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# Unregulated built-up area expansion on Santorini Island, Greece

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## ABSTRACT

Unregulated built-up area expansion is a typical practice in Greece mostly on the islands, it is driven by the mass tourism development and the demand for second houses. Significant social, economic and environmental issues are linked to this practice. Santorini, a Greek island – which is characterized by important natural and cultural heritage properties and intense tourist development – is chosen here for the empirical part of the study. This paper attempts to study and quantify both the unregulated built-up area expansion and its impact on the natural and cultural environment. The intense ex-urban built-up area expansion that takes place on Santorini is interpreted on the basis of the Greek spatial planning framework so that its weaknesses that emerge will address the issue.

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## KEYWORDS

Spatial planning; traditional settlements; insular landscape; Santorini; Greece

## 1. Introduction

### 1.1. Built-up area expansion on the islands

Built-up areas expansions in Greece and, more particularly on islands and in coastal zones, are very often spontaneous, driven mostly by self-promoted, housing strategies. These areas expansions drive to polarization that results from the continuous concentration of built-up areas in coastal zones, where most of the population and the productive activities are located. Greece has always been economically oriented towards the sea, primarily because of the geomorphology of the continental area. Nevertheless, in recent decades tourism development and the intense demand for second houses have contributed significantly towards Greece's 'coastalization', a common feature of Mediterranean countries in general (Benoit & Comeau, 2005). It occurs with various spatial typologies: linear that could be along with road network, the coastal area and along with ridges, etc., in clusters which involves a peri-urban zone of built-up areas that expand out of the delineation of settlements. These ex-urban hybrid areas can follow a sort of land use plan or arise as the result ad-hoc individual choices, thus forming scattered built-up areas clusters (Kizos, Tsilimigkas, & Karampela, 2017).

There are many studies on Greece that have focused on the mode of informal built-up area expansion in urban areas that have analysed the causes of this practice. The main

driving forces for built-up area expansion are the housing demand, the loose or non-existent implementation of a spatial planning framework, the land speculation, etc. Although some of these processes are on the margins of legal or illegal procedures, the lack of enforcement of land use plans and building laws encourages them. But there are more reasons than just illegal practices and/or malpractices from landowners are in effect. One of these is the overall choice to link economic development in Greece with buildings construction since the 1960s. Another reason these owners form political and voting clientele who are promised by all political parties to 'legalize' illegal buildings. These developments have turned practically all fields or land plots into potential real estate plots for future 'development'. In all these areas, infrastructures were missing and 'the state' was expected to step in and provide all the necessary ones (roads, sewage, power, drinking water, etc.) (Karidis, 1996, 2008).

The main effects are: the intense pressure on the environment and natural resources, landscape degradation, the significant increase of the cost of creating and maintaining urban infrastructures; and, last but not least, this practice sacrifices the possibility of sustainable urbanization in the future to these hybrid clusters (Cecchini et al., 2019; Chorianopoulos, Pagonis, Koukoulas, & Drymoniti, 2010; Chorianopoulos, Tsilimigkas, Koukoulas, & Balatsos, 2014; Salvati, 2013). This mode of built-up area expansion leads to unnecessary consumption of valuable land resources, pushes and transforms the valuable peri-urban agricultural land and the peri-urban forest into built-up areas – a practice that affects the ecosystems – disperses urban infrastructures (electricity, freshwater, drainage system, routes) and increases the car use. This practice of housing development has also social consequences, such as the segregation of residential development, weakening of social infrastructures and services as well as under-funding of central areas (Chorianopoulos et al., 2010; EEA, 2016).

Unfortunately, unregulated very often illegal built-up area expansion has become common process for peri-urban areas on islands and in coastal zones (Salvati, 2013). Islands are fragile socio-spatial systems that face developmental difficulties due to their small size and isolation, but, at the same time, they have important natural and cultural heritage properties that are considered as advantages in sectors such as tourism that produces the principal income for the islands (Baldacchinos, 2004; Spilanis & Karayiannis, 2009). Being the dominant and the most significant profitable production sector for the islands, tourism has resulted in putting significant pressure on the primary and secondary production sectors, which have shrunk significantly (Tsartas, 2003; Tsilimigkas & Kizos, 2014). This shift is not only important from a socio-economic point of view but also because mass tourism has significant spatial footprint that concern, among others, areas of scattered tourist facilities, waving traditional activities, shrinkage of agricultural production and abandonment of cultivation on terraces, etc. This is more intense in cases when tourism development exceeds the carrying capacity of local socio-spatial systems.

Mass tourism development on islands, combined with the second houses increasing demand, is the principal factor for built-up areas expansions on islands. This type of built-up areas expansion creates strong residential pressures on areas of high fragility. The clusters that are created by this mode are usually concentrated: along the coastal zone (sea proximity), on ridges (attraction for the view), in proximity to places with special cultural value, such as traditional settlements or archaeological sites (Kizos et al., 2017; Tsilimigkas, Kizos, & Gourgiotis, 2018).

The degradation of cultural and natural heritage properties is a critical issue connected with the local development mode and the excessive built-up areas development mode. Landscape is the result of the amalgam of cultural and natural environment. It has formed as the result of the primary and secondary production sectors (Aretano, Petrosillo, Zaccarelli, Semeraro, & Zurlini, 2013; Petanidou, Kizos, & Soulakellis, 2008). Aspects connected with mass tourism development mode – such as high seasonality (Terkenli, 2005), services and infrastructures useful only during the summer (Tsartas, 2003) – create pressure on material environment. Pressure on immaterial level is also significant, since it results in changing the lifestyle of island residents, commodifying local culture, losing traditions and local practices and degrading local social networks (Terkenli, 2005).

