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Morphogenetic processes in Greece as a threat to mankind

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Abstract

The purpose of this paper is to draw attention to the extent of the threat imminent in the contemporary dynamics of the relief in Greece. The majority of the territory of Greece is tectonically unstable. Volcanic phenomena represent another potential danger for this territory. The endogenous processes, despite the dangers they entail, contemporarily result in less material damage than the catastrophic exogenous processes. Young fluvial and denudation landscapes prevail in Greece. Therefore, slope processes together with erosion and river accumulation play a major role in their transformation, thus creating a morphogenetic system, which is extremely resistant to anthropopressure. Greece's relief and geological structure provide the favourable conditions for landslides. In the recent years, more and more commonly almost every incident of torrential rain has resulted in short but frequently tragic floods.

Key words: morphogenetic process, Greece, hazard

Introduction

In geomorphological research currently conducted all over the world, the issue of contemporary morphogenetic processes is increasingly present. This is due to the fact that both fast and slow changes in the morphology of the relief exert direct or an indirect influence on the entire environment, including the economy.

The Mediterranean region is usually associated with picturesque landscapes and wonderful weather. In fact, however, the mountains, coupled with contrasting climate and mismanagement of space, may pose a serious threat for the region's dwellers. In recent years, this problem has become particularly acute in Greece.

Catastrophic morphogenetic processes are the most dangerous when their consequences affect densely populated, predominantly urban areas. On the other hand, cities and their surroundings are the areas which have been most significantly transformed by man, which means that the morphogenetic processes in those areas are subject to exceptionally strong anthropopressure, both direct and indirect. At the same time, it should be borne in mind that the morphogenetic role of the anthropogenetic factor is additionally reinforced by the fact that this region has for centuries been intensely transformed by man.

Geomorphological and archaeological research proves that numerous, catastrophic "natural" processes took place here in the past. Usually, their strength would be related

to an increase in various aspects of anthropopressure. For instance, it is presumed that the burying of ancient Olympia was an indirect consequence of irrational grazing, which accelerated the erosion in the drainage basin of the Kladeos stream and, in turn, led to the increased supply of material in the zone of alluvial fan (Vita-Finzi 1969).

The purpose of this paper is to draw attention to the extent of the threat imminent in the contemporary dynamics of the relief in Greece. Such phenomena as seismicity, volcanism, landslides, floods and processes occurring in delta plains were also taken into account.

Morphogenetic hazard

The majority of the territory of Greece is an tectonically unstable area. Suffice it to say that the country lies in the most seismically active region of Europe (Fig. 1).

In the 20th century alone, over 100 shocks exceeding six degrees Richter were recorded, including 12 stronger than 7 degrees. By comparison, the Athens earthquake in 1999, which resulted in the death of over 120 people, was 5.9 degrees Richter. Therefore it can be said that the seismic threat is quite high (Fig. 2). However, the documented number of casualties (Fig. 3) show that contemporary technology allows to control the danger to a considerable extent. This is best illustrated by the fact that as a result of all the earthquakes in the 19th century over 9,000 people lost their lives (including 3,500 during the 1881 earthquake on the island of Chios), while the 20th century were somewhat times less tragic (Papazachos B.&C. 1989).

