LANDSCAPE INDICATORS: A PROMISING TOOL FOR THE ANALYSIS OF TOURIST LANDSCAPE STRUCTURE

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Abstract

The coastal landscape of the Aegean islands has long been established as one of the most famous tourist attractions of the Mediterranean for its multivariate natural and cultural profile. The uncontrolled growth of the tourism industry in many Greek coastal destinations has caused enormous pressures and significant alterations to their natural and cultural landscape.

This paper analyzes the spatial distribution of tourist elements in a coastal landscape, with the aid of a set of landscape indicators, the result of a methodological framework for the description, appraisal and assessment of coastal tourist landscapes and future impacts from tourism industry.

The case study of Kefalos, Kos examines chronological changes upon the density of human-made or built elements, the degree of transportation transportation network connectivity, the spatial organization of tourist land uses and alterations upon the views towards the tourist attraction, with the aid of Remote Sensing and GIS techniques.

The methodology is based on a system of landscape metrics developed within a GIS framework, in order to simplify and quantify current ongoing change and to provide simple measures standardized for time and place. Landscape metrics were used on orthorectified aerial photographs to quantify changes on spatial arrangement of patches (such as density, connectivity, distribution, etc.).

The application of such analytical tools represents a novel methodological approach to Greek landscapes of tourism. It demonstrates the value of landscape indicators in a quantitative landscape assessment for the understanding of Greek tourist landscape formation and future trends of tourism development.

Keywords: tourist landscape, coastal landscape, landscape indicators, landscape metrics, geographic information systems (GIS), Greece.

1. Introduction

The uncontrolled growth of the tourism industry along Greece's coastline has caused enormous pressures and significant alterations to its natural and cultural landscape. Greek islands are especially prone to tourism pressures and environmental, economic, social and aesthetic impacts. As a result, the analysis of tourism impacts upon the coastal landscape, and more specifically the alterations of its structure, emerges as a very promising field in the interdisciplinary area of tourism and landscape research.

In the area of landscape assessment, a large number of quantitative methodological tools, more specifically landscape metrics, have been developed and applied to the field of landscape ecology (McGarigal and Marks, 1994). On the other hand, in tourism research, indicators so far used referred to socio-economic aspects of tourism. Besides these, international bibliography in the interdisciplinary field of landscape science, as well as of tourism studies, indicates an absence of quantitative methods (indicators) for the assessment of the state of the spatial structure of a tourist landscape.

The objectives of this study were:

(a) Description of long-term landscape change, in order to view the various eras of landscape use as a whole (part of a continuum) and

(b)Interpretation of landscape change resulting from impacts of tourism, with the help of a quantitative approach.

Therefore, the central research problem of this paper was the development of specific landscape indicators and their appropriate metrics (Herold *et al*., 2005) for the spatial analysis of the tourist landscape. The emphasis is on its morphological appearance, since landscape morphology constitutes a product of variable natural and human impacts, thus becoming a mirror of the human imprint upon the land. This imprint achieves its most apparent, direct and potent form in the morphology of the landscape, itself by definition *visually* articulated (Johnston, 2000; Jackson, 1994).

2. Methodology

2.1 The study area

The study presented here was carried out in a landscape which is in the process of gradually being transformed into a tourist one (Jafari, 2003), while still maintaining much of its typical rural character, in combination with many of the defining factors of tourist attraction (beach, antiquities, night life, infrastructure etc.)

The study area Kefalos bay, is situated in the southern part of Kos Island. Kos is located in the south-eastern Aegean Sea, opposite to the coast of Asia Minor, at the entrance of Halicarnassus gulf. (Markoglou 2004). Until the early '70s, Kefalos was an agricultural region with relatively intensive agriculture and indigenous species of reeds and sedges in the river plains. With the establishment of Club Mediterranee in 1980, mass tourism gradually gained a stronghold, as the seaside was being occupied by bungalows, apartments, 'tavernas' and cafeterias. In 1990, tourism development slowly extended towards the interior of the valley. Land use change in the form of urbanization and the abandonment of agriculture seem to be the main transformation factors for the area and its landscape. Since 2002, there has been an increase of tourist accommodation units along the main road network, a gradual loss of landscape diversity, a replacement of natural elements by touristic ones and an alteration or damage of local natural or cultural attractions responsible for the attractiveness of the area.