## 1.2. Cultural heritage of islands

### 1.2.1. The landscape of islands

The study of the landscape is linked with many different scientific disciplines – such as: human and physical geography, ecology, planning, sociology, history, etc. – thus demonstrating the complexity of the issues involved and making an interdisciplinary approach mandatory for an integrated landscape protection and management (Tress, Tress, Decamps, & Hauteserre, 2001, 2005). Landscapes are a result of the osmosis of material and immaterial features (Marcucci, 2000; Tsilimigkas & Kizos, 2014), and their value concerns not only outstanding landscapes but all types of landscapes: landscapes of everyday life, rural landscapes, urban landscapes, industrial landscapes, etc. (Council of Europe, 2000). According to the European Landscape Convention (ELC): ‘... landscape is an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors’ (Council of Europe, 2000). Landscape is a carrier of the history and the evolution of the place, since a future landscape will convey elements and processes occurring today, thus rendering the landscape an integral part of place identity (ICOMOS, 2008; Marcucci, 2000). So, it is demonstrated that the dynamic character of the landscapes itself makes them vulnerable to changes. As it is known, a landscape changes according to natural processes and human activities, of whom the latter change it faster and often in violent terms (Plieninger et al., 2016), and endanger the ‘identity’ of the place (ICOMOS, 2008).

On islands the landscape vulnerability is even more pronounced due to the special character of physical geography of the islands and the particularities of their local socio-economic systems, which can be summarized as follows: The small size that concerns the limited space, limited natural resources and limited population (Spilanis, 2012) as well as their geographical fragmentation and discontinuity. These features, combined with their peripheral position within the poles and national development axes, mainly emerge accessibility issues and create developmental difficulties (Karampela, Kizos, & Spilanis, 2014; Spilanis, Kizos, & Paraskevi, 2012).

On the one hand, the small size and isolation have contributed to creating the unique and vulnerable natural and cultural landscape of the Greek islands. The islands’ carrying capacity is limited, thus being unable to accept large-scale activities and constructions without a negative impact on their landscape and, eventually, on their identity (Tsilimigkas & Derdemezi, 2017). On the other hand, the aforementioned island particularities make them attractive and lucrative places for developing specific but in small scale

activities such as aquaculture, conversion of renewable energy resources, exploitation of underwater resources, and, more particularly, islands that are attractive places for tourist activities (CEMAT, 2000). These activities and the structures that accompany them create land-use conflicts either among themselves or with the sensitive environment and the vulnerable landscape of islands (Tsilimigkas & Rempis, 2018).

Within this context, the importance of the island landscape and the threats that it faces from abrupt changes are recognized, and the incorporation of the landscape in the spatial planning system seems to be absolutely necessary. At European level, this fact was mainly propounded by the European Landscape Convention (ELC) (Council of Europe, 2000). The ELC, despite the fact that was adopted by the Greek national policy with ten years delay by Law 3827/2010 (OGG, 2010), was an important step towards the integral landscape protection and management. Law enactment ended the former situation where many laws, although they referred to landscape issues, had no single vision on landscape management and protection. On the contrary, landscape protection was fragmented and concerned primarily landscapes that were considered as of outstanding natural or cultural value.

Initially, the interest was limited to the protection of natural landscapes: In Law 1469/1950 (OGG, 1950) and, within the context of the dominant views of the era, there was the delineation of zones as Landscapes of Special Outstanding Natural Beauty (LSONB) ('Topia Idiaiterou Fysikou Kallous or TIFK', in Greek). In Legislative Degree 996/1971 (OGG, 1971) the need for protection of the forest and the protection of special natural landscapes was highlighted. In 1975, the revision of the Greek Constitution took place, and the protection of both natural and cultural environment as a state priority was introduced (OGG, 1975). Law 1650/1986 (OGG, 1986) aimed at environmental protection, and there were guidelines to this direction in the Constitution, so that environmental protection was the dominant priority during that period. With Law 2831/2000 'General Building Regulation (GBR)' ('Genikos Oikodomikos Kanonismos', in Greek) (OGG, 2000) and Law 3028/2002, (OGG, 2002) for the protection of antiquities and Cultural Heritage in general,' it was implied the need for protection and management of the cultural landscape, primarily that of traditional settlements and preservation of buildings.

### *1.2.2. Traditional settlements of islands*

The traditional settlements of the Cyclades islands were localized taking into consideration the following factors: (a) their natural environment so to avoid disasters caused by natural phenomena like prevalent powerful wind; (b) the inhabitants has accessibility to natural harbours; and (c) the inhabitants could be either in proximity with rare cultivated or in naturally fortified locations. These settlements have been influenced and changed by physical, geographical and principally socioeconomic factors (Yiannakou, Eppas, & Zeka, 2017). From the sixth century until the beginning of the ninth century AD, the main priority for their localization was how the inhabitants defend themselves from the pirates. That period the settlements were compact; the houses were not spacious; they had rather very small windows and doors. The settlements were localized on the hills without direct access to the sea but with view of it. After the end of the piracy era, small settlements developed in coastal areas so the inhabitants had accessibility to the sea, since a road network had not been established yet on the islands, and the interconnection among settlements was mainly made by boats. Coastal settlements were also served a

variety of occupations, such as fishery, pottery and trade. The rapid tendency for coastalisation on islands began in the middle of the twentieth century. The settlement development was unregulated, as an expansion of old coastal settlements, and the two key factors of the built-up area expansion have been the tourist development and the demand for a second house (Kizos et al., 2017).

In Greece, the protection of traditional settlements was institutionalized in the early 1970s by the General Building Regulation (GBR) enactment Law 8/1973 (OGG, 1973), subsequently, partially amended, completed and revised but without substantially change of its regulatory character. The traditional settlements of the Cyclades islands were nominated and delineated by the Presidential Decree (PD) 594/D/78 which was completed subsequently by 504/D/88 (OGG, 1978, 1988). While the building regulations for the traditional settlements were defined according to PD 345/D/89 (OGG, 1989), completions and modifications to the terms and restrictions were laid down subsequently by Law 3201/2003 (OGG, 2003a). However, these regulations were delayed, since on several islands, such as Mykonos, Santorini, Paros, etc., tourism has been growing strongly since the 1960s and 70s (Tsartas, 2010), with the result significant pressures have already been put on and morphological alterations have been caused in traditional settlements of these islands. Protection and integrated management of coastal areas and islands – especially of areas characterized by natural and cultural heritage – is a complex, multi-scale and multi-discipline procedure, in which local societies should have a crucial role to play (Papatheochari & Coccossis, 2019; Rempis, Alexandrakis, Tsilimigkas, & Kampanis, 2018).

