Geographic Information Systems (GIS), comparison of results, provision of land use for the year 2020 and finally the development of scenarios.

More specifically, the aim of this chapter was to examine the evolution of land use on the Island of Skiathos on the dates 1945, 1996, 2007 and the current situation in terms of population, infrastructure and development.

With the contribution of Geographic Information Systems (GIS) and the orthophotomaps, the spatial planning of the land uses can be evaluated for all these years and the total area can also be calculated.

Once the thematic maps were created, the model of Cellular Automata (CA) was implemented to make provision on land use development in 2020. In our forecast, human factors such as forest fires were not taken into consideration.

The procedure followed in the study of land use change in the Island of Skiathos was the following:

1. Data input

2. Analysis of land use change

3. Model development

4. Simulation

5. Provision

1. Data input

The data entered were: land use in 1945 and 1996, distance from roads, distance from the coastline and distance from the main road. Due to the high correlation between the distance from the main road and the distance from the coastline, the distance from the main road was not involved in the model [23,24].

2. Analysis of land use change

The land use changes were determined by comparing two maps, one of 1945 and one of 1996 [12,16–18].

3. Model development

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We used artificial neural networks to create the dynamic transition maps which would be introduced in the model of cellular automata [22].

Five parameters were used in neural networks:

- Neighborhood: size 2 (i.e., 5 × 5 = 25 cells)
- Learning rate, momentum and max iterations number (0.1, 0.05, 1000). These parameters define the neural network training process. Large learning rate and momentum lead to rapid learning. Small learning rate and momentum provide slow but more stable learning. The stability has to do with the large variations in the graph.
- Hidden levels: we defined one hidden layer with 10 nodes—neurons.

4. Simulation

The simulation was achieved by cellular automata. The cellular automata took account of the original map, the factors affecting land use changes and the model developed in the previous paragraph. The cellular automata operates as follows:

- The simulator takes the transition probabilities and calculates the number of cells that have changed.
- The simulator calls the cellular automata model and adds the original map of land use and variables.
- The model scans the cells and calculates the transition probabilities in each class.
- The simulator creates a mesh level "certaincy": each cell defines the difference between the two largest probabilities of lattice transition levels.
- The simulator creates a mesh with the most possible transitions: the cells are transition classes with the highest probability of transition. This mesh level is the auxiliary level to the next step.
- For each class of transition, the simulator is looking to mesh with the most potential transitions the number of cells with the greatest change.

Following the above procedure, the cellular automata gives the result of the simulation for a repetition (iteration). Applying a second iteration, the result of the simulation will be used as an initial land use map. Therefore, in each iteration, we used the previous simulation as initial state land use [1–5,21].

5. Provision

Using the model developed above, we created a forecast for 2020. The prediction was performed using the structure of the above model in which to investigate land use change maps were used in 1945 and 2007 [7,8].

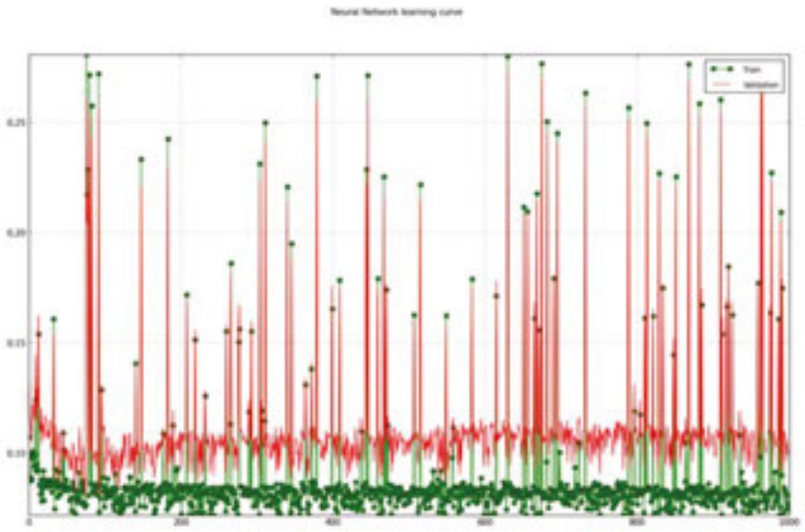

Figure 1. Neural network learning curve.

3. Results and discussion

For the year 1945, we have digitized the land uses in the Island of Skiathos. In Figure **1**, the thematic map resulting from the digitization is presented.