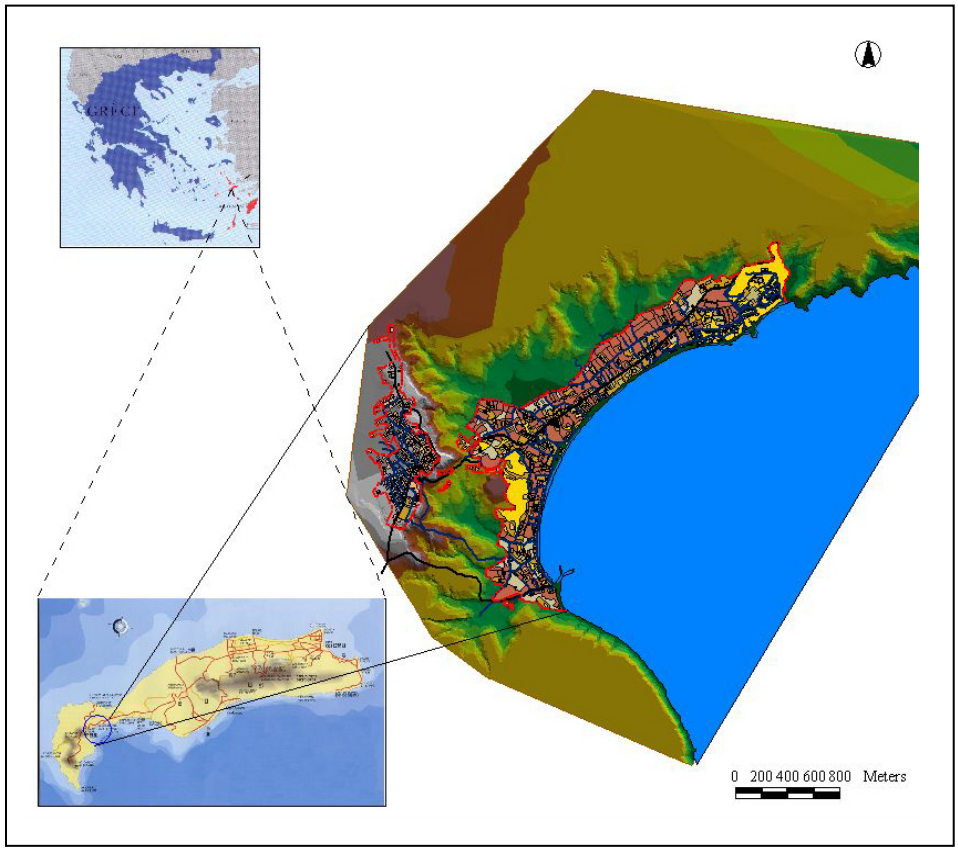

Figure 1.Location of the study area

2.2. Data processing

Black and white aerial photographs of a scale 1:30000 were scanned at a resolution of 1000 dpi for 1981, 1995 and 2001. The 80's was a transformative decade for the study area; thus, capturing the state of the landscape at the beginning of this decade was considered very important. The second date (1995) was chosen as indicative of the type of tourism development and landscape changes that became very noticeable during that period. The final date of 2002 marks the end of the fieldwork of our research period, that aimed to capture as clearly as possible the tourist transformation of this coastal landscape.

In order to create the Digital Elevation Model (DEM) of the area, topographic maps (1:5000) were scanned and their contour lines digitized at a 20m interval. All GIS layers were georeferenced to the Greek

national grid EGSA ’87. Aerial photographs were orthorectified, using the DEM created above, topographic maps and the corresponding camera calibration files. The georeferenced maps and the orthorectified aerial photographs of the three time periods (1981, 1995 and 2002) allowed image overlay and easy comparison. Land uses and transportation networks were then digitized, in order to estimate and visualise changes among the three temporal layers. Viewshed maps were created with the help of the DEM. The latter maps cover the area visible from observation points presented by the nodes of the road networks in the DEM.

