

Development of sea level rise scenarios for the Cyclades Islands in Greece under the concept of global climate change

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ABSTRACT

One of the most critical issues associated with global warming is the expected change in sea level rise (SLR) relative to the land and how this phenomenon will affect the coastal areas and their ecosystems. Sea level rise is a natural hazard directly affecting coastal and island societies putting in jeopardy their economic and natural environment. This work is a preliminary assessment on the degree of inundation occurring in the Cyclades Islands (Aegean Sea) due to a potential sea level rise. Using Geographic Information Systems (GIS) as a tool, three sea level rise scenarios were developed in order to depict the percentage of the island area covered. This study is the first step in estimating the vulnerability of these island areas to sea level rise. Further work is in process in order to compare these inundated areas and estimate the economic loss for each different case.

Introduction

One prevalent issue today related to climatic change is sea level rise and its impact on the environment and the human society of the coastal zones and islands. Nicholls et al. (1996), stated that this issue coincides with the extraordinary socio-economic development of the coastal fringe causing a number of irreversible economic and social impacts on the coastal populations. The terminal effects of sea level rise in coastal areas and islands fall into four categories: ecological impact on the most vulnerable ecosystems, economic impact due to instabilities in the natural environment, changes in the way of life but also in the place of residence for populations adjacent to vulnerable areas and finally, the way of adaptation into the ongoing changes of the political, economic, cultural and institutional environment (Katsibardis, 2005). The most severely impacted sectors are expected to be the residential and recreational areas, agricultural land, and the natural ecosystem.

Mediterranean coastal areas housed 36% (Eurostat, 2011) of the EU coastal regions' population in 2009 with a trend to increase by 1.4% in 2025 (Goudert and Larid, 2011). Mediterranean coastal regions benefit services to businesses and individuals which mainly include transport and coastal tourism, with tourism holding a significant

position accounting for around 19.0% of the hotels in the European Union (Eurostat, 2011).

One third of the population in Greece lives no further than 2 km from the coastline, also hosting the majority of the tourist activities especially during the summer period (Coccosis and Mexa, 2004). Cyclades is a group of islands in Greece, located in the central Aegean Archipelago. The islands consist of 24 inhabited small and medium size islands and a significant number of uninhabited small islands and islets with a surface area of approximately 2,528 km². Their population has increased from 94,005 to 111,181 between 1991 and 2001 (Coccosis and Mexa, 2004). This island complex hosts a variety of ecosystems which although limited in size, they host significant ecological features and protected areas that are included in the Natura 2000 Network. The island complex of Cyclades comprises one of the most significant tourist destinations in Greece with 6% of accommodation units housed in this area in 2010 (Chatzidakis, 2011). The island complex of Cyclades is physically and socio-economically vulnerable to accelerated sea-level rise, due to its low topography and its high touristic value.

The main objective of this study was to depict the inundated area through the development of three scenarios of sea level rise, in four of the main touristic islands of the island complex and assess the percentage of influence in the urban areas located adjacent to coast.

Materials & Methods

Data were provided by the Hellenic Military Geographical Service and included the elevations in relation to mean sea level and the polygons of urban areas adjacent to the sea. Elevation datasets were in polyline format and through interpolation techniques (Topo to Raster), raster format was produced. The user-defined pixel size of the DEM was 5m. Three different scenarios of sea level rise were developed illustrating the inundated areas after a sea level rise of 0.3m, 0.6m and 1m respectively. Basic statistics were computed for model results to determine total land area inundated at each different case.

Results

The results indicated that $0.64 \pm 0.45\%$ of the study area would be submerged under the scenario of 0.30 m sea level rise, $0.95 \pm 0.68\%$ under the scenario of 0.60 m sea level rise and $1.31 \pm 0.96\%$ under the scenario of 1 m sea level rise. Following these estimations, four representative examples are presented, illustrating the total area of inundated land (Table 1).

Table 1. Percentage of inundated land according to three different scenarios of SLR in four islands of Cyclades Archipelagos.

| Island | Total area (km ²) | Total area of inundated land (%) | | |
|---------|-------------------------------|----------------------------------|-----------|--------|
| | | SLR 0.30m | SLR 0.60m | SLR 1m |
| Syros | 84 | 0,74 | 0,93 | 1,15 |
| Naxos | 431 | 0,87 | 1,06 | 1,28 |
| Paros | 197 | 0,55 | 0,88 | 1,25 |
| Mykonos | 86 | 0,42 | 0,72 | 1,02 |

Syros is the geographic, administrative and commercial center of Cyclades with 20.000 inhabitants, constituting the largest demographic island of the Cyclades complex. Results indicated that 0.74% and 1.15% of the area will be lost by flooding under a minimum of 0.30 m and a maximum of 1 m inundation levels respectively, while according to the most plausible scenario of SLR=0.60 m, the inundation level would reach 0.93% of the total island area (Fig.1).

