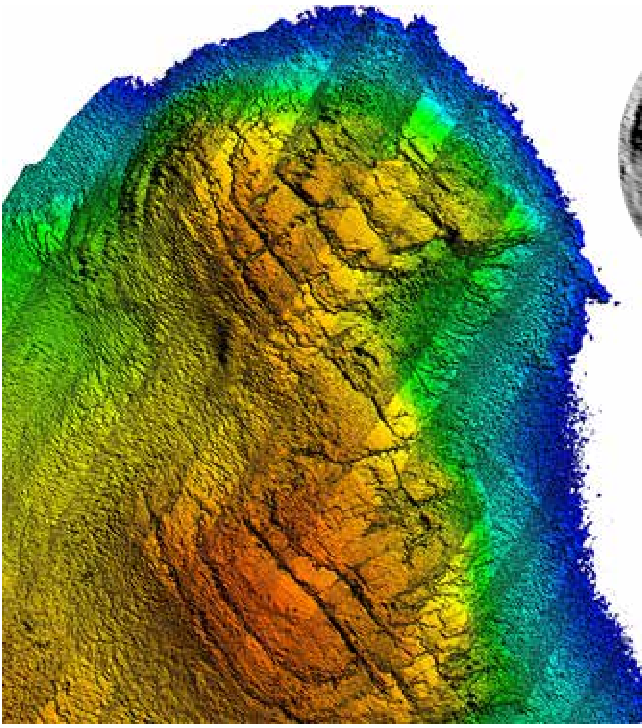
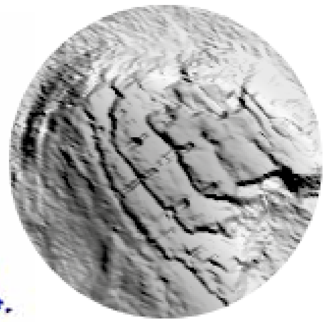
Pivot IV

Social Wellbeing





Zonqor Paradelia

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35° 53' 11.8980" N, 14° 34' 19.3497" E

CHAPTER 18

Risk Assessment: Supporting Public Policy in an Uncertain World

John Agius, Marc Bonazountas, George Karagiannis, Elena Krikigianni and

Chrysovalantis Tsiakos

Introduction

As the emergency management paradigm shifted from response to prevention in the 1980s (Auf Der Heide, 1989), risk assessment progressively turned into a key requirement for civil protection authorities (Schwab, Eschelbach, and Brower, 2007). The European Commission Directorate-General launched the Risk Assessment and Mapping Guidelines for Disaster Management in 2010, whilst the European Parliament and Council Decision 1313/2013/EU on a Union Civil Protection Mechanism requires Member-States to develop risk assessments at national or appropriate sub-national level by 2015 (FIAU, 2013). In parallel, the development of national risk assessments (NRA) became an ex ante conditionality (Baubion, 2013) of the EU Cohesion Policy 2014-2020.

The process of the Disaster Risk Assessment (DRA) development is therefore more vital than the outcome. Prevention is better that cure when it comes to natural and man-made disasters. However, the hazards and threats facing a community may not be known and, even if they are, funding is rarely if ever sufficient to address all of them at the same time. In addition, policy-makers are increasingly required to prioritize the use of scarce resources in an uncertain planning environment. Pressures from the electorate may cause public policy to increase community vulnerability by supporting development in unsafe areas, adopting unsafe building practices and diverging funds from emergency management.

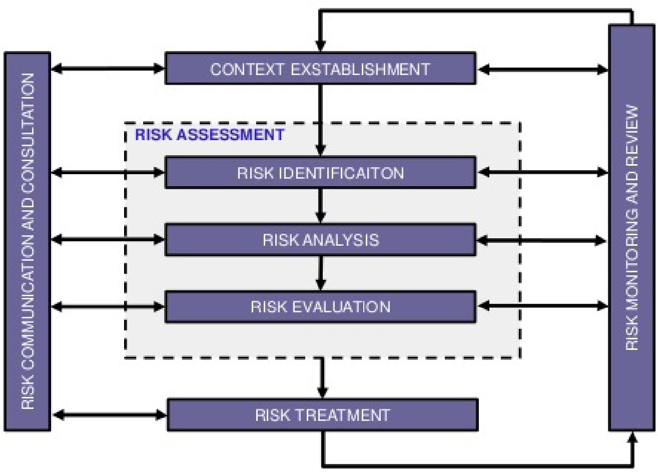
The purpose of a risk assessment is to support decision-making in an uncertain environment, by identifying the hazards and threats that a community is facing and comparing their expected consequences. The process of developing a risk assessment is fundamentally an educational endeavor that can foster a shared understanding of the challenges that a community needs to address.

This study provides an innovative comprehensive approach to the development of disaster risk assessments as strategic planning tools for communities and countries. It outlines the procedure and main steps, to identify and manage the risks and describes the methodology for developing a disaster risk assessment in a defined territory. Finally, this methodology is applied to the Maltese islands with a view of evaluating the risk from known threats and hazards that have potential to significant impact to the Malta's security.

Methodology

The European Commission Risk Assessment and Mapping Guidelines (EC, 2010) adopt the risk assessment process established in ISO 31000:2009 (ISO, 2009). This process (figure 1) is used as a baseline for the National Disaster Risk assessment methodology.

Figure 1: Risk assessment and management process



Source: (ISO, 2009)

The developed methodology employs a 7-step process