2.3 Data analysis

The proposed indicators were formed on the basis of the most crucial impacts on the morphology of the tourist landscape, such as urbanization, fragmentation of space, land use multifunctionality, road network extension and deterioration of views. The above set of indicators belongs to a methodological framework for the analysis of tourist landscape (Goltsiou, 2007). Through a combined application of landscape metrics, remote sensing and landscape character assessment methods, the latter framework aims at the measurement of attributes of the state of a landscape and, more specifically, composition and configuration of tourist landscape elements. Of these, the most significant indicators (Goltsiou, 2007), also selected for this analysis were: a) percentages of land uses, b) density of human-made or built elements, c) spatial distribution of built elements in the tourist landscape, d) transportation network development and connectivity and e) degree of visibility towards the seashore. Their calculation is based on existing landscape metrics found in landscape ecology, geography of networks and visibility analysis.

Percentages of land uses are one of the most important landscape indicators for the assessment of landscape (spatial) structure, since these illustrate the transformation of the tourist landscape, representing the general tendency of change and the geographical distribution of these land uses (Patil et al. in Gallego et al., 2000). In order to calculate the above indicator, thematic maps were produced from topographic ones. Land cover metrics were derived from maps of land uses for the time periods 1981, 1995 and 2002.

The density of human-made or built elements is an important indicator for the estimation of the urbanization of the tourist landscape. In the current study, the most appropriate metric for the quantification of building density is patch density (PD).

$$PD=n_i /A\ (10{,}000)\ (100) \qquad (1)$$

n_i =number of patches of patch type (class) or landscape I, A=total landscape area (m^2)

The spatial distribution of built elements in a tourist landscape is also a critical measurement of landscape urbanization, degree and type of tourist development, and scale and maintenance of local identity (Herold et al., 2005). With the aid of nearest neighbour index (N), it was possible to analyse element patterns (clustered, evenly spaced, random) and, therefore, develop a clearer idea of landscape structure.

$$N= h_{ij} \qquad (2)$$

h_{ij} =distance (m) from patch ij to nearest neighboring patch of the same type (class), based on patch edge-to-edge distance, computed from cell center to cell center.

The analysis and derivation of the above index was based on kernel density estimation method (for details see O’Sullivan and Urwin, 2003). A normal kernel estimator was chosen with a bandwidth of 30m.

The transportation network development and connectivity was another indicator of the development of the area and its transformation through time (Bradford and Kent 1977). The most commonly utilized indices to describe the evolution of transport networks are the alpha (α) and gamma (γ) indices. The alpha (α) index is the ratio: *existing circular connections/max number of circular connections*, and presents the way (circular or radical) a network is developed and varies between 0 and 1 (maximum connectivity).

$$\alpha= u/(2v-5) \qquad (3)$$

e=number of edges, ν=number of nodes, u=e-ν+s, s=number of unconnected graphs

The (γ) index is the ratio: *existing links/max number of links* and presents the percentage of connectivity for a given network.

$$\gamma=e/v \qquad (4)$$

The degree of visibility towards the landscape of tourist interest refers to the visibility ratings comprising a measure of how many times the seashore is seen from all the possible viewing points-nodes of the transport network system. For index calculation, viewsheds for the years 1981, 1995 and 2002 were composed. Each viewshed was computed from the nodes of the primary and secondary road network, because these were considered the most strategic points of circulation, where tourists have easy visual access towards various directions (Fairweather et al., 2001).

3. Results and discussion

3.1. Percentage of land uses

According to the results, shown in Table 1, in 1981 arable land occupied the larger part of the landscape, in contrast to 1995 and 2002, when arable land and farmland appear diminished, while tourist accommodations and settlements increased in size. On the other hand, planting structures remained unchanged. Olive groves and residual spaces, demonstrated a significant increase in size. In conclusion, urbanization and abandonment of agricultural land describe the situation of the landscape until 1995 (Figure 2). However, until today, all such changes in Kefalos occur at a slow pace and their spatial patterns may still be reversible.

The above indicator helps us understand the components of tourism development, and more specifically those of a tourist landscape, and follow the general tendency of change and the geographical distribution of these land uses.The composition of land cover types is crucial since it affects the orientation and movement of the tourist in the landscape.