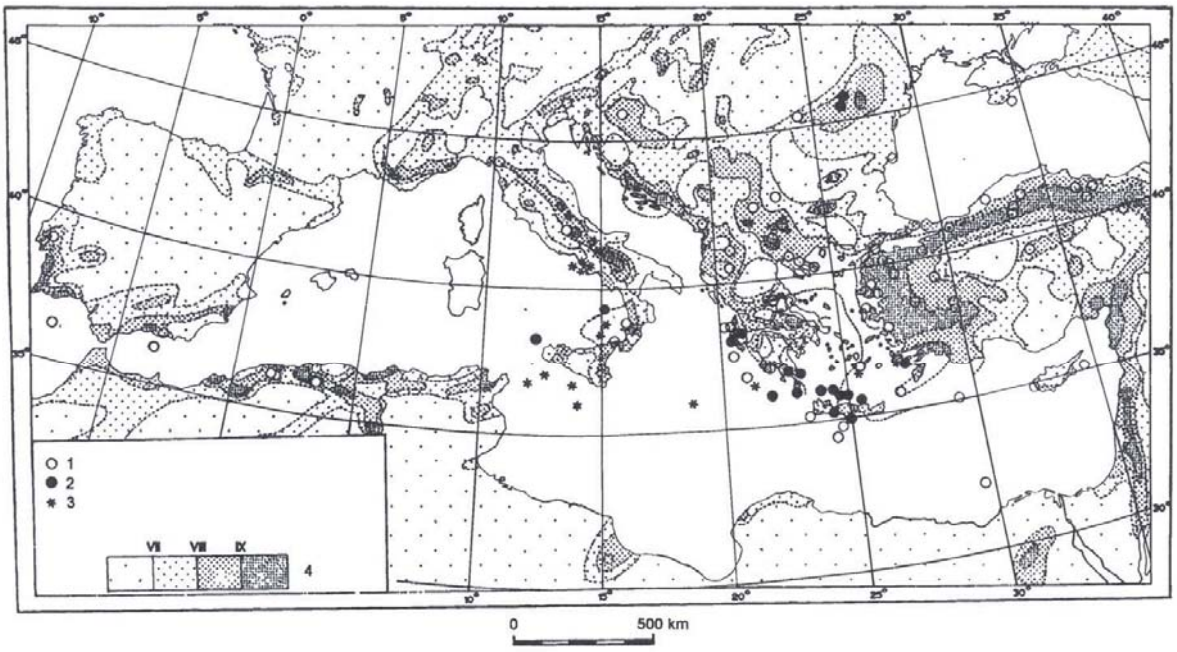

Fig. 1 Seismicity of the Mediterranean region (after Karnik 1966; Papazachos B. & C. 1989): 1 – Epicenters of shallow (h<60 km) earthquakes of magnitude M≥6,3 (in the years 1901–1980); 2 – Epicenters of intermediate and deep (h≥60 km) earthquakes of magnitude M≥6,3 (in the years 1901–1955); 3 – Volcanoes; 4 – Maximum earthquake intensity in MCS scale

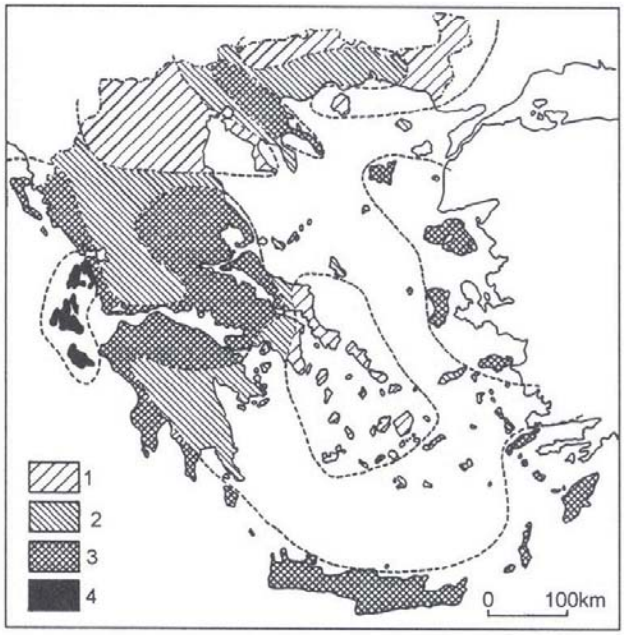

Fig. 2 Seismic hazard in Greece (after Papazachos B. & C. 1989): 1 – small, 2 – medium, 3 – high, 4 – very high

Volcanic phenomena represent another potential, albeit limited, danger for the territory of Greece. Contemporarily, the Santorini archipelago is the most active area in this respect, while historically no less than 13 eruptions (periods of activity, lasting up to three years) were recorded here, including three in the 20th century (in 1925, 1939 and 1950). Owing to their relatively gentle character, they did not pose a serious threat for the islands' population. It should not be forgotten, however, that the volcano's area is a popular tourist destination, whereas geological data indicates that in the past (e.g. in the 15th century B.C.) eruptions that occured in the region were catastrophes on a global scale.