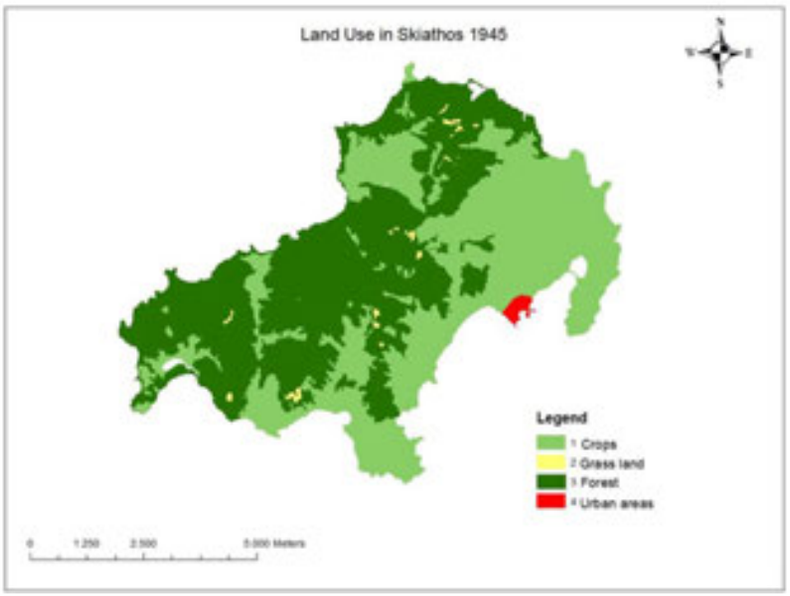

Figure 2. Land uses in Skiathos Island in the year 1945.

In Figure **2**, the digitization and the categorization of the land uses in the year 1945 can be observed. Also, the percentage contribution of each land use type is presented in the Figure (3) and Table (2).

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Land Uses	Total Area (ha)
Crops	2229.81
Grass land	28.54
Forest	2413.64
Urban areas	24.29

Table 2. Land uses (total area: ha) in the year 1945.

