

# The application of GIS in Tourism Carrying Capacity Assessment for the Island of Rhodes, Greece

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**Abstract.** Tourism industry is fundamental for any national economy and its development is crucial for economic growth and social progress worldwide. In Greece, tourist arrivals averaged 1,070,942 persons per year from 2007 until 2016 while tourism revenues averaged 884 € million per year from 1997 until 2016.

In this paper, “Tourism Carrying Capacity” or TCC is assessed for Rhodes Island, Greece. The TCC indicates the maximum number of people that may visit a destination simultaneously, without degrading the physical, economic and social environment and decreasing visitors’ satisfaction. Rhodes Island is one of the most popular international Greek tourism destinations. The arrivals from January of 2014 until June of 2016 were 1,902,660, while permanent population is 115.000 inhabitants and seasonal exceeds 200,000. The first signs of saturation were noticed after 2000. The calculation of a unique numerical value for the TCC is not representative as a set of sustainable tourism indicators should be used according to the PAP/RAC methodology. So, GIS is used for results presentation since it offers a valuable tool to support decision-making for sustainable tourism planning and development. Spatial analysis will provide a framework of policies. The outcome will be GIS based plans aiming at sustainable tourism development.

**Keywords:** Carrying Capacity Assessment, Island of Rhodes, GIS

## 1. Introduction

The carrying capacity is an evolving tool to monitor the sustainable development (Wei, Huang, Lam, Sha, & Feng, 2015). According to the World Tourism Organization (WTO) Tourism Carrying Capacity (TCC) is defined as the maximum number of people that may visit a tourism destination at the same time, without deteriorating the physical, economic and socio-cultural environment and inducing unacceptable changes in the quality of the visitors’ satisfaction. The calculation of a unique numerical value for TCC is not representative and objective because carrying capacity’s meaning is multidimensional. On the contrary, it is more realistic to expect many different

carrying capacities depending on management goals. A set of carrying capacity indicators could be used for. According to the type of tourist destination, it is possible to focus on different issues. In coastal areas and islands tourist density, the use of beaches and tourist infrastructure, congestion of facilities and others should be considered (Kyriakou, Sourianos & Vagiona, 2011b).

GIS consists a precious assistant tool for stakeholders in order to use it as a support decision system. The use of this tool by development authorities can contribute to investigate the following (Antouskova & Mikulec, 2011), (Jovanovic & Njegus, 2008): Threats and opportunities for development, Visitors’ flow, Facilities availability, Use of and resource, Tourism impacts, Modeling and prediction of crucial factors. Furthermore, GIS may have potential benefits also for tourists by developing interactive maps and web-based services, embedded with videos and photos.

In the sector of sustainable tourism, the role of GIS maybe crucial. GIS can be used for analysis, planning and monitoring of indicators, conflicts leading to the identification of optimum locations for tourism development (Ulmasova, 2011).

## 2. Methodology

Rhodes Island is located in the southeastern Aegean Sea and it is the largest among the Dodecanese islands as it covers 1,401 sq. km (Prokopiou, Tselentis, Mavridoglou & Lagos, 2014), has a coastline of 253 km and 70 km of beaches. The island of Rhodes is one of the most popular international Greek tourist destinations. However, significant signs of saturation have been noticed since 2000 (Kyriakou, Sourianos & Vagiona, 2011a).

The municipality of Rhodes is consisted of 10 municipality units after the implementation of Kallikratis law (Kyriakou, Sourianos & Vagiona, 2011b). Some social and spatial data are presented in Table 1. The population of island was decreased while the city of Rhodes concentrates most of the inhabitants.

At the current study, all municipality units of Rhodes Island were selected in order to investigate some tourism carrying capacity indices for every one of them. The

selection of the indices was based on data availability for every municipality unit. The first index is Population Density (PDI) and it is calculated by the following equation (Lagos & Diakomichalis, 2011):

$$PDI = \frac{Population}{Area} \quad (1)$$

The Seasonal Population Density Index (SPI) was calculated by the same equation using seasonal population instead of permanent population (Lagos & Diakomichalis, 2011).