### *1.2.3. Archaeological sites of the islands*

Apart from traditional settlements, archaeological sites are also omnipresent on the Greek islands. Although these sites fall under cultural protection and management and there are declarations, policy and laws at international, European and national levels, they have undergone important pressures primarily due to built-up areas excessive dispersion. Law 3028/2002 (OGG, 2002) provides spatial regulations that refer to the delineation of archaeological sites and the areas in proximity. In case archaeological sites are outside the delineation of official settlements, the development of the zone – either for productive activities or for buildings construction – is determined depending on the protection zone statutory regulations (OGG, 2002). In case that the archaeological sites are within the delineation of official settlements, any type of work in existing buildings requires permission from a special control body, the construction of new buildings must comply with strict terms and restrictions in order not to alter the morphological character of the settlement (OGG, 2002). For the Cyclades islands, the responsible authority that deals with the management of archaeological sites and ensures the correct implementation of the existing legislation on the protection of antiquities is the Cycladic Archaeological Service (MCS, 2018).

### *1.3. Spatial planning framework and ex-urban built-up areas expansion*

Spatial planning policies and spatial planning implementation in Greece are relatively recent and the most important steps have been made from the 1980s onwards. This can be understood should the particular historical circumstances, political choices and

social and economic conditions that have taken place in the country are taken into consideration (Karidis, 2008). Although efforts were made to draw up a spatial planning framework in the 1970s, they had no success. In 1983, Law 1337/83 (OGG, 1983) was approved. It was destined to be a transitional law in order to fill the gap that had been created in planning legislation but, eventually, its implementation was prolonged too much, since it was expanded until the end of the 90s (Christofilopoulos, 2007). That law provided two main plans for sites and settlements: the General Urban Plan (GUP) ('Geniko Poleodomiko Schedio', in Greek) and the Urban Study (US) ('Poleodomiki Meleti', in Greek). For the present paper research the most important tool approved by the law is the 'Urban Development Control Zone (UDCZ)' ('Zoni Oikistikou Elegchou', in Greek), which is a statutory tool, intended to regulate, among others, land use, and conditions and constraints for buildings constructions for the unregulated built-up area expansion in peri-urban zones and in areas of environmental interest (Serraos, 2007).

In the late 1990s, a new era for the spatial planning started by two law enactment: First, Law 2508/97 (OGG, 1997) – which replaced Law 1337/83 (OGG, 1983) and implemented urban planning according to the principles of sustainable development – and Law 2742/99 (OGG, 1999) that enacted provisions for strategic spatial planning mostly at regional and national scale (Giannakourou, 2012, 2008). Second, Law 4269/14 (OGG, 2014) was the following institutional framework for spatial planning. It reorganized regional and city planning regarding to: levels, instrumentalities, procedures and the content of plans. However, there was no emphasis on resolving the issue of harmonizing the plans between different or same spatial planning levels, considered as the main malfunction of the spatial planning system (Giannakourou, 2015). Subsequently, in 2016 Law 4269/14 (OGG, 2014) was replaced again by the most recent Law 4447/16 (OGG, 2016a), which defines strategic planning at national and regional spatial planning levels and regulatory planning at local spatial planning level. After a period of intense institutional revisions and replacements, the Greek spatial planning system consists of three levels: National level, regional level and local level.

At 'national level', there are: (i) the 'General Spatial Planning and Sustainable Development Framework' (GSPSDF) ('Geniko Plaisio Chorotaxikou Schediasmou kai AEIFOROU ANAPTXYXIS', in Greek) (OGG, 2008a), which, according Law 4447/16 (OGG, 2016a), is revised to 'National Spatial Strategy' ('Ethniki Choriki Stratigiki', in Greek); and (ii) 'Special Frameworks on Spatial Planning and Sustainable Development' (SFSPSD) ('Eidika Plaisia Chorotaxikou Schediasmou kai AEIFOROU ANAPTXYXIS', in Greek) (OGG, 1999) which, according Law 4447/16 (OGG, 2016a), is revised to 'Special Spatial Frameworks' ('Eidika Chorotaxika Plaisia', in Greek) (OGG, 2016a); each of these frameworks concerns a sector that drives to critical spatial footprint: (a) Industry (OGG, 2009a); (b) Tourism (OGG, 2009b, 2013), which is under revision; (c) Renewable Energy Sources (RES) (OGG, 2008b); and (d) Aquaculture (OGG, 2011).

At 'regional level', there are the 'Regional Frameworks on Spatial Planning and Sustainable Development' (RFSPSD) ('Perifereiaka plaisia Chorotaxikou Schediasmou kai AEIFOROU ANAPTXYXIS', in Greek), which, according to Law 4447/16 (OGG, 2016a), they are renamed into 'Regional Spatial Frameworks' (RSF) ('Perifereiaka Chorotaxika Plaisia', in Greek). There is one RFSPSD for each of the 12 administrative regions (NUTS2) of Greece, whereas for Attica, the 13th region, there is a Master Plan (MP) ('Rythmistiko Schedio', in Greek).

At 'local level', there are: (i) the General Urban Plan (GUP) ('Geniko Poleodomiko Schedio', in Greek); and (ii) the Open City Spatial and Housing Organization Plan (OCSHOP) ('Schedio Chorikis kai Oikistikis Organosis Anoichtis Polis', in Greek). Law 4447/16 (OGG, 2016a) replaced GUP and OCSHOP by introducing Local and Special Spatial Plans (LSPs and SSPs) ('Topika kai Eidika Chorika Schedia', in Greek).

