# An Aegean island earthquake protection strategy: an integrated analysis and policy methodology

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*Viewing an insular setting as a distinct risk environment, an effort is made here to develop a methodology for identifying core issues related to earthquake risk and disaster protection policy, adjusted to the 'specificities' of such a context. The methodology's point of departure is the inherent condition of the 'island operating as a closed system', requiring an attempt to assess and optimise local capacity (social, political, economic, institutional and technical) to deal with an earthquake emergency. The island is then treated as an 'open system', implying that in the event of a disaster, it should be able to maximise its ability to receive and distribute external aid and to manage effectively population evacuation and inflows/outflows of aid resources. Hence, an appropriate strategic policy approach could be developed by integrating the 'open' and 'closed' system components of an island setting. Three islands from the Aegean Archipelagos in Greece—Chios, Kos and Nissyros—serve as case study areas.*

**Keywords:** copying capacity, earthquake protection, islands, vulnerability

## Introduction

This paper aims to highlight the distinctiveness of islands as a unique risk context and the implications that this has for protection and safety policy issues. Clearly, our attempt, which focuses on an all-encompassing event, the earthquake, falls within the wider problematic of seeking to construct a multidisciplinary and multidimensional methodological approach to disaster analysis and safety policymaking (Bankoff, Frerks and Hilhorst, 2004; Blaikie et al., 1994; Hewitt, 1997; Mitchell, Devine and Jagger, 1989). The aforementioned problematic has, among other things, led to enriching notions such as vulnerability, hazard, risk and resilience, and to the production of widely accepted terms of reference and policy tools (ISDR, 2003; UNDP, 2004). Thus, disaster is viewed here as an end product of a complex interplay of the different physical, socio-cultural, economic, organisational and governance features of an insular area and the characteristics of natural events (Pelling, 2003a; 2003b). This perception implies a notion of seismic safety that could be accomplished through the continuous progression of analysis, goal achievement and priority redefinition at all planning levels (AREL, 1984; Delladetsima, 1997; Burby, 1998).

 
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Given the distinct risk context of an insular setting, planning for disaster contingencies cannot involve the adoption of the same terms and criteria as for inland regions. Isolation, transport accessibility and population features are the most important domains in structuring an island protection policy. Consequently, 'earthquake risk in an Aegean island context' implies, above all, the need to deal with a variety of spatial insular typologies, and it is predominately defined by two major sets of parameters:

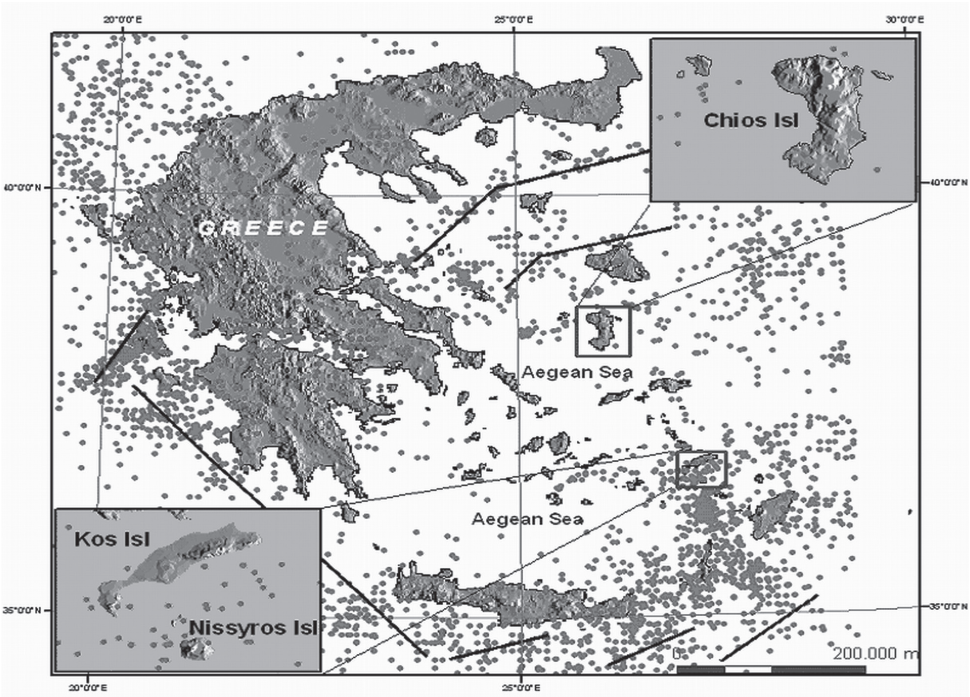
- the geographical uniqueness—by definition—of the island, arising from its inherent physical and socio-economic characteristics as shaped by the conditions of remoteness, isolation and self-sufficiency; and
- the exceedingly unpredictable and all-encompassing hazard in the Aegean: the earthquake; accompanied by a multiplicity of secondary hazards such as, landslides, submarine landslides, volcanic eruptions and tsunamis (Papanikolaou, 2004).

These sets of parameters can have decisive impacts on the extent and intensity of a seismic disaster in an insular area. They also determine the post-seismic response and recovery patterns and the type, scale and duration of external support. To address these issues in more depth, three islands of the Aegean Archipelagos serve as case study areas: Chios, Kos and Nissyros (see Map 1). The Aegean Archipelagos comprise more than 100 inhabited islands—out of a total of approximately 1,000—which vary in terms of their size, geomorphology, seismicity, demography, built environment, and urbanisation and development patterns. Moreover, with regard to the Aegean Archipelagos, and the Greek islands in general, a prime common characteristic is that the vast majority of the islands have a diverse range of earthquake disaster experience. Consequently, there have been cases during Greece's post-Second World War seismic history of earthquakes affecting islands and causing massive devastation and out-migration flows—the Ionian Islands in 1953, Santorini in 1956 and Agios Efstratios in 1968. In addition, earthquake hazards have impacted disproportionately on small islands compared to bigger ones (or to mainland regions). What is more, small islands have received far less attention vis-à-vis their recovery policy and media coverage. This was the case, for instance, with the island of Agios Efstratios following the 1968 earthquake disaster.

Nowadays, disaster effects are not as dramatic as in the past. What has become more revealing, however, are the different chain effects on the insular economies. The island of Lefkas, for example, was affected by a catastrophic event (Ms[1]=6.4) on August 14 2003 (Anastasiadis et al., 2004, pp. 1–7). The island received an injection of exceptional reconstruction/repair funding amounting to EUR 29,450,000 (Ministry of Environment, Physical Planning and Public Works, 2005) from the central state. Despite this, however, in the following year it experienced significant negative effects on the local economy, especially a reduction in incoming tourist flows (Ministry of Environment, Physical Planning and Public Works, 2005).[2]

Contrary to this, there are also islands that have managed to absorb less costly catastrophic earthquake effects. This has been the case with the island of Skyros, which was hit by an earthquake (Ms=6.1) on 26 July 2001 (Earthquake Planning and Protection Organisation, 2001). The earthquake caused considerable damage to the main town,

**Map 1** Earthquake epicenters (Ms>5) in the Aegean Sea and location map of the islands of Chios, Kos and Nissyros




**Source:** National Observatory of Athens

triggering landslides, among other things, and generating long-term water supply problems due to the decline of the water table.[3] Yet the island has managed to recover very fast, as a result of the high concentration of the damage in the main town, leaving the main infrastructure and tourist installations virtually unscathed.

Hence, the earthquake is a hazard that has critically affected the history of the Greek islands and the Aegean in particular, shaping distinct vulnerability conditions and response patterns and tailoring variable local mitigation practices.

The islands selected as case studies (Chios, Kos and Nissyros) are highly diversified insular areas in relation to their size, history and development patterns. Moreover, all three have a long history of earthquakes,[4] having experienced maximum intensities of VII to XII MMS[5] over the past 500 years.

## Islands as distinct research and policy milieus

Islands are highly diverse entities that exhibit vast differences with respect to their own internal geographic structure (between districts of the same island) and even more relative to neighbouring isles. This may well be the reason that research and documented policy patterns (of relevance here) appear disjointed, have varying points of focus, and attract disproportionate degrees of attention. Insular entities are mostly found in research and policy works on specific natural hazards (Gamble, 2001; Heliker, 1990) and are associated with developmental/environmental approaches that seek, for instance, to construct vulnerability indices and policies (Haitink, 1998; Briguglio, 2000). In general, the island risk context has been revealed primarily in cases where insular regions are a core characteristic of a country as whole (Pelling 1998). Thus, it would seem that a more coherent body of research and policy practice tends to stem mostly from the field of 'island states'[6] (Lewis, 1990), rather than from island regions belonging to broader state entities, which is our main concern here.

Indicative in this respect is the fact that a most pertinent work on island vulnerability, Pelling and Uitto, 2001, also focuses on small island states. It could be argued, therefore, that there is a relative underestimation of 'island regions' compared to 'island states' in disaster research and policy, which is also evident in the policies of international institutions and in particular of the European Union (EU). Only in the late 1990s did the EU begin to see the island regions of member states as distinct risk entities. This has gradually raised awareness of the need for natural hazard safety policies,[7] which in consequence provided the impetus for the launch of a number of EU initiatives[8] on the risk element of island settings. 'Europe has many islands, and it is of utmost importance to address their needs in a targeted manner and include them in any national risk management plan.

From the vulnerability standpoint, the particularity of islands is that they have to face many combined types of hazards on a small territory (Vetere Arelano et al., 2004, p. 14). Hence, to our knowledge, although growing research and policy emphasis is now undoubtedly placed on islands as risk contexts, consistent interest is relatively new. In all likelihood, for this reason, information on adopted analytical tools, policy practices and institutional developments in insular regions, remains scattered and relevant documentation is not widely accessible.

## Island features affecting seismic vulnerability

The key question that arises at this point is: what are the distinct features determining an island risk context and how do they influence an earthquake disaster situation? The cases of Chios, Kos and Nissyros shed light on some of these features (see Table 1); in other words, the case study islands exhibit wide diversities in relation to distinct characteristics such as their demographic composition, human geography (especially variations between summer and winter periods), settlement structure and building stock, accessibility/transport conditions and adopted emergency plans, in combination with the local coping capacity or response potential (as this is defined by their administrative adequacy, their available critical resources and evacuation plans and their ability to administer external aid). The three selected islands seem to elucidate a wide range of island typologies[9] and for this reason their study can enlighten the assessment of an overall insular risk situation.