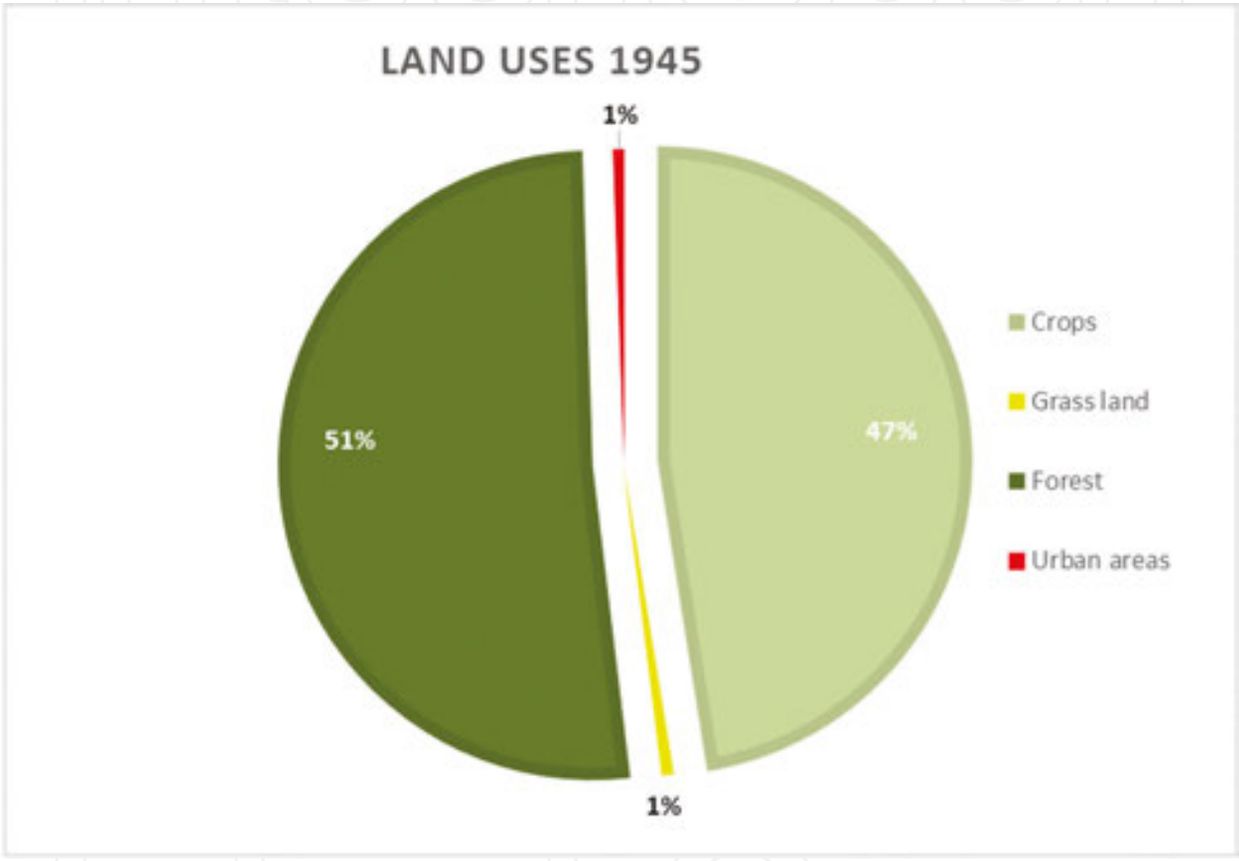

Figure 3. Land uses (% area) in Skiathos Island in the year 1945.

In Figure **3**, it can be observed that the land use with the largest area is the forest (51%) followed by the crops (47%) with a small difference. Finally, the categories grass land (1%) and urban areas (1%) have occupied the same percentage of land and also in very low levels compared to the other two categories.

In Figure **4**, a thematic map of the year 1996 for the Island of Skiathos is presented.

The growth of urban areas is evident from the above map. This means the reduction of the rest of the categories of land uses with the exception of the grass land. More specifically, the percentage of each category is presented in the next chart.

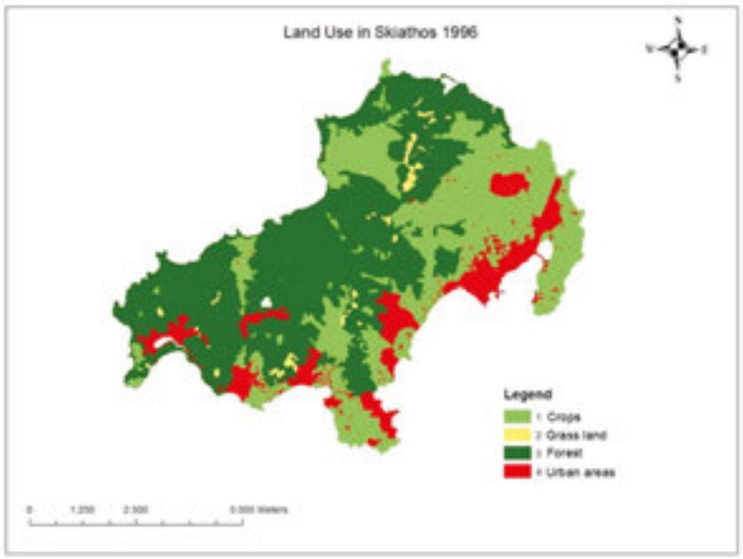

Figure 4. Land uses in Skiathos Island in the year 1996.

Land Uses	Total area (ha)
Crops	1697.57
Grass land	62.82
Forest	2398.26
Urban areas	532.93

Table 3. Land uses (total area: ha) in the year 1996.

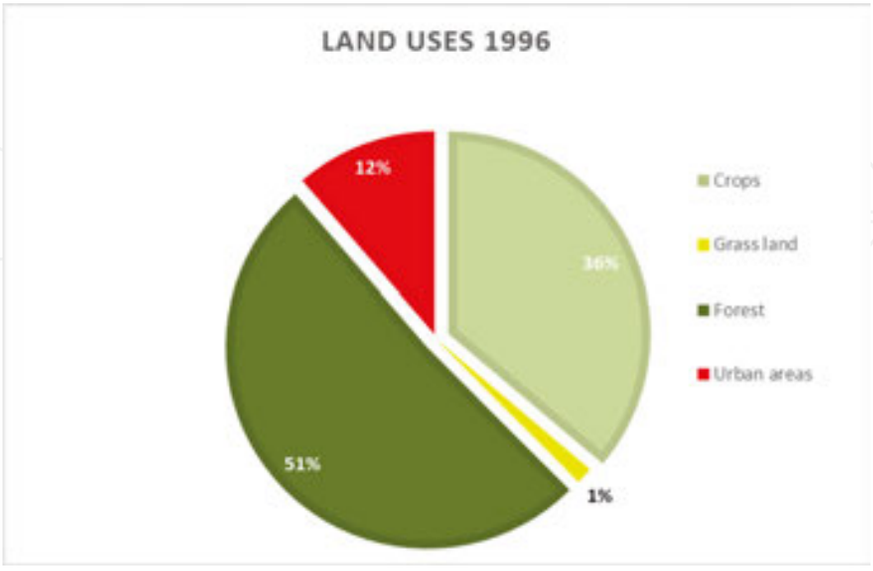

Figure 5. Land uses (% area) in Skiathos Island in the year 1996.