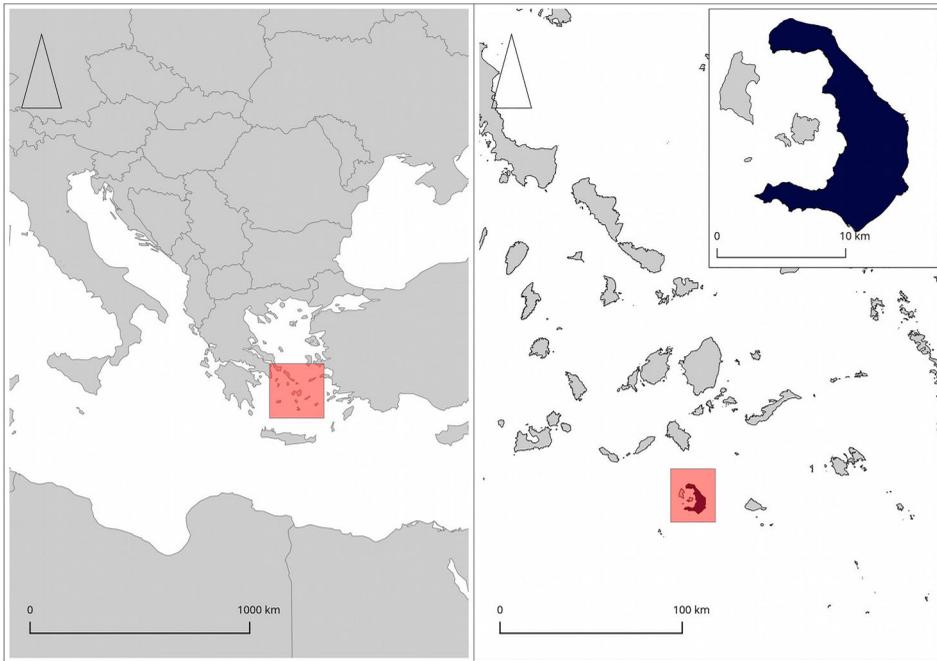
Santorini belongs to the South Aegean Region, and, at regional level, it falls within the strategic directions of the RFSPSD of South Aegean (OGG, 2003b). On Santorini there are 15 settlements with official delineation and 16 traditional settlements of which four have not institutionalized boundaries. The traditional settlements – such as: Vothon, Emporio, Thira, Megalochori, Oia and Pyrgos – were nominated by PD 594/D/79 (OGG, 1979), whereas the traditional settlements, such as Akrotiri, Exo Gonia, Episkopi Gonia, Imerovigli, Karterados, Mesaria, Foinikia, Tholos, Ammoudi Bay and Armeni Bay, were nominated by PD 504/D/1988 (OGG, 1988). The terms and building restrictions for traditional settlements are in the two aforementioned PDs and, for the Cycladic traditional settlements that have nominated by PD 594/D/79, there is completion and modification according to PD 345/D/89 (OGG, 1989). For the settlements Fira and Imerovigli there is GUP, according to Law 1337/83 (OGG, 1987), whose main purpose is to integrate and expand built-up areas in the urban plan and determine the land uses for the peri-urban zones. In April 2017, the proposal for amendment of the existing GUP was published. For the peri-urban areas of Thira, Oia, Vothonas, Vourvoulo, Emporeio, Exo Gonia, Episkopi Gonia, Imerovigli, Karterado, Megalochori, Akrotiri, Messaria and Pyrgos there is institutionalized UDCZ (OGG, 1990), which was modified by and completed with PD 144/D/2012 (OGG, 2012).

## 2. Materials and method

### 2.1. Santorini island

For the empirical part of the present study, Santorini island was chosen, which belongs to the Cycladic complex of islands in the Aegean Sea (Figure 1). The surface of Santorini is 76.05 km<sup>2</sup>, and the permanent population 15,231 people (ELSTAT, 2011). The main productive activity is tourism, which is constantly expanding, while the agricultural sector and the 'processing crafts' are shrinking. More specifically, in 1991, the percentage of employment in primary production sector was 9%, in secondary sector was 36% and in tertiary sector was 55%. In 2001, the percentage of employment in primary production sector was 6%, in secondary sector was 28% and in tertiary sector was 66%. Accordingly, in 2011, the percentage of employment in primary production sector was 28%, in secondary sector was 16% and in tertiary sector was 56% (ELSTAT, 2011). The increase in primary sector may be justified with the creation of the patent called 'Protecting Designation of Origin (PDO)' for some local agricultural products. These changes of economical nature have also led to cultural alterations. Apart from agricultural products, primary and secondary sectors have created a good number of characteristics of the island landscape, terraces, traditional agricultural structures and cobbled streets (Kizos & Koulouri, 2005; Petanidou et al., 2008).

The terrain morphology of Santorini was shaped during the eruption of the volcano in the seventeenth century BCE, which created the caldera. On caldera's side the relief is particularly steep, with intense slopes and morphological discontinuities (Antoniou, Lappas,



**Figure 1** . Location map for Santorini island. Source: authors' analysis.

Leoussis, & Nomikou, 2017). The rest of the island is characterized by lowlandness. The highest peak is Prophet Elias at 567 metres. The islets Nea and Palia Kameni, which are in caldera's centre, and the mountain of Prophet Elias belong to the network Natura 2000 because of their natural qualities and the rare and endemic plants and the whole island is considered as LSONB (OGG, 1998, 1950). According to PD 108/D/2016 (OGG, 2016b), there are ten archaeological sites with institutionalized boundaries on Santorini, which are: Akrotiri, Gavrilos hill, Ancient Thira – Prophet Ilias – Saint Nikolaos, Monolithos, Fira Mines, Koloumpo, Castle of Skaros, Castle of Pyrgos, Castle of Emporio and Castle of Oia. The special architecture with local volcanic materials (Ritzouli, 2017), combined with the unique island landscape of the caldera, have made Santorini one of the most popular tourist destinations in the world.

## 2.2. Working scale

In order to determine the working scale here, two principal issues were taken into consideration: first, the study question, and, second, the data-sets availability. Therefore, in this study the working scale is fixed on 1:20.000, and is considered as a typical scale for physical spatial planning that is appropriate for the paper's questions. For the purposes of this study, there have been used the Aster DEM with  $30 \times 30$  metres cell size and ASTER GDEM, which is a product of METI and NASA (METI & NASA, 2011), and, eventually, the DEM was resampled in  $20 \times 20$  m pixel size (Waldo, 1988). However, the creation of some spatial data required a different scale approach. For the digitalization of the delineation of official settlements the working scale chosen here was 1:5.000, so that a more

detailed data set could be created, and it was made an effort so that the digitization of buildings could be as accurate as possible, so the working scale that was used is 1:1.000. These datasets have also been resampled in  $20 \times 20$  m pixel size.