**Table 1** Main features of the case study islands related to seismic vulnerability and emergency response capability

| | Island of Chios | Island of Kos | Island of Nissyros |
|---|---|---|---|
| Administrative level | Prefecture capital; with various municipalities. | Sub-prefecture capital; with municipalities. | Local authority. The island is a municipal unit. |
| Demographic composition | Large percentage of dependent and elderly members of the population in the island's hinterland. | Young demographic structure and foreign population permanently residing on the island. | Very high percentage of elderly members in the population structure. |
| Human geography | Population increases during summer months mostly connected to people of local origin; they do not permanently reside on the island. High degree of population concentration in the main town of Chios. | Extraordinary population rise during the summer months due to tourism.<br>Fairly balanced settlement growth and population distribution. | Marked population increases during the summer months, especially highly mobile daily visitors. |
| Building stock and settlement structure | There is one main, dominant urban centre and a vast number of declining smaller settlements, with aged building stock, in the hinterland. | Balanced settlement structure with new building stock.<br>Large numbers of big hotel units scattered all over the island. | Old building and poorly maintained stock.<br>Buildings constructed using local systems. On the whole, settlements, with aged building stock. |
| Accessibility / transport conditions | The island has a port and airport. Fairly good road network, but some of its segments are highly problematic.<br>Efficient airport coverage. Existence of an important complementary port installation in the west of the island. A prevailing highly problematic connection between the main port and the core town of Chios. | The island has a port, airport and good road network.<br>Highly efficient airport coverage. There is, however, no second port installation. In addition, the island is characterised by a problematic connection between the main port and the core town of Kos. | The island has a port and heliport, but a deficient road network.<br>Nissyros suffers from a severe lack of external transport connections, particularly during winter months. |
| Emergency institutions | The island possesses all prefecture/regional and local authority institutions and services. It also has a major hospital unit. Of relevance is the extended role of the army in service provision during normal and emergency periods. | Kos has a rather efficient administrative structure. The island provides some (as a sub-prefecture) regional authority institutions/services and all local authority ones. It relies a lot on the extended role of the army in emergency situations. The hospital unit is small in relation to the scale of demand. | Huge service deficiencies. There is an absolute dependence on the adjoining island of Kos. |

## The methodological approach

All of the above-mentioned features have a marked geographic/physical dimension as well as a social/organisational one. It is through this conjunction that an effective vulnerability risk analysis and seismic safety protection policy methodology can be constructed. Vulnerability, as Pelling (1998) points out, consists of physical and social components. 'Physical vulnerability refers to weaknesses in the structural fabric of the city, such as inappropriate standards for housing construction or the inequitable distribution of physical infrastructure. Physical vulnerability is an outcome of patterns of social vulnerability, an area of concern that has rarely been approached by urban planners, politicians or academics. Social vulnerability is shaped by peoples' means of access to and mechanisms in the distribution of economic resources, political rights and social claims (Pelling, 2001, p. 4). This dialectic relation between physical and social vulnerability assumes particular importance in the determination of overall island – human vulnerability, taking into account the distinctiveness of the insular environment.

One needs to stress, however, that, in a study of island earthquake protection, the investigation of physical vulnerability as a starting point might prove to be a highly complex task. In principle, it must involve—as a prerequisite—quantitative seismic risk assessments, which in turn presuppose on the one hand, thorough seismic hazard estimations on an appropriate scale, and on the other, precise physical vulnerability assessments of buildings and infrastructure. There could be many island cases, though, where the available seismological/geological data and/or building infrastructure inventories are not of the required level of reliability. Moreover, a vulnerability assessment of historic assets, buildings constructed using local systems and entire settlements if carried out could itself necessitate a series of research projects. In addition, a detailed seismic risk assessment would require considerable effort and resources (not often available) and would have little to contribute to the urgently needed actions that have to be implemented to tackle the noticeable critical risk and vulnerability problems of insular Aegean settings.

Nevertheless, the analytical/operational method that this paper seeks to construct, should allow for appropriate flexibility to incorporate from a medium- or long-term perspective a quantitative seismic vulnerability assessment in order to produce a portrayal of the spatial distribution of anticipated damage (Earthquake Planning and Protection Organisation, 1998; Dandoulaki et al., 2006). This should be viewed as complementary to approaches that seek to identify social vulnerability, which in many insular contexts could prove to have gravitating importance in determining overall vulnerability levels.

On the basis of what has been said, a methodological approach can be designed with sufficient flexibility to incorporate physical and social components and the ability to adjust to the distinctiveness of an insular entity. The framework for developing such a methodological approach is defined by two different but overlapping perceptions or conditions, each of which reflects a basic situation vis-à-vis the pattern of response by an island to an earthquake hazard. That is, the island is seen as a 'closed' and an 'open' system.[10]

**Condition I (the island as a closed system):** each island is a self-contained entity that is called upon to cope with an earthquake emergency without external help for many hours or perhaps days. In this case, the approach centres on a view of the island as a 'closed system', in the sense of optimising the ability of its components (human and technical resources and infrastructure) to deal with emergency needs. To this end, the elements at risk in the social and built environment should be examined in an integrated manner. Consequently, emphasis is placed on: a) identification of inherent vulnerable conditions on the island (population groups, an aging building stock, dwindling settlements and a poorly designed/maintained road network); and b) an evaluation of possible losses and needs, as well as on the operational and organisational adequacy of the response system (services, institutions, human potential and infrastructure) and coping capacity (or the ability to use existing resources in an effective reaction that can reduce disaster losses), which are directly or indirectly part of the overall seismic safety policy (which is primarily determined by existing critical emergency functions and the island's institutional adequacy to tackle emergencies). This two-fold emphasis emanating from the closed system condition aims to establish the correlation—in locational and operational terms—between the local coping capacity system and the exceptional demands that manifest during any earthquake disaster. The impact of an earthquake on an island can normally go beyond local coping capacity and require emergency operations that usually require external assistance.

**Condition II (the island as an open system):** in the event of an earthquake disaster, the 'open' system island should be able to maximise its ability to receive and use external support effectively, such as human and technical resources and water and food supplies, and ensure that the population can be evacuated to the mainland or to neighbouring islands if deemed necessary. Perhaps the most extreme and illustrative example of an island unable to operate as an open system is that of Santorini during the 1956 earthquake. The island remained virtually cut off from supplies, having no efficient port to receive goods to meet such exceptional needs, and there was no effective evacuation policy. The reconstruction process, therefore, made its first priority the building of a new port, and the highly innovative 'Recovery Committee' of the period had to initiate, inter alia, the production of building materials from local resources and organise the training of local construction labour (Dekavalas, 2003).

Thus, with respect to an open system island, attention should focus on assessing the vulnerability and capacity of components such as:

- points of entry and exit (airport and harbour installations);
- the existing formal (or informal[11]) distribution/emergency network;
- regional/national accessibility conditions on the island; and
- the potential of its communication and information technologies.

Each island is thus treated like a system with 'gates' through which relief (emergency personnel, supplies and information) flows in and is channelled effectively towards areas in need and evacuees flow out (especially tourists and non-permanent residents, injured persons, and the like). These gates constitute the system's points of 'entry/exit' for distributing/transporting the population and resources, to and from the interior of the island.

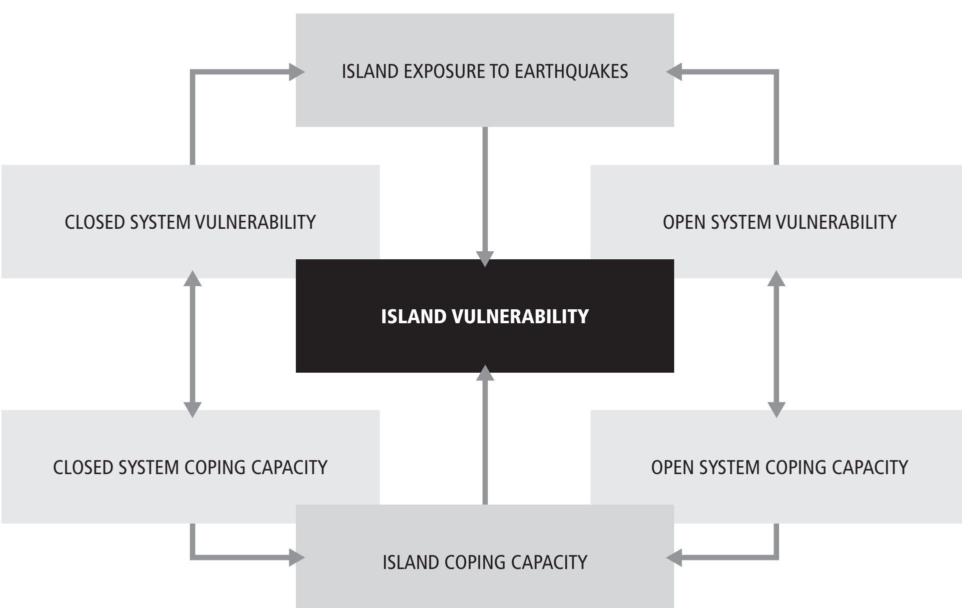
Consequently, an open system island imports (and exports) information resources and population flows from its external environment (neighbouring islands and the mainland country). The open system, therefore, imports the necessary 'inputs' (and respectively the outputs) that can offset negative conditions that escalate on an island in a disaster context and that allow it to maintain the critical variables of the closed system in operation. When necessary inputs cannot be imported from the surrounding environment and or their quantity is insufficient, it is possible that the island will face a total disaster situation. Hence, there is a dialectical relationship between the closed and open system approach of the island setting. On this basis, the closed system represents one of the major mechanisms for ensuring community survival and for absorbing at least the first waves of a disaster event. The strength of island communities has a lot to do with the way in which they utilise their local assets before, during and after a disaster event—that is, 'as much as possible by strengthening existing organizations and procedures by supplementing them rather than supplanting them' (Alexander, 2002, p. 4).

