# CHARTING SEA VISIBILITY ALONG COASTAL AREAS IN THE CONTEXT OF COASTALITY

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**Abstract**

As this paper is aligned with an effort to establish a comprehensive approach to coastal areas, one way to put this approach to practice is to base it on some quantifiable indicator. In a recent paper the notion of Coastality has been coined [Kiousopoulos 2008b]. Coastality is a means of quantifying the attractiveness of space with respect to the effect of coastal areas. It refers to both artificial and natural areas, at local level and can be quantified in practical terms. Coastality is measured for both artificial and natural environment. Natural Coastality depends on the physical characteristics of the coastal environment, sea visibility included. Artificial Coastality is an indication of the exploitation of the coastal areas by humans.

The present work refers to one of the main components of Natural Coastality, sea visibility, i.e. the view that each location of the terrestrial part of a coastal area has to the sea. Actually, this paper is a case study to prove the usefulness of applying the concept of visibility as part of Coastality in order to quantify the attractiveness of coastal areas. There is also the need to shed some light in some aspects concerning the practical application of the concept of Coastality.

The case study refers to a specific local area. However, it is easy to imagine widespread applicability, given the availability of public domain global or near-global datasets, such as the ASTER Global DEM recently published. The use of globally available datasets also contributes to the treatment of the coastal areas without the side-effects imposed by the artificial delineation caused by country borders. This conforms well to the recent European directive INSPIRE [Inspire 2007] calling for common transnational standards with respect to data and metadata.

KEYWORDS: Coastality, Sea Visibility, Indicator, Coastal Typology, ICZM, Spatial Planning, Greece.

## 1. INTRODUCTION

### 1.1. Coastal space and indicators

The global history of urbanization and the international demographic statistics prove that human settlements of any type and size seek to be concentrated in this narrow strip near the shorelines [Mumford 1961; UNFPA 2007]. As a consequence, the coastal territory is under great pressure due to the human activities, as they are expressed through coastal land uses. [Clark 1995; Stanners & Bourdeau 1995; OECD 1997; UNEP 2001; Benoit & Comeau 2005; EEA 2006; Valiela 2006; Goudie 2006].

The policy response to the resultant land uses strong conflicts fluctuates widely. During the last 30 years and especially after the Earth Summit held in Rio de Janeiro, coastal nations are encouraged to develop their own integrated coastal area management (ICZM) infrastructures [UN 1992, Brachya et al. 1994; UNEP 2001]. Moreover, in order to be aware of the occurring changes, monitoring process is obligatory. The quality of monitoring depends on using methodologies and tools, indicators included. It is noticeable that AGENDA 21 (paragraph 17.8) promotes the developing of indicators to improve “capacity to collect, analyse, assess and use information for sustainable use of resources, including environmental impacts of activities affecting the coastal and marine areas”.

Because of the previously displayed reasons, and -additionally- in order: to enrich the spatial planning procedure, to support all the involved stakeholders, to get on a successful governance process, a continuous effort to improve and to expand the already used indicator’s system is needed. The nowadays research on indicators -as an analysis tool- is very productive, worldwide, mainly for environmental uses. [UN 1996; UNEP 2000; EEA 2005]. More recently, numerous ambitious initiatives have been introduced aiming to solve problems such as: the fragmentation of datasets and sources, the lack of harmonization between datasets at different geographical scales, the gaps in availability etc [Nebert 2004; INSPIRE 2008].

Normally, environmental indicators cover the general needs of coastal studies, but not in an adequate way. The spatial notion is almost totally absent across [OECD 1998; UNEP 2000; EC 2002; NOAA 2007]. This means that the geographic/geomorphologic information that characterizes and gives a special appearance in every examined coastal area is not regarded as valuable to be incorporated in the majority of proposed indicator cores. In this manner, vital spatial information concerning coastal abiotic environment and in situ human activities is either missing or ignored.

## 1.2. The meaning of Coastality

'Coastality' is not a common term. It is very rarely used [Plane 2005]. The majority of dictionaries and glossaries do not contain the entry 'coastality'. But, according to the more probable etymological explanation it seems to express the proximity to the sea and perhaps the quality to live by the land next to the seashore.

On the other hand, **Coastality** (**C**) has been launched since 2005 [Kiousopoulos & Lagkas, 2005], as a new indicator aiming to calculate exactly how much "the land affected by its proximity to the sea", to assess the magnitude of coastal characteristics, to measure "**how coastal a coastal area is**". In this context, Coastality is designed to reach the intensity of coastal characteristics (along the coastal space, at local level) by the combination of the natural-abiotic features and the man-made impact on the coastal space. Therefore, Coastality can be divided into Natural Coastality and Artificial Coastality, according to the following approach:

1. **Natural Coastality** depends on the natural characteristics of the coastal environment and the general feeling due to the land-sea interaction. Natural Coastality aims to measure these characteristics and classify coastal areas according to them. It can be approached via two sub-indicators, the 'coastal feeling' [Kiousopoulos 2009] and the **visibility** to the sea (sea visibility).

