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Citizens' Perspective on Coastal Erosion in Greece

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Abstract: Coastal erosion is a major coastal hazard in Greece. This work aimed to assess the perceptions of citizens about coastal erosion. We developed a questionnaire containing 25 questions that was distributed online and filled out by 1636 respondents. A surprising find was that 33% of the respondents were not aware of the phenomenon of coastal erosion. On the other hand, among those respondents who are aware of coastal erosion, there is a basic understanding of the major factors promoting erosion and its impacts. Responses also highlighted a lack of information and awareness from the media and public authorities, while the vast majority considered that protecting the coast from erosion should be important or a priority. Our findings stress the need for awareness-raising activities about this important natural hazard.

Keywords: coastal hazards; questionnaire; geographic information systems; society; Mediterranean; public opinion

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1. Introduction

The coastal zone has been inhabited by humans since ancient times due to the multiple ways they benefit from it, for instance, when it comes to food and other resources, habitation, and agriculture [1–3]. Its utilization has increased nowadays due to industries and trading [4,5].

In the last few decades, the aesthetic value of the coastal zone has also been recognized. The coasts are a main tourist attraction in most countries. It is worth mentioning that according to the United Nations World Tourism Organization [6], tourism accounted for 10.3% of the global gross domestic product and 10% of the global workforce. In the European Union, coastal tourism is the most important tourist sector [7].

At the same time, due to the benefits described above, the coastal zone is one of the most densely populated areas globally. An estimated 40% of the global population, that is, roughly 2.5 billion people, has been calculated to live at a distance of less than 100 km from the sea [8]. As a matter of fact, 20 out of the 33 cities whose population exceeds 10 million inhabitants are coastal ones [9]. 37% of the global population was estimated to reside in the coastal zone by 2017, but this has increased presently [8]. Recent studies have estimated that by 2041–2060, the global population of low-altitude coastal areas will reach 1 billion people [10,11].

In other words, the coastal zone houses three different and essential aspects of human activities: the activities themselves (tourism, trading, resource exploitation, etc.), the built environment (settlements, industrial facilities, touristic facilities, transportation, facilities for network, water, electricity, and other services, etc.), and the institutions and entities responsible for them (law, government, culture, etc.) [12]. The increased habitation and other human activities in the coastal zone led to a proliferation of exposure to the corresponding hazards, coastal erosion among them, which means that their impacts on coastal communities and society will increase in the future [11]. By 2050, the number of people threatened by coastal hazards is expected to exceed one billion [11].

Coastal erosion is the permanent removal of coastal material from the coastal zone, resulting in the shoreline's retreat and the progression of the sea landward, and can be a long- or short-term natural process [13]. It consists of two regimes, namely erosion of beaches and erosion of coastal cliffs. Regarding the former, it is the result of a negative equilibrium between the total amount of sediments that are deposited in the coastal zone and that of the sediments that are removed from it. Coastal erosion is driven by many factors, both natural and anthropogenic ones [14]. When it comes to the natural processes that cause it, some of them include biogenic activity, but primarily wave activity and coastal currents [15–17]. While normal waves contribute to a significant extent to the erosion of the coasts, storms and storm-induced waves are among the most important factors in coastal erosion [18–20].

Based on that, coastal erosion is highly affected by the climate and the properties of the coastal zone, that is, the morphology, composition, and sedimentary characteristics of the coastal sediments or cliffs, etc. [15–17]. What is more, a coast's exposure to wave activity is a key factor controlling its susceptibility to coastal erosion. A beach that is characterized by higher wave activity (or, correspondingly, a higher extent of exposure to the waves) is more susceptible to coastal erosion [21].

As far as the anthropogenic causes of coastal erosion are concerned, some of the most important human activities that provoke and/or accelerate coastal erosion include sand extraction from rivers and beaches, the construction of dams, coastal constructions (breakwaters, jetties, sea walls, rock walls, groins, etc.), and groundwater overpumping, which often results in land subsidence [22]. However, such interventions only have a local or regional impact on the coastline. The indirect, yet most important, human intervention increasing coastal erosion is climate change [23,24].

It is important to mention that coastal erosion due to climate change has two aspects: storm and tsunami-induced coastal erosion, which takes place rapidly, and global sea-level rise, which occurs at relatively low rates [13]. It is also important to clarify that coastal erosion can potentially become a hazard rather than a natural process when society fails to adapt to it, for example, when a community is established in a low-lying coastal area.

Coastal erosion is a problem faced by many countries globally [25–29]. A significant proportion (31%) of the global sandy coasts lying at a low altitude host a population density that exceeds 500 persons per km^2. According to Vousdoukas et al. [30], 13.6–15.2% of such coasts, or equally, a coastline length of 36,097–40,511 km, is expected to face serious problems of coastal erosion by 2050. 70% of the coasts globally are already undergoing erosion [13,31].

The global sea level has been rising at rates in the order of 1 mm per year over the last 6000 ka [32,33]. However, based on satellite images and GPs measures, this rate has been shown to have increased due to climate change [34–37] and is expected to increase even more [11,38], as it is associated with thermal expansion, ice melting, and changes in land water storage [35].

The coastal zone is very sensitive to sea-level rise [35,39,40]. More specifically, sea-level rise has been shown to increase coastal erosion [35] and is expected to accelerate it even further in the future, with negative impacts on ecosystems, human residence, infrastructure, food resources and security, and cultural and natural heritage [11]. The main reason for this is that the more the sea level rises, the higher the proportion of the coastal zone that is affected by wave activity and coastal currents. Moreover, climate change has resulted in an increase in wave activity and currents [41–45]. It is clear that the most vulnerable areas to coastal erosion due to human interventions, climate change, and sea-level rise are coastal, low-lying cities, deltaic regions, islands, coastal wetlands, etc. [11,35,46]. It is also clear that climate change and the consequent future sea-level rise and coastal erosion will pose a great threat to many coastal communities and any other type of human activity that takes place in the coastal zone, such as industries. The most typical consequences of coastal erosion with regard to human activities include property loss, irreversible damage to infrastructure, and forced migration [47–49]. Finally, the sea-level rise and the consequent coastal erosion

are expected to affect global tourism as well, which in turn will have a very negative impact on the global economy [50–52].

Many measures have been taken in many coastal areas to prevent coastal erosion. Such measures include either hard or soft engineering ones [45,53,54]. Hard engineering methods include jetties, sea walls, rock walls, groins, gabions, and breakwaters. These methods are usually effective at a local scale, but they have a significant impact on the coasts' sedimentation and morphodynamic regime, which usually causes a nearby coastal zone to be eroded [55–57]. Moreover, they are very expensive to construct as well as maintain, and they are also highly unaesthetic [53,54].

Soft engineering methods are characterized by a lower cost compared to the previous category, whereas they have been proven equally effective (and in some cases, even more effective) than hard engineering measures, as they have been shown to aid in the widening of the beaches where they are applied as well as nearby beaches [53,54]. At the same time, they can attract more tourists without negatively affecting the aesthetics of the coastal zone. Their main drawback is that they are not always applicable and/or efficient.

As far as Greece is concerned, its coastline roughly reaches a total length of 15,000 km, 60% of which belongs to the Greek mainland and the rest to the insular part of the territory [58], rendering it one of the countries with the longest shoreline in comparison to its area. More than half of the shorelines are rocky, composed either of hard (44%) or soft rocks (14%), while a very low percentage (6%) are mud coasts. The rest of the shoreline is composed of beaches (36%) [59]. Coastal erosion is a major problem in Greece, as almost one third of its coastline (28%) is subject to erosion, with general rates in the order of 0.3 to 0.5 m per year [60]. More specifically, the highest percentage is found in the Cyclades and the Dodecanese, where 26% of the islands are subject to coastal erosion, followed by the islands of the Northern Aegean (15%), Central Macedonia and Attica (10–11% each), northern Crete and East Macedonia-Thrace (6% each), and the Peloponnese (4%) [60]. Several studies have taken place in Greece for the study of coastal erosion, e.g., [61–66]. Alexandrakis et al. [63] applied the coastal vulnerability index (CVI; [67]) to the entire coastal zone of Greece, taking into consideration an expected sea level rise of up to ~40 cm by the year 2100 and estimating high vulnerability for 60% of the Aegean coast and very high vulnerability for the remaining 40%. A recent study by Tragaki et al. [66] assessed the vulnerability of the coasts of the Peloponnese to coastal erosion and estimated that 17.2% of the shoreline is characterized by high or very high vulnerability. Similarly, Vandarakis et al. [61] estimated that 40% of the coastal zone of Rhodes Island is characterized by high or very high vulnerability.

In this context, the aim of this work was to understand the public's perception of coastal erosion, their knowledge of this natural hazard, and their perspective on awareness levels. For this purpose, we developed a questionnaire that was distributed electronically. Responses are analyzed and discussed to assess the level of citizens understanding of coastal zone issues.

2. Materials and Methods

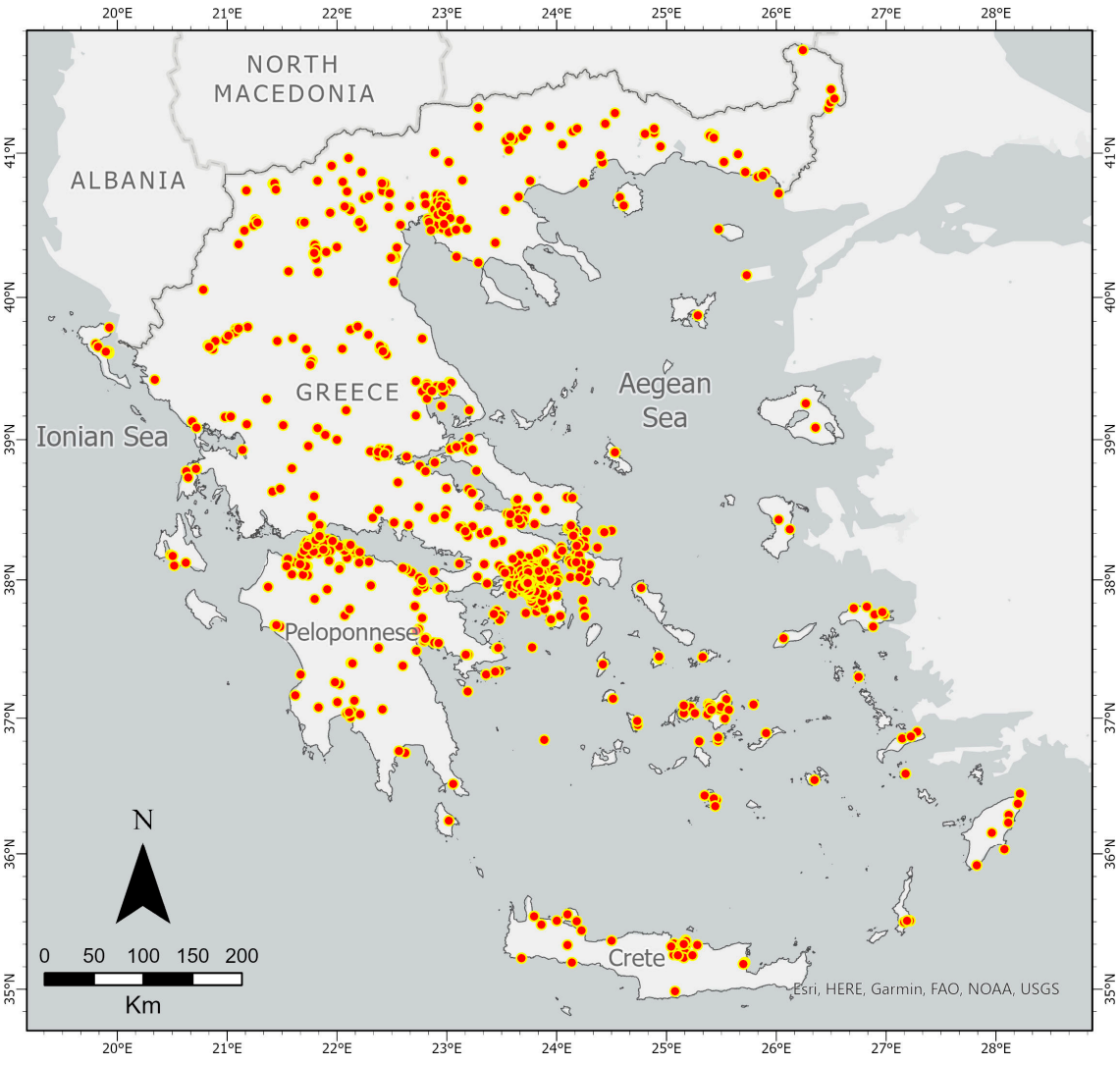
To analyze the public's perception of coastal erosion in Greece, we developed a GIS-based questionnaire that included 25 questions. The questionnaire was developed using the online tool ArcGIS Survey123. It was composed of 25 questions in Greek; the first part of the questionnaire contained questions to obtain demographic information for the participants; the second part contained questions to understand their relationship to the beach; and the third part assessed their knowledge and awareness of coastal erosion hazards. The questionnaire is provided in English in the Supplementary Materials.

The questionnaire was distributed electronically using various social media networks during the period of March 2021 to December 2022. Given the fact that we were able to follow the number and distribution of participants throughout the survey period through the online web map, we tried to cover the entire Greek region. For this reason, when neces-

sary, we also contacted local journalists throughout Greece to distribute the questionnaire through municipal websites, local journals, and webpages.

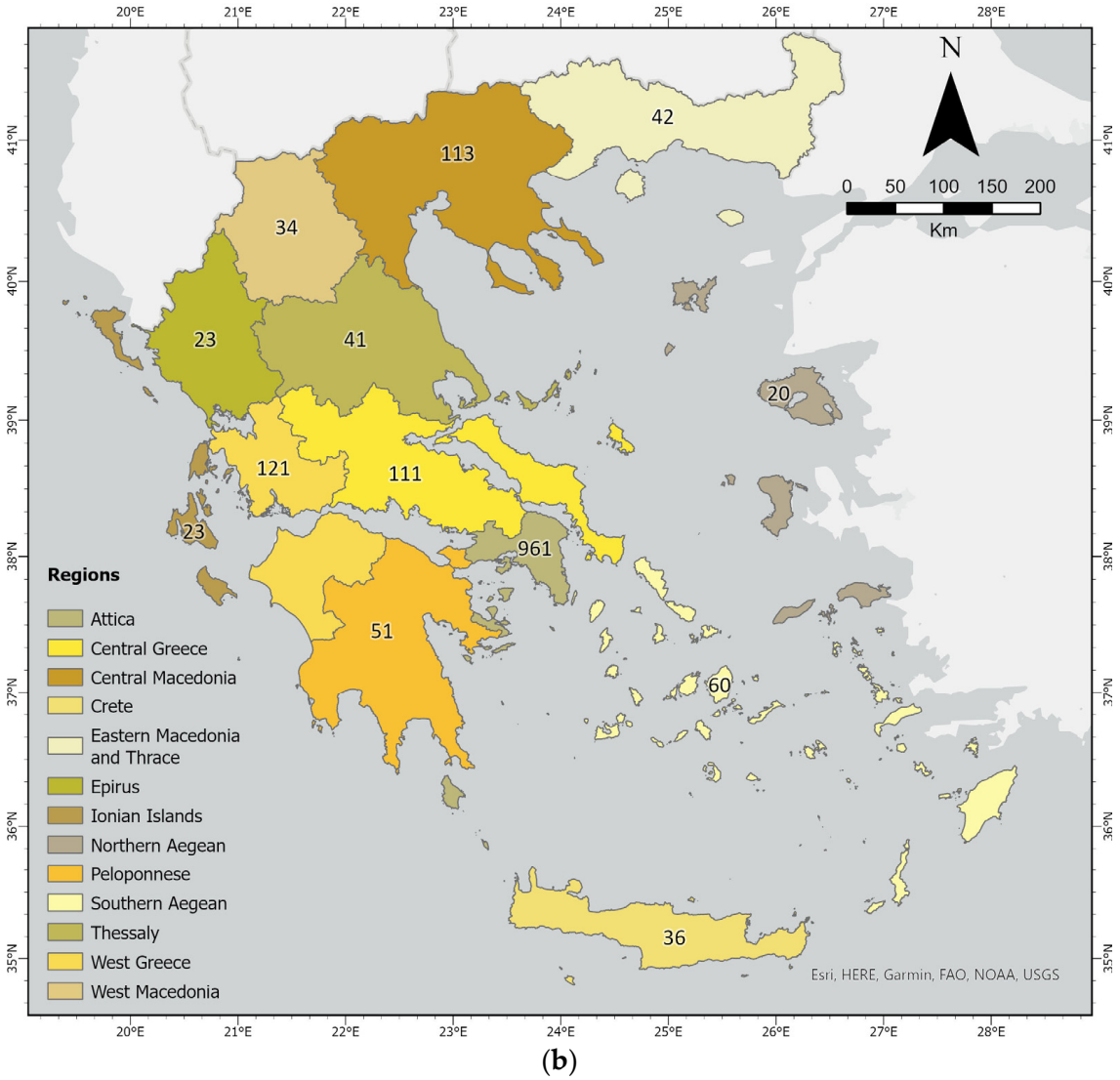
3. Results

In total, the questionnaire received 1636 responses, with a good geographical distribution (Figure 1). Regarding the participants demographics, 67.8% of the respondents were women and 32.2% were men. In terms of age range, 26% of respondents were below 25 years old, 10.1% were in the age range 26–35, 16.5% were between 36 and 45 years old, 32.5% were between 46 and 55 years old, and 14.9% were older than 55 years. The vast majority of participants, i.e., 90%, have a higher education level (Figure 2). 9.4% of participants are high school graduates; 2.6% have an after-high school education; 52.6% have a bachelor's degree; 30% have a master's degree; and 5.3% have a doctoral degree. Among the participants, 35.9% stated they have professional training related to environmental sciences.



(**a**)

Figure 1. *Cont.*



(**b**)

Figure 1. (**a**) Distribution of participants who answered the questionnaire; (**b**) number of questionnaires answered in each region of Greece.

Regarding the participants' relationship to the beach and frequency of visits, the vast majority are local visitors or tourists. In fact, 29.2% of respondents are permanent residents, 60.4% are local visitors, and 48.5% are tourists. During the summer, 37% of respondents visit the beach every day, 35% 2–3 times per week, 12.5% once a week, and 11% visit the beach 1-2 times per month. Half of the participants (55.3%) also visit the coast during the winter. The main activities are swimming and walking (>70%), while other activities such as camping, fishing, etc. have a percentage smaller than 5%.

The next important question was whether the participants knew about the phenomenon of coastal erosion. 67% of the respondents stated yes, 14.1% replied no, and 18.9% stated they were not sure (Figure 3). Among the various age groups, it seems that older age groups were more aware of coastal erosion as the positive responses increased. At ages below 25, 55.4% of participants stated they knew about the phenomenon of coastal erosion. At ages above 55, 79% declared they were aware of the phenomenon. A similar trend can be noted for the education level of respondents. Based on the responses, the higher the level of education, the higher the percentage of participants who know about the phenomenon of coastal erosion. The percentage is 55.4% for those with a high school degree and reaches 86.5% for those with a PhD. Permanent residents responded positively to their awareness of coastal erosion phenomena by 75%, local visitors by 65.6%, and tourists by 60.2%.

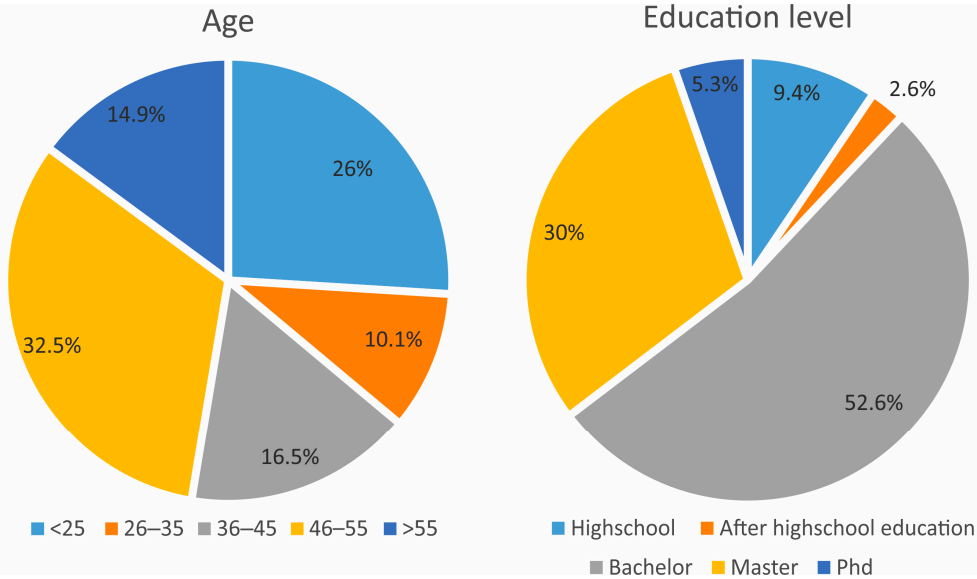


Figure 2. Age distribution and education level of participants.

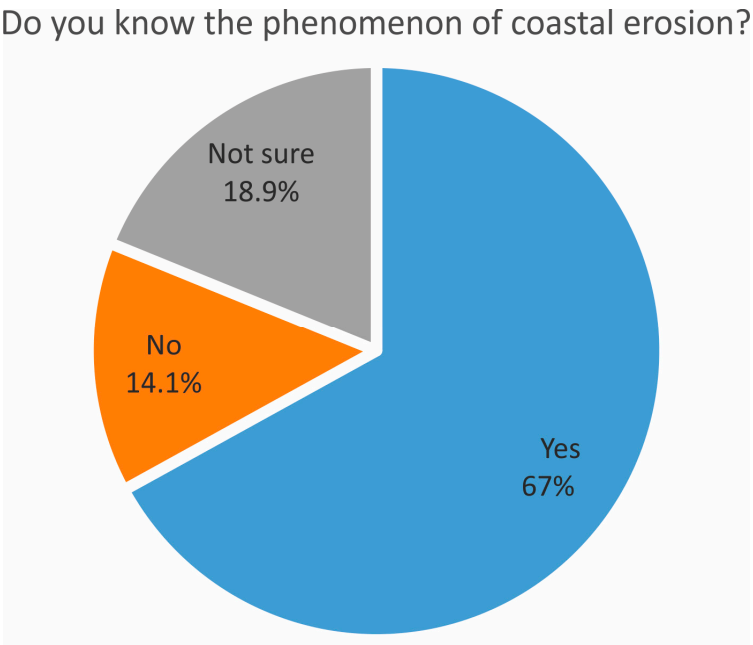


Figure 3. Among the participants, 67.7% are aware of the phenomenon of coastal erosion.

Regarding the factors responsible for coastal erosion, participants could select more than one choice; they consider climate change among the significant ones by 65.3%, followed by constructions on the coastal zone by 42.7%, interventions of private individuals by 41.9%, material removal by 36.7%, and indifference of local administration by 33.6% (Figure 4). Among those who did not opt for climate change as a factor responsible for coastal erosion, they considered material removal and construction on the coastal zone among the main factors.

Regarding the main problems caused by coastal erosion, the degradation of coastal ecosystems received 75.8% of responses, followed by loss of natural beauty with 52%, loss of land with 44.7%, and loss of benefits to the local community from tourism with 26%, while 8.8% of respondents stated they did not know.

Respondents were also asked to comment on whether they have noticed changes on the beaches they have visited for a range of years. 19.5% noticed changes in the last

1–2 years, 41.1% in the last 5–10 years, 14.1% in the last 10–20 years, and 4.5% in the last 20–30 years, while 20.7% stated they had not noticed any changes. Among those who have noticed changes, 46.7% selected coastline retreat, 45.2% construction of infrastructure (walls, docks, restaurants, paths, etc.), 41% loss of sand, and 25% construction of protective works (breakwaters, sea walls, etc.).

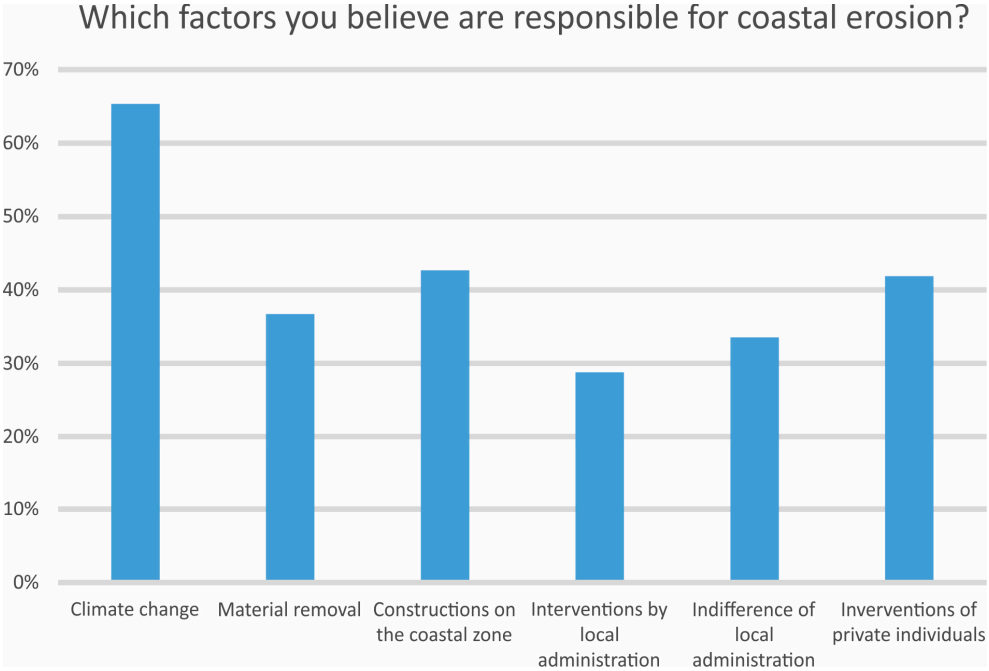


Figure 4. Participants' responses regarding the factors responsible for coastal erosion. They could select more than one answer.

Regarding the measures the state should take to control or prevent coastal erosion, installing a monitoring system was considered very important by 42% of the respondents, followed by the prohibition of sand extraction by 41.8%, installing protective works by 33.6%, and limiting touristic activities by 13.2%.

A total of 95.4% of the participants consider that the protection of the coast from erosion should be a priority or important, with only a small percentage (1.8%) considering it not important or answering, "I don't know" (2.8%).

Respondents were also asked their opinion on beachrocks. A total of 62.6% of the respondents stated they have noticed beachrock formations; 23% have not seen them, and 14.2% were uncertain. Participants were also asked how they felt about this coastal formation. A small percent (10.9%) responded that they would like to destroy such a beachrock slab for easy access. 63.7% suggested maintaining the beachrock slab, covering it with sand, or even taking preventive measures to avoid destruction (Figure 5).

To understand the participants' perception of natural hazards in general, they also responded to their concern about fires with 45.8%, earthquakes with 36.7%, tsunamis with 28.4%, landslides with 19.4%, and coastal erosion with 14.1%.

The participants were also asked to assess the level of information and warnings from the responsible authorities and media on coastal erosion. 56.6% of respondents consider that media information on coastal erosion is increasing, while 13.5% consider it to be stable (Figure 6). The level of information and warning from the responsible authorities on coastal erosion is considered adequate by 7.3% of the respondents, while 80.3% of the participants consider they have insufficient or very insufficient information.

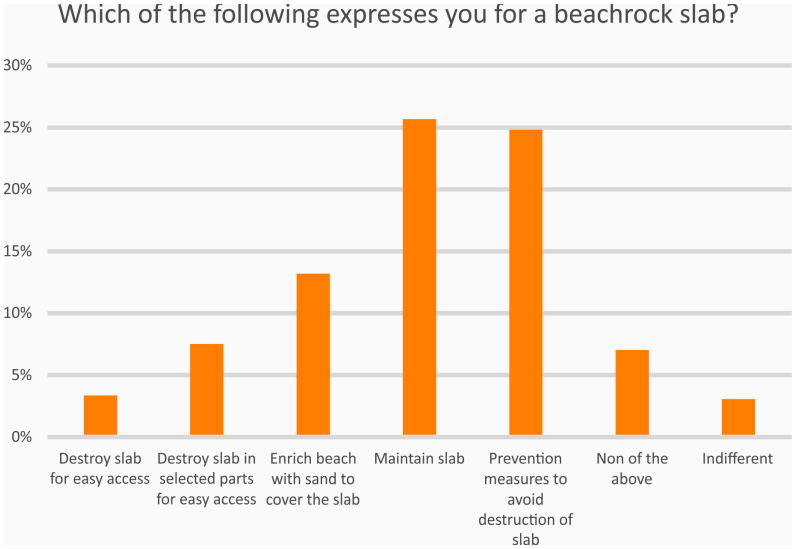


Figure 5. Participants' responses regarding the presence of beachrocks on the coast.

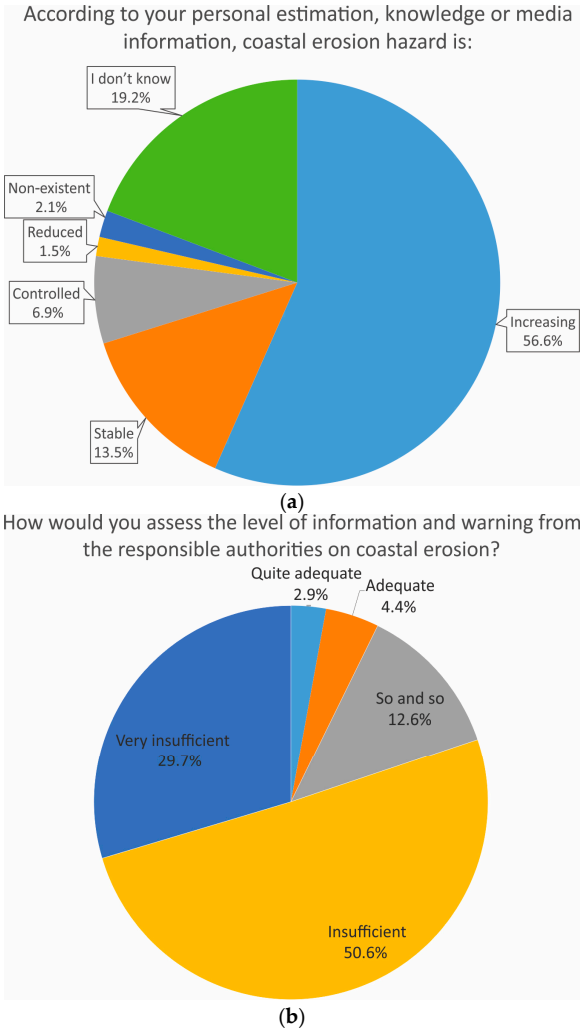


Figure 6. Participants' responses regarding the level of information on coastal erosion issues (**a**) from the media and (**b**) from the responsible authorities.

Finally, participants were asked how they would react if they were on the beach and noticed some researchers with measuring equipment, in order to assess their interest. 75.6% of the respondents claimed they would be interested in their research and approach them; 9.5% would not care; 1.5% would be bothered by their presence; and 13.5% would not do any of the choices offered.

4. Discussion

As already noted, coastal erosion is a major coastal hazard in Greece. Our results show in general that citizens are more concerned about natural hazards such as fires and earthquakes. Diakakis et al. [68] in a study on the public's perception of flood risk in Greece had similar findings, where earthquakes and forest fires were ranked before floods. This should not come as a surprise, as such events are usually sudden, and even when they are not directly experienced by citizens, they have extensive coverage by the media. Coastal erosion, on the other hand, may often be a more long-term process, and its impacts may concern those who have direct experience with the phenomenon. In addition, citizens tend to worry about uncontrollable and catastrophic events that lead to loss of life in comparison to other events that are related to smaller losses [68].

Given the fact that Greece has a coastline of 15,000 km [58], which is the longest coastline in the Mediterranean Sea Basin, it is surprising that 33% of the respondents were not aware of the phenomenon of coastal erosion. An analysis of the responses suggests that there is a relationship between the age of the participants, their education level, and their knowledge of the coastal erosion phenomenon. Alves et al. [69] had similar findings in a study they performed on coastal erosion perception in Cadiz (Spain), concluding that the higher the education level, the higher the degree of coastal erosion awareness.

In our case, this fact may be related to a lack of environmental awareness, and it may also be related to the fact that the vast majority of participants (80%) considered that responsible authorities provide an insufficient level of information on coastal erosion. This lack of awareness often leads to poor behavior in the coastal zone, as it is often also taken for granted. For instance, uncontrolled tourist development on coastal dunes leads to their leveling and consequent destruction [46].

Regarding the causes of coastal erosion, there seems to be awareness of climate change and its effects based on the responses, as 65% of the participants have chosen climate change as one of the factors affecting coastal erosion. It is also evident that citizens are aware of the impacts various human interventions may have on the coastal zone. Based on the participants responses, some participants consider human interventions (in various forms) to be the main factors in coastal erosion. This agrees with the findings of Tourlioti et al. [70], who assessed residents' knowledge and perceptions about coastal erosion on Lesvos Island. This can also be linked with the respondents' answers regarding changes they have noticed on the beaches they visit. 42% have stated they have noticed changes in the last 5–10 years. Among these changes, the prevailing answers included coastline retreat, loss of sand, and construction of infrastructure. The main drivers of coastal erosion in Greece are human activities, the most representative ones being the intense coastal development due to trading and tourism, the construction of dams, and the channelization of rivers [60]. Moreover, as many parts of the Greek shoreline are low-lying, they have been affected by the impacts of climate change [63]. Some of the most typical coastal areas in Greece that are subject to erosion due to human interventions include Diolkos, Corinth [71,72], Marathon, Attica [73], the coasts of Rhodope Prefecture [74], the broader area of Alexandroupolis harbor [75], the delta of the Nestor River [76], and the Cyclades [46,77].

An impressive 96.3% considered that protecting the coast from erosion should be important or a priority. Many respondents consider installing a monitoring system on an annual basis as a means for coastal erosion control or prevention by the state. Many participants also considered the prohibition of sand extraction as a very important action, followed by the installation of protective works such as breakwaters.

Respondents were also asked their opinion on beachrocks, a "controversial" formation in the coastal zone. Beachrocks are known to act protectively against coastal erosion [78]. At the same time, they are often regarded as an obstacle to swimmers' easy access to the sea. As a result, they are often removed by local authorities to facilitate residents, and hence the hosting beaches are subject to erosion. This is a common practice in many coastal areas across Greece. 62.3% of the respondents stated they have noticed beachrock formations and were asked how they feel about this coastal formation. A small percentage (10.9%) responded that they would like to destroy such a beachrock slab for easy access. 63.7%, however, suggested maintaining the beachrock slab, covering it with sand, or even taking preventive measures to avoid destruction.

An interesting find in our research is the interest of respondents regarding research on the coastal zone, as 75.5% stated they would approach researchers with measuring equipment on the coastal zone. This suggests that many citizens would be interested in and would benefit from some educational or awareness activity, as they would gain knowledge and understanding of how the coastal system works.

Overall, it seems that among those respondents who are aware of coastal erosion, there is a basic understanding of the major factors promoting erosion and its impacts. At the same time, there is a lack of information and warnings on this hazard from the responsible authorities, leading to inadequate education for those who have no knowledge of coastal erosion.

Our findings stress the need for awareness-raising activities about this important natural hazard. Considering that age and education level play a role in coastal erosion awareness, it is evident that education is fundamental to conveying information and knowledge. Awareness activities should take place at all levels of education, with a particular focus on primary and secondary education. Teachers' education in the natural environment and geosciences should be a priority, and they should aim for activities that will provide them with the tools to educate their students accordingly. Interactive activities can play a significant role, especially those that take place outdoors [79]. When outdoor activities are not feasible, other tools can be useful, such as virtual trips [80]. However, awareness and information activities should not be limited to one target group. A study by Koutrakis et al. [81] on public stakeholders' perceptions of Integrated Coastal Zone Management (ICZM) and coastal erosion in the region of East Macedonia and Thrace (see Figure 1b) showed a lack of knowledge about the coastal zone and aspects of ICZM. It seems that it falls into the responsibility of the coastal scientific community to act and develop the necessary actions and tools to increase awareness of the vulnerability of the coastal zone. However, local authorities should work with scientific bodies to effectively disseminate knowledge and not only address people who already have an awareness background. Onsite educational activities addressed to various target groups, including citizens, teachers, stakeholders, and municipalities, should be a priority, and involved parties should make an effort to publicize these activities to the media as well.

5. Conclusions

The aim of this work was to understand the public's perception of coastal erosion. For this purpose, we developed a questionnaire that was distributed electronically and was filled out by 1636 participants, with a very good distribution across the Greek territory. The vast majority of respondents have a background in higher education. Our findings show that 67.7% are aware of the phenomenon of coastal erosion and have a basic understanding of the major factors promoting erosion and its impacts. However, responses also highlighted a lack of information and awareness from the media and public authorities, a fact that stresses the need for increased educational activities for this hazard.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/geosciences13070191/s1.

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