Table 1.Percentage of land uses

LAND USES	YEAR 1981	YEAR 1995	YEAR 2002
Arable land	67,23%	36,58%	34,77%
Clubs-restaurants	-	1,05%	1,11%
Planting structure	19,95%	19,35%	19,09%
Tourist accommodations	1,83%	6,05%	6,21%
Settlement	4,50%	8,85%	9,08%
Olive groves	2,80%	8,69%	7,77%
Commercial uses	-	0,42%	0,42%
Residual spaces	3,65%	19,00%	21,57%

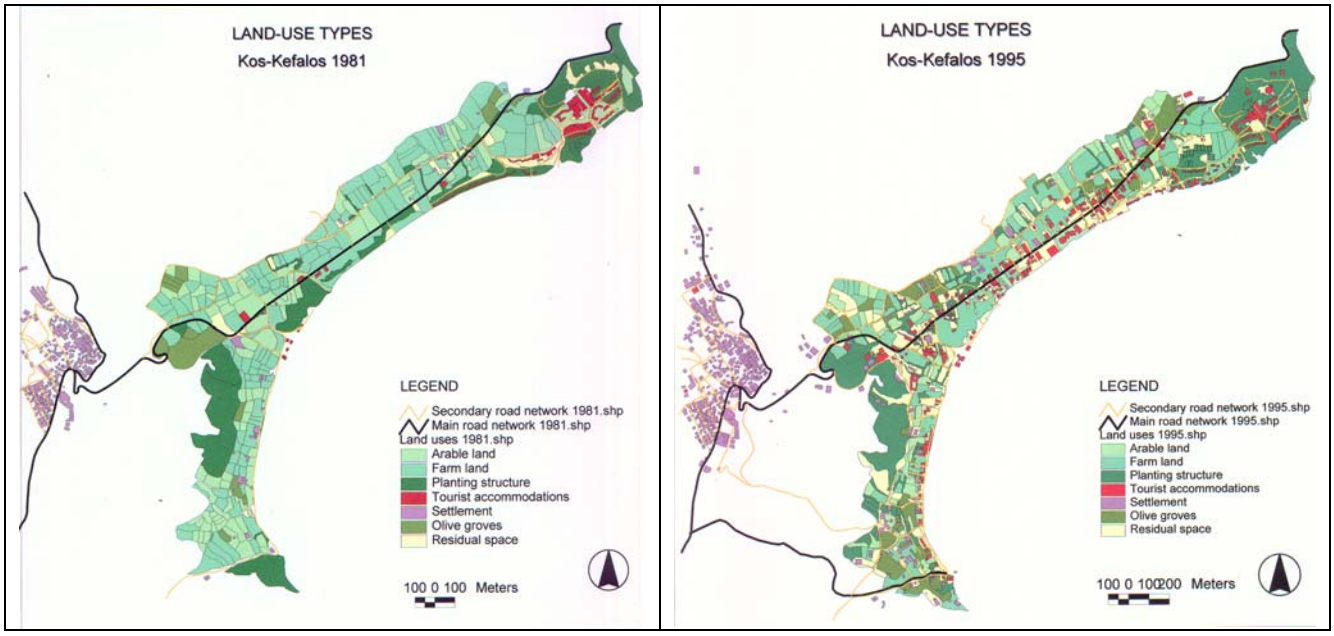

Figure 2. Temporal layer maps of the distribution of land use categories in the district of Kefalos for the years 1981 and 1995.

3.2. Density of human-made or built elements

The land uses with the highest values in the patch density index (PD) for the time period 1981-2002 were tourist accommodations and settlement (Table 2). Residual land, cultivated and arable land correspond with the middle values of density, while olive groves, commercial uses and bars-restaurants present the lowest values of density.

Table 2. Patch density results for the various land uses

LAND USES	1981	1995	2002
Planting structure	14.47	48.38	45.37
Residual spaces	10.85	56.93	53.88
Tourist accommodations	32.55	125.24	129.73
Arable land	5.07	39.14	36.15
Olive groves	5.07	20.64	19.14
Settlement	57.88	183.59	207.01
Clubs-restaurants	-	27.75	29.78
Commercial uses	-	15.66	15.66

The density of human made or built elements proved to be an important indicator of the urbanization of the tourist landscape. This is not only a structural index but also a functional one. It describes the density of urbanization along the coastline and the degree of interruption of continuity in the tourist landscape. This index, is another measurement of size and spatial heterogeneity in the tourist landscape (Mc Garigal and Marks, 1995).