Potentially, the operation and strength of the open system is 'tested' during the latter stages of an emergency response period and short-term recovery phase. It is clear that effective vulnerability analysis and policy could be structured by integrating elements from both the closed and open system (see Figure 1). The emphasis placed on an open or closed system approach and the various components could be the outcome of the definition of local priorities and the development of a community vision based on consensus. It can also emanate from the actual cultural, economic, geographical and social condition of each island (degree of remoteness, accessibility, distance from the mainland or the administrative island capital, duration and intensity of the tourist season, awareness and preparedness levels in terms of human resources and equipment).

What we are trying to do here is to identify those components of both systems that, among many others, appear to be the most essential in the construction of a seismic safety policy for an insular environment.

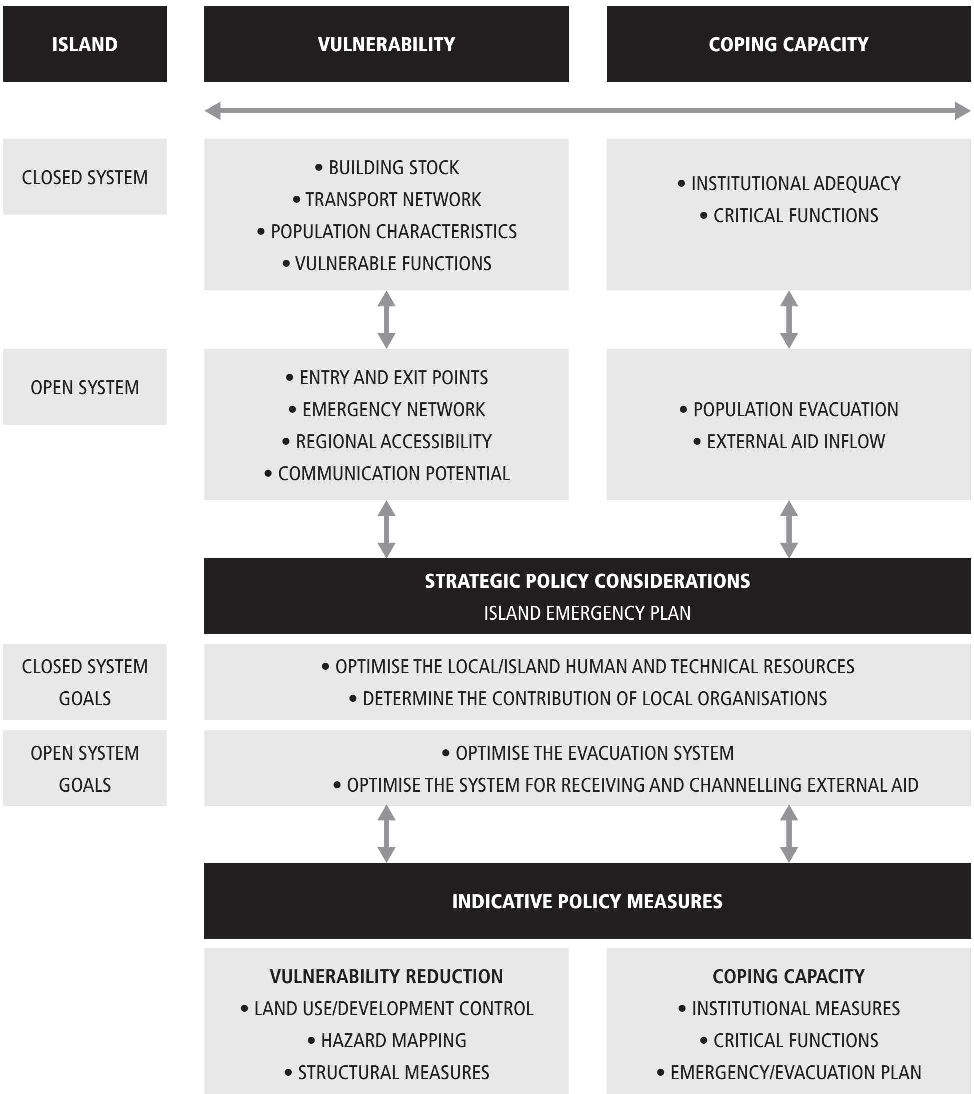
Safety policy relates here to what is defined as mitigation, which 'comprises all actions designed to reduce the impact of future disasters. These usually divide into structural measures (the engineering solutions to problems of safety) and non-structural measures,

**Figure 1** Island vulnerability and coping capacity



which include land-use planning, insurance, legislation and evacuation' (Alexander, 2002, p. 6). Nonetheless, as a general remark, there seems to be an overall quest to reconstitute the 'closed system safety culture' of islands in Greece, since this has been dismantled as a result of uneven post-war development trends. In other words, the closed system approach appears to be widely needed, to a greater or lesser extent, in the majority of Aegean island contexts. Most islands have been dominated by a policy rationale that has paid little attention to emergency preparedness, leading to overwhelming local reliance on assistance from outside and even more from the central state—the core geographical expression of which is the metropolitan agglomeration of Athens.

**Figure 2** Island vulnerability: coping capacity components and policy considerations



## Main vulnerability and coping capacity factors

For this reason, there is a need for a methodology for an island setting that is able to grasp the complexity of the conditions involved (including economic, operational, physical and social ones), which together determine catastrophic potential.[12] This implies, as a precondition, the ability to generate constant knowledge of the changing environment and to identify vulnerability fluctuations all over the island territory. In this respect, a major matter of concern pertains to the identification of the appropriate components that more accurately reflect the operation of the island as a 'closed system' and 'open system' in an earthquake emergency. In the context of the proposed methodology based on a reading of the Aegean setting, the following components have been identified:

- In the case of the 'closed system' analysis, the island components linked to a potential vulnerability condition are: the building stock; the transportation network; the composition and distribution of the population; and the location of vulnerable functions (see the following section).
- As for the open system approach, vulnerable components relate exclusively to the points of 'entry and exit', structural efficacy and broader regional accessibility conditions (see Figure 2 above).

In turn, the key coping capacity factors of the closed system are defined by the location and effectiveness of critical functions and the efficacy of the local governance system (including non-governmental organisations (NGOs), voluntary agencies and professional bodies). The latter comprises the entire spectrum of agents and organisations operating on the island, at different levels of administration, performing different roles and assuming different degrees of importance in an emergency. Meanwhile, the open system coping capacity has to do mostly with population evacuation and the island's ability to receive and distribute external aid.

## The island as a closed system

Based on the approach described above, the analysis of islands as closed systems (see Maps 2 and 3) places emphasis first on the main vulnerability features, such as building stock, the transportation network, population characteristics and vulnerable functions. Second, with respect to the islands' coping capacity, two major components are taken into account:

- the operational and organisational efficacy of critical emergency structures; and
- the institutional adequacy of the insular governance system to meet emergency demands.

