PROTOTYPE MODEL OF CARRYING CAPACITY IN TOURISM: THE IMPLEMENTATIONS FOR THE ISLAND OF RHODES

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Abstract

Sustainable tourism can be defined as the tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities. From the above definition it is mention that sustainable development ties together concern for the carrying capacity of natural systems with the social and economic challenges faced by humanity.

Carrying capacity is defined as the maximum number of people that may visit a tourist destination at the same time, without causing destruction to the physical, economic, socio-cultural environment and an unacceptable decrease in the quality of visitors' satisfaction. Today, controlling tourism growth has become a central policy issue for the tourism trade and it is noteworthy that carrying capacity assessment has become an important tool for facilitating planning and developing policy issues for the industry.

In this paper we use present a model for assessment the carrying capacity.It is the first time that we apply the valuation of carrying capacity indicators of Greek islands in a new prototype model, which examines twenty indicators regarding environmental and tourism for the island of Rhodes.

Based on the proposed model first the results from Island of Rhodes are compared with the indicatorsfrom all the Greek islands, the islands in North Aegean Archipelagos and the islands in Dodecanese Archipelagos. At least a comparison between the municipalities of Islands of Rhodes is presented.

Keywords: Sustainable Tourism, Island of Rhodes

Island of Rhodes

Island of Rhodes is an island in Greece, located in the eastern Aegean Sea (Fiq. 1). It is the largest of the Dodecanese Archipelagos islands in terms of both land area and population, with a population of 115,490 is the fourth larger island of Greece. It covers an area of 1,390 sq. km and has 70 km of beaches.

The present municipality Rhodes was formed at the 2011 local government reform by the merger of the following 10 former municipalities that became municipal units (constituent communities in brackets)

Table 1:

municipalities	beaches length	inhabitants	hotel beds	rooms to let beds	total seasonal population	beach impact factor (people/m of beach)
ARHAGELOS	6	7758	1044	629	9437	1,6
ATTAVIROS	3	3214	79	11	3307	1,1
AFANDOU	12	6557	6673	1667	14909	1,2
IALYSOS	8	10275	16606	951	27840	3,5
KALLITHEA	10	9979	16828	4733	31550	3,2
KAMIROS	16	5315	127	168	5626	0,4
LINDOS	9	3719	5516	3568	12812	1,4
SOUTH RHODES	70	4315	3357	359	8101	0,1
PETALOUDES	12	11858	3357	912	16139	1,3
CITY OF RHODES	5	54802	16575	1752	73134	14,6
TOTAL		117007	70162	14750	201919	

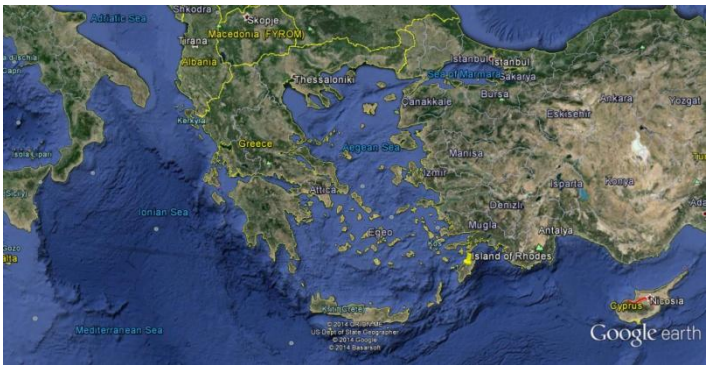

Figure 5. The Island of Rhodes.

Island of Rhodes is one of the major tourist destination in Greece (Tables 1 &2). Tourism supply in Rhodes includes more than 130,000 beds which cover tourism demand with more than 1,5 million international tourist arrivals per year. The Rhodes environment, both natural and man-made as the cultural and historical heritage can sustain a polymorphic tourism product for

Table 2.Arrivals in Rhodes Airport

Year	International		Domestic	
	Arrivals	Departures	Arrivals	Departures
2009	1.321.806	1.327.955	407.960	418.717
2010	1.416.991	1.428.051	364.260	372.306
2011	1.717.477	1.737.505	332.505	343.958
2012	1.593.298	1.606.937	294.635	305.532
2013	1.781.768			

Table 3.Cruise passenger arrivals

Year	Arrivals (Ships)	Arrival (Passenger)
2010	536	565.786
2011	526	588.171
2012	448	472.308
2013	373	409.991

Environmental indicators

The need to develop and apply sustainable development indicators in order to facilitate the assessment and evaluation of impacts from the tourist industry has been

documented in several studies.Since 1980 the idea of sustainable development became was established in policy and academic circles to discuss the combination of development and environment. Now, after 20 years, the environmental indicators can analyse the environmental condition of tourism destinations.Tourism development is adding to already existing pressures in coastal areas. Population densities are increasing in the tourism coastal regions during seasonal peaks.