The Tourism Operation Index (TOI) was calculated from the following equation (Lagos & Diakomichalis, 2011):

$$TOI = \frac{Hotel\ beds + Rooms\ to\ let\ beds}{Population} * 100 \quad (2)$$

Tourism Density Index (TDI) was calculated from the equation (Lagos & Diakomichalis, 2011):

$$TDI = \frac{Hotel\ beds + Rooms\ to\ let\ beds * 100}{Population * Area} \quad (3)$$

Finally, the Beach Impact Index or BII (Lagos & Diakomichalis, 2011):

$$BII = \frac{Seasonal\ Population}{meters\ of\ beaches} \quad (4)$$

The final outputs are presented in TCC maps, in which the vulnerable areas of Rhodes Island and the candidate areas for possible sustainable tourism development are depicted.

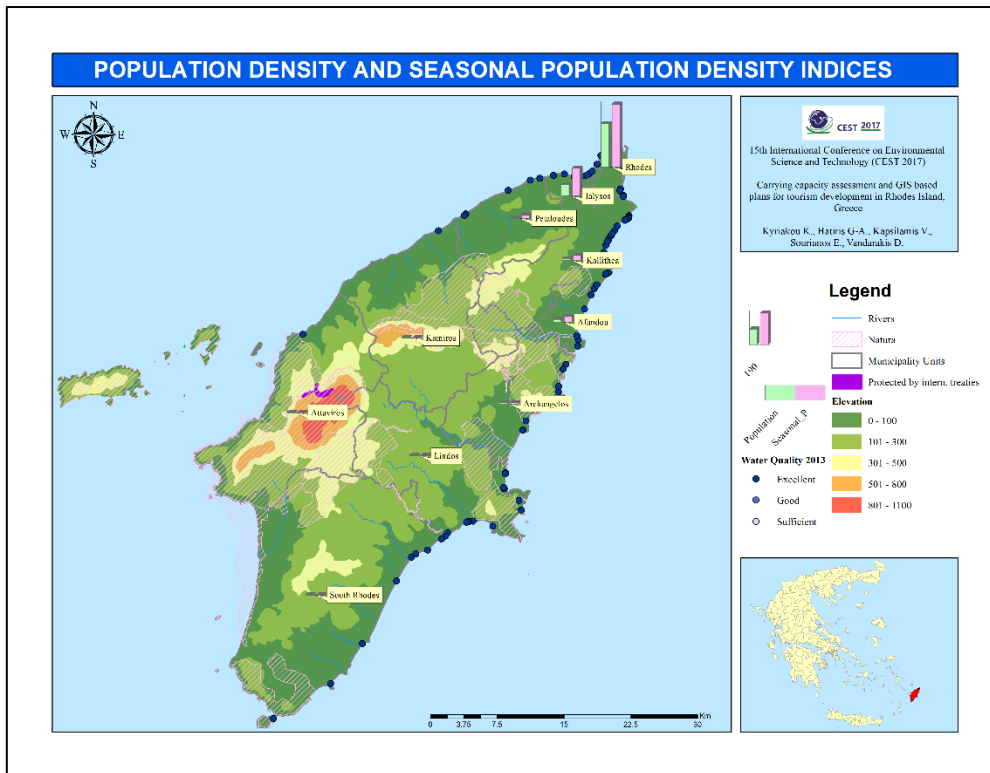
**Table 1.** Social and Spatial Data of the Municipality Units in Rhodes Island

Municipality Unit	Inhabitants (2001)	Inhabitants (2011)	Area (km <sup>2</sup> )	Beach length (km)
<b>Archangelos</b>	7,758	7,758	115,375	6
<b>Attaviros</b>	3,214	2,433	234,350	3
<b>Afandou</b>	6,557	6,911	46,100	12
<b>Ialysos</b>	10,275	11,331	16,700	8
<b>Kallithea</b>	9,979	9,364	109,750	10
<b>Kamiroi</b>	5,315	4,720	211,825	16
<b>Lindos</b>	3,719	3,957	178,900	9
<b>South Rhodes</b>	4,315	3,561	379,050	70
<b>Petaloudes</b>	11,858	14,962	89,150	12
<b>City of Rhodes</b>	54,802	50,636	19,481	5
<b>Total</b>	<b>117,792</b>	<b>115,633</b>	<b>1,400,681</b>	<b>151</b>

### 3. Results and Discussion

As it is presented in Figure 1, the quality of swimming seawaters is excellent for all the beaches of Rhodes Island for 2013 according to National Open Data Catalogue of Greece (geodata.gov.gr, 2015). Regarding the density of permanent population, the PDI's maximum values are pointed out for the cities of Rhodes and Ialysos.