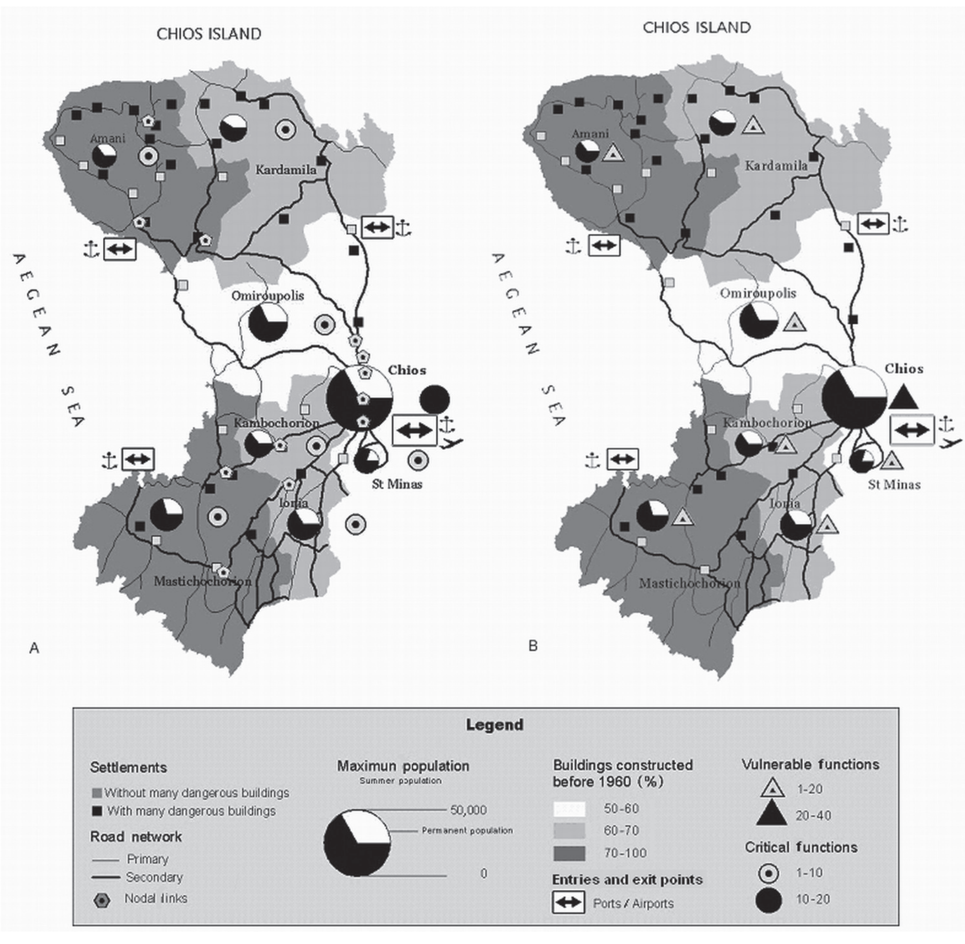
### Vulnerability of the closed system

#### *Vulnerability of the building stock*

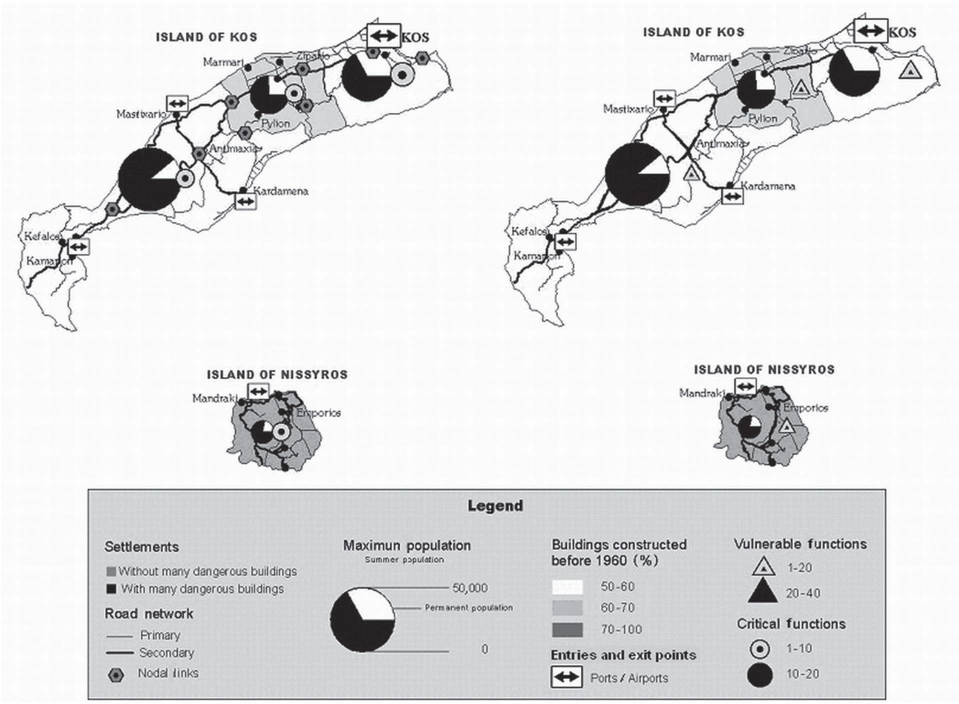
Many islands have a large proportion of predominately small settlements with old, poorly maintained building stock and dwindling numbers of inhabitants. There are also several towns and villages that retain the traditional local urban structure and building stock—characterised by irregular and narrow roads, inadequate open spaces and old non-engineered fabrications—that, in principle, imply increased seismic vulnerability. In these cases, secondary effects that hamper post-seismic response actions could accompany potential structural collapse or damage. These could become even more critical during the summer when settlements experience acute population rises. In other words, the distribution of the building stock, its age and applications are factors that largely shape emergency demand patterns, having a decisive impact on the ability of the system to respond to a seismic catastrophic event. Thus, the building stock should be examined as an all-encompassing vulnerability component that can determine potential losses, emergency needs and the ability of the closed system to respond.

A vulnerability assessment of existing buildings could serve this purpose, based on locally defined criteria and observations, housing surveys and inputs (technical reports) from local civil engineers and architect's registrars, as well as even on local authority policy considerations, especially in small settlements. A main criterion in this respect

**Map 2** Chios Island as a closed (A) and open system (B)



**Map 3** Kos and Nissyros Islands as closed (A) and open systems (B)

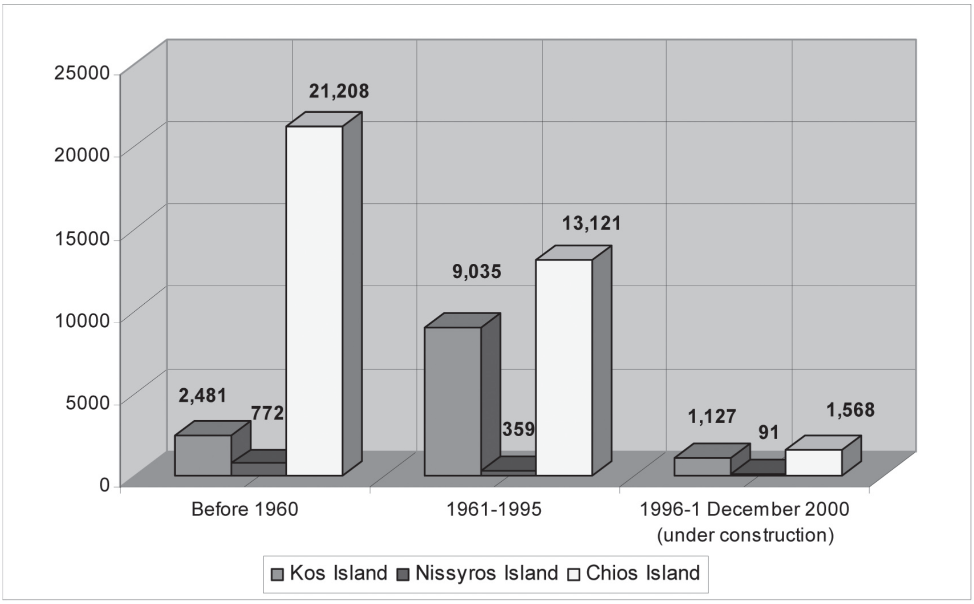



is the construction year, relating relatively to the applied seismic design code. Islands that have seen rapid growth or decline trends over the past 20 years are faced with a situation of abandonment of local buildings and/or conversely with speculation-driven building constructions.[13] Coupled with the fact that Greece has now reached the point where buildings designed in accordance with the latest seismic codes perform reliably from a seismic perspective, the building code level correlates with the acceptable safety level enforced by the Seismic Design Code (amended most recently in 2002).

Consequently, the percentage of non-engineered buildings in each municipality should be considered, since it has become apparent that this part of the building stock requires evaluation and improvement with respect to its seismic performance. Obviously, this does not imply that buildings erected using local construction systems perform poorly in an earthquake. What is important in this regard is knowledge of the building system adopted (local techniques, practices and materials used) and the type of structural interventions required to boost the earthquake performance of built-up fabrications (Touliatos, 2004). Actually, research work carried out by the National Technical University of Athens for a study of the local building system in Nissyros revealed, as a key parameter for increasing earthquake performance, the need to intervene in a comprehensive manner (for a number of buildings that form a unit or even for a whole settlement) and not to adopt a separate approach for each distinct building (National Technical University of Athens, 1999).

Apropos the case study islands, on Chios, more than one-third of the building stock (36.6 per cent of the total) is concentrated in the main town.[14] Yet, the basic

**Figure 3** Number of buildings according to construction period on Chios, Kos and Nissyros islands




**Source:** NSSG, 2000, http://www.statistics.gr/StatMenu.asp (accessed December 2005)

characteristic is old building stock, which clearly signifies increased vulnerability (see Figure 3). Approximately two-thirds of building assets were constructed before the enactment of the first Greek Seismic Design Code in 1959 and around 50 per cent of them were built before 1919. This, in combination with the fact that a large number of buildings are in declining settlements—largely abandoned and/or in a poor state of maintenance—corroborates the view of a particularly high seismic vulnerability level. An additional vulnerability problem on Chios is the extensive presence of buildings built using local construction systems and listed buildings (of morphological or historical interest) and a good number of traditional settlements.

On Kos, by contrast, the building stock is comparatively new: 30 per cent of the island's structures were built before the introduction of the Seismic Design Code in 1959 (see Figure 3). Vulnerability on Kos, however, has more to do with the quality of new buildings, the dispersal of building assets and new construction in the rural hinterland and coastal zones. There may well be problems with the quality of the materials used in a new construction and deficient building controls. Moreover, one needs to take into account rapid developmental trends on the island, which in recent decades have led to an escalation in private speculative constructions.

The building stock vulnerability condition is different on Nissyros, where two-thirds of fabrications were built prior to 1960. Hence, an examination of seismic vulnerability centres on the management of old building assets. This issue is, of course, of prime concern for this third island, which is extremely remote and in decline.

### *Transportation network—internal accessibility*

Internal accessibility, and more specifically the transportation network, is another key component of island vulnerability. The road system should be examined with respect to its carrying capacity, geometry, physical conditions and observed traffic flows, taking into account 'normal' periods of operation and 'potential crisis situations'. Total traffic flows are heavily influenced by peak flows, especially in the main towns, which in turn are dominated (during the summer) by automobile traffic. An additional consideration is whether the road passes through settlements (something that often happens in the Aegean region), as it might become blocked due to building collapse or falling structural elements.

The case studies illustrate the range of issues involved; a key road network problem on Chios, for instance, pertains to the poor (or rather non-existent) hierarchical relationship between the primary and secondary road system. Many areas have no alternative connections. Detailed analysis and mapping (NKUA, UA and MA, 1998) has revealed the critical need to create surpasses or bypass roads in a great number of settlements, since the primary network cuts through them. In addition, given the difficulties (economic and functional, for example) involved in establishing detour roads, an urgent policy priority seems to be to enforce specific measures to increase safety conditions and to prevent the blockage of roads by debris, including retrofitting or demolition of dangerous buildings, inspection of building facades adjacent to main roads, removal of dangerous elements, and transport and parking controls.

The same problems apply but to lesser extent on Kos. Attention here should focus primarily on building controls related to suburban development or tourist resort areas along the coast.

On Nissyros, the problem arises mostly because of the absence of a circular road around the island and bad accessibility in the volcano area, since there is only one road link.

### *Population characteristics and human geography fluctuations*

The demographic composition of the islands adds to overall vulnerability. An aging population, a large proportion of dependent persons and uneven population distribution in combination produce a vulnerable state of affairs. Vulnerability conditions could thus become more severe and widespread in an island setting, where, for example, elderly population groups reside in old building stock (Daniele and D'Antino, 1988; Dandoulaki and Delladetsima, 2004). By contrast, members of the younger demographic strata—with a greater response capability and better access to relief and recovery assistance (Schawab et al., 1998, pp. 11–14)—live in newly built reinforced concrete framed building stock.

It is important therefore to have a clear understanding of those characteristics that indicate an island population's level of vulnerability to a seismic disaster. This can be derived from 'conventional population distribution patterns', especially in the winter. The features to be examined in detail are: the population density; the age structure distribution of the population; and the population structure by municipal area.

The population of Chios, for instance, is not at all evenly distributed. Some 44 per cent of the total population is concentrated in the largest town (Chios), while the rest is highly dispersed among smaller settlements. Aging is a feature that applies to the island population as a whole, as well as to the population of each distinct municipality, with the exception of the main town.

From the standpoint of conventional demography, the situation on Kos is more positive than that on Chios, particularly since the population level during the winter is smaller. Moreover, some gender and age distribution data paint a relatively differentiated picture. For the most part, Kos does not face significant demographic problems and most settlements on the island display similar trends to those of the island as a whole.