2. **Artificial Coastality** expresses the size of the mankind impact on a coastal area. Shoreline accessibility via all means of transport and the percentage of built-up areas within the terrestrial part of the coastal areas are the two sub-indicators, which will be used to give the Artificial Coastality.

| | | |
|---|---|---|
| **COASTALITY** | { Natural Coastality | { Coastal Feeling<br>{ **Sea Visibility** |
| | { Artificial Coastality | { Built-up areas<br>{ Accessing possibilities |

Figure 1. The semantic framework of Coastality (and Sea Visibility).

According to the previous analysis, a potential formula for Coastality could be the next one [Kiousopoulos 2008a]:

$$C = nC + aC = \frac{(\alpha \cdot c_f + \beta \cdot s_v) + (\gamma \cdot s_a + \delta \cdot b_a)}{\alpha + \beta + \gamma + \delta} \qquad [1]$$

where: C, nC, aC : Coastality, natural Coastality, artificial Coastality,
cf , $s_v$ : Coastal feeling, Sea visibility,

$s_{\alpha}$ , $h_{\alpha}$ , : Shoreline accessibility, Build-up areas,
$\alpha$, $\beta$, $\gamma$, $\delta$ : positive coefficients.

Coastality does not annul the existed coastal indicators. It will act additionally, with the further aim to improve the spatial planning procedure and to support the local authorities and all the involved stakeholders. Coastality is a complex indicator which intends to distinguish coastal areas according to the scale (values) of a set of very significant characteristics. It is considered to have a remarkable capability to derive the differences: i) at the same coast at two different periods of time and ii) at different coasts at the same time. The scale of those differences seems to be very significant to pre-estimate the quality of the abiotic coastal environment, at local level. Moreover, as far as the existing typology of coastal area concentrates mostly on global, continental or country level, the previously represented indicator could fill the gap in coastal areas' typology at local level.

## 2. CASE STUDY

### 2.1. Sea Visibility options

At a first level, 'sea visibility' or 'visibility' refers to whether the sea is visible from a given location or not. The definition of visibility becomes more complex at a second level, and visibility refers to whether the part of the sea that can be seen from a given location is more or less interesting. The definition and experimentation with what is actually implied by the term visibility is a research objective by itself. The intention is to evaluate several alternative definitions of visibility in the future.

During this case study, the notion of visibility (from the land part to the marine part of a coastal area) has the following two potential dimensions, i) visibility to the shoreline (Vc) and ii) visibility to the sea (Vs). The values of both the dimensions represent the percentage of the shoreline or the sea that is visible from each (terrestrial) location. The maximum value is 100% or 1 (one), for each of them. Thus, the maximum value of their sum is 2 (two), and the (initial) form of the visibility formula is:

$$V = \mathbf{Vc} + \mathbf{Vs} \qquad [2]$$

In order to incorporate the negative components that eliminate the visibility emotion/pleasure, the above formula is transformed by the following parameters. First, by the distance from the shoreline of each land unit of the examined coastal area and second by the combination of distance and altitude (namely the inclination) of each land unit.

1. Distance to the coastline (*d*). It negatively relates to the positive feeling of the view to the sea. The value of *d* is zero on the coastline, i.e. it has no impact on *V* for these areas. At a distance *B*, where *B* is the 'width' of the land, *V* is reduced in half. In

specific $B = E / \alpha^* =$ area of coastal area divided by its ideal coastal length [Kiousopoulos 2008a]. Also, for maximum distance $d = 2B$, the value of $V$ becomes zero, as evident in function (3).

$$V = [\ Vc + Vs\ ]\ X\ \mathbf{[\ 0.5 + (B - d)/2B\ ]} \qquad [3]$$

2. The value of (z) is the slope of the ground at each location. The contribution of this parameter is regarded natural for 10% of slope (value of 0.1 or an approximate 5.7° angle). The value of (z) becomes positive as the slope deviates (above or below) from the 10% set. In other words slopes other than the 10% are associated with a negative impact on visibility. At the extreme case, the value of $V$ can become zero due to excessive slope (47.7° angle).

$$V = [\ Vc + Vs\ ]\ X\ [\ 0.5 + (B - d)/2B\ ]\ X\ \mathbf{[\ 1 - |z - 0.1|\ ]} \qquad [4]$$

It is obvious that the visibility values fluctuate between 0 (zero) and 2 (two). The closer the $V$ value is to 2, the greater the range of vision (and the supposed pleasure to be there), from the territorial to the marine part of every examined coastal area.

