IDENTIFYING CHANGES IN TOURIST COASTAL LANDSCAPES

USING LANDSCAPE METRICS

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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 the form of large hotel units, in many Greek tourist destinations, has caused enormous pressures and significant alterations to the natural and cultural landscape of Greek coasts. Many rural landscapes on the islands of the Aegean are in the process of decline and are slowly transformed to tourist attractions.*

This paper examines landscape change and evolution from a rural coastal landscape to a tourist one. The study focuses on the area of Kefalos at the south part of the island of Kos and presents the chronological changes upon the morphological and functional elements of the tourist landscape 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 of patch characteristics, such as size, shape and edges and of spatial arrangement of patches (such as fragmentation, connectivity, diversity, density metrics, isolation /proximity and contrast metrics) over time and space. The application of such analytical/ representational tools represents a novel methodological approach to the Greek landscapes of tourism, by demonstrating the value of landscape metrics in a quantitative landscape assessment for the Greek tourist landscapes.

Keywords: rural landscape, tourist landscape, coastal landscape, landscape metrics, geographic information system (GIS), Greece.

1. INTRODUCTION

The development of tourist activities along Greece's coastline, has gradually led to extensive areas of land being entirely devoted to mass tourism, in response to international demand for "sun-sea-sand" holidays. The Greek islands and especially the Aegean islands are prone to tourism pressures and environmental, economical, social and aesthetic impacts. Tourism industry tends to overwhelm local economies and agriculture sector declines. As a result, agricultural land is abandoned, giving its place to tourist infrastructures. Rural landscapes face the phenomenon of desertification, and tourism globalization (Terkenli, Theano S. 2000).

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Different models for assessing the change on landscape patterns proved to be a practical and efficient approach to understanding human impacts in many landscapes (Bender et al 2005, Lausch and Herzog 2002; Van Eetvelde and Antrop 2004; Koukoulas and Blackburn 2004) . In this research we tend to examine landscape metrics such as the complexity of the patch shape, and the development of the network system(Cook Edward A.2002), as the medium to assess changes in the composition of the rural landscape and metamorphosis into a tourist one . These metrics selected here have been tested in other disciplines but not in tourist landscape research.

The study presented here was carried out in a landscape which is gradually transforming into a tourist one but still maintains its typical rural character. This methodology will serve the goals of:
(a) Description of long-term landscape change in order to view the various eras of landscape use as a whole;
(b)Interpretation of landscape change resulting from tourist influences with the help of a quantitative approach;

2. STUDY AREA

The study area is Kefalos bay which is situated at the southern part of the Kos Island. Kos is located at the south eastern Aegean sea opposite the Minor Asia coast at the entrance of Halicarnassus gulf. Kefalos developed and maintained its culture over time, assimilating the various influences of tourism and preserving its Greek character (Markoglou A. 2004). Today the landscape of Kefalos consists of flat fertile valleys along the gulf, surrounded by hills and mountainous promontories towards the South West.

Until the early ‘70s, Kefalos was an agricultural region with relatively intensive agriculture and grasslands in the river plains. The Hora of Kefalos was situated where the village is nowadays and the sandy beaches were untouched by tourism, covered by Junipers and Peruvian mastic trees. At this time large-scale mining started and lasted till the ‘80s, when tourism became the basic economic resource of the area. During the period of 1970-1980 the inhabitants of Kefalos were basically occupied in the merchant navy and earned enough money to buy land along the coast and start their own tourist enterprises. This continues to-date: most tourist accommodation units are small and family scale. With the introduction of the Club Mediterranee in 1980, mass tourism has gradually appeared and the seaside was occupied by bungalows, apartments, taverns and cafeterias. Tourist development slowly extended towards the interior of the valley. Nowadays hotel units appear all along the main road and tend to reach the Hora. The transportation system was basically developed after 90’s. Although, the place still maintains a great degree of its typical rural character, it is gradually transforming into a tourist landscape. Urbanization of the land and abandonment of the agricultural fields seem to be main transformation factors for the area.