Furthermore, in all study areas, a noticeable characteristic is that the human geography of the islands changes significantly during the summer due to internal and external tourism, and to the return of non-permanent residents (Brigulio et al., 1996; Tsiartas, 1998, pp. 58–62). In the summer, there is an exceptional population rise, placing an extra burden on all island functions. It is often the case that this sharp population increase is out of step with the islands' available human and technical capacity to meet potential disaster demands, remaining more or less the same as in the winter.

What is more, very little is known about the coping capacity of the private sector (Mileti, 2001, p. 224), especially that of the tourist industry (Drabek, 1994), to meet emergency demands during peak seasons. A study carried out by the National Kapodistrian University of Athens, the University of the Aegean and the Ministry of the Aegean (NKUA, UA and MA, 1998), based on interviews with hotel representatives, revealed a prevailing 'ordinary' policy logic that fails to take account of emergency evacuation requirements. Earthquake awareness has been limited to respecting 'building bylaws and safety considerations'. To make matters worse, a significant percentage of this extra population on the Aegean isles is tourists who, in most cases, have not experienced earthquakes and have not developed seismic awareness. This fact generates an additional vulnerability condition and for that reason human geography fluctuations require a detailed examination of:

- the rate of population increase on the islands during the tourist season;
- where this additional population is prevalently concentrated; and
- where it comes from.[15]

Maps 2 and 3 above show the distribution of the population of the islands of Chios, Kos and Nissyros in the summer and winter, based on official statistics and data collected through empirical research.[16] With regard to Kos, the population increase during the peak tourist season (March–October) and the geographical distribution of such a rise on the island constitute perhaps the most critical issues in terms of seismic protection policy. It is obvious that the population of the island multiplies during the tourist season at an astounding rate. In many districts of Kos, the increase is as high as 400 per cent, occurring in the main town and in other settlements, as well as in the rural hinterland and in coastal areas.

### *Vulnerable functions*

A crucial island vulnerability component is the location and structural efficacy of what we generally call vulnerable functions. These are characterised by:

- a high population concentration, daily and seasonally;
- the special nature (non-voluntary) of the occupancy of space;
- increased potential to generate multiple destructive effects, such as explosions and fires; and
- a high degree of importance as economic, administrative and cultural functions for the survival and reconstruction of the region.[17]

Vulnerable functions could be recorded and mapped, for example, via an empirical survey of the total island area. Emphasis could be put on the location of 'high population concentration functions' and 'special space occupancy functions', especially when seasonal parameters are taken into account. Thus, it is clear that all of the study area islands are characterised by an excess of 'high population concentration' and 'special space occupancy' functions. This is what is happening in particular vis-à-vis the agglomeration of Chios and its surroundings. The problem also persists on Kos, although slightly less seriously than on Chios, due to its size and settlement structure.

## Coping capacity factors of the closed system

### *Institutional adequacy—emergency planning*

Institutions and organisations of the local/island governance system directly involved in emergency planning and post-seismic response—either at a regional, prefecture or local level—play a vital role in prompt and effective disaster response and aid provision. Due to geographical distance, remoteness and reduced response potential, emergency plans drafted for insular districts tend to assign key roles to the central and regional administrations, reflecting an overall mistrust or a lack of local capabilities. This is especially evident in the Aegean context and in the study areas, where administrative regions or prefectures comprise numerous islands. The enacted emergency plans fail to tackle this particularity and have proven rather rigid in designating the government tiers responsible for disaster planning and management. In other words, the rationale adopted for islands is the same as that for 'mainland' regions. Furthermore, given that emergency services tend to concentrate on the most affluent and larger, urbanised islands, the smaller and most remote ones are left aside, with virtually no local emergency support system. This, in conjunction with the fact that many islands are located some distance from the regional capital—which disposes most of the personnel and technical and emergency response infrastructure—constitutes a critical factor in the shaping of the insular system's coping capacity.

Hence, assessing the adequacy of local institutions and their resources, examining the extent of their involvement in the emergency planning process and identifying their preparedness level are important elements for evaluating the system's coping capacity. The case study islands are highly illustrative. For example, although the islands of Chios and Kos are equipped with well-developed and detailed emergency plans—as compared to other parts of the country—there does appear to be a problem with the institutional adequacy of local governance systems. The uniformity of the policy rationale adopted does not seem to be compatible with the particularities of the actual insular milieus. Significant problems arise on Kos merely because the island does not form an integral prefecture, the administrative unit deemed responsible by law (General Emergency Plan 1999) for emergency planning and response at the local level. Thus, institutions outside of Kos, especially those in the prefecture's capital, which is located on another island (Rhodes), could potentially take most critical decisions. Moreover, while earthquake awareness among local institutions is fairly good, on all islands, this seems to be primarily the case at the regional (prefecture or sub-prefecture) level; at the municipal level it is not so good. Institutionally, municipal/local organisations have been allocated virtually no substantial role in dealing with key emergency issues, such as disaster management (human resources, equipment and infrastructure), tourist population evacuation, post-earthquake usability and damage inspections. This is principally a problem for the island of Nissyros, which due to remoteness and isolation, on the one hand, is bound to respond as an autonomous nucleus in an emergency. On the other hand, the entire spectrum of emergency policy resources, according to the enforced General Emergency Plan (1999), is the responsibility of the prefecture—that is, of an institution operating outside of local/island jurisdiction.

### *Critical functions*[18]

Critical functions are those that are overburdened and take on special significance during an emergency. The location, capacity and contingency potential of critical functions on an island are core inputs in an efficient emergency response. An increased vulnerability condition is therefore revealed on Chios, where emergency services are concentrated in the already congested main town. Additionally, it is worth highlighting the problematic nature of certain island municipalities in that they remain virtually cut off from any local emergency support system.

On Kos, too, all critical functions are concentrated in the main town. Potentially, the adverse effects produced by this concentrated distribution pattern of critical functions can be diminished through the creation of new decentralised services and staffing by the individual municipalities. The correlation between the allocation of human resources potential implicated in the operations of 'critical functions' (in each municipality) and the existing 'vulnerable functions' reveals a moderate gradation of vulnerability among the various municipalities of the island. Also, the location of the municipality (and sub-prefecture capital) of Kos is special inasmuch as it must support the other municipalities.

The picture of Nissyros is a fairly positive one with respect to the analogy between available critical functions and the insular geography. But the isolation of Nissyros and the problems thus raised are such that it should not be subjected to the same degree of comparison as the other island municipalities.

## The island as an open system

Inherent in the island as an 'open system' is the capacity of its components to survive and to respond to a disaster based on the relationship with the external environment, be it adjacent islands, the regional or national mainland setting or even international institutions or organisations. In the event of an earthquake hazard, therefore, the following components should be taken into account:

### Open system components

*Capacity and adequacy of islands' points of entry and exit*

Islands' points of entry and exit (harbours and seaports, secondary ports, heliports and airports) are the open system components that require the most attention. The two main questions that arise are:

- To what extent and under which weather conditions is an island able to accept external aid?
- How can one safeguard an evacuation process through the available exits?

Hence, issues of concern are the state of infrastructure and equipment, entry connections, sensitivity to weather conditions and endorsed emergency plans. An island might suffer from excessive congestion problems both with respect to outgoing (during an evacuation period) or incoming flows, in which case no entry space is available to receive external aid. At the same time, an entry point, such as a harbour, is in principle a highly vulnerable entity (Siegel and Bjur, 1985).

The situation in terms of points of entry and exit on Chios, for example, is fairly problematic (see Maps 2 and 3 above). More specifically, Chios has an airport that can adequately meet needs under normal circumstances. It appears capable of fulfilling emergency requirements in that it is rarely cut off in winter and summer and no particular malfunctioning problems have been reported due to increased traffic. There may perhaps be a problem in that it is just 1,500 metres from the main town, meaning that its operation could be affected by congestion or the blocking of some roads, since the main road axes that link the airport with the town and with most other areas pass through the urban agglomeration of Chios.

The entry and exit system on Kos is quite adequate, mainly because of the suitable position (and capacities) of the airport, but also because of its location vis-à-vis the island's ports. These two basic points of entry and exit are in diametrically opposite positions, spanning almost the entire island. In other words, the operation of each point of entry (airport/port) will not be affected by congestion or crowding, which might occur in an emergency. The need to bypass the town to approach the harbour, as on Chios, is an intervention issue of primary importance.

On Nissyros, the port is the main point of entry and exit. Experience after the 1996 seismic event, which caused damage to buildings in the main village of Nissyros, revealed as a core problem the inability of the port to receive and accommodate external aid—which hampered emergency operations. Note should be taken here of the fact that Nissyros harbour is frequently cut off in the winter for as long as 10–15 days at a time. However, dredging and widening works have enhanced the port's capacity. In addition, the heliport on Nissyros has contributed to the alleviation of this crucial problem, improving the possibilities for providing assistance and transportation.

### *Emergency distribution network*

The efficacy of the open system depends significantly on the capacity to identify post-disaster needs (emergency health care, food, water and shelter) and to mobilise (and receive) necessary resources and to transport them to affected areas. This has a lot to do with the existence of what we call an 'emergency distribution network'. Such a network sustains an effective relationship between the surrounding environment and the insular interior and can provide direct access from the exterior to the island's mainland.

The primary road network is a key subset of the emergency network and thus emphasis should be given to its connections with settlements, the island's points of entry and exit, the critical functions, and those sections of the island that require special treatment (like areas of concentrated tourist activity), since they will bear the main burden of carrying supplies/material and evacuating the population. The outcome of such a correlation could lead to the defining of what we call the 'nodal links'. In essence, the nodal links constitute hindrances to the smooth and unimpeded access of emergency forces and to the transport of the population and emergency supplies. In a way, the nodal links and the respective 'strategic axes' that connect them should be a planning priority both in terms of land-use control and structural reinforcement.

Accordingly, surveys in the study areas have shown (NKUA, UA and MA, 1998) concentrations of collisions along main roads and secondary distributor roads, pointing up the need for urgent consultations among the authorities in charge of determining a road hierarchy in the event of an emergency. These consultations will enable the authorities to promote agreements on appropriate traffic management schemes and to discern strategic axes to meet emergency demands. By way of example, because of the nature of the island of Chios—concentration of highly vulnerable elements, such as harbour facilities, the airport, the hospital and the power station, in the urban complex and in the broader city of Chios—most of the nodal links and the four strategic axes tend to be concentrated in the island's southern districts. Kos, by contrast, has one major strategic axis and the island is not facing substantial problems from the standpoint of the emergency network, given that, to a greater or lesser degree, bypass possibilities exist.