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As noticed in Figure **5** and **Table 3** in the year 1996 urban areas have increased (12%). On the other hand, crops have been reduced (36%). Finally, the percentage area of the forests (51%) and the grass land (1%) remained the same.

In Figure **6**, a thematic map of the year 2007 for the Island of Skiathos is presented.

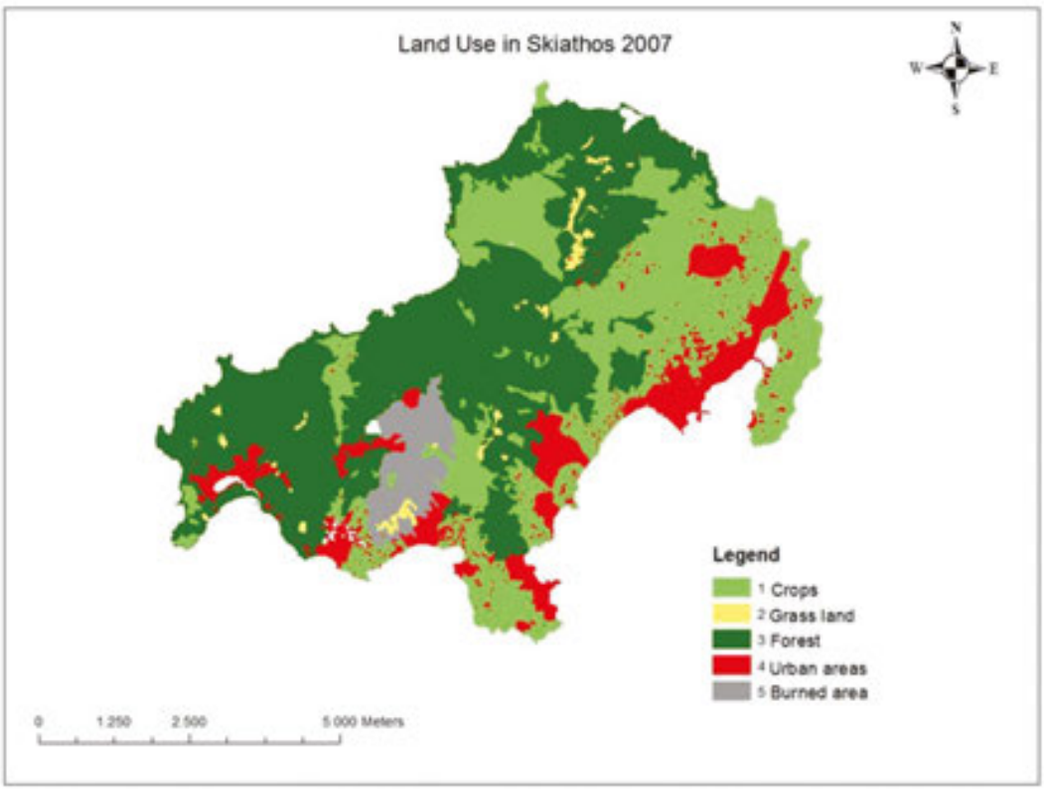

Figure 6. Land uses in Skiathos Island in the year 2007.

In the year 2007, a burned area can be noticed, from the above thematic map. It resulted from a fire in the Island of Skiathos in 2006. The area burnt was previously a forest area. This means that the percentage of forest area has been reduced. This can be observed in Figure **7** and **Table 4**.

Land Uses	Total Area (ha)
Crops	1675.46
Grass land	66.07
Forest	2169.35
Urban areas	553.87
Burned area	219.83

Table 4. Land uses (total area: ha) in the year 2007.