## 2.2. The study area

The municipality of Milies, part of the prefecture of Magnisia, located in the center of the Hellenic Republic, is selected to serve as the study area [Figure 2]. The selection is based on the realization that this municipality is coastal and at the same time its territory is quite inhomogeneous, in terms of geomorphologic characteristics. Altitude, for example, ranges from the sea level to as high as 1500 meters. The aspect of the slope of mountain Pelion at that study area faces towards Pagasiticos gulf. At approximately 500 meters of altitude, the slope retreats and gives its way to a flat area that hosts some of the famous traditional settlements, viz. Pinacates, Vyzitsa and Milies (from northwest to southeast). At the level of the sea there exist some of the more recently established settlements named Kato Gatzea and Kala Nera. The dominant aspect of all the settlements on the slope is mainly south. They are all protected from the strong northeast winds of the Aegean Sea.


Figure 2.  Locator map for the study area.

## 2.3. Methodology

The case study is based on the construction of suitable cartographic layers in a geographical information system. The work is based on the raster structure as it is more suitable for modeling. Visibility is estimated for each location in the study area. The basic data that were used for the needs of the present study are the contour lines, at an interval of twenty meters. The source of the contours is topographic maps, at a scale of 1/50.000, obtained from the national mapping agency [figure 3]. A ten meters resolution Digital Elevation Model (DEM) is created based on the contour lines. A shaded relief [figure 4] is derived from the DEM to facilitate the comprehension of ground topography. The slope at each location is also derived based on the DEM. Finally, visibility is estimated for each location within the municipality, based again on the DEM. Visibility is calculated based on the creation of straight lines that connect each location to each of the points of interest (sea and coastline). Subsequently, it is determined whether each line crosses the relief or not. In order to differentiate between locations that have a more open view towards more points of the coastline or of the open sea, the number of visible points is summed. Consequently, it is not only a matter of the coastline or the sea being visible from a particular location or not.  An estimate of the quantity of the visibility, if we can name it as such, is also calculated. As an upper bound, the distance of ten kilometers is set. Passed the ten kilometers limit, it is assumed that visibility is practically zero. The value set, i.e. ten kilometers, is subjective but, we believe, within reasonable bounds. It is known that the width of the coastal zone is also currently a topic of debate and research. The distance from the sea is shown in figure 5.

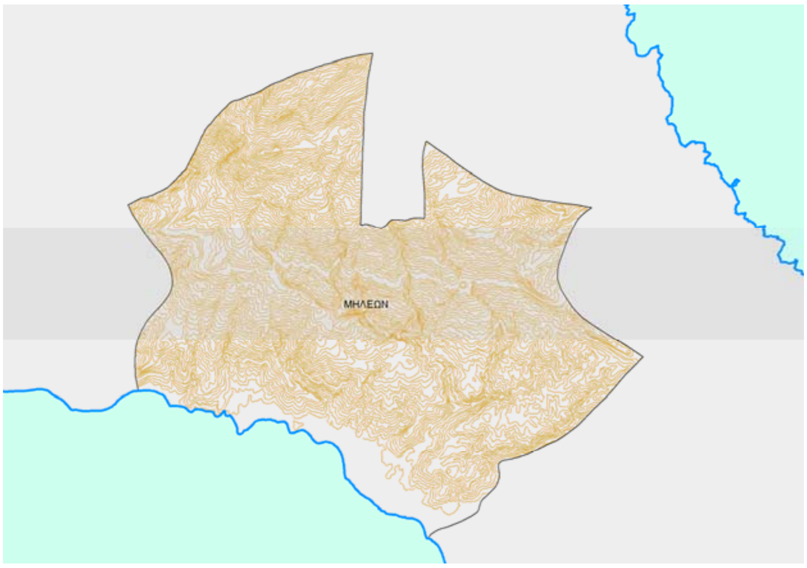


Figure 3.  Contour lines for the study area.

It is worth noticing that despite the fact that the coastline and the sea is obviously a linear and an surface element respectively, for practical reasons visibility is not calculated towards all locations in them. A distinct number or points is selected instead, that are spread at a reasonable distance so that no degradation in the result is expected, due to this simplification. The simplification is done in order to reduce computational requirements and time. The final result, showing the combination of sea and coast visibility is presented in figure 6.