### *Regional accessibility*

Islands have distinctive accessibility problems such as potential loss of transport links. Not all islands are remote in terms of their distance from the mainland, but 'insularity' itself implies a degree of isolation from other places. More specifically, islands are accessible only by non-continuous-flow transport means (ship or air) and thus congestion may occur at a small number of entry points (harbours and airports), from where people, goods and provisions are transported to other mainland places or districts in the island hinterland. What is more, weather conditions must be taken into account at all times with respect to island accessibility, especially during the winter, when there is always the possibility that connections to and from the island will be severed for a few days.

Overall, in relation to accessibility, an island is far more vulnerable than any other geographical entity. The problem as expressed in the case study areas has to do most with the reduction of available links during winter (by sea or air), combined with the augmented possibility of islands being cut off due to the weather. At the same time, increased transport connections to the islands during the summer present new and severe problems, caused by excessive population increases due to incoming tourist flows.

### *Communication potential*

Communication network scarcities make insular societies more vulnerable, and they could suffer a loss of effectiveness when confronted with the particular demands of rescue and emergency services. Consequently, disasters, such as an earthquake in adverse winter weather conditions, can result in more severe losses than in other parts of the mainland. Furthermore, because of the long distances, the emergency/rescue services need more time to reach those in trouble and reconstruction of infrastructure can take days to get under way. As a result, the risk of deficiencies in communications should be seen as an integral open system vulnerability issue. Today, for example, emergency communication and related infrastructure problems are not serious on Chios and Kos; such problems seem to persist mostly on Nissyros.

What appears to be a matter of high priority, however, is that many communication systems available on the islands are very heterogeneous, technologically incompatible (for joint action in an earthquake emergency) and operated by distinct institutions (army, police, regional and local authorities, coastguards, central ministries, fire brigade, ambulance service and NGOs). There is a need, therefore, to develop systems that are coordinated or interconnected, open to end users from different organisations (local, national and international), evolutionary and adaptive, enabling end users to share their knowledge, tools and results in systematic risk management and civil protection.

## Coping capacity factors of the open system

### *Evacuation of non-permanent population*

Especially on islands that are extremely popular with tourists, a crisis event, such as a severe earthquake, will likely generate a massive outflow of people, thereby exerting exceptional pressures on existing infrastructure, necessitating in turn the implementation of urgent evacuation procedures (Drabek, 1994; 1996; Dipartimento della Protezione Civile–Prefecture of Naples, 1995–2001). The number of people—as well as the distribution of the non-permanent population—is an indicator of the challenge faced by the island system in meeting evacuation demands. To this end, other kinds of information, including that on expected evacuation compliance, current tourist occupancy rates and probable evacuation destinations, are deemed necessary. Also essential could be information on the number of vehicles expected to move, the number of vehicles from each island travelling to specific inland locations, and the types and characteristics of available routes, as well as comparisons of traffic flows to forecast scenarios.

The three case study areas exemplify variable potential in terms of evacuation demands. On Chios, summer population increases due to the arrival of many tourists are hard to quantify; estimates could be based on the capacity of its hotels (11,996 registered beds according to the 2001 census) and on information on rented accommodation or 'staying-as-guests' status. It has been estimated (NKUA, UA and MA, 1998; 2001), for instance, that the total number of visitors—whether from abroad or from Greece—does not exceed 2,000 in late July and early August (the peak period). The level diminishes from mid-August. Consequently, the average population rise during the peak summer months is estimated at approximately 2,000, a figure that should constitute the core 'policy entity' for emergency planning on Chios.[19]

The population increase on Kos[20] exceeds the census level by some 30,000, on average, during the peak period. Based on the same assumption as above, therefore, 30,000 persons should constitute the core population 'policy entity' for emergency planning on Kos.

### *External aid inflow*

It should be possible to receive and to channel effectively external aid to insular areas in need. The capacity of the 'gates' of the island to receive external aid, as well as to accommodate it spatially and to provide all necessary facilities for its installation and efficient function, is of major significance. Furthermore, the organisational efficiency and the availability of potential 'aid receiving' locations, such as storage and maintenance areas, on the island lie at the heart of efforts to secure an effective relief policy. It should be mentioned that on all of the case study islands, no pre-emptive action to determine such areas has been registered. This is partly explained by the fact that municipalities and communities tend to view 'relief policy' as a higher tier (prefecture) matter. However, they are very much aware of the fact that some specific policy features, such as accessibility difficulties, a lack of available space and communication problems, may delay or even annul a relief intervention by the prefecture, at least in the immediate post-earthquake period (NKUA, UA and MA, 1998).

For that reason, it seems that the institutionally enforced role of the prefecture prevails over the one of the local authority, which by definition is far closer to potential emergency needs. This is stipulating a philosophy that somehow such a responsibility of the local authorities and local communities in emergency periods should be transferred to somebody off the island. Set in this context, the actual requirements (physical, transportation, storage, for instance) for receiving any potential external aid have not been taken into consideration at all at the local policy level and in all three islands under study.

## Some strategic policy considerations

Given the previously developed approach, and information on the study areas, what is particularly challenging is the formulation of a mitigation strategy in an integral manner, keeping in mind local conditions and the specificity of each island. Strengthening the islands' vulnerability reduction condition and elaborating an effective seismic protection strategy requires first shifting from a static vulnerability perception to a dynamic one and mainstreaming this approach within institutional dynamics (Vetere Arelano et al., 2004). In turn, developing a strategic approach for the islands necessitates an effort to take fundamental decisions and actions that shape and guide the (open or closed) island system, and influence drawbacks to its seismic response potential. The process is bound to concentrate on key selected issues and on knowledge of available resources, and requires constant evaluation of the strengths and weaknesses of an island—a review of the events and changes that occur inside and outside of the entity.

Hence, the main goals derived from an examination of the island as a closed system are:

- to promote optimum utilisation of local/island human and technical resources in an emergency; and
- within this framework, to determine specifically the contribution of local institutions/agencies to an emergency response, placing emphasis on those basic services related to managing and monitoring all closed system components.

The policy goals subsequently derived from an evaluation of the island as an open system are:

- to optimise the evacuation system—identifying and gathering together the population in need, accommodating these people in safe places, and moving them towards exit points and then to other destinations on and off the island; and
- to optimise the system for receiving external assistance and channelling it to where it is needed.

## Key institutional agents and partnerships

The available resources and personnel of the various institutions, public organisations and NGOs are involved to a varying degree in the emergency planning process—different in some ways to the mainland's policy rationale. Consequently, we are dealing with very distinct preparedness systems (somewhat informal, not defined by statutory processes) on each island, based on material conditions that are not at all common to the ones seen in the mainland context.

Given the distinct risks in insular environments, related to scarcity and/or unbalanced distribution of resources and human potential, it is evident that in a process of priority definition, prominence should be given to those components that respectively determine the coping capacity of the island as a closed and open system. In general, the adopted organisational patterns on each island reflect the mainland's top-down model of vertical transmission of command and control orders and feedback, based on information that (presumably) is received locally during an emergency or early recovery period. In principle, there is an overall absence of designed 'horizontal' schemes involving the emergency institutions and organisations on the various islands. In other words, the operational efficacy and coping capacity optimisation of an island could depend to a great degree on the capability to create local partnerships—between institutions, departments, NGOs and organisations—at a horizontal level. Such schemes could be different on every island, depending on local characteristics, human potential and available equipment and resources.

Thus, the key institutional agents in an insular area that could play a predominant role in shaping strategic policy and determining the response effectiveness of the island are, above all, the local, prefecture and regional authorities. The most notable are the institutions and organisations operating on the island that are directly involved in emergency planning and post-seismic response.

Greece's experience reveals that, in most cases, local authorities assume a leading role in disaster situations within their jurisdiction (Earthquake Planning and Protection Organisation, 1998; Dandoulaki and Parcharidis, 2001). Local authorities should be seen as the main domains of local knowledge on the exposure and vulnerability of settlements within their sphere, as well as on the allocation and distribution of aid to areas in need. On an island, the role of local institutions is accentuated in relation to building capacity to tackle emergencies. In addition, institutions and organisations in charge of the island's 'gates' (port and aviation authorities) play a highly critical part during 'maximum demand periods', such as the peak tourist seasons and/or at times when the island could be cut off due to bad weather. A key area of concern centres on the adequacy of available supply reserves for the periods in question, and the ability of the 'gates' to satisfy emergency needs.

Table 2 attempts to draft some potential partnership schemes, which could obviously vary from island to island—derived from the study of the three case study areas. The importance of each partnership scheme is indicated by its relation to the potential

**Table 2** Earthquake emergency partnership schemes for island areas

| Regional institutions (Island prefectures) | Local Institutions | Horizontal Partnership Schemes |
|---|---|---|
| Regional Coordinating Unit<br>Prefecture's Council Office | Local Coordinating Unit<br>Major's Office | A |
| Port Authorities (PA) | PA local institutions | B |
| Civil Aviation Authorities (CAA) | CAA local institutions | |
| Civil Protection Department | Local Civil Protection Office | C |
| Fire Department | Municipal Police | |
| Police Department (PD) | PD local branches | |
| Ambulance Service (AS) | AS local branches | |
| Regional Hospital Unit | Local ambulatories | |
| Public Works Department | Local Public Works Office | D |
| Planning Department | Local Planning Office | |
| Transportation Department | Local Environmental Office | |

| | | |
|---|---|---|
| Regional Electricity Board | Local branches | E |
| Regional Telecommunication Organisation | Local branches | |
| Health Department | Social Welfare Office | F |
| Education Department | | |
| Social Welfare Department | | |
| Archaeological Heritage Department | Local Cultural Agency | G |
| Historical Heritage Department | | |
| Agricultural Department | Public Green Areas Office | H |
| Forestry Department | | |
| Regional NGOs | Local NGOs | I |

**Table 3** The importance of each partnership scheme in relation to the potential mobilisation of the island as a closed and/or open system

| Horizontal Partnership Schemes | Closed System | Open system |
|---|---|---|
| A | High | High |
| B | Moderate | High |
| C | High | High |
| D | High | Moderate |
| E | High | Moderate |
| F | High | Low |
| G | Moderate | Low |
| H | Low | Low |
| I | Moderate | Moderate |

**Table 4** A framework for generating island setting scenarios that correlate basic uses with population intensity on weekdays and seasonal variations

**Winter period (days)**

| | Monday | Tuesday | Wedneday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| Public offices | | | | | | | |
| Retail areas | | | | | | | |
| Tourist areas | Daytime intensity of use (e.g. high/moderate/low) | | | | | | |
| Recreation coastal areas | | | | | | | |
| Housing areas | | | | | | | |
| Industry | Noon/nighttime intensity of use | | | | | | |
| Road network | | | | | | | |

**Summer period (days)**

| | Monday | Tuesday | Wedneday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| Public offices | | | | | | | |
| Retail areas | | | | | | | |
| Tourist areas | Daytime intensity of use (e.g. high/moderate/low) | | | | | | |
| Recreation coastal areas | | | | | | | |
| Housing areas | | | | | | | |
| Industry | Noon/nighttime intensity of use | | | | | | |
| Road network | | | | | | | |

mobilisation of the island as a closed and open system (see Table 3). The partnership schemes lie at the heart of efforts to build disaster resistant island communities through education and training. These efforts are based on appropriately designed scenarios that correlate basic uses with population intensity on weekdays and seasonal variations (see Table 4).