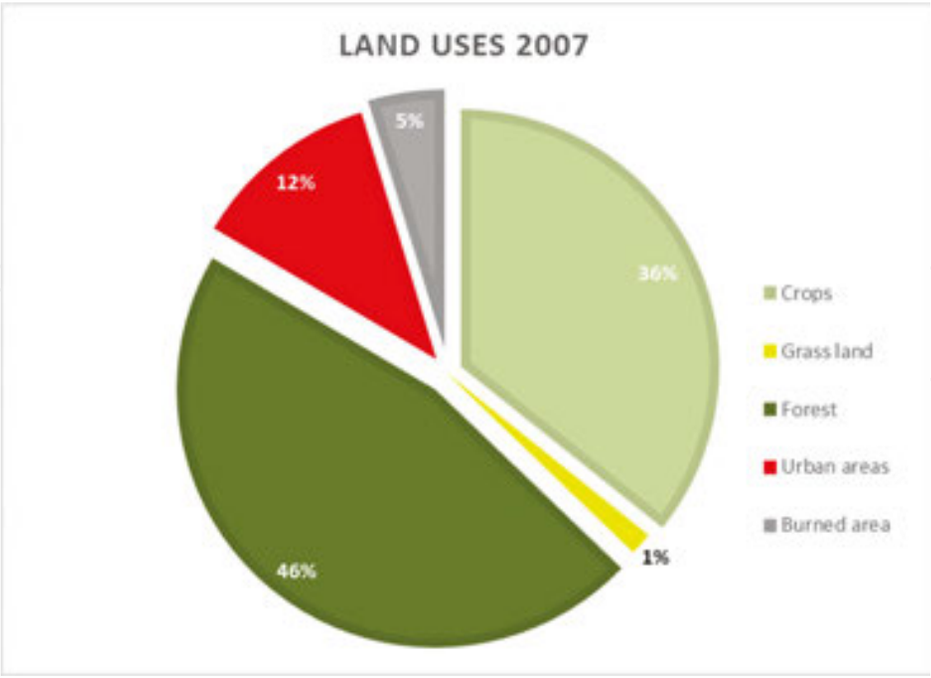

Figure 7. Land uses (% area) in Skiathos Island in the year 2007.

In the year 2007, there was a decrease in the percentage of forest land, while rates of other types of land use remained stable. This is a direct result of the burnt area. From 1945 to 1996, there was a great variation in land use changes in relation to 1996 and 2007. This happened because the interval between the two time periods (1945–1996) is too long (51 years) as opposed to the period 1996–2007 which is only 11 years. That is because there were no data for intermediate dates.

Then, the land uses were significantly changed in these three dates. More specifically, in Figure 8, the area for each land use can be observed for each year.

In the above chart, a large increase in urban areas in 1996 and the reduction of forest areas in 2007 can be observed. The reduction of the forest areas was mainly due to the appearance of the burnt areas. Also, the crop areas have shown a significant decrease in 1996 mainly due to the growth of the urban areas.

Land Uses	1945–1996	1996–2007
Crops	0.313530517	0.013196376
Grass land	0.545686087	0.049190253
Forest	0.006412983	0.105520087
Urban areas	0.954421781	0.037806706
Burned areas		1

Table 5. Comparison of land uses.

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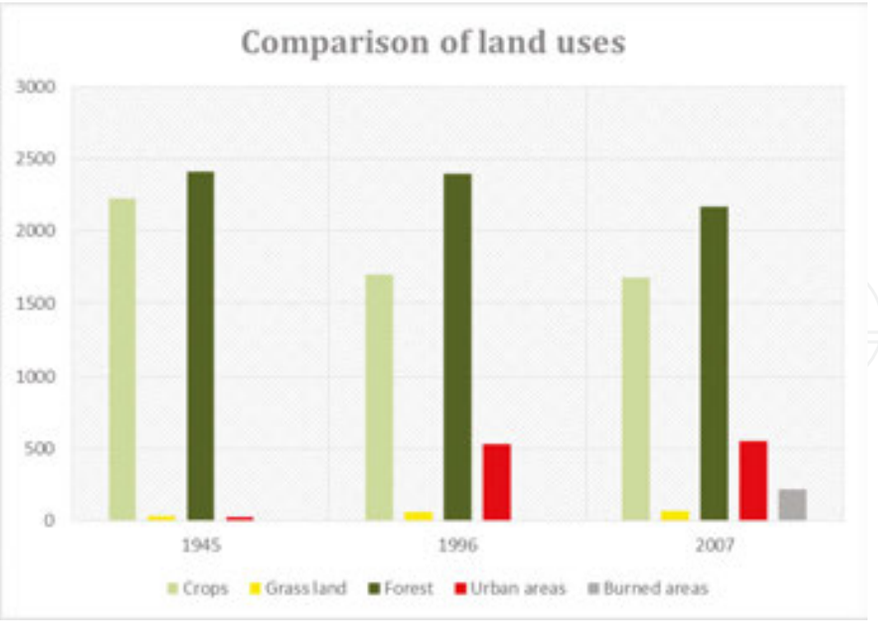

Figure 8. Comparison of land uses.