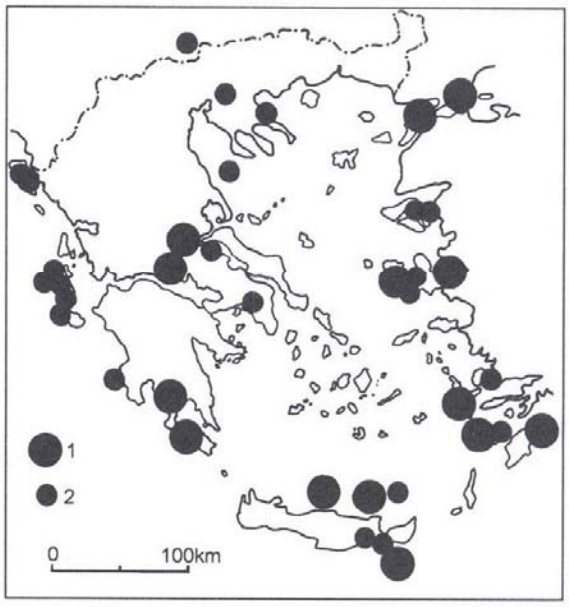

Fig. 3 Greek earthquakes which killed more than 100 people (in the years 550 BC–2000 AD) (after Papazachos B. & C. 1989, partly changed and extended): 1 – Epicenters of earthquakes which killed more than 500 people; 2 – Epicenters of earthquakes which killed 101–500 people

It should be emphasized that Santorini was regarded by the ancient Greeks as an inactive volcano. It did not resume its activity until 197 B.C. Even though the past 50 years were a period of its tranquillity, statistical analyses carried out by Greek geophysicists point out that there a danger does exist. They suggest that the probability of Santorini's eruption in the coming 100 years is higher than 90% (Papazachos B. & C. 1989).

The second Greek volcano active in the historical times (in particular in the 19th century) is located on the island of Nisyros in the Dodekanese archipelago. Its most recent eruption took place in 1888. However, geophysical research indicates that the seismic activity in this region has been slowly increasing (Lagios et al. 1998).

The listed endogenous processes, despite the dangers they entail, contemporarily result in less material damage than the catastrophic exogenous processes, the overview of which is presented below.

In terms of relief, young fluvial and denudation landscapes prevail in Greece (with mountain and upland areas accounting for over 70 per cent of the area). Therefore, slope processes together with erosion and river accumulation play a major role in their transformation, thus creating a morphogenetic system, which is extremely resistant to anthropopressure. These processes are additionally reinforced by climatic conditions (Tab. 1), and primarily by the fact that in Greece precipitation does not occur evenly throughout the year, but is mainly limited to the autumn and winter season (with monthly rainfall exceeding one third of the annual total) and is violent in character.

Tab. 1 Regional disparities in the basic climatic characteristics in Greece (average values for the period 1981–1990)

Meteorological stations:	**Kozani**	**Athens**	**Rhodes**
Average precipitation:	459.0 mm	397.7 mm	629.9 mm
Months	*Share in annual precipitation:*		
X–IV	65 %	88 %	98 %
V–IX	35 %	12 %	2 %
Average temperature in January:	2.4°C	8.7°C	12.5°C
Average temperature in July:	24.5°C	28.3°C	26.7°C

Source: Statistical Yearbook of Greece 1999

Greece's relief and geological structure, i.e. considerable local height differences and commonly occurring layers of rock (flysch and molasse in the west and schist in the east) as well as a dense network of tectonic lines, provide the favourable conditions for landslides. The available materials (Fig. 4) indicate, they pose a particular threat to the localities situated on the slopes of Pindos. However, the area is one of the least populated in Greece (Fig. 5), which naturally does not imply that the danger should be underestimated. This is most evident in the analysis of 800 landslides in Greece, carried out by Koukis and Ziourkas (1989), which proved that over 70 per cent of those phenomena affected populated areas and over 20 per cent – areas under cultivation. In addition to lithological and morphological factors, the destruction of natural plant cover

(confirmed in over 60 per cent of cases), played a considerable part in the development of those processes. Unfortunately, there is no data on the casualties and material damage inflicted by the described processes.