## Objectives and priority-setting criteria

Apropos objectives formulation and priority-setting criteria, it must be stressed that long-term investment decisions and costly engineering structural measures could, with difficulty, gain wide social and political approval. This is particularly evident in the Aegean, especially on the most remote and deprived case study islands, such as Chios and Nissyros. As a result, long-term and high-cost risk mitigation initiatives have a better 'implementation chance' if integrated into normal budgetary allocation procedures and systematically linked to actual developmental needs and land-use policy (Godschalk, Kaiser and Berke, 1998, pp. 85–118).

It is strongly believed here that, under existing circumstances in the Aegean, immediate emergency response measures (predominately in the social and organisational domain) should be the top priority of a seismic protection strategy. A second step might involve the implementation of medium-term measures (for example, planning for the relocation of dangerous and critical emergency facilities, such as police and fire stations), leading not only to an improvement in the island's preparedness level, but also to the betterment of overall safety conditions. During a third stage, long-term risk mitigation measures, such as the regeneration of small settlements or a more balanced land-use policy for tourist development, could be put in place.

In other words, given the particularities of local conditions, the approach is bound to place more emphasis on emergency response from a methodological and policy priority definition standpoint.

Tables 5, 6 and 7 overleaf condense some policy guidelines, corresponding to a number of vulnerability and coping capacity features deduced from the analysis of each island.

**Table 5** Vulnerability/coping capacity features and policy guidelines for the island of Chios

| Chios prefecture/municipalities | | |
|---|---|---|
| | **Features** | **Policy guidelines** |
| Vulnerability | There is a combination of population dispersal during the summer and a highly problematic demographic composition outside of the main conurbation. This distribution pattern could deteriorate in the long run.<br><br>Approximately two-thirds of buildings are non-engineered structures built before 1960; one-half of these were constructed before 1919. Part of this building stock is located in declining settlements, implying in turn that they are poorly maintained or even abandoned.<br><br>In Chios there is a vulnerability problem concerning the extended number of historical buildings or buildings with an important heritage. | Implement long-term measures that increase flexibility and the mobility of inhabitants.<br><br>Provide renewal/betterment incentives for the island's building stock.<br><br>A dual intervention in terms of structural vulnerability reduction and building conservation is needed as an extended policy condition throughout the island.<br><br>Implement safety measures of a structural nature and that pertain to traffic (for instance, inspection of buildings adjacent to main roads and removal of dangerous elements, traffic regulation, and parking controls).<br><br>Re-organise the road network and create bypasses, for instance, in order to lessen possible disaster effects.<br><br>Identify alternative port installations that can complement the main port and augment external connections vis-à-vis accessibility of the island as whole.<br><br>Increase the capacity of the port—in terms of bulk and space availability—to receive emergency supplies and to meet evacuation demands. |
| Coping capacity | A core-planning response problem has to do with accessibility of the island's more remote areas. There are also scarcities in emergency communications infrastructure.<br><br>Emergency planning based on the General Plan is not in tune with the specific features of the island.<br><br>Problems arising at the operational level concern the non-defined involvement and role in an emergency of the three government tiers (central, regional and local).<br><br>Many remote small communities do not have any critical functions and thus could play only a small part in emergency planning and response. In general, they exhibit low preparedness levels. In these areas, seismic protection and relief is perceived as an 'external' issue, especially a prefecture matter. | Increase the capacity and effectiveness of critical functions, such as the Regional Emergency Unit, Fire Department and Police Department.<br><br>Need to revise the national emergency planning guidelines and adjust them to island conditions.<br><br>Promote the 'autonomy' of settlement nuclei outside of the main conurbation and increase their response capability at the outset of a disaster. Need to integrate into this immediate response logic for mobilisation all available human resources and equipment, until assistance from the main city can reach the area.<br><br>Develop an emergency planning educational, training and informational system, adjusted to local conditions and needs. |

**Table 6** Vulnerability/coping capacity features and policy guidelines for the island of Kos

| Kos sub-prefecture/municipalities | | |
|---|---|---|
| | **Features** | **Policy guidelines** |
| Vulnerability | Summer tourism is the core particularity of Kos, since the population increases dramatically. Population rises during the peak summer months affect the island's population size and demographic composition. This marked increase involves the agglomeration of Kos and the other main settlements, villages and rural areas of the island.<br><br>Another major characteristic derived from tourist development is the existence of big hotel units throughout the island.<br><br>The system of entry/exit points on Kos is adequate, mainly due to the suitability of the location (and capacity) of the airport, but also because of its situation in relation to the island's ports.<br><br>The road network does not present substantial problems. Nevertheless, the main connection to the airport passes through many towns. This might cause problems of congestion and overcrowding in an emergency. | Design and construct evacuation routes and refugee spaces as part of the normal policy of urban planning.<br><br>Boost the capacity of the port—in terms of bulk and space availability—to receive emergency supplies and to meet evacuation demands.<br><br>Promote all actions stipulating capacity expansion and an increase in the functionality of secondary ports, in order to create a more accessible hinterland in each administrative unit.<br><br>Reorganise the road network, and create bypasses, to lessen possible negative disaster effects.<br><br>Construct bypass roads, especially in the segments of the island that the primary road passes through.<br><br>Enforce building and land-use controls in areas adjacent to primary road network sites. Measures such as building facade inspections and the removal of dangerous elements, parking controls and traffic regulation should be urgently promoted. |
| Coping capacity | Emergency planning, based on the General Plan guidelines, is not adequately adjusted to the specific features of the island, the most notable of which is the island's high tourist population.<br><br>The main municipality of Kos is involved in emergency planning and there is some cooperation with the other municipalities and the sub-prefecture. However, this is not enough, taking into account the magnitude of potential problems. | Training of employees and employers engaged in the tourist industry is also needed, together with the dissemination of safety information to both members of the local population and tourists.<br><br>Foster cooperation between local authorities, the central government and the tourist industry sector in earthquake emergency planning.<br><br>Involve all parties that deal with the tourist industry in emergency response, and assign specific roles.<br><br>Need to give preparedness training to personnel involved in emergency policy. Information must be distributed to the population and tourists.<br><br>Increase overall operational capacity through improvements in emergency/telecommunications technology. |

**Table 7** Vulnerability/coping capacity features and policy guidelines for the island of Nissyros

| Nissyros municipality | | |
|---|---|---|
| | **Features** | **Policy guidelines** |
| Vulnerability | Long-standing development problems of the island lie at the heart of contemporary vulnerability conditions; there has been both a demographic decline and a reduction in building stock.<br><br>Although nowadays there are signs of a reverse trend, the effects of out-migration are still felt.<br><br>Moreover, around two-thirds of the building stock was constructed prior to the enforcement of a national Seismic Design Code.<br><br>Tourism is the main economic activity, but this is 'overspill' tourism from Kos and of a 'one-day-visit' type.<br><br>Socio-economic life on the island depends on the adjoining island of Kos, with regard to basic services such as health care and education. | Integrate systematically development planning objectives and investment patterns into major long-term risk mitigation interventions.<br><br>Implement, as a first priority, short-term measures such as safety inspections of existing buildings and demolition of dangerous buildings or structural elements in the streets of the main settlement. |
| Coping capacity | Communication and transportation difficulties are the main characteristic of Nissyros.<br><br>The port is the only point of entry to Nissyros. Frequently, the island is cut off for as long as 10–15 days due to bad weather.<br><br>There is a heliport on the island. Nevertheless, access by helicopter is sometimes impossible due to weather and other variables.<br><br>The core planning/emergency problems arise because of the isolation and remoteness of the island.<br><br>The Nissyros municipality emergency plan is based on the rationale that assistance will come mainly from the prefecture and thus underestimate local potential. | Reconsider the emergency planning policy for the island (involving central, regional and local institutions); seek to maximise the response capacity of the heliport.<br><br>Reconsider and redesign the national emergency planning guidelines for small islands. The island should increase its operational capacity as an autonomous 'nucleus'. There is thus a need for reciprocal readjustments. The local emergency plan should, above all, aim to increase the island's response capacity for some days without any external support. It is imperative that the municipality is assigned a central role and that all local resources are fully mobilised.<br><br>Preparedness at the local level should also involve training of the local population, through engagement in emergency response exercises. |

## Conclusion

This paper has attempted to highlight the importance of the island setting as a risk context and in turn as a specific mitigation emergency planning field. In this respect, it has sought to present a methodological framework that may be applied consistently to studies of insular areas. Islands are indeed highly particular and diversified risk contexts. This is easily seen when the numerous existing paradigms are taken into consideration. Different features emerge that influence potential seismic losses, including coping capacity and of course seismic safety policy needs. Furthermore, it seems that adopted policies, at least as the case of the Aegean demonstrates, tend to transfer mechanically 'mainland' disaster mitigation patterns that have little understanding of the island environment.