Naxos is a large island with 20.000 inhabitants with imposing mountainous volumes and is considered to be the most fertile island of Cyclades. Naxos is the most vulnerable island relative to the other three islands, since it risks losing a higher percentage of land namely 0.87%, 1.06% and 1.28% for SLR 0.30 m, 0.60 m and 1 m respectively (Fig.2).

Paros is a well known and highly acknowledged tourist destination with high tourist frequentation in summer period and less population during winter. SLR of 0.30 m and 0.60 m would lead to land loss of 0.55% and 0.88% of the total island area respectively whilst SLR of 1 m would lead to 1.25% land loss (Fig.3).

Mykonos is located in the center of Cyclades islands, known for its cosmopolitan character attracting high -income tourists. According to the best scenario for SLR of 0.30 m, 0.42% of the total area would be lost, whilst according to the worst scenario of reaching 1 m, almost 1% of the total island surface would be lost. According to the most plausible scenario for SLR of 0.60 m, the inundation level would reach 0.72% of the total island area (Fig.4).

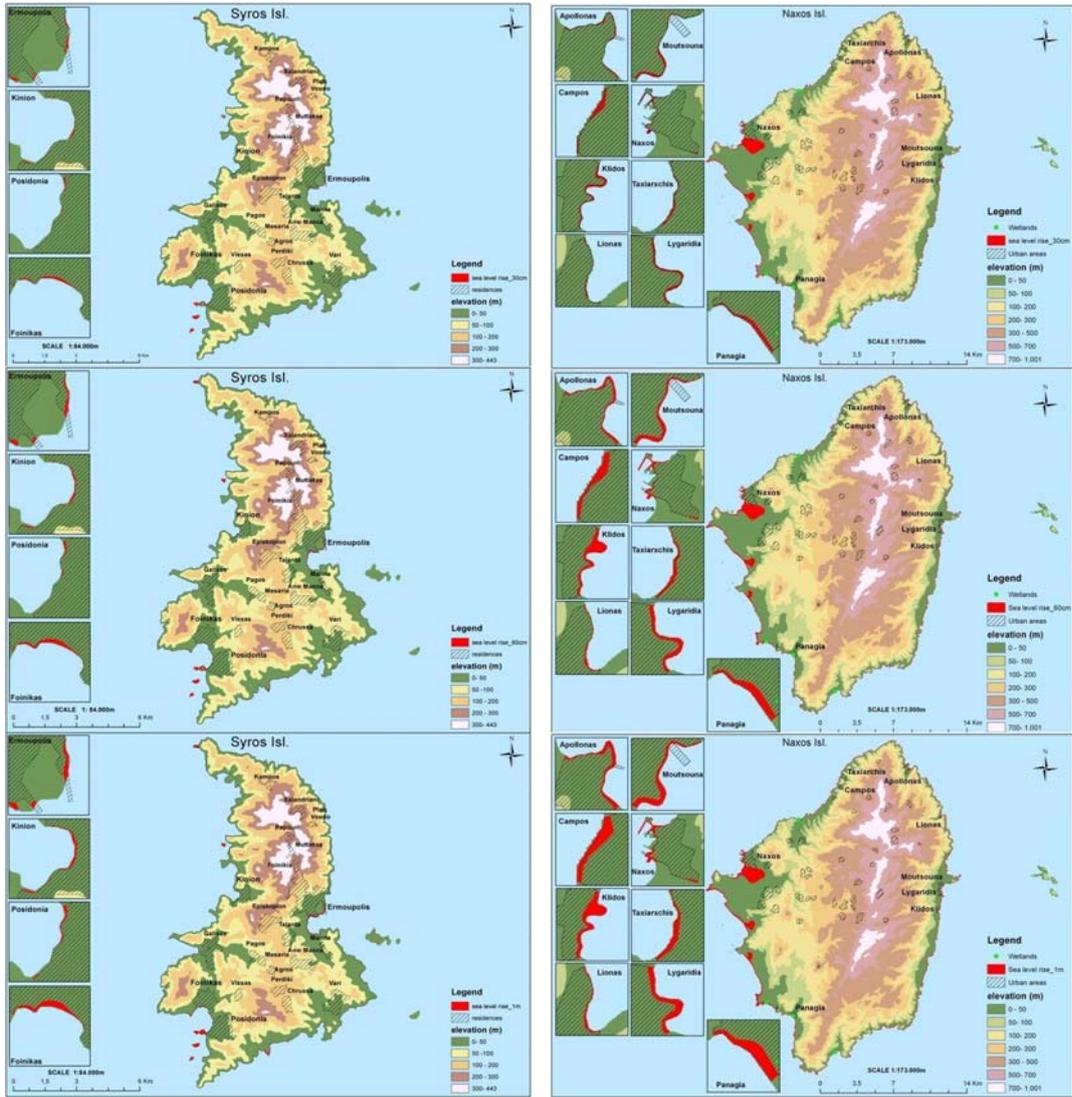


Figure 1, 2. Projected sea level rise (0.30m, 0.60m, 1m) for Syros and Naxos Isl. respectively