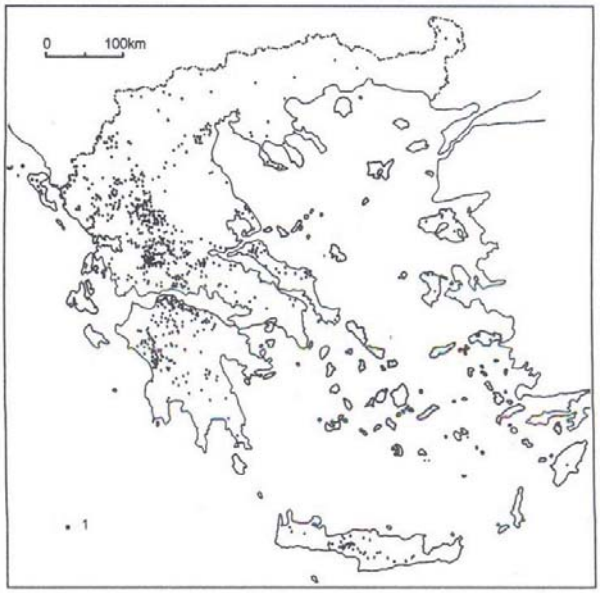

Fig. 4 Occurrence of landslides in Greece (after Koukis & Ziourkas 1989): 1 – Location of landslides

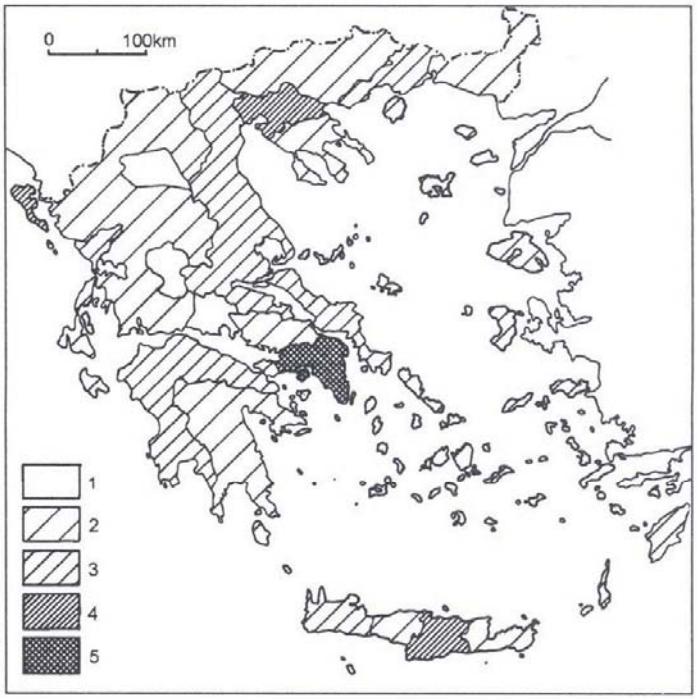

Fig. 5 Population density (persons per sq. km) in Greece (according to average data for first-level administrative units in 1991): 1 – less than 20; 2 – from 21 to 50; 3 – from 51 to 100; 4 – from 100 to 500; 5 – over 500

A network of intermittent streams, particularly dense in Greece (with many of the streams having their mouths in towns and villages – Fig. 6) provides a natural runoff mechanism for rainfall water. Many of the streams intersect large cities. However, in

the recent years, more and more commonly almost every incident of torrential rain has resulted in short but frequently tragic floods. In 1999 alone, huge material losses (in addition, sadly, to loss of life) were recorded in the area of Orestias (January and April), Ioannina (May), Edessa, Drama (June); also, whole regions suffered during the autumn of this year, in October and November, e.g. Achaea, Elis, Laconia in Peloponnese, Thesprotia in Epirus, Pieria in Macedonia, and many areas in Attica.

The situation did not improve much in the subsequent years. In Greece, autumn is the season that is particularly dangerous in terms of floods. Nonetheless, more and more frequently problems occur in the summer, even though – for climatic reasons – this season could be considered as safe. For instance, in 2002 Moschato, a borough in Athens, was flooded three times – in July, August and September.