3. DATA

The analysis of landscape change from a rural landscape to a tourist one was based on a variety of sources, including topographic and historical maps, aerial photographs, land registers with geodetic survey maps and land plot records, as well as various statistical and archival data. Aerial photographs from four different periods (1960,1981,1995,2002) together with topographic maps, were acquired from the Hellenic Army Geographical Service. From these data sources, information regarding the relief, land uses and the transportation network of the site were collected using GIS techniques and photo interpretation.

4.METHODOLOGY

4.1 GIS processing and landscape feature mapping

Black and white aerial photographs with scale 1/30000 were scanned at a resolution of 1000 dpi for 1981 and 1995. The 80's have been an important decade for the study area and capturing the state of the landscape at the beginning of this decade was considered very important. The second date was chosen as the important period for tourism development and landscape changes were very noticeable.

Topographic maps (1:5000) were scanned and their contour lines were digitized at 20m interval, in order to create the Digital Elevation Model (DEM) of the area. All GIS layers were georeferenced to the national grid EGSA '87. Aerial photographs were orthorectified using the DEM created above, topographic maps and the related camera calibration files. The georeferenced maps and the orthorectified aerial photographs of the two time periods (1981, 1995) allowed image overlay and easy comparison. Land uses and transportation networks were digitized in order to estimate and visualise changes between the two temporal layers.

4.2 Landscape metrics

The selection of metrics proposed in this paper, rests on the assumptions that a) the complexity in landscape elements shapes is indicative of the degree that man has intervened in nature, b) the more tourist developed an area the bigger the degree of network's connectivity and the bigger the percentage of landscape occupied by tourist infrastructures. The percent of landscape of farm land, consolidated urban fridge, planting structure, arable land, tourist activities, and hotels, are also indicative of spatial heterogeneity of land uses and their transformation during the crucial period of tourism development in 1981-1995.

With regard to shape complexity two metrics were applied and their results were evaluated. The first one was the perimeter-to-area ratio which is particularly useful in discriminating elongated landscape elements. The second one based on Patton's (1975) diversity or edge index measures the degree of remaining "naturalness" and therefore is particularly useful to show the degree of substitution of natural to man-made structures. [1] Their applicability to investigate changes from a rural landscape to a touristic one was evaluated in this paper.

Transportation network development and connectivity was the third index of the development of the area and its transformation through time (Bradford M. G. and W. A. Kent 1977). The most common indices to describe the evolution of transport networks[2] 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. The (γ) index is the ratio: *existing links/max number of links* and presents the percentage of connectivity for a given network.

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[1] Patton's diversity or edge index=$\frac{\text{land use perimeter}}{2\sqrt{(\text{Land use area} \times \pi)}}$

[1]Patton's diversity or edge index describes the relationship between patch area and boundary length and provides useful information about the potential edge effect that may be present in a specific patch.

[2] A simplified form of a network system called graph consists of vertices (or nodes) and edges (link or arc).

5. RESULTS AND DISCUSSION

The data analysis was performed using Arc View GIS (v. 3.2) software and conclude to the following results for each one of the three proposed landscape metrics.

1. Land use type and Percentage of the total area
Maps of Land uses for the time periods 1981 and 1995 are presented in Fig. 1.