## 2.2. Data

### 2.2.1. Variables 1: built-up areas and settlements delineation

The CLC data-sets provide time-series of geo-spatial data for European countries concerning the years 1990, 2000, 2006 2012, 2018. The data derived in 1:100,000 and 1:500.000 scale are suitable for regional and national scale analysis. Four types of land cover have emerged: artificial surfaces, agricultural areas, forest and semi-natural areas and wetlands – water bodies. Built-up space defined by artificial surfaces include the following layers: continuous urban fabric, discontinuous urban fabric, industrial or commercial units, road and rail networks and associated land, ports, airports, mineral extraction, dump and construction sites, green urban areas and sport and leisure facilities; the rest is non-built-up space. Although CLC data-set provides data that ensures both temporal analysis and the possibility to compare different cases in the European space, they were not considered appropriate in the present study, as the derived scales 1:100,000 and 1:500.000 are not consistent with the paper question.

The soil sealing raster layer contains continuous values ranging from 0 to 100% of coverage, representing different degrees of soil sealing according to the structures (EEA, 2015) and providing built-up areas. Although they are open, freely accessed and at an appropriate scale ( $20 \times 20$  m pixel size), these datasets are considered that they do not have the necessary accuracy; thus, they are considered as inappropriate for the questions of the present paper.

In order to approach the paper questions – that is, (a) how to study the ex-urban built-up area expansion on Santorini island and (b) to discuss the driving forces and consider the consequences of these practices on natural and cultural environment – accurate datasets in small scale should be created. Within this framework, it was considered that digitizing built-up areas is the most appropriate method to approach the study questions. Although it is particularly time-consuming, it can be much more accurate than standard remote sensing methods. It was also considered that the creation of time-series of data – concerning the built-up area and study the temporal overview of the evolution of ex-urban built-up area expansion – exceed the paper purposes.

To identify built-up areas, the buildings were digitized from the orthophoto maps that were provided by the National Cadastre and Mapping Agency (NCMA, 2018). The orthophotos were georeferenced in GGRS84, and the shooting became from 2007 until 2009. The non-urban areas have spatial resolution 50 cm. and geometrical accuracy on the ground  $RMSE_{xy} \leq 1.41$  m. (NCMA, 2018). During the process of georeference, there were difficulties in distinguishing between built-up and soil sealed but non built-up areas. Generally, the cells that are presented as a white roof in the orthophoto maps were considered to be built-up areas. Nevertheless, the digitalization was based on the shape too, since many roofs are not white but grey or brown. The difficulty in recognizing each building is greater in the amphitheatrical construction of Santorini. Big building complexes for tourist purposes were considered as united built-up areas. Santorini is an island of constantly tourist development, and the built-up areas have been expanded from 2007

to 2009 until today, and many new buildings have been built. Thus, in order to achieve the most accurate result of the current images, the satellite images of google earth were used as an auxiliary digitization source.

The built-up area is grouped into buildings within and outside the boundaries of official settlements. For this differentiation the construction of spatial data of the institutionalized boundaries was necessary to be made. Collecting the OGGs that contain the diagrams of the boundaries of official settlements and providing the delineation in a non-digital format (i.e. in paper, often unreadable), has been a complicated and time-consuming process that requires to communicate with Santorini's public authorities too. The diagrams had to be scanned and projected on the reference system GGRS87 using the orthophoto maps provided by NCMA (NCMA, 2018). The projection is also a complicated task due to the bad resolution quality of the diagrams that do not provide the best accuracy. Subsequently, the boundary of each settlement of Santorini was digitalized. However, here it should be underlined that most of the times the institutionalized boundaries do not coincide with the real settlements limits. Furthermore, there are not institutionalized boundaries in the case of four traditional settlements: Foinikia, Tholos, Ammoudi Bay and Armeni Bay.

From the buildings groups within and outside settlements' boundaries, it has been illustrated that in many areas of the island residential densities are the same to or higher for the outside settlements' boundaries buildings when compared to inside settlements' boundaries buildings (Figure 2(a)).