3.3. Spatial distribution of built elements in the tourist landscape

Results of the analysis of the nearest neighbour index (N) (Table 3) for each year (1981, 1995 and 2002) presented a chronological tendency for tourist land uses (tourist accommodation and clubs-restaurants) of less than 1. This is an evidence of clustering of tourist land uses. Results of the nearest neighbour index (N) for built land uses tended towards 1, which is an evidence of random distribution.

Table 3. Nearest neighbour index (N) results

Nearest neighbor index (N)	YEAR 1981	YEAR 1995	YEAR 2002
Tourist accommodation	0.45	0.38	0.38
Clubs-restaurants (B)	-	0.31	0.32
Built land uses (Γ)	0.35	0.47	0.49
Tourist land uses	0.45	0.39	0.39

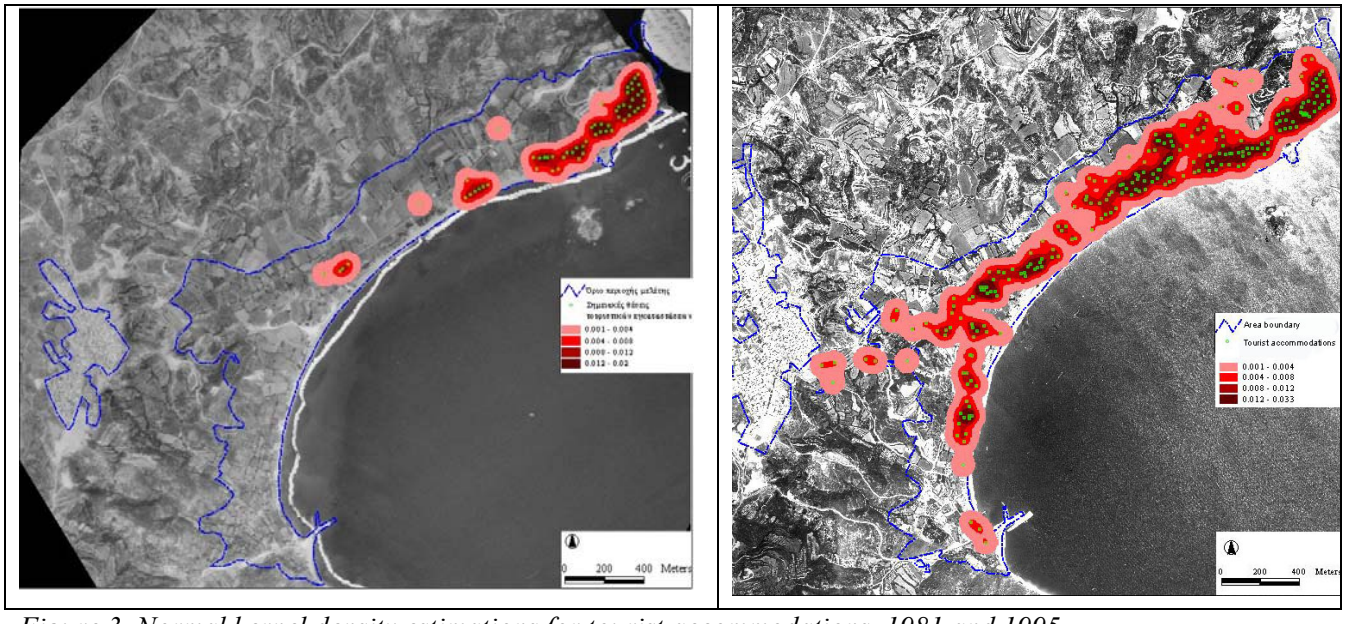

Figure 3. Normal kernel density estimations for tourist accommodations, 1981 and 1995.

Kernel density estimations produced for spatial distributions of tourist accommodations showed that the intensity of points- hotels- in 1981 was higher in the area of Club Med (Figure 3). Areas of higher

density are shown in darker tones and vise-versa (those with lower densities are shown in lighter tones). In 1995, kernel density surfaces expanded all along the seafront up to the old port. Tourist accommodations presented higher densities towards the area of Club Med, in comparison to clubs and restaurants which showed higher densities in the area of the old port. In 2002, there was no noticeable difference in accommodation infrastructure densities since1995.