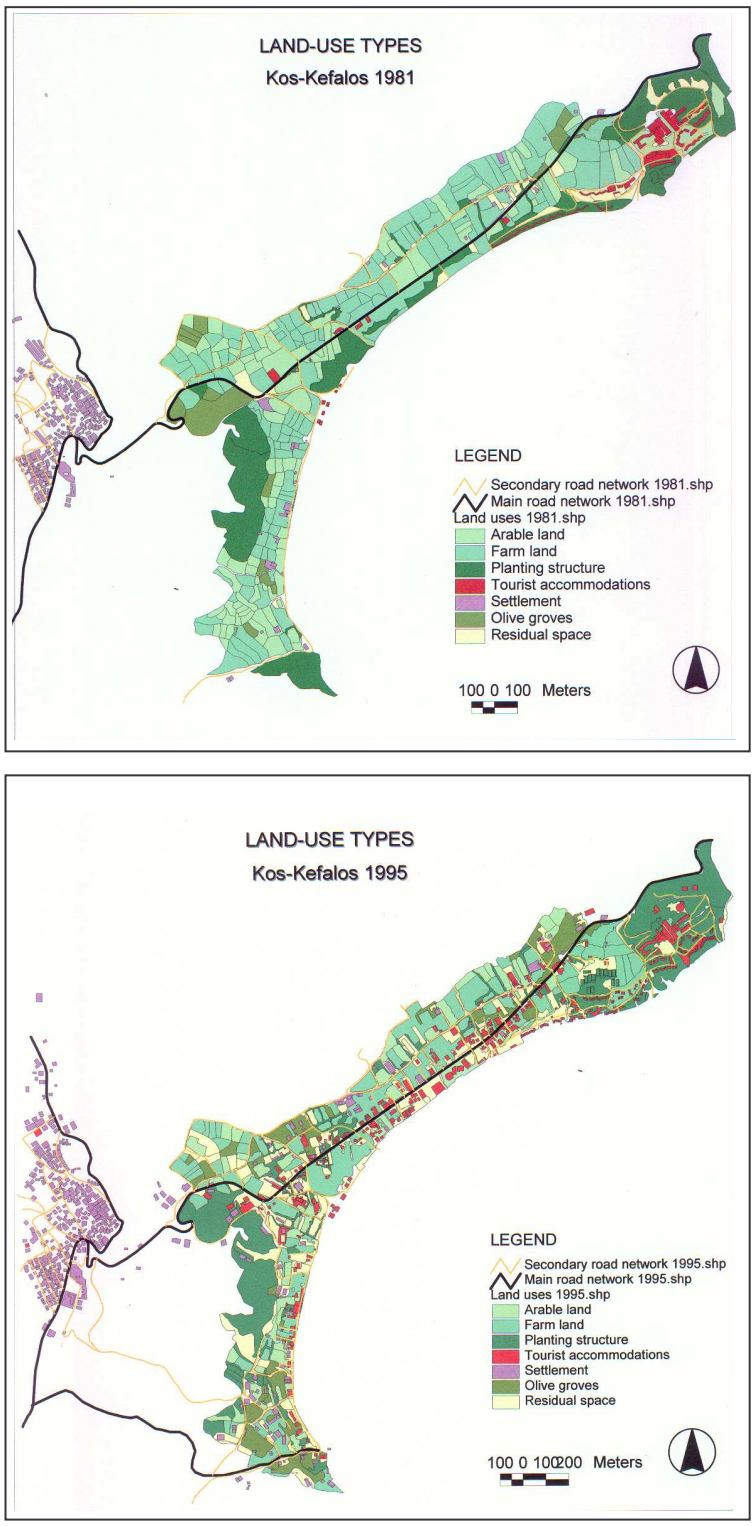


Fig. 1 Temporal layer maps of the distribution of land use categories in the district of Kefalos.

Table 1 shows that in 1981, the beginning of the tourist development of Kefalos, rural areas occupied the larger part of the landscape, in contrast to 1995, when arable land and farmland are diminished and tourist accommodations and settlements doubled their size. On the other hand, planting structures and olive groves present a small increase of their size. Residual spaces, however, demonstrate an increase, almost 4,4 times their size.

LAND USE	%AREA (1981)	%AREA (1995)
Arable land	22%	9,6%
Farm land	39%	23,6%
Planting structure	23%	24,4%
Tourist accommodations	3%	6,9%
Settlement	5%	9,5%
Olive groves	6%	8,4%
Residual spaces	4%	17,6%

Table 1.Landscape metrics show the range of land uses.

In conclusion, urbanization and abandonment of agricultural land describe the situation of the landscape till 1995. However till today all such changes in Kefalos occur at a slow pace and their results outcome may still be reversible. This simple metric gives us an indication of future landscape development, for purposes of drafting proposals for landscape management, as well as for stopping or reversing unfavourable tendencies.