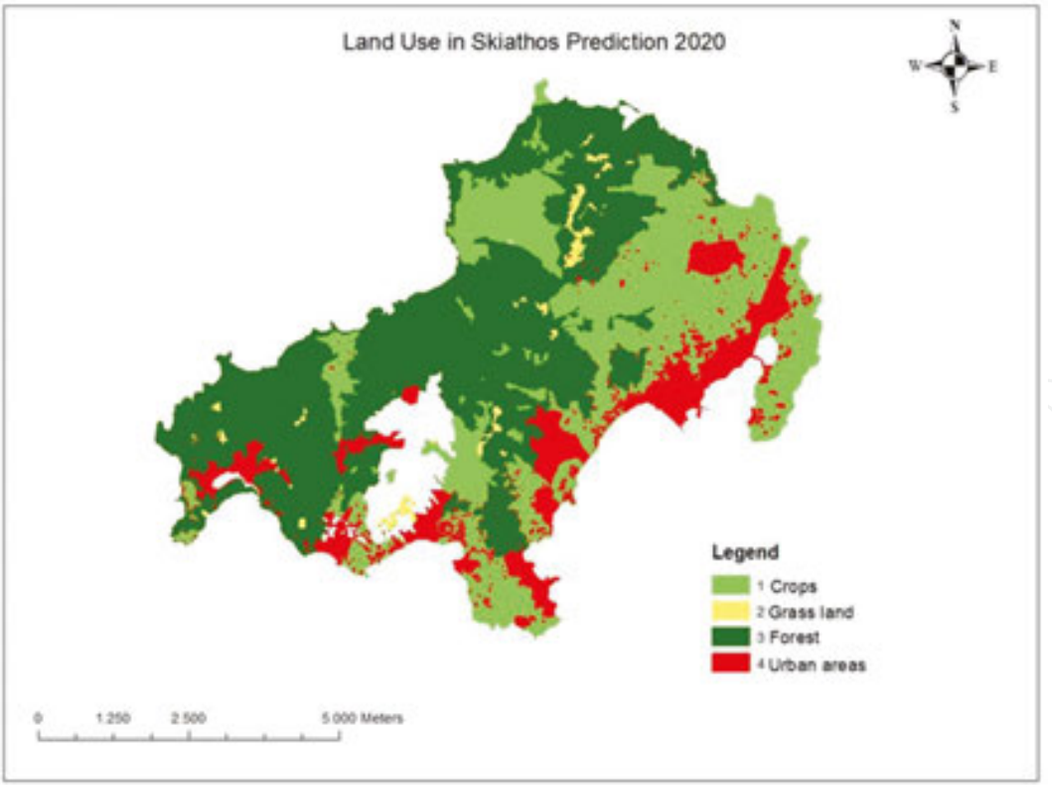

Figure 9. Land uses in Skiathos Island in the year 2020.

Urban areas, between the years 1945 and 1996, largely increased in a percentage of 95% (**Table 5** and **Figure 8**) a thematic map is presented, deriving from the model cellular automata which predicted the land uses in the Island of Skiathos in the year 2020.

As it can be observed in the above thematic map, in the model the burned area was not taken into account, it was left to reforest naturally. In Figure **10**, the percentage of each category of land use is presented, according to the model of cellular automata.