In this study indicators for waste management, pressure on the coast line, illegal building, shore and marine pollution, use of fresh water resources have been used in order to address the sustainability profile of tourist development in Island of Rhodes.

Methodology

The proposed model based on sixteen variables which take values from 0 to 100. The sixteen variables can be divided into different groups.

The main objective of the first group of variables is the rating of environmental characteristics and infrastructure of the area, the group includes twelve of the sixteen variables (Table 3) and the score for each one of these variables is obtained by using questionnaires or personal observation and qualitative indicators of each area.

Table 4.Environmental and infrastructure variables

Variable name	Description	Measurement
x_1	Urban waste management	0-100
x_2	Legality of buildings	0-100
x_3	Protection of noise nuisance	0-100
x_4	Garbage management	0-100
x_5	Protection of pesticides using	0-100
x_6	Over pumping in sea waters	0-100
x_7	Sufficient quantity of water resources	0-100
x_8	Sufficient quality of drinking	0-100
x_9	Forest clearance	0-100
x_{10}	Forest clearance	0-100
Variable name	Description	Measurement
x_{11}	Conservation of the landscape	0-100
x_{12}	Adequacy of green areas	0-100

The second group consists of 4 variables (Table 4). The score of each region is derived using quantitative data and quantitative indicators. It should be noted that for quantitative indicators 13-15 high score correspond to a large burden on the environment and therefore the variable should have little score in the model, for reversal and mapping the value of the indicator to a 100-grade scale descriptive analysis was used, extreme values was excluded and finally from environmental literature minimum tolerable limits for environmental burden was defined.

Table 5.Environmental and infrastructure variables

Variable name	Description	Measurement
x_{13}	Beds per kilometre of beach	0-100
x_{14}	Beds per square kilometre	0-100
x_{15}	Beds per inhabitants	0-100
x_{16}	Blue flags per kilometre of beach	0-100

From these sixteen variables three individual indexes and the final score are calculated.

Ground Index

Ground Index Y_1 is derived from the following equation:

$$Y_1 = \frac{b_1 \cdot x_1 + b_4 \cdot x_4}{2}$$

wherex_i is input variable to the model and b_i the correspond weight (Table 5).

Table 6.Ground Index

Variable name	Description	Weight
x_1	Urban waste management	1
x_4	Garbage management	1

Water Index

Water Index Y_2 is derived from the following equation:

$$Y_2 = \frac{b_5 \cdot x_5 + b_6 \cdot x_6 + b_7 \cdot x_7 + b_8 \cdot x_8}{10}$$

wherex_i is input variable and b_i the correspond weight according to Table 6.

Table 7.Water Index

Variable name	Description	Weight
x_5	Protection of pesticides using	1
x_6	Over pumping in sea waters	2
x_7	Sufficient quantity of water resources	3
x_8	Sufficient quality of drinking	4

Urban and Nature Index

Urban and Nature Index Y_3 is derived from the following equation:

$$Y_3 = \frac{b_2 \cdot x_2 + b_3 \cdot x_3 + b_9 \cdot x_9 + b_{10} \cdot x_{10} + b_{11} \cdot x_{11} + b_{12} \cdot x_{12}}{15}$$

wherex_i is input variable and b_i the correspond weight according to Table 7.

Table 8 .Urban and Nature Index

Variable name	Description	Weight
x_2	Legality of buildings	3
x_3	Protection of noise nuisance	3
x_9	Protection of fire incidents	2
x_{10}	Forest clearance	2
x_{11}	Conservation of the landscape	3
x_{12}	Adequacy of green areas	2

Total score

Total score Y_{Score} is derived from the following equation:

$$Y_{Score} = \frac{\sum_{i=1}^{12} b_i \cdot x_i + b_{14} \cdot x_{14} + b_{15} \cdot x_{15}}{45}$$

for area without beach, and

$Y_{Score} = \frac{\sum_{i=1}^{16} b_i \cdot x_i}{55}$, otherwise.

Variables x_i and correspond weights b_i are presented at Table 8.