2. Distribution of patch shape complexity

The patch shape complexity index analysis provided us with a series of results of the changes in the frequency of regular or irregular shapes for every land cover class (Forman Richard T.T. 1995), for the time period 1981-1995. The resulting dimensions for each landscape class are standardized to a simple Euclidean shape (e.g. circle or square). Using Patton's index the circle has a shape complexity index of 1 and a square of 1,13 (or 13% more complex than the square).

Arable land and farmland patches present a great frequency of regularity from 1-1,15 without major differences over the years. This enhances the historical fact that in the Mediterranean, the Romans applied their system of geometric land division to extensive rural areas.

The irregularity of complexity for the natural elements such as planting structures is around 2 (100% more complex than the circle), and it is almost stable for the time period 1981-1995. This is explaining the increase of planting areas around tourist infrastructures that we see on the aerial photos. In our site this is obvious in the case of the Club Meditteranee which uses non indigenous species to obscure the incongruous view of the main building. However, hedges are also following the geometry of arable land, contradicting this irregularity which explains why the index is basically from 1-2.

Interesting changes are noticed among the tourist accommodations (Fig.2). In 1981, the mode of the distribution of patch shape complexity index is 1,2 and there was a noticeable distribution of great irregularity of shape. In 1995, more family hotels were built and the mode of patch shape complexity index is 1,2. Large hotel units may sometimes be more diverse in shape, in comparison to small units which have diminished because of many land ownership factors.

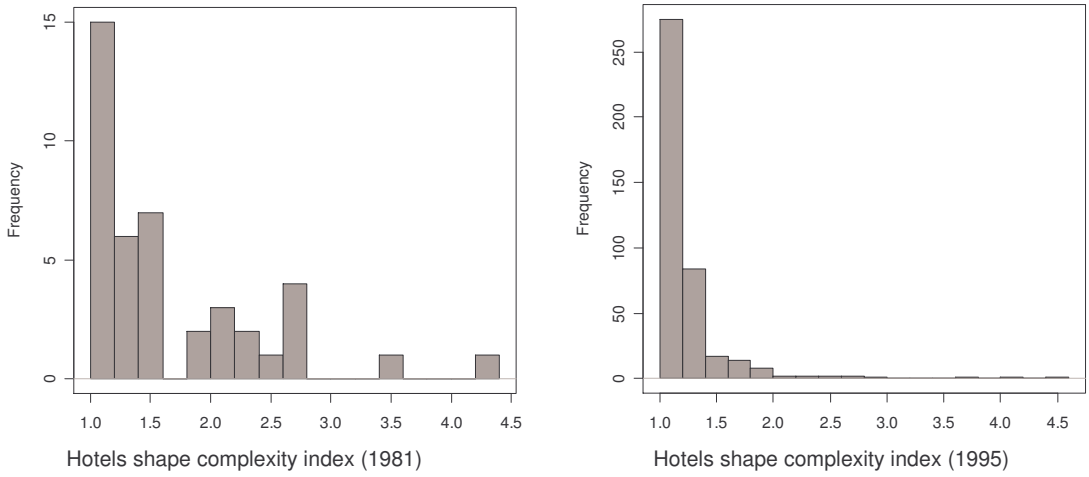


Fig.2. Shape complexity index frequency distributions for tourist accommodation units in 1981 and in 1995

Fig. 3 shows that the right tale of the distribution of olive groves has increased and therefore their shape complexity (Fig.3). This shows that intervention to olive groves has been increased and patches appear more complex.