### **2.2.2. Variables 2: cultural heritage**

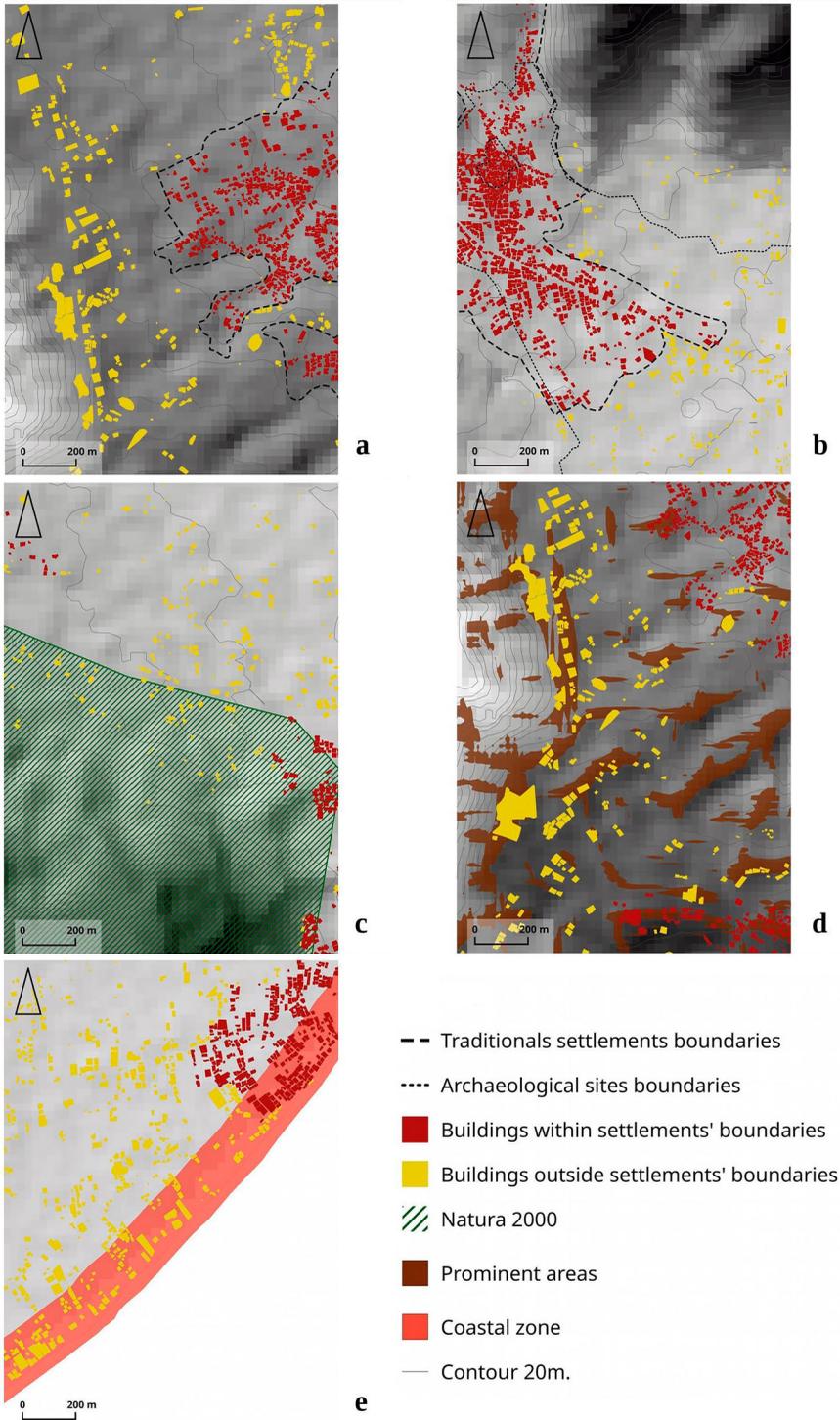
For the management and protection of cultural heritage, both traditional settlements and archaeological sites of Santorini were examined. The boundaries of traditional settlements were acquired by the process that has been described above. For the digitalization of the boundaries of traditional settlements the similar process was followed. In the OGG for the archaeological sites of Santorini (OGG, 2016b) there are orthophoto maps with the boundaries of the archaeological sites that were projected on GGRS87, and then the boundaries were digitalized. In areas that there are traditional settlements' and archaeological boundaries in proximity, it is noted that there is perplexity as the boundaries are not identical in regions that should have been. Generally, the definition of one delineation does not take account of the one and the other (Figure 2(b)). In many areas there are small gaps between the two boundaries and in these cases the buildings are not affected from the special terms and limitations for buildings.

### **2.2.3. Variables 3: natural heritage**

For the protected natural heritage sites the Natura 2000 site of the European ecological network (Figure 2(c)) that concerns a network of nature protection zones (OJEC, 1992) was used. The Aster DEM provided the elevation, the slopes, the ridges and the peaks of Santorini island (METI & NASA, 2011). According these data, the map of 'prominent' areas (Figure 2(d)) and the map of coastal zones were made (Figure 2(e)).

## **2.3. Methods.**

In this paper, it is examined how the unregulated built-up expansion affects both the cultural and natural environment of Santorini island. On the one hand, the traditional



**Figure 2 .** Areas of Santorini that demonstrate the construction of data and the issues that arise. Source: authors' analysis.

settlements and the archaeological sites were taken into consideration for cultural heritage. In order for the built-up area to have a digital format, percentage of the buildings that are inside or outside the traditional settlements boundaries or the archaeological sites boundaries were exported.

On the other hand, the Natura 2000 network was considered for the natural environment, and the percentage of the built-up area that is within Natura 2000 network area of Santorini was exported. Moreover, it was observed that there are buildings that are localized in ‘prominent’ areas. According to their terrain, ‘prominent’ areas are defined for the study purposes as areas that are considered to be locations with wide visibility to and from these areas. ‘Prominent’ areas are mostly places in altitude, but even in plane areas there are ‘prominent’ places in the uplifts of the terrain. Thus, for ‘prominent’ areas to be spatially determined, the elevation, the slope, the ridges and the peaks were taken into account. The terrain was grouped in three categories based on both the elevation and slope, as shown in [Table 1](#).

The peaks, the ridges and the planar areas consisted of the synthesis of the elevation and the slope so that the ‘prominent’ areas can be exported. The underlying reason of this composition is for extra importance to peaks and ridges as well as to weight even in level areas to be given. ‘Prominent’ areas are defined by the synthesis of (a) the peaks areas, which are either Level areas, Semi-Fragmented areas or Fragmented areas; and (b) the ridges, which are either Semi-Fragmented areas or Fragmented areas ([Figure 3\(c\)](#)).

As far as the natural environment is concerned, the percentage of the built-up area that is within the coastal zone was examined too. To determine the coastal zone, three buffers with different distance from the coastal line were created: 200, 500 and 1000 m., and consist of the synthesis of elevation and slope ([Table 2](#)) (Tsilimigkas, Deligianni, & Zerbopoulos, 2016).