This clearly highlights the need for a diversified method for dealing with vulnerability analysis and seismic protection planning strategy in island environments. Specifically, what is required is a method that, on the one hand, defines a broader common framework that can be shared by islands (necessary for increasing analytical knowledge and policy effectiveness), and on the other, can be embedded in distinct island contexts (grasping the exceedingly varying institutional, socio-economic and physical conditions). Given also the multidisciplinary nature of our purpose, the suggested methodology can define a common broader comparative framework for islands for wider analytical and policy purposes. The approach departs first from the presumption of the island operating as a 'closed system', entailing an attempt to evaluate and in turn to optimise the ability of the local potential (human/technical resources and infrastructure) to deal with an emergency seismic situation. The second presupposition is to treat the island as 'open system', which, in the event of an emergency, should be able to maximise its ability to receive and distribute effectively external support and to ensure the evacuation of the population to mainland areas or neighbouring islands. These two presumptions can be broken down in the light of scenarios based on seasonal variations of potential demand.

Highly revealing in this respect is the multiplicity of elements identified from the examination of only three island case areas in the Aegean Archipelagos. Briefly, the analysis of the islands as 'closed systems' depicted a variety of physical vulnerability typologies associated with different urbanisation patterns and settlement structures. As a second layer, social vulnerability fluctuations have a lot to do with the distribution of the population and the extending geographically aging structure. In any case, a local vulnerability component is the rate of population increase during the tourist season and the distribution of this rise across the island's surface. Moreover, at the same time, different locational patterns of vulnerable functions are recorded—according to the different uses—and characterised either by over-concentration or dispersal.

In terms of island coping capacity as a closed system, there does appear to be a problem related to the institutional adequacy of local governance systems. The uniformity of the policy rationale adopted does not seem to be compatible with the particularities of actual island settings. In addition, a problem commonly shared—although to a different extent—pertains to road network accessibility and its ability to meet emergency demands. This has to do with the relationship between primary and secondary road links and with insufficient building and land-use controls along the island's road network. Finally, critical functions tend to be concentrated in the main towns while certain municipalities of the islands remain with virtually no local emergency response system.

With respect to the islands as open systems, the vulnerability conditions centre on the entry/exit system and the road network. These tend to involve different location and functional problems. Some of them have to do with the proximity of the main ports and airports to the major town and with the fact that many municipalities are not served by secondary port installations. Deeply associated with this is the scarce capacity and safety of the main strategic road links and their ability to meet emergency demands. The coping capacity strongly gravitates on the type and magnitude of potential demand due to the seasonal fluctuation of the population. There are severe differences in defining the core 'planning entity' for emergency population evacuation. To this, one should add differences in the age structure and composition of the population to be evacuated, language and communication difficulties and other factors.

Finally, concerning the inflow of external aid, a mixed and rather confusing situation has been identified related to precautionary physical requirements for receiving and distributing aid. There is also a lot to be done on the institutional tier in terms of defining the roles of the different government levels in emergency planning and response so as to acknowledge and enforce the role of local authorities especially on islands far from the regional and prefecture centres.

The abovementioned components can be jointly analysed and produce specific mitigation policies that can increase the capability of the local island structure to respond to emergency demands. The operational efficacy and coping capacity optimisation of an island could strongly depend on the capability to create local partnership schemes at a horizontal level. In terms of objective formulation and priority setting criteria for vulnerability reduction, the island paradigms examined here seem to indicate that the implementation of short-term, low-cost community-based measures can actually pave the way for a higher-cost, long-term earthquake mitigation strategy. Total vulnerability reduction requires the complementary implementation of measures developed on various planning levels and on a macro (entire island) and micro (settlement) basis. Risk reduction as a general goal could thus be accomplished through a continuous process of priority redefinition at all planning levels.

Within the limits of this paper, our aim has been also to contribute further to the debate on island seismic protection and to delineate the scope for further work, seeking to conduct more detailed and extended investigations into the particular features of island areas. There is also work to be done on a systematic assessment of policy experiences and the development of innovative seismic safety planning practices for islands. Furthermore, there seems to be a need to start a wider debate with other island research and policy milieus with a view to sharing experiences and fostering collaborative networks.

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## Endnotes

[1] Ms stands for surface-wave magnitude.

[2] Between 2003 and 2005, approximately EUR 3,180,000 was spent on rebuilding and repairing major infrastructural works. An additional EUR 11,115,000 is currently being spent on similar ongoing projects. Furthermore, expenditure by the Lefkas Prefecture on minor infrastructural repair work amounted (up until 2005) to EUR 1,260,000. An additional EUR 2,030,000 during this period was spent on rebuilding and repairing public housing, while a biding process for public works repairs is expected to reach EUR 4,960,000. Aside from public works, the island received EUR 6,030,000 in grants from the Ministry of Environment, Physical Planning and Public Works for private housing and business repair and reconstruction schemes (corresponding to 30 per cent of the cost of each individual building). See Ministry of Environment, Physical Planning and Public Works, 2005.

[3] High priority exceptional expenditure in Skyros has centred on the repair and reconstruction of the medieval castle in the main town and stabilisation of the slopes around it, amounting to EUR 1,830,000. See Ministry of Environment, Physical Planning and Public Works, 2004.

[4] More specifically, Chios is surrounded by tectonic faults and suffered consecutive devastating earthquake disasters in 1820 and 1856, which left the main city in ruins, and in 1881, which affected primarily the southern part of the island. Kos is also surrounded by active faults and experienced devastating earthquakes in 1933 that led to the rebuilding of the main city. Nissyros has an active volcano and, especially since 1996, seismic activity has been constantly registered (Ms=4 up to Ms=5). In 1996, a seismic event caused serious damage to the building stock of the main village of Mandraki. In 1997, seismic activity escalated (Ms=4.5 up to Ms=5.5), and the earthquake event that occurred on 7 July was accompanied by landslides in the volcano crater (Papanikolaou et al., 1998, pp. 11–33).

[5] Modified Mercalli Intensity Scale.

[6] This is the case with countries such as Cyprus, Iceland, Indonesia, Japan and Malta, as well as the Caribbean and Pacific Island States. The specificity of small island states was recognised by the United Nations (UN) in the context of the United Nations Conference on Trade and Development (UNCTAD) in the 1980s and 1990s. The Alliance of Small Island States (AOSIS), established during the 'Second World Climate Conference' in 1990, impacted on the agenda of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, in 1992. In turn, at the Barbados Conference on Small Island Developing States in 1994, Small Island Developing States (SIDS) were recognised as special fragile and vulnerable entities, leading to the adoption of the Programme of Action for the Sustainable Development of Small Island Developing States (SIDS-PoA).

[7] The activities of the Council of Europe, the Conference of Local and Regional Authorities and the Mediterranean Action Plan of the United Nations Environmental Programme (UNEP) have focused policymakers' attention on island problems (Coccossis, 1998). Nowadays, islands are officially viewed in EU policy as specific policy entities and/or problem areas (CEC, 2001, p. 8). Of relevance also are the initiatives of the European Commission with the African, Caribbean and Pacific (ACP) states, which paid special attention to the vulnerability of SIDS (Haitink, 1998).

[8] To mention but a few: Small Islands Network; the 'Eurisles' information system; the European Islands Network on Energy and Environment; the EU-funded project 'Storms and Environmentally Sensitive Atlantic Coastal Areas of the European Union'; and the International Scientific Council for Island Development (INSULA). The latter non-governmental organisation (NGO) was established in 1989 and concentrates on promoting awareness and developing a common future for the islands, supporting necessary cooperation and information exchanges in the scientific and technological fields.

[9] The three islands have been studied in the context of a research programme entitled 'Seismic protection policy for islands' coordinated by Professor Demetrios Papanikolaou, Department of Geology, National and Kapodistrian University of Athens. The paper contains some of the findings of the aforementioned programme and of further research carried out by the authors.

[10] 'The idea of process is inherent in all systems, process at different levels. A system exists in relation to an environment, and that system may be "open" or "closed" in relation to that environment; that is an open system is not isolated from its environment and its materials or energies or information are exchanged with the environment on a regular manner. A system is closed if it operates without such interchange' (Chadwick, 1971, p. 45).

[11] An example of the operationalisation of an informal emergency network in a recent disaster in Greece is that of the fishermen who employed in an exceedingly active and committed way their vessels during the 2000 *Samena* ferry-boat shipwreck off the island of Paros.

[12] The suggested methodology can be fully supported by exploiting the capabilities of Geographic Information Systems technology, which enables the storage, management, examination and visualisation of all geographical information related to an effective vulnerability risk analysis and the development of a seismic safety protection policy. Further exploitation involves the application of network analysis algorithms in order to introduce mitigation measures in the most timely and cost-effective way.

[13] Nevertheless, one must consider the degree of maintenance, possible past extension or re-conversion works effectuated and present use.

[14] Based on National Statistical Service of Greece data (NSSG, 2000).

[15] On Kos, for example, the main origin countries of tourists are: United Kingdom (36 per cent); Germany (25 per cent); Netherlands (7.4 per cent); Denmark (5.7 per cent); and Sweden (5 per cent). On Chios, the main origin countries of tourists are: Netherlands (29 per cent); Norway (21 per cent); Austria (13.5 per cent); and Belgium (10.5 per cent). NKUA, UA and MA, 1998 (re-elaborated in 2005).

[16] NKUA, UA and MA, 1998.

[17] Vulnerable functions are those exhibiting a: 'high degree of population concentration' (cinemas, theatres, sports venues, and retail, education, entertainment and religious buildings); 'special nature of space occupancy' (nurseries, primary schools, elderly care homes, orphanages and detention centres; 'increased risk potential' (fuel depots, oil stations, inflammable material storage sites and chemical facilities); and 'economic, administrative cultural functions' (productive/economic units, administrative services, historical and archaeological sites, museums, libraries and historical archives).

[18] Critical functions are: health care provision (hospital units, first aid centres, clinics, health care centres; emergency response functions (regional emergency unit, fire brigade, police, traffic police, municipal police, coastguards, military units); transportation (airports, ports, bus stations, road network); communication/information services (emergency co-ordination unit, public telecommunication company, post offices, radio/television stations, VHS radio amateurs); and lifelines (power stations and distribution networks, water supply authorities and installations, sewage/sewerage networks).

[19] With regard to population inflow, empirical research based on estimations of the island's municipalities and communities has revealed the same order of magnitude.

[20] Elaboration of data from NSSG, 2000, http://www.statistics.gr/StatMenu.asp (accessed December 2005).

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