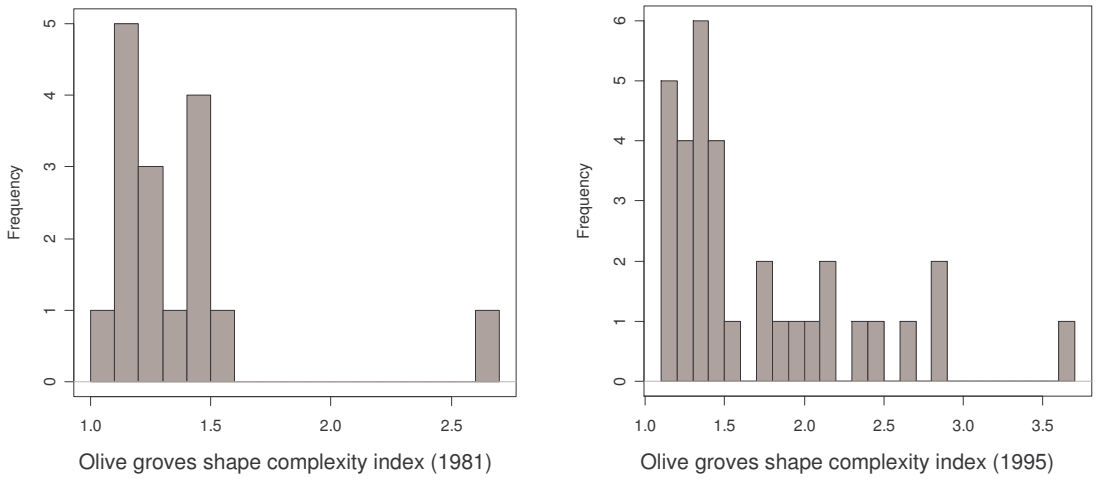


Fig.3. Shape complexity index frequency distributions for olive groves in 1981 and in 1995

Residual land presents a variety of the patch shape complexity index in 1995, in comparison to 1981 (Fig. 4). This is a dramatic increase of unused land, especially around tourist accommodations as it is shown on the aerial photos.

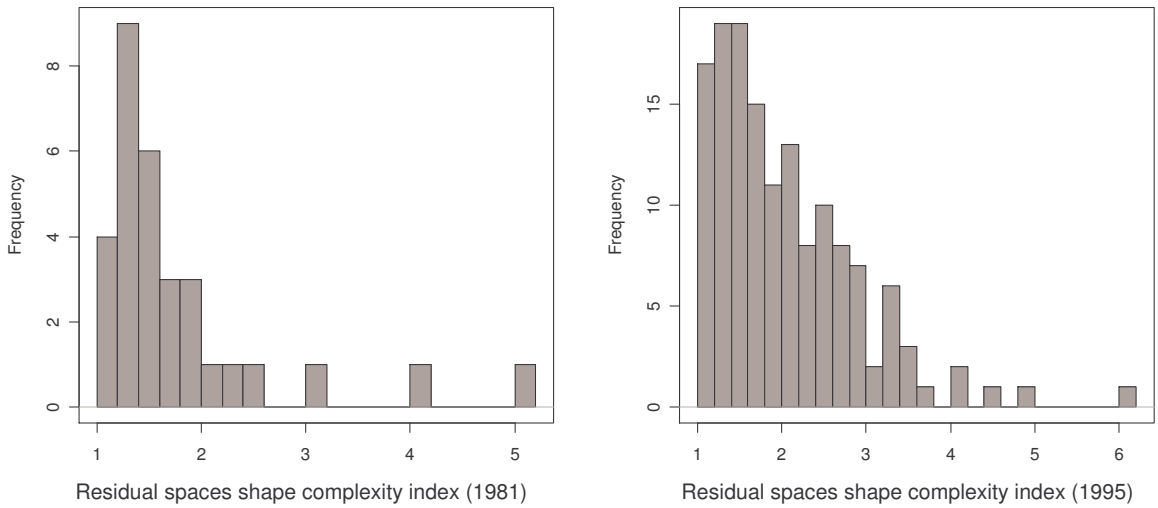


Fig.4. Shape complexity index frequency distributions for Residual spaces in 1981 and in 1995

The above index proved very useful in understanding many common assumptions drawn about the history of the place and its tourism development.