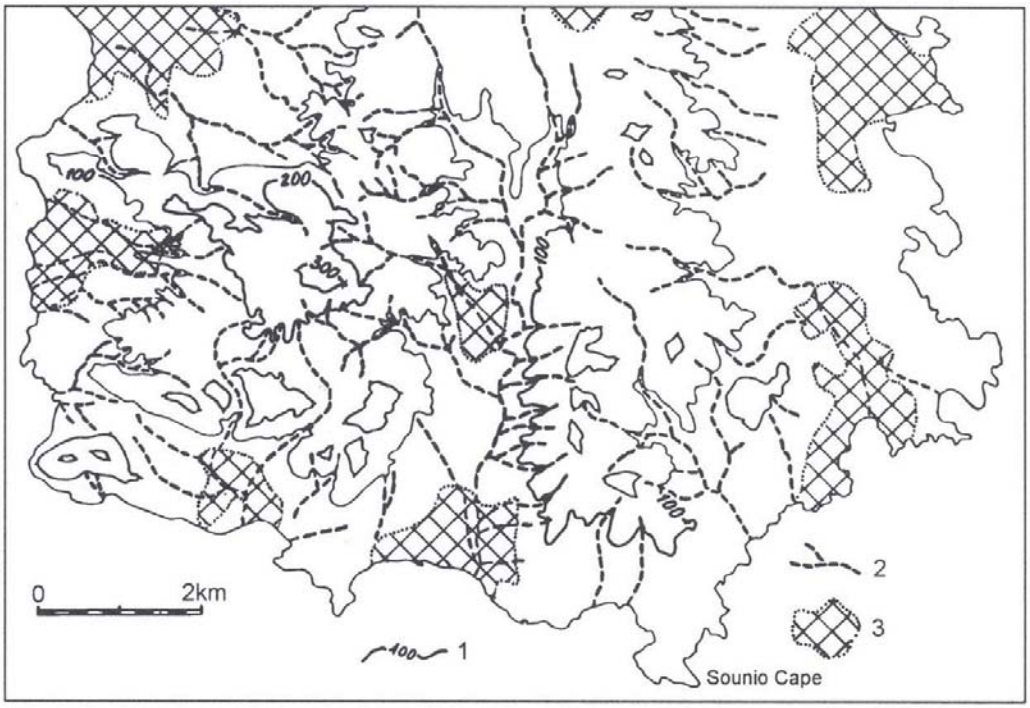

Fig. 6 Location of villages and intermittent streams in SE Attica: 1 – Contour lines; 2 – Intermittent streams' channels; 3 – Main localities and areas covered by crops

Water is not the only problem; another is the material that the water carries, since, owing to intensive denudation processes, short watercourses in the Mediterranean transport up to three times as much material as the largest of the world's rivers (Poulos et al. 1996).

It should be mentioned that nearly 70 per cent of Greece's population live in uplands surrounded by steep mountain slopes, as a result of which the threat of short but catastrophic floods becomes even greater. For example, the Attica Basin, a 400-km^2 area inhabited by at least one third of the country' population, is drained by a network of watercourses, mainly intermittent streams, with partly or wholly built-up channels. They empty into two rivers: the Kifissos and the Ilissos, which end their run in the Moschato borough (Fig. 7), inhabited by over 20,000 people. Their mouth sections

were completely sewered and cannot discharge the rainfall water. In such conditions, even a regular rain in the north of Athens, a dozen or so kilometres from the sea, may (and indeed does) cause tragic floods.