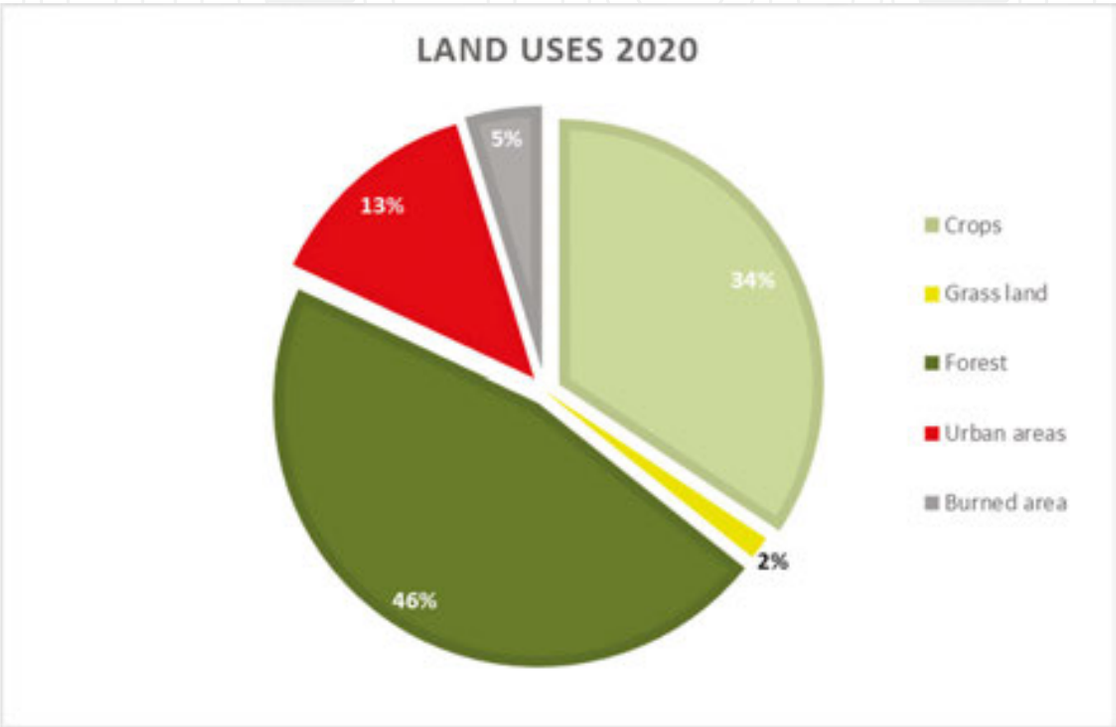

Figure 10. Land uses (% area) in Skiathos Island in the year 2020.

All the categories should be reduced except from the urban area and grass land which should increase.

In **Table 5**, a comparison between the land uses and the years is presented.

Land Uses	1945	1996	2007	2020
Crops	2229.81	1697.57	1675.46	1601.49
Grass land	28.54	62.82	66.07	64.82
Forest	2413.64	2398.26	2169.35	2157.18
Urban areas	24.29	532.93	553.87	618.34
Burned areas	-	-	219.83	219.83

Table 5. Land use (area: ha) in the years 1945, 1996, 2007 and 2020.

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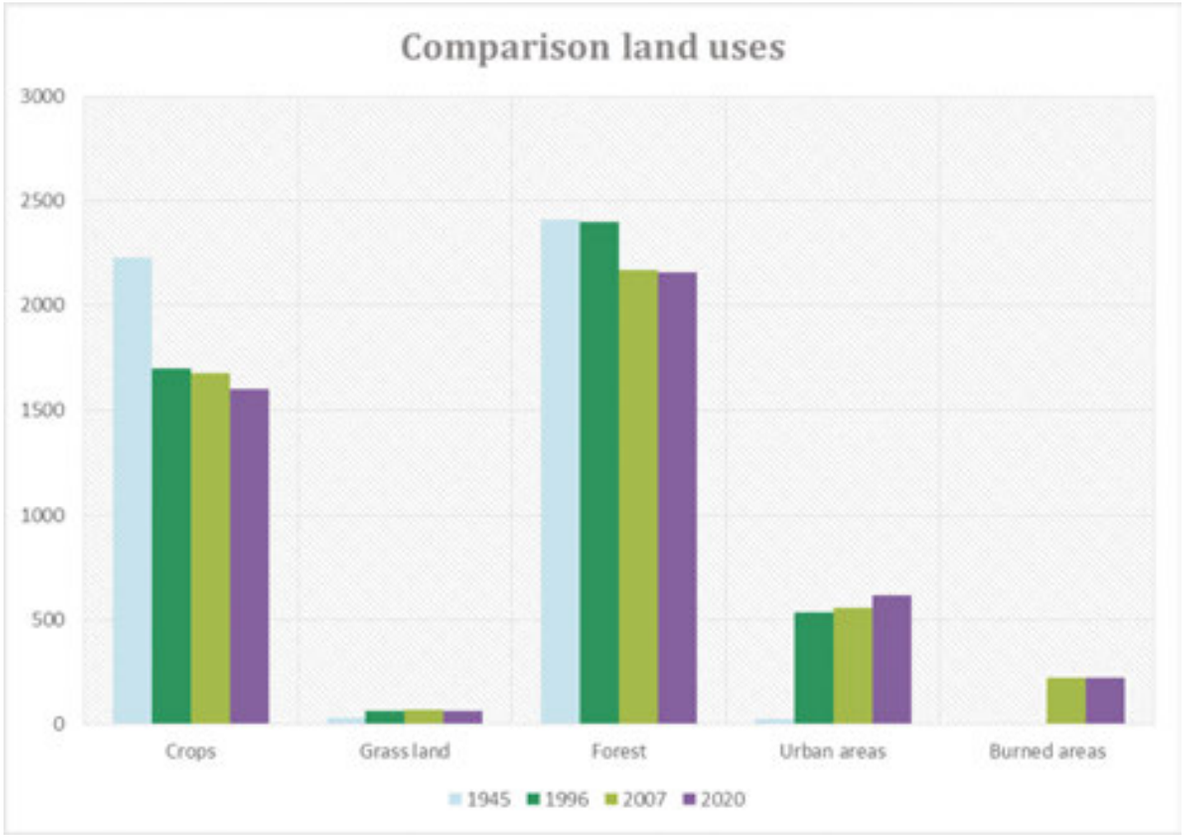