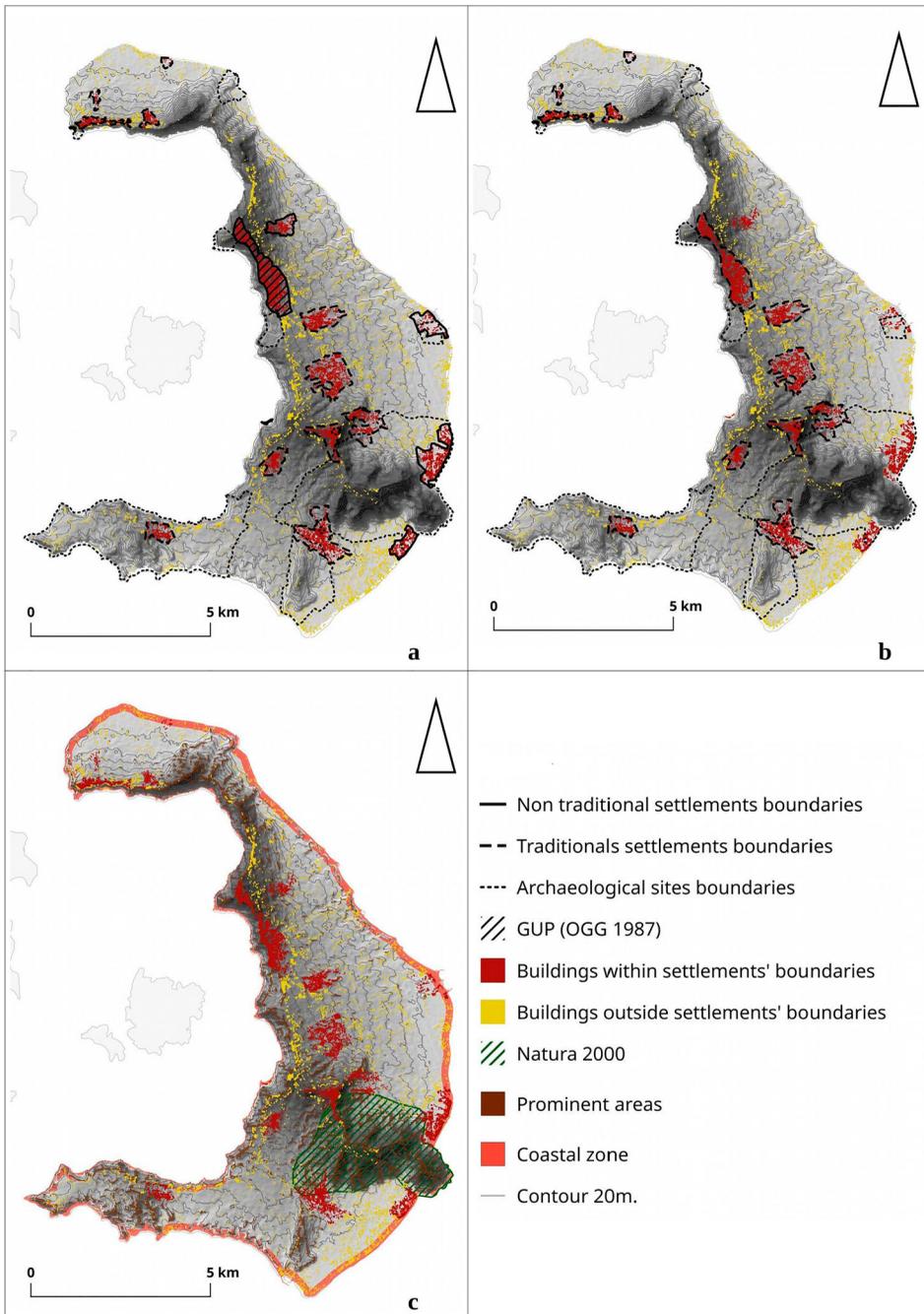
### 3. Results and discussion

The total area of the island is calculated 76.05 km<sup>2</sup>, the total built-up area is 3.07 km<sup>2</sup>, which means approximately 4.04% of the total island area. Of 3.07 km<sup>2</sup>, on the one hand, 1.49 km<sup>2</sup> is within settlements boundaries, which means approximately 48.56% of the built-up area and 1.96% of the total island area. On the other hand, 1.58 km<sup>2</sup> is outside settlements’ boundaries, which means approximately 51.44% of the built-up area and 2.08% of the total island area ([Table 3](#)).

**Table 1** . Terrain categorization based on elevation and slope.

Category synthesis	Criteria
Level areas	Plane area: elevation 0–100 m and Flat area: slope 0–7%
Semi-Fragmented areas	Plane area: elevation 0–100 m and semi-Steep area: slope 7–15%
	Transition zone: elevation 100–300 m and Flat area: slope 0–7%
Fragmented areas	Transition zone: elevation 100–300 m and semi-Steep area: slope 7–15%
	Mountainous area: elevation 300 < m and Flat area: slope 0–7%
	Plane area: elevation 0–100 m and Steep area: slope 15 – <%
	Transition zone: elevation 100–300 m and Steep area: slope 15 – <%
	Mountainous area: elevation 300 < m and semi-Steep area: slope 7–15%
	Mountainous area: elevation 300 < m and Steep area: slope 15 – <%

Source: authors’ analysis.



**Figure 3** . The effect of built-up area of Santorini in areas of cultural or environmental interest. Source: authors' analysis.

The above analysis has shown the excessive built-up area expansion that takes place on Santorini island. Built-up areas outside the settlements boundaries are 0.09 km<sup>2</sup>, which means approximately 2.88% higher than the built-up areas within settlements

**Table 2** . Determination of coastal zone.

Distance from the coastline (metres)	Level areas	Semi-Fragmented areas	Fragmented areas
200	O	O	O
500	O	O	X
1000	O	X	X

O = The area is considered as coastal, X = The area is not considered as coastal.

Source: authors' analysis.

**Table 3** . Built-up area that affects the area of cultural or natural interest.

		Within settlements' boundaries		Outside of settlements' boundaries		Total built-up area	
		km <sup>2</sup>	%	km <sup>2</sup>	%	km <sup>2</sup>	%
		Built up areas	1.49	48.56	1.58	51.44	3.07
Areas of cultural interest	Within traditional settlements	0.12	36.66			0.12	36.66
	Within Archaeological sites	0.36	11.74	0.3	9.87	0.66	21.61
Areas of environmental interest	Natura 2000	0.09	3.08	0.05	1.66	0.14	4.74
	Prominent areas	0.27	9.1	0.23	7.57	0.5	16.67
	Coastal areas	0.14	4.82	0.24	7.81	0.38	12.63

Source: authors' analysis.

boundaries (Table 3) (Figure 3(a)). This demonstrates the need for re-delineating the boundaries. More specifically, the boundaries – apart from the fact that they were defined many years ago and in periods with different needs and less spatial pressures than today's – have never been defined by a coordinated procedure with specific criteria conforming to the real boundaries of the settlements or by the physical geography of the area.