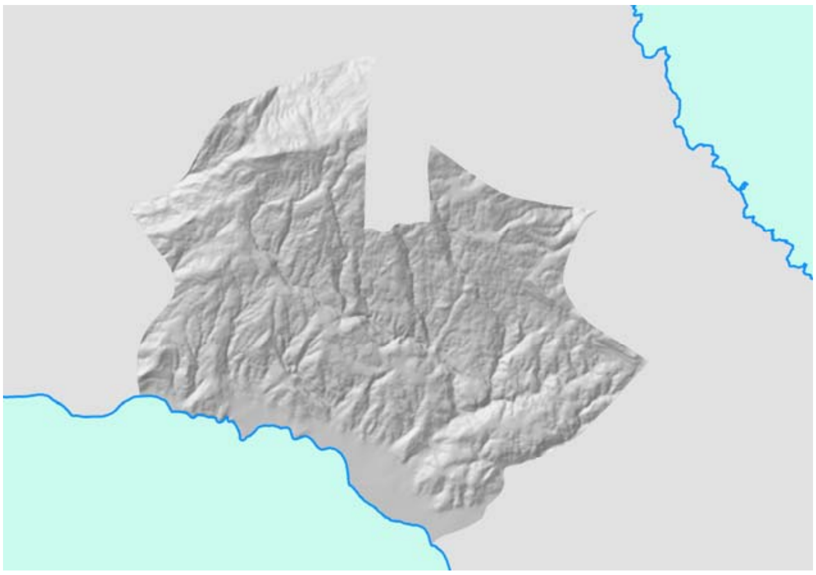

Figure 4.  The shaded relief created for the study area.

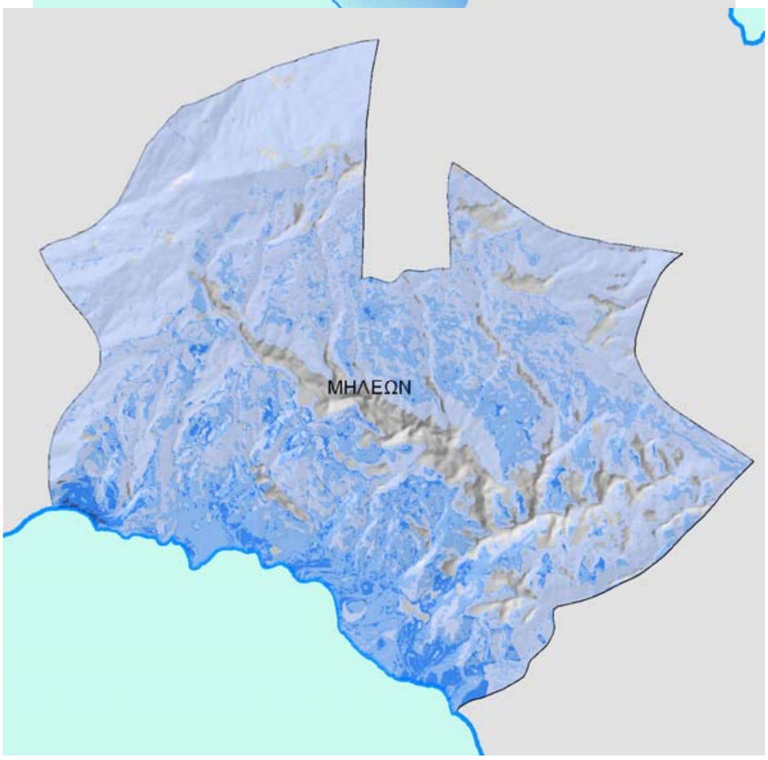


Figure 5. Distance from the sea for the study area.

Figure 6. Final visibility estimated combining both sea and coastline visibility.

## CONCLUSION

A first finding of this paper is that the indicator introduced (sea visibility) can be calculated without significant problems in most locations of the world. All needed data for calculating this indicator are widely available today. The formula used to estimate (V) might be improved in the future by incorporating more parameters or by combining the available parameters in a different way. One parameter to be added could be 'land use' which can have a positive or a negative effect on (V), given that some land uses attract humans whereas others disturb theme in different ways.

A second finding is that it would be useful to apply the proposed method to other case studies, preferably in a diverse range of relief formations. This would permit to gain a better insight on the actual meaning of the parameters examined on the ground. An auxiliary method could be to estimate V values for several virtual coastal areas that have ideal shapes.

However, what is more interesting is the actual use of the indicator introduced. If we can successfully summarize the effect of sea visibility in a single value, this paves the way for establishing a typology. The coastal areas can then be classified according to this parameter. It is probably more meaningful to imaging that administrative units, not autonomous locations, in coastal areas can be characterized by this value. The way forward would then be to use the typology as a means to study spatial tensions as sea visibility is a major factor attracting human interaction.

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