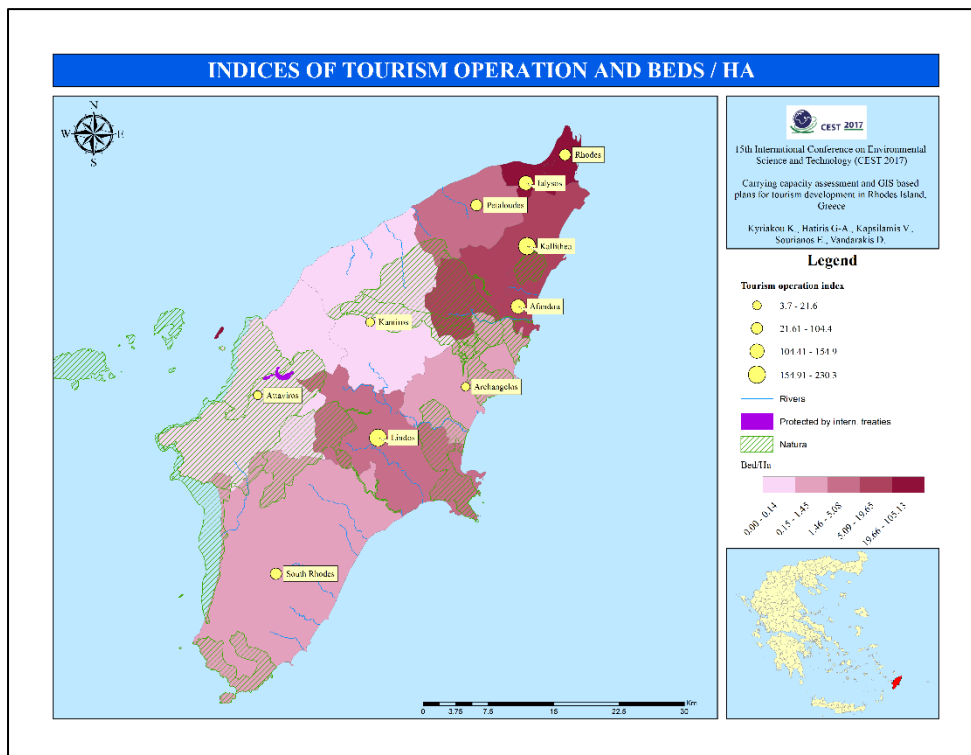
The same pattern is noticed also for the seasonal population density. All other areas of the Island don't vary significantly.



**Figure 1.** Population Density and Seasonal Population Density Indices

At Figure 2, indices of tourism operation and bed per acres are presented. The highest values of tourism operation index occur for Kallithea, Lindos and Ialyssos. The TOI values for these areas exceed 100 indicating critical tourism “over – development” that may be proved harmful.