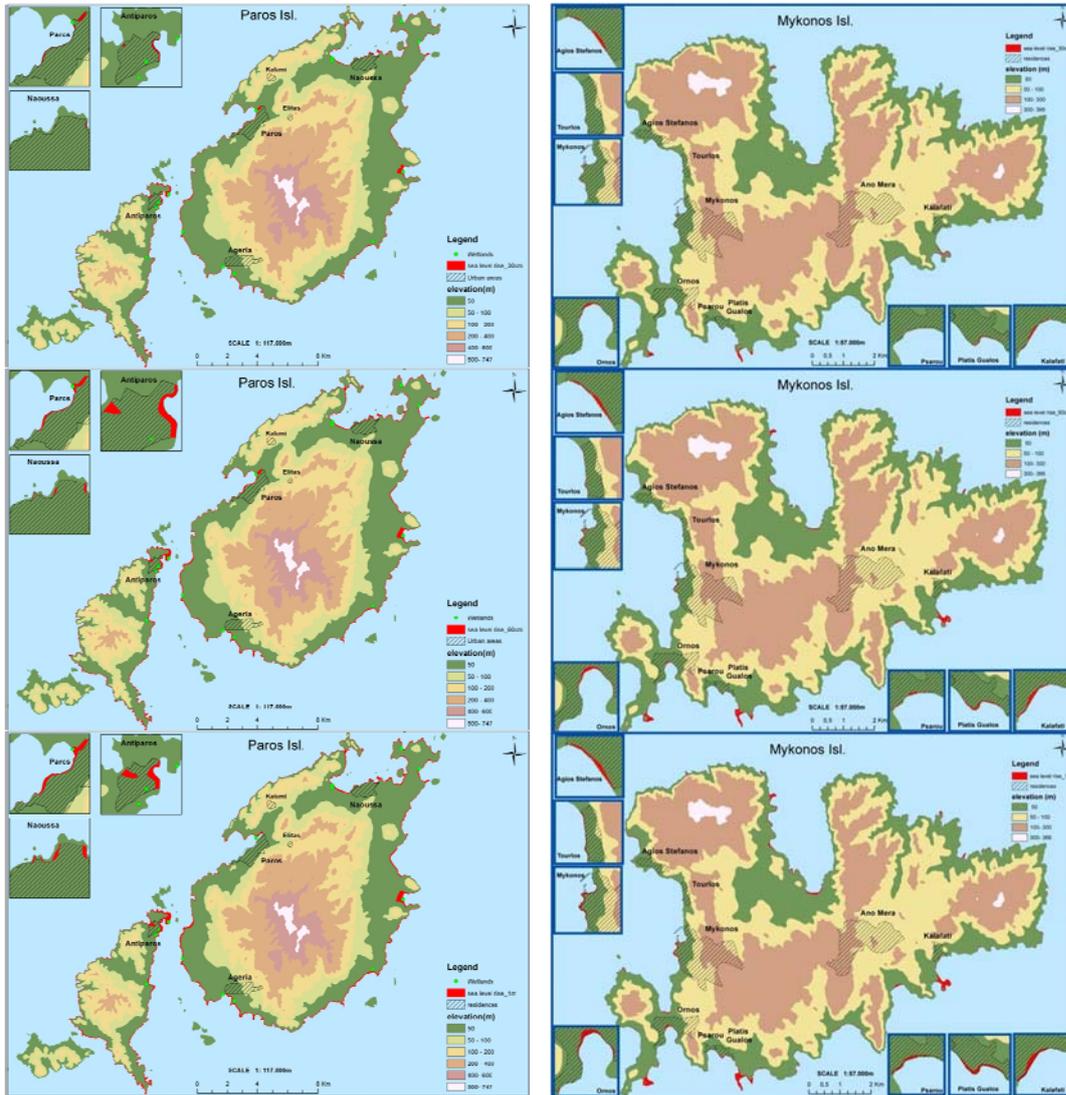


Figure 3, 4. Projected sea level rise (0.30m, 0.60m, 1m) for Paros and Mykonos Isl. respectively

Discussion

The projected inundated coastal areas include important parts of the islands in terms of urban areas and infrastructure such as part of urban regions, ports, coastal wetlands and tourist destinations (such as beaches). It is evident from the preliminary results of this initial study that further research is imperative in order to assess the complex issue of sea level rise, its impact on the study area and the degree of vulnerability of the local environment and ecosystems, in order to take measures, elaborate and implement a plan for adaptation/remediation. In addition further work is needed to estimate the economic impact of the sea level rise on the fragile economy of Cyclades Islands which is highly depended on coastal and marine tourism.

According to Katsibardis (2005), three key concepts have to be taken into consideration in order to comprehend the complex issue of the climate change as a threat referring to the anthropogenic interference, the degree of vulnerability and the potential of a system to adapt to change.

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