The above results highlight the value of this indicator in demonstrating the spatial evolution of a tourist landscape and the relationship of landscape structure with the socioeconomic functions of the area. According to Pearce (1995:147), concentrations of tourism development indicate tourist attractions while the evolution of land uses and the high diversity of tourist uses, point to the fact that these processes are a product of economical forces. The random distribution of buildings illustrates the unsuccessful planning of tourist infrastructure uses and the degree of organisation of structures catering to tourism (Herold *et al.,* 2005).

3.4. Transportation network development and connectivity

The degree and manner of connectivity in the transport network system of Kefalos, as presented in table 4, is analyzed with the aid of α and γ indices. γ index results show that the transportation network presents a low degree of connectivity for the time period under study (1981-2002). α index results demonstrate middle-range circular network connections, thus indicating that the network still remains at the first stages of its development.

Table 4. α and γ indices in 1981,1995,2002

YEARS	Number of nodes	Number of links	Index α	Index γ
1981	70	87	0,07	0,20
1995	145	170	0,09	0,39
2002	145	170	0,09	0,39

The indices above, as well as the following topological maps (Figure 4), aid us in understanding the direction of transportation network system development, which, in this case, is not circular but radial. The following maps depict the gradual development of the road network system, in the time period 1981-1995.

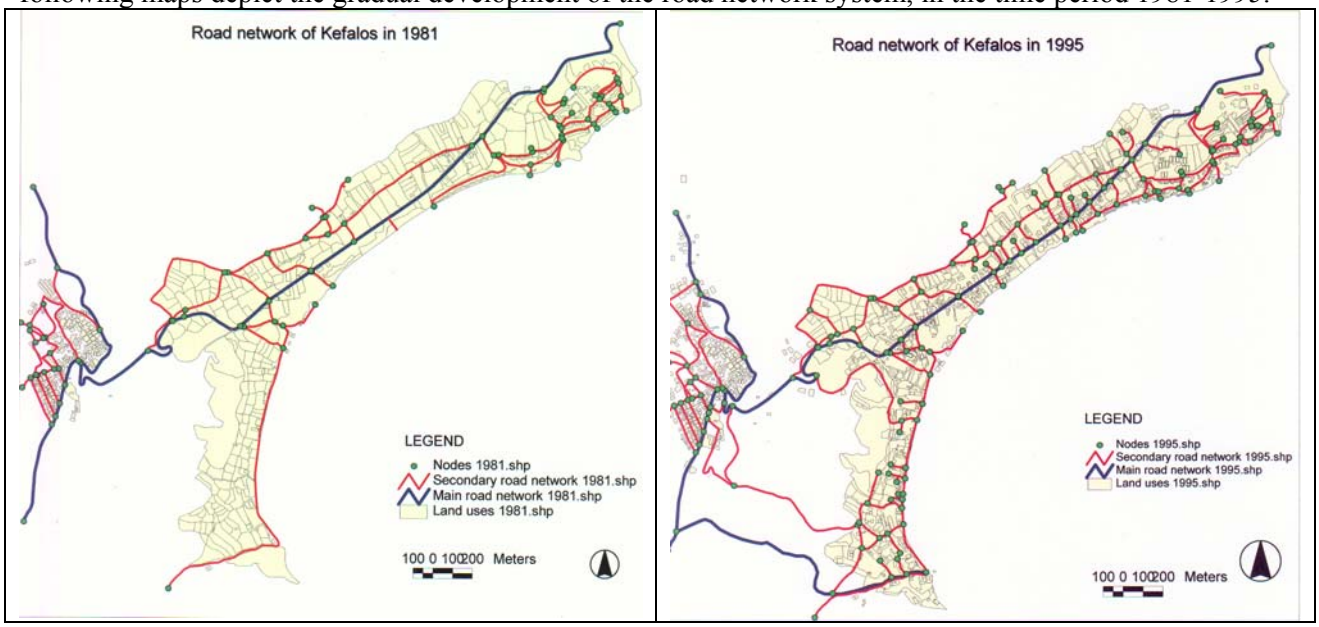

Figure 4. Network systems in 1981, 1995.