Table 9.Total Score

Variable name	Description	Weight
x_1	Urban waste management	5
x_2	Legality of buildings	3
x_3	Protection of noise nuisance	3
x_4	Garbage management	5
x_5	Protection of pesticides using	1
x_6	Over pumping in sea waters	2
x_7	Sufficient quantity of water resources	3
x_8	Sufficient quality of drinking	4
x_9	Protection of fire incidents	2
x_{10}	Forest clearance	2
x_{11}	Conservation of the landscape	3
x_{12}	Adequacy of green areas	2
x_{13}	Beds per kilometre of beach	5
x_{14}	Beds per square kilometre	5
x_{15}	Beds per inhabitants	5
x_{16}	Blue flags per kilometre of beach	5

Results

Environmental indicators by municipality are presented at Table 9 (a & b). According the results for the urban waste management (indicator x1) Arhagelos, Afandou, Kallithea, Kamiros and NotiaRodosare the municipalities with the major pressures. There is protection to environment against illegal buildings (x2), and the level of protection against the noise (x3). Garbage management (x4) is cohered at all the municipalities with places of sanitary burial. Protection against pesticides using (x5) is implemente in all the municipalities except Ialysos and Lindos. There are no any incidents from over pumping in sea waters (x6). The quantity of water resources is adequate (x7) as also the quality of drinking water (x8). There are no fire incidents except LindosAtaxiros and Petaludes (x9). Incidents of forest clearance (x10) happened in tourist area as Afandoy, Ialysos Kallithea and southern Rhodes.

Table 10a.Environmental Indicators per municipality

Nuts Code	Discription	x1	x2	x3	x4	X5	x6	x7	x8
PO2	Rhodes town	100.0	100.0	50.0	80.0	100,0	100,0	100,0	100,0
PO3	Arhaggelos	0.0	100.0	100.0	80.0	100,0	100,0	100,0	100,0
PO4	Attaxiros	30.0	100.0	100.0	80.0	100,0	100,0	100,0	100,0
PO5	Afandou	0.0	100.0	100.0	80.0	100,0	100,0	100,0	100,0
PO6	Ialysos	65.0	100.0	0.0	80.0	0,0	100,0	100,0	100,0
PO7	Kallithea	20.0	100.0	50.0	80.0	100,0	100,0	100,0	100,0
PO8	Kamiros	20.0	100.0	100.0	80.0	100,0	100,0	100,0	100,0
PO10	Lindos	60.0	100.0	100.0	80.0	0,0	100,0	100,0	100,0
PO11	Sout Rhodes	0.0	100.0	100.0	80.0	100,0	100,0	100,0	100,0
PO12	Petaloudes	60.0	100.0	100.0	80.0	100,0	100,0	100,0	100,0

Table 30b. Environmental Indicators per municipality

Table 10 presents the total score, calculated as the arithmetic mean, and the standard deviation by environmental variable for whole theIsland of Rhodes. High score is presenting to the following variables : legality of buildings, protection of noise nuisance, garbage management, protection of pesticides using, over pumping in sea waters, sufficient quantity of water resources, sufficient quality of drinking and adequacy of green areas, the mean score for these variables are between 80%- 100%.

The management of the urban waste (v1) with 35.50 % indicates that the urban waste management has lack of efficiency, due the many incidences of forest clearance the correspond indicator takes the low score 60.0%.The non-effective protection against fires in forests are serious threat for the environment, so the score to correspond variable, x10, is only 60.0%.

Nuts Code	**Discription**	**x9**	**x10**	**x11**	**x12**	**x13**	**x14**	**x15**	**x16**
PO2	Rhodes town	100.0	100,0	80.0	100.0	678,23	2549,6	850,7	0,31
PO3	Arhaggelos	100.0	100,0	0.0	0.0	186,44	186,4	16,32	0,24
PO4	Attaxiros	0.0	100,0	100.0	100.0	34,35	34,35	0,34	0,02
PO5	Afandou	100.0	0,0	50.0	100.0	1375,4	1375,4	223,77	1,54
PO6	Ialysos	100.0	0,0	50.0	100.0	3368,3	3368,3	1068,9	1,77
PO7	Kallithea	100.0	0,0	50.0	100.0	3911,08	3911,0	231,64	2,48
PO8	Kamiros	0.0	100,0	100.0	100.0	8.0	8.0	1,02	0,04
PO10	Lindos	0.0	100,0	80.0	0.0	1188,3	1188,3	73,73	3,63
PO11	Sout Rhodes	100.0	0,0	80.0	100.0	105,1	105,1	12,90	1,16
PO12	Petaloudes	0.0	0,0	100.0	100.0	258,4	258,4	49,28	0,36