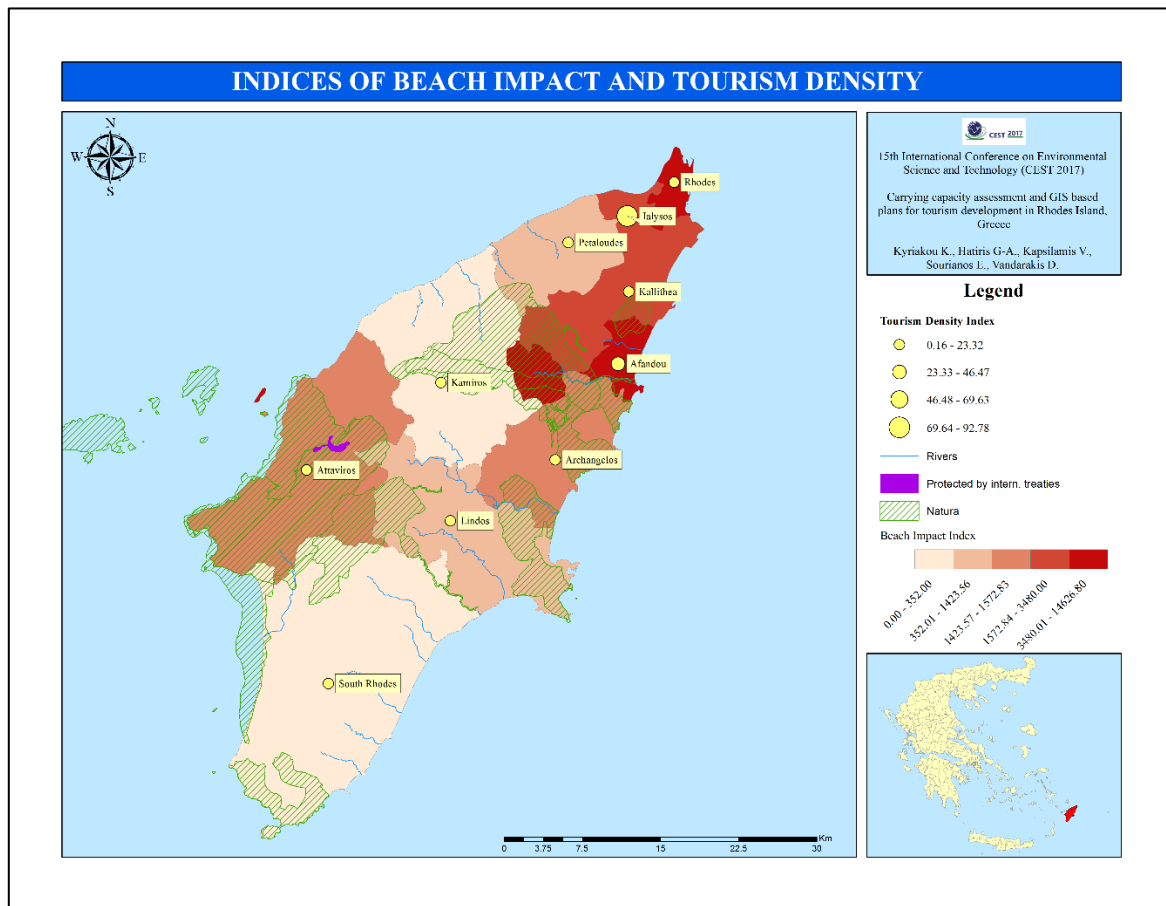
On the contrary, areas such as Attaviros, Archangelos and Kamiros that are not – yet - so attractive for the tourists have the lowest TOI values. So, it is concluded that the capacity of beds varies according to the tourists’ choices.



**Figure 2.** Indices of Tourism Operation and Beds per Acre Indices

Concerning the index of beach impact (BII), the highest value is approximately 1400 and it stands for the municipality units of Rhodes and Afandou (Figure 3). High BII values occur for Kallithea and Ialysos while South Rhodes and Kamiros have the lower BII values.

So, it is concluded that tourists do not opt these beaches. Last but not least, the TDI's highest value is calculated for Ialysos followed by Afandou. Oppositely, the TDI's minimum values are calculated for the areas of Petaloudes and Attavros.



**Figure 3.** Indices of Beach Impact and Tourism Density

#### 4. Conclusion

Rhodes Island's plethora of natural beauties has made it one of the most popular Greek destinations for many years but community's welfare could be endangered by the great numbers of visitors. The seasonal population reaches its peak during the high season, mainly in the city of Rhodes. In the other municipality units, no significant increase of population during the summer is noted except for Ialysos, Kallithea and Afandou. In these cases, the seasonal population density index is almost double from the population density index and this consists a significant evidence of tourism saturation for the specific areas. The quality of swimming water is characterized as excellent for all the beaches, so there is not any evidence for water degradation. The factor of tourism index is also high enough for the same areas reassuring the previous conclusion. The factor of bed per acres indicates the same phenomenon as well as the index of tourism density and beach impact.

Summarizing, after having investigated the above factors, it is concluded that the municipality units of Rhodes city, Afandou and Kallithea are characterized by intense tourism

pressure and can be characterized as saturated. This means that stakeholders should consider measures for controlling tourism development otherwise environmental and social degradation will be an inevitable result. On the contrary, areas such as South Rhodes and Kamiros are potential candidate places for sustainable tourism development promoting alternative forms of tourism (conference, cultural, sports). These kinds of tourism contribute to tourism sustainable development without any negative impact. Last but not least, at the current study, GIS was used as a tool of tourism factors investigation and the contribution was significant. The visualization of the factors assists to an easier and more efficient way of study.

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