3. Transportation Network development

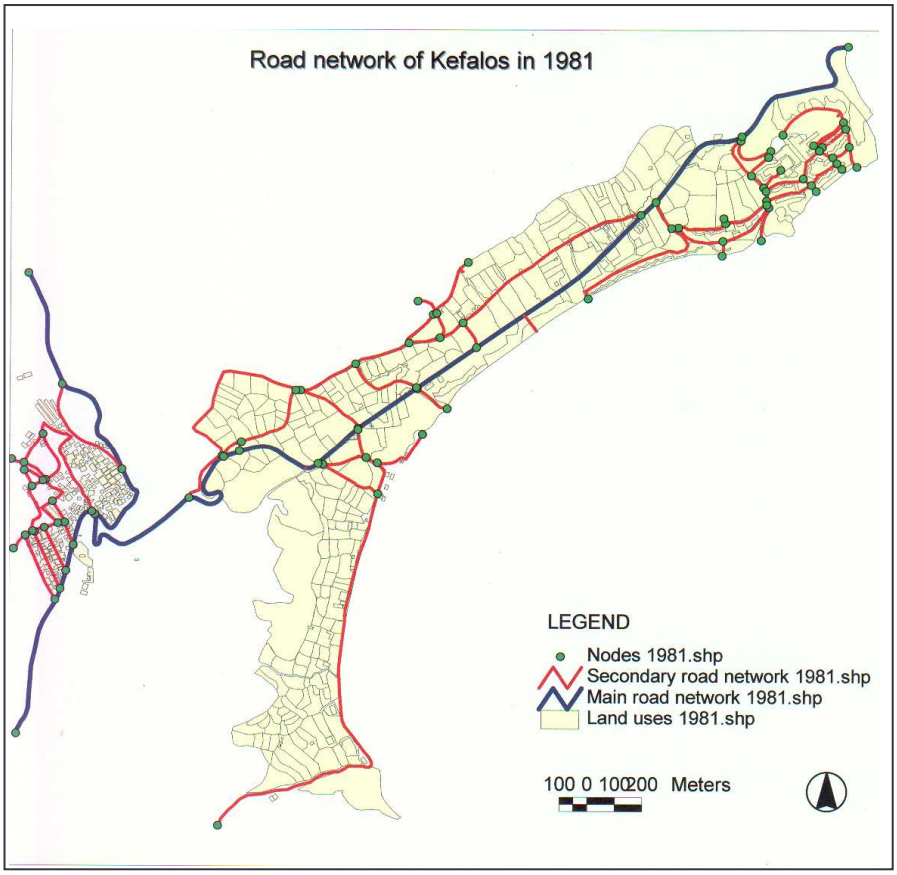
The degree and the way of connectivity of transport network system in Kefalos, presented table 2, is analyzed with the aid of α and γ indices.

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

Table 2. α and γ indices in 1981,1995

The γ index shows that the transportation network in this time period presents a low degree of connectivity.
The α index demonstrates the medium circular connections of the network, which remains at the first stages of its development in 1995. This helps us the directionality of network system development, which at this case is not circular but radical.

The above indices and the topological maps (Fig. 5) aid us in understanding the tourist development of the area. At the beginning of 1981 we had small poles of interest along the sea coast. As tourism development progresses we recognize two additional basic poles in this development (the port and the Club Mediterannee), connected with feeder routes with the interior. Slowly in time, interior tourist poles have appeared and feeder lines continue to develop in larger ones. Since interconnections between the above poles seem to be completed, more connections between the sea and the village are now appearing.