Table 11 .Environmental Indicators for Island of Rhodes. Mean Score and Standard Deviation by Variable

Variable Code	Variable Name	Mean	StDev
X1	Urban waste management	35,5	34,2
X2	Legality of buildings	100	0
X3	Protection of noise nuisance	80	35
X4	Garbage management	80	0
X5	Protection of pesticides using	80	42,2
X6	Over pumping in sea waters	100	0
X7	Sufficient quantity of water resources	100	0
X8	Sufficient quality of drinking	100	0
X9	Protection of fire incidents	60	51,6
X10	Forest clearance	50	52,7
X11	Conservation of the landscape	69	31,8
X12	Adequacy of green areas	80	42,2

Table 12.Infrastructure Indicatorsfor Island of Rhodes

Indicator Code	Indicator Name	Range of values	Mean	StDex
I13	Beds per kilometre of beach	0-100	62,39	39,29
I14	Beds per square kilometre	0-100	36,68	43,15
I15	Beds per inhabitants	0-100	59,52	39,85
I16	Blue flags per kilometre of beach	0-100	11,54	28,03

According Table 12, InfrastructureIndicators I13to I15 forIsland of Rhodes arein low level, this score indicates large burden of the environment. The certifications of quality of the beaches (blue flags) in Greece is not a very developed procedure so the score as Rhodes is quite close to the Greek mean value.

Table 13. Indexes and Total Scorefor Island of Rhodes

	Mean	StDex
Ground Index	57,75	17,1
Water Index	98,00	4,22
Nature Index	75,13	10,35
Total Score	59,97	11,08

The scores of the three indexes and the total score is presented at Table 13. Low score at waste and garbage management leads to low level score to ground index. Water and Nature index are in very good level but the total score is almost 60%.

Table 14. Variable, Indexes mean Scores for Islands in two Archipelagos and all Greek Islands.

	GREEK ISLANDS	**NORTHERN AEGEAN ISLANDS**	**DODECANESE ARCHIPELAGO**
	Mean	Mean	Mean
X1	27,94	26,7	25,71
X2	54,64	66,03	83,87
X3	84,94	82,86	78,06
X4	57,05	45,24	53,55
X5	64,64	65,24	70,97
X6	77,49	70,48	80,97
X7	66,77	55,73	59,68
X8	75,15	70,63	62,90
X9	71,83	81,59	67,10
X10	80,68	73,33	61,29
X11	71,79	73,81	80,65
X12	66,51	61,27	79,35
I13	61,15		
I14	38,04		
I15	58,55		
I16	15,38		
Ground Index	42,37		
Water Index	72,05		
Nature Index	71,48		
Total Score	57,075		

Comparing the variables scores for Island of Rhodes (Table 11), whole Greek Islands, the mean scores of Dodecanese Islands, Island of Rhodes belongs to this archipelago, and the close to Rhodes archipelago of Northern Aegean Islands (Table 14) the following comments can be made:

- Island of Rhodes have a score close or above the mean score of Dodecanese Islands, except the variables Protection of fire incidents, Forest clearance, Conservation of the landscape.
- The scores for Northern Aegean Islands for the most of the variables are worsen than Dodecanese Islands. Again Island of Rhodes have lower evaluation to the variables Protection of fire incidents, Forest clearance, Conservation of the landscape.
- Island of Rhodes presents better assessment of the mean value of whole Greek Islands except, again the three same variables: Protection of fire incidents, Forest clearance, Conservation of the landscape.

The overall assessment of Island of Rhodes is better than the mean value of all Greek Islands except the three variables about fires and forest clearance.

According the final scores of the model the Greek Islands can be classified into three groups.

- For the Islands in the 1st group the main findings are serious environmental problems with lack of infrastructure and problem regarding natural sources. Tourism could be developed after the solutions of these problems
- The Islands in the 2nd group is in the middle between tourism saturation and island that tourism could be developed is sustainable limits. The basic Greek tourism destinations belongs to this group.

- The Islands in the 3rd group don't have massivetourism according the area of the island. As there are some islands with eliminated tourism supply. For The Islandsin this group the opportunity is to design and developsustainable tourism policies.

The Island of Rhodes is included in to the second group with limited difference from the third. If the decisions of the local government must be focus to the problems with the forest and also the future tourist development must be designed based on the principle of sustainability. The proposals to the next paragraph leads to this direction.