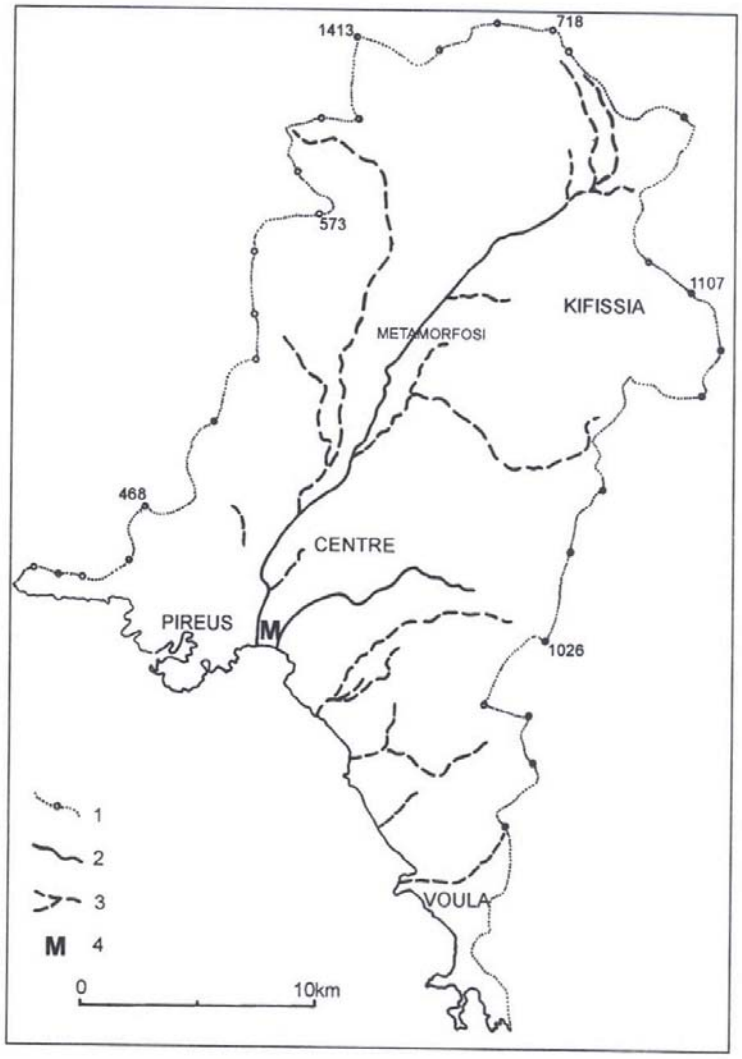

Fig. 7 Drainage pattern in the Attica Basin: 1 – Watershed and main peaks; 2 – Rivers; 3 – Intermittent streams; 4 – Location of the Moschato district

The reasons for such phenomena are primarily attributed to lessened retention caused by deforestation (mainly as a consequence of fires which, particularly in the early 1990s, were a real pestilence) and narrowed riverbeds due to an expansion of housing development. It is assessed, for instance, that only one forest fire in the Chalkidiki peninsula brought about a five times higher denudation rate in the river basins concerned (Poulos et al. 1996, after Theocharopoulos & Angelides 1991).

The latter factor adds to another kind of threat, related to the fact that Greece is a seismic region. This was particularly evident during the 1999 earthquake in Athens, when the partially built-up and levelled valley slopes suffered the most.

According to statistics, forests account for 22% of the country's surface area. This share varies from region to region and ranges from nearly 5% in Crete to over 30% in

Trace (Tab. 2). Areas which are situated in the vicinity of towns and cities and densely populated areas, that is, those which are most likely to suffer from various natural calamities, are subject to most severe deforestation. For instance, in some drainage basins of eastern Attica, the share of forests in the total surface area has decreased (following the 1995 and 1998 fires) from 40–60% to under 10%. Afforestation attempts cannot compensate for such huge losses.

Tab. 2 Regional disparities in woodiness and size of reafforestation in Greece

Regions	Woodiness (1991) [%]	Forest area (1991) [km^2]	Area reafforested in the years 1989–1998 [km^2]
Greater Athens	15	5109	70
Central Greece excluding Athens and Euboea	25		
Euboea	29	2671	30
Ionian Islands	9		
Aegean Islands	14		
Thrace	32	2774	75
Macedonia	26	8921	127
Epirus	26	2380	17
Peloponnese	21	4393	33
Thessaly	20	2743	30
Crete	5	388	11

Source: Statistical Yearbook of Greece 1999

The vast delta plains, which are Greece's agricultural hinterland, are subject to a special kind of threat. The largest such surface is the Thessaloniki Plain, with the three rivers: the Aliakmon, the Axios and the Loudias. Increased denudation caused by man led to the valley's speedy accumulation in historic times. There was a time when the Thessaloniki Bay could be transformed into a lake, with the severing of waterway access to the Thessaloniki harbour.

On the other hand, the construction of dams (about a dozen on the Axios, including one nearly 30 km away from the river mouth; one on the Aliakmon – close to 50 km away from the river mouth) leads to a substantial loss in the material carried into the delta, which in turn leads to erosion processes and consequently to a threat to agricultural areas. Thus far, on nearly 90 km^2 of such land farming had to be discontinued, owing to the encroaching of saline water (Poulos et al. 1996).

The destruction of natural plant cover and the expansion of residential housing into areas which constitute natural runoff for flood water (e.g. valley slopes for intermittent streams) results in other kinds of threat, related to the fact that Greece is a seismic area. The latter factor adds to another kind of threat, related to the fact that Greece is

a seismic region. This was particularly evident during the 1999 earthquake in Athens, when the partially built-up and levelled valley slopes suffered the most, including the collapse of two large industrial facilities in the Metamorfosi borough.

Conclusion

In view of these considerations, the inherent character of the natural environment should never be underestimated, and the specific type of the morphogenetic system should be taken into account while taking economic decisions. In the case of fluvial and denudation relief, riverbeds should remain under special protection.

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