Figure 11. Comparison of land uses in the years 1945, 1996, 2007 and 2020.

In Figure **11**, a significant reduction in the crop areas can be observed between the years 1945 and 1996. In the next years, the reduction was smaller. As for the grass land, there was an increase between the years 1945 and 1996 and a minimum increase in the next years. Also, from the chart it can be observed that grassland occupies the smallest area in the Island of Skiathos.

Forest areas was the category of land use occupying the largest area in the island. However, the greatest reduction in forest areas happened between the years 1996 and 2007, due to the fire which took place in the island.

Finally, the category presenting the greatest increase was urban areas and, more specifically, between the years 1945 and 1996. There was an increase in urban areas during the next periods as well. Burned areas have been recorded in the year 2007 due to the forest fire of 2006 in the south-west part of the Island of Skiathos.

4. Scenarios

Taking into consideration the above analysis and results, two sustainable spatial development scenarios for the Island of Skiathos were proposed. The first scenario is derived from the results

obtained from the prediction (application of the model of cellular automata), while the second scenario refers to a more realistic model of development with a focus on environmental protection and sustainable development.

4.1. Trend scenario

This scenario concerns the development of the island in the next years. It results from the application of the model of cellular automata for the year 2020 and shows us an increase in tourism and urban areas.

In the south part of the island, pockets should be created between the urban areas. This scenario does not favor the environment. Also, the sector of the agriculture constantly decreases as the area of gross land reduces in 2020.

Moreover, the northern part of the island will be isolated as there will be no development. The infrastructures in this part of the island are few.

4.2. Sustainable scenario

As an alternative approach, this scenario has a central idea of establishing rules and a comprehensive plan for spatial planning. The new development model is described spatially through the following guidelines—interventions:

- The design and implementation of a Local Spatial Plan for the entire Island of Skiathos
- The implementation regulations

More specifically, we proposed a Local Spatial Plan for the entire Island of Skiathos. More specifically, it includes the following areas:

i. Regulations and incentives

ii. Delimitation of settlements

iii. Land use zones

The regulations include both construction limits and permitted land uses in each area of the island (what is allowed and what is forbidden). It also includes incentives, mainly financial.

4.3. Comparison of the scenarios

The sustainable scenario has more advantages than the trend scenario, as it proposed spatial planning and protection of the environment. Also, there is no development in the south part of the island and particularly an increase in tourism.

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5. Conclusions

The diversification of land uses is a result of human activities in the Island of Skiathos. More specifically, it depends on the economic situation, the development and the population of the Island. Also, another parameter is the human factor.

From the above analysis regarding land uses over the years, a great difference between categories of land uses was noticed. What should be mentioned is the increase of urban areas at the expense of forest and crops areas. This happened due to an increase in the population in the island and the increased number of tourists arriving in the island during the last summers.

Therefore, two scenarios, for the Island of Skiathos, were proposed. However, the sustainable scenario offered a more balanced development for the Island of Skiathos. Essentially, the sustainable scenario proposed a rural plan for the whole island.

There has been no other research regarding land uses in Skiathos Island in the past, and, also, this is the first digitization of the area. There is no rural plan for the Island of Skiathos, as well.

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