Table 6.Classification of Greek Islands according the final scores of the model

ISLAND	SCORE	ISLAND	SCORE	ISLAND	SCORE	ISLAND	SCORE	ISLAND	SCORE
KALYMNOS	26,87	MYKONOS	40,337	SYROS	49,83	CEFALONIA	57,56	FARMAKONISI	69,091
EGINA	28,282	AMORGOS	40,771	KYTHNOS	50,285	SYMI	57,745	ARKI	70
PAROS	30,5	CHALKI	40,825	MATHRAKI	50,604	CHIOS	57,77	NAXOS	70,28
EAAELEFONISI	31,025	SIFNOS	42,023	SAMOS	50,68	DOKOS	58,182	AGIOS EFSTRATIOS	70,363
AGISTRI	31,818	SKIATHOS	43,321	THIRA	51,111	KITHIRA	58,565	AGIOS ACHILIOS	72,302
ANOULIANI	32,229	POROS	43,631	ANAFI	51,147	THIMENA	58,791	INOUSES	76,965
SPETSES	33,758	CORFU	44,09	ERIKOUSA	51,92	THIRASIA	58,805	SALAMINA	78,72
IOS	33,994	PAXI	44,608	ANTIPAXI	52,726	ANDROS	58,87	STROFADES	81,818
MEGISTI	34,669	KOS	45,14	TRIZONIA	53,315	RHODES	59,97	NISI IOANNON	94,888
SCHINOUSA	35,972	ASTYPALAIA	45,292	TILOS	53,562	FOURNI	60,393		
SKOPELOS	36,032	KARPATHOS	46,39	PSARA	53,748	ANTIPAROS	61,264		
ALONISOS	37,032	HYDRA	46,91	AGATHONISI	54,094	KASTOS	61,338		
SIKINOS	37,258	PSERIMOS	47,029	PALIO TRIKERI	54,335	THASOS	61,631		
TELENDOS	37,273	KEA	47,25	GAVDOS	55,493	KASOS	62,804		
MILOS	37,499	IRAKLIA	47,697	OTHONI	55,532	LESVOS	63,94		
LEROS	37,876	DONOUSA	47,83	ITHAKI	55,96	MITILINI	63,94		
KOUFONISI	38,177	KIMOLOS	47,911	LEFKADA	55,97	CRETA	65,81		
FOLEGANDROS	38,909	SKYROS	48,087	MEGANISI	56,177	ANTIKITHIRA	67,971		
PATMOS	39,376	NISIROS	48,969	IKARIA	56,92	LIPSI	68,479		
TINOS	40,2	ZANTE	49,76	KALAMOS	57,33	SERIFOS	68,727		

Proposals

1. The increasing public interest in nature and landscape preservation is, today, considered a major positive factor in the tourist development process. It is true that the growing influx of visitors can exert strong pressures on fragile ecosystems.
2. Tourist development indicators for Rhodes lead us to conclude that the tourism industry should aim at extending the tourist season to include more months, attain occupancy well over 50% for April, October, and probably more visitors with varied interests and expectations of the island, organization for the protection and development of environmentallysensitive areas.
3. Due to the increased tourism demand, it is suggested that all the areas with environmental interests must be protected by a special organizationthat, doesn't exist for the time in Rhodes except the National Park of Samaria. Nature 2000 Network areas are a step in the right direction, but must be supported with effective management schemes.
4. Extension of tourism services for the winter season months by developing and marketing novel tourist activities particular for the island (mountaineering, cultural events, conferences etc).
5. Completion of urban waste treatment plants and network, appropriate garbage handling (urban garbage treatment - olive oil press residuals management), restriction of illegal buildings at cities and coasts, control of hotel's urban waste management systems.
6. The concept of linking visitors with culture, nature and the environment in a harmonious way is not a new idea, but is now viewed on a global scale.
7. Long-term, successful community involvement has preserved many popular rural tourist destinations such as the wine regions of Europe and the United States, many rural communities have acted on instinct, rather than governmentaldirectives or support, and usually with enough individualinvestment to achieve results
8. Alternative tourist development is conceptually related to sustainable development includes approaches to deal with development and economic options, to preventenvironmental damage and to involve public and stakeholders in decision-making processes. It is proposed that serious efforts have to made in the direction of formulating viable policies and developing tools for effective implementation and control, as till now alternative tourism is not yet massivelydeveloped in Rhodes. xiii. Tourism industry of the island must be extended by supporting winter time charter flights.
9. Planning is conceptually related to sustainable development. It includes approaches to deal with development and economic options, to preventenvironmental damage and to involve public and stakeholders in decision-making processes,
10. Completion of the treatment of urban waste and garbage and
11. Deal with the problem of illegal buildings, noise nuisance from the municipalities. In some of them the problem seems very serious.

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