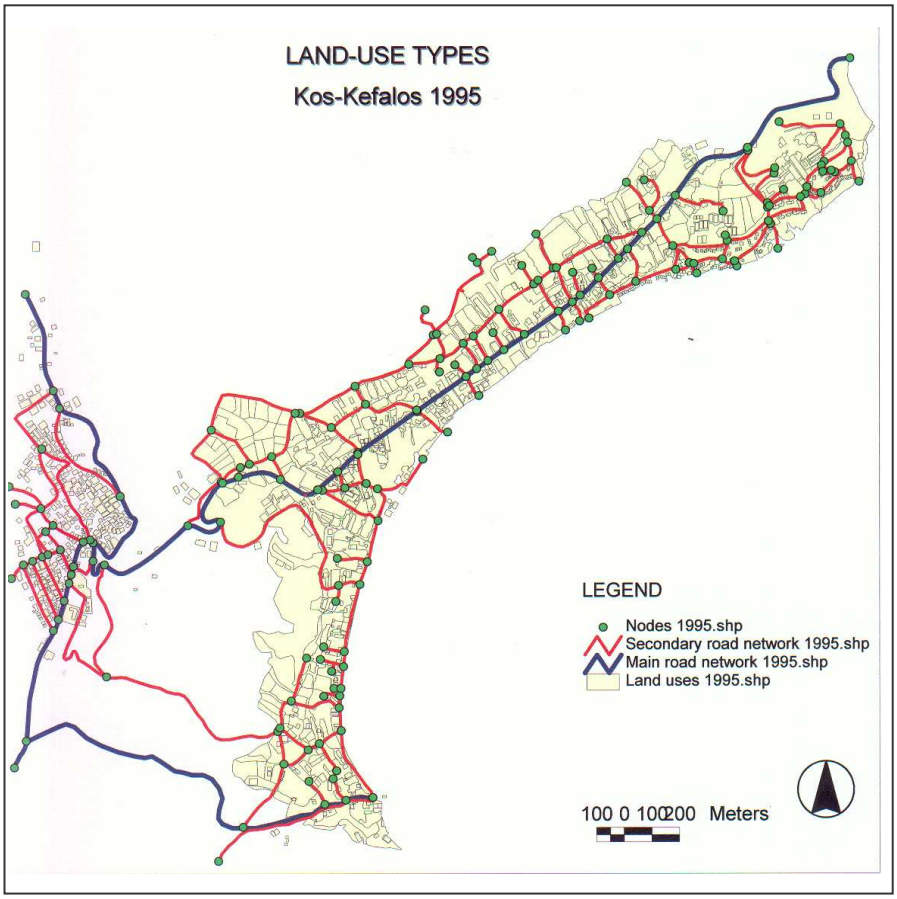


Fig.5 Network systems in 1981 and 1995

4. CONCLUSIONS

The above set of indicators is just a subset of a larger group of indicators which describe structural and functional changes in tourist landscapes. They may be applicable to any location, on cultural landscape change as a tool for the description and analysis of change. These metrics are deemed valuable in extracting information that could not be detected only on the maps. This quantitative approach used to explain historical landscape changes, seems to be an important and promising tool for the prediction of future tourist landscape changes. However, landscape metrics are not a panacea, but in combination with other data from both natural and social sciences may prove to be a basic requisite for constructing a realistic simulation of future local-level tourist landscape development.

REFERENCES

1. Bender O., Boehmer H. J., Jens D., Schumacher Ph. K., 2005. Using GIS to analyse long-term cultural landscape change in Southern Germany. Landscape and Urban Planning **70**, p.p.111–125

2. Bradford M. G. and W. A. Kent, 1977. Human geography: theories and their applications. Oxford University Press, p.p.180

3. Cook E. A.,2002. Landscape structure indices for assessing urban ecological networks. Landscape and Urban Planning **58**, p.p.269–280

4. Forman Richard T.T.,1995.Land Mosaics. The ecology of landscapes and regions. Cambridge: Cambridge University Press.

5. Koukoulas S., Blackburn G.A., 2004. Quantifying the spatial properties of forest canopy gaps using LiDAR imagery and GIS. International Journal of Remote Sensing Vol **25**,no 15, p.p.3049-3071.

6. Lausch A., Herzog F.,2002. Applicability of landscape metrics for the monitoring of landscape changes: issues of scale, resolution and interpretability. Ecological Indicators Vol **2**, p.p.3-15.

7. Markoglou A., 2004.Kos Through the Engravings of European Travellers and Cartographers (15^{th}-19^{th} century).Kos: Municipalities of Kos-Dikaios-Herakleides.

8. Patton, D.R., 1975.A diversity index for quantifying habitat “edge”. Wildlife Society Bulletin,**3**,p.p.171-173.

9.Terkenli, Th. S. , 2000. Landscapes of tourism: a cultural geographical perspective. In Briassoulis, Helen and Jan van der Straaten (Eds.), Tourism and the Environment: Regional, Economic, Cultural and Policy Issues, Revised Second Edition Dordrecht: Kluwer Academic Publishers. pp. 179-202

10.Van Eetvelde V., Antrop M,2004. Analyzing structural and functional changes of traditional landscapes—two examples from Southern France. Landscape and Urban Planning **67**, p.p.79–95.