There are many traditional settlements on Santorini that justify the big percentage of buildings that are within their boundaries. Caution should be given to construction outside the limits of traditional settlements but within a proximity area to them, due to the fact that this kind of built-up area dispersion could put a great deal of pressure on traditional settlements (Figure 3(b)). Some nominated settlements either are parts of archaeological sites or contain archaeological sites. The case of buildings that are outside settlements boundaries but inside archaeological sites (Figure 3(b)) poses a risk that archaeological sites can be degraded.

The Natura 2000 area has a small percentage of construction which is not only because of the special conditions for interventions that exist as a protected area, but also because the Natura 2000 area covers the mountainous part of the island (Figure 3(c)). The percentage of buildings that are placed on prominent areas is not negligible, that is, 0.5 km<sup>2</sup>, which means approximately 16.67 km<sup>2</sup> (Table 3) (Figure 3(c)). Buildings in prominent areas that do not follow the prevailing architecture and the local scale can be main cause of negative effects on landscape qualities.

According to Eurostat 2018, the development of tourism has led to coastalization in Greece, since 93% of hotels and other short-stay accommodations have been established on coastal zone (Eurostat, 2019). In the coastal zone of Santorini the percentage of buildings that are outside the boundaries of settlements is bigger than the percentage of buildings within the boundaries by 0.1 km<sup>2</sup>, which means approximately 2.99% (Table 3) (Figure 3(c)). Coastalization can be developed either in a coastal zone that only a few

houses existed before rather than a settlement, so in this case the process is unplanned and the residential tissue is not compact, or it can be developed around preexisting settlements in peri-urban clusters (Kizos et al., 2017; Salvati, 2013).

The above geo-spatial analysis of built-up area of Santorini can further be shed light upon by statistical data. According to building census 2011, in Santorini there are above 14.000 buildings of which 67% corresponds to residential use, 9% corresponds to hotels and 24% to other uses (ELSTAT, 2011). 2% of buildings were built up before 1919, 19% were built up between 1919 and 1960, 52% were built up between 1961 and 1990, 22% were built up between 1991 and 2005 and 5% were built up from 2006 onwards (ELSTAT, 2011).

#### 4. Conclusion

The built-up area expansion in Greece has been growing rapidly in coastal rural cities and settlements, and, more specifically, on islands such as Santorini, which are particularly touristic. The impact of built-up expansion is a crucial issue on islands, when fragile socio-spatial systems characterized from sensitive natural and cultural environment is considered.

Greece is one of the most touristic countries in Europe and the Mediterranean Sea. Its main tourist resource is its islands, their climate, landscape and their particular cultural heritage. Tourism has been the main driver of the economic growth of most Greek islands and the whole country. The total participation of tourist sector in the Gross Domestic Product (GDP) was about 31% for 2018 (GTC, 2018a). In 2018, Greece had above 30 millions of international tourist arrivals, ranking it the eighth-most touristic country among the European countries (UNWTO, 2018). In 2016, Greece was in the third place of preference by European tourists and in fourth place by non European tourists, among Mediterranean areas, for luxury tourism (GTC, 2018b). Santorini is one of the most popular destinations having above 8.500 tourist arrivals/km<sup>2</sup>, which is the highest density among islands of North and South Aegean Region (Kizos et al., 2017) The NUTS 3 Thira, where Santorini belongs, has 364 hotels of various classes and 1445 rooms for rent, which are the highest numbers for Cyclades (GTC, 2018c). Thus, Santorini is considered as a worldwide destination both from an environmental and a cultural point of view.

It has a distinctive volcanic landscape, but also numerous traditional settlements with quality architecture that is differentiated from the other Cycladic islands. This has led to built-up expansion by building primarily tourist infrastructures and second houses in a excessive mode. The built-up areas are developed by spontaneous self-promoted housing strategies, driven by market dynamics (Kizos et al., 2017). Fragile balance for the local socio-spatial system and excessive tourism development, combined with the loose spatial planning framework, have led to landscape pressure that very often drive outstanding cultural and natural heritage properties to degradation. Understanding the cultural and natural value of the landscape by locals and tourists, avoiding mass tourism development and enhancing spatial planning that concerns: efficient regulations of land uses, settlements management and deterrence of the built-up expansion are considered necessary for the sustainable development of the islands and the maintenance of their unique natural and cultural environment.

It is widely accepted that the phenomenon of built-up expansion does not concern only Greek islands. It concerns almost all coastal and islands areas of north Mediterranean countries driven from the same driving forces tourist development and demand for second houses. Many cases are presented in literature concerning Italy, Spain, Southern France, Turkey, Cyprus, Croatia and Malta trying to shed light on this practice analysis, on presentation of driving forces, on planning efforts to manage these fragile socio-spatial systems. Balearic islands are a mass tourism destination that has led to expansion of urbanization. Traditional settlements in the centres of the area have overlapped by a 'wall' of buildings in the coastal area (Pons & Rullan, 2014) Agapiou et al. (2015) have analysed the spatial patterns of urban sprawl in order to study the impact of urban sprawl in cultural heritage in the city of Paphos, an area in Cyprus that has intense urbanization. Hepcan, Hepcan, Kilicaslan, Ozkan, and Kocan (2013) have studied and analysed the alterations of the landscape of Ismir, where the urban fabric have evolved from rural, low-density model to an urban and high-density area mainly along road network and coastal zone.

Finally, we can conclude from the present study that, although there are many common aspects on built-up expansion practices in coastal zones and on Santorini island (so the exchange of experiences is really useful), 'local' environmental and cultural *particularities* are a pivotal point and should be taken seriously into account, and local societies should be part of the solution. Thus, we cannot accept that there is a 'global' solution for every issue and can be widely adopted. 'We can accept to think globally but act locally'.

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