3.5. Degree of visibility towards the landscape of tourist interest

The most interesting results of visibility index analysis were produced from viewpoints (nodes) along the main transport network system, parallel to the coast (Figure 5, 6), and other ones along the secondary network system (Figure 7, 8). In 1981, building density is low and does not affect visibility towards the seashore. In contrast, in 1995 and 2002, visibility is strongly affected by building characteristics, density and position of all sorts of built elements along the coast. The obstruction of open views towards the seashore is crucial to the tourist landscape of Kefalos, since it may disorientate the tourist and create false impressions of landscape identity and sense of place.

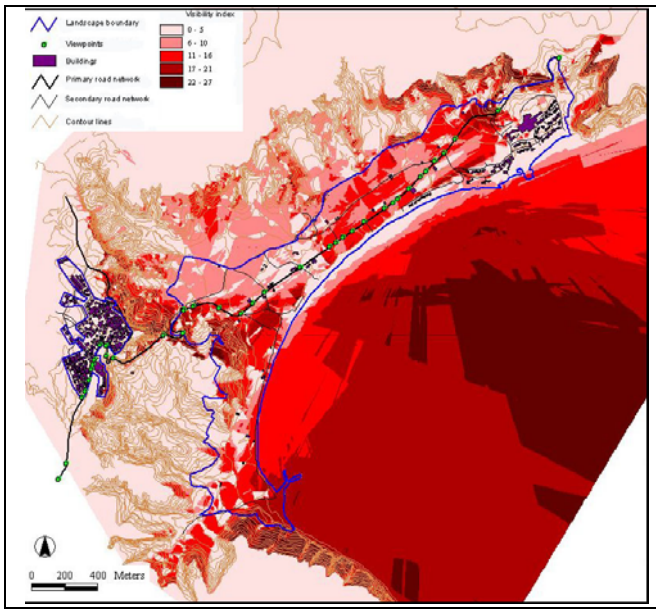

Figure 5. Viewsheds from the main network system in 1981

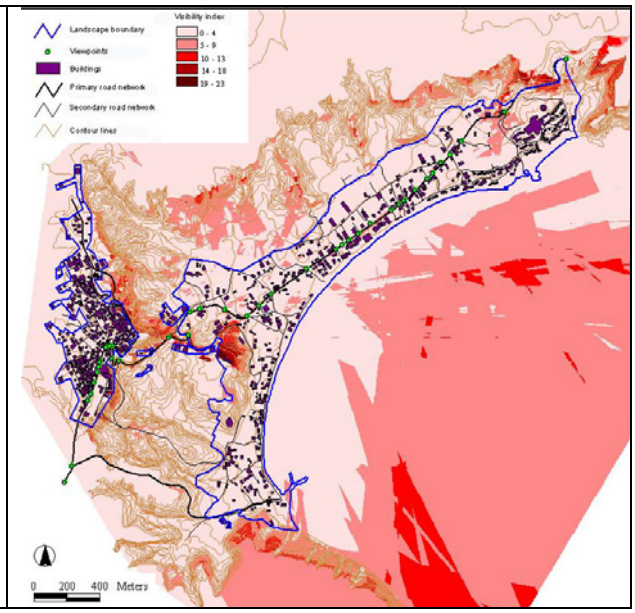

Figure 6. Viewsheds from the main network system in 1995

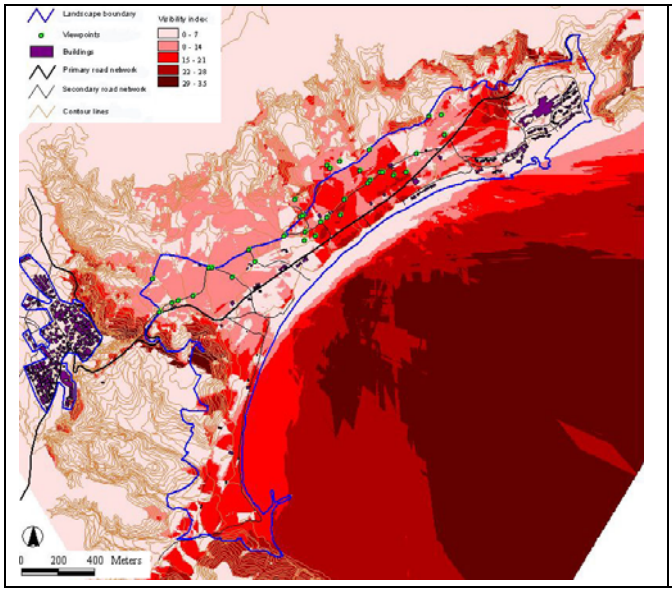

Figure 7. Viewsheds from the secondary network system in 1981

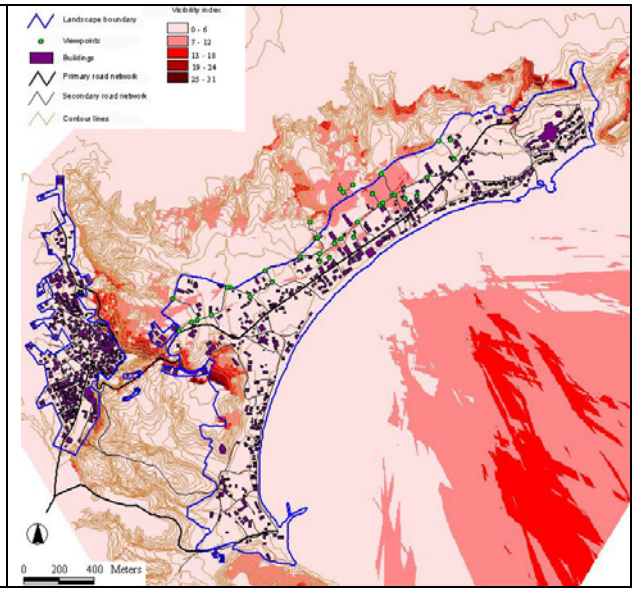

Figure 8. Viewsheds from the secondary network system in 1995

In conclusion, visibility analysis with the aid of visibility indices constitutes an objective analytical method in lieu of conventional field survey affected by the subjectivity of the observer. One of the advantages of visibility indices and viewsheds is that they may substitute field survey in areas that are not accessible to the observer (Bahaire *et al.,* 1999).

4. Conclusions

On the basis of all previously-presented results, the described landscape indicators proved particularly valuable in understanding the spatial evolution of a tourist landscape, as well as predicting future trends of tourism development of the specific area. Although tourism development has already been much studied and many attempts of interpretation have been made through models such as the evolutionary models of Butler, Miossec, Opperman and Gromsen, assessment and analytical interpretation has remained largely subjective. Tourist landscape assessment with the aid of indicators, such as was attempted above, introduces objectivity, reliability and replicability to this analysis.

The changing structure of the tourist landscape of Kefalos, as revealed through the indices and thematic maps presented above, presents an area at a stage of medium tourism development, with increased urbanization of a linear type along the seashore, abandonment of agricultural land, disperse building

distribution, concentrated tourism land uses and a simple network system gradually enriched by secondary interconnections of nodes. All these findings support Pearce's claim (1995) that the higher the tourism development, the greater the degree of connectivity and tourism land use percentages. It is worth mentioning that tourism land uses with high values of density tend towards a regular pattern of distribution, while settlement with also high values of density tends towards the random pattern of dispersion. This spatial distribution of land use patterns in the tourist coastal landscape of Kefalos contributes to a decreased visibility of the tourist attraction, and landscape fragmentation which might lead to a future loss of identity (Antrop, 2004). Moreover, according to Pearce (1995:147), spatial distribution of tourist uses affects tourism development and, therefore, is strongly connected with land value. Therefore, distance of tourism infrastructures from the seashore results in a decrease of land values and higher building density.

The structure of the tourist landscape of Kefalos, as described through the above indices and categorical maps, reflects its sociological, economic and historical changes (Hehl-Lange, 2001), as well as political decisions and tourism impacts upon the coastal landscape for the twenty-year period under study. Therefore, landscape assessment with the aid of the above set of indicators offers better understanding of tourist behavior, local behavior and political decisions, in order to direct a more balanced flow of tourists towards landscape attractions, and thus strengthen geographically remote areas. This set of indicators may be a subset of a larger group of indicators describing structural and functional changes in tourist landscapes. They may be applicable to cultural landscape change at any location; employed as a tool in the description and analysis of landscape change; and valuable in extracting information difficult to detect on maps or field surveys. However, landscape indicators are not a panacea. Rather, in combination with other types of data from both the natural and the social sciences, they prove to be a basic requisite for constructing a realistic simulation of on-going and future local-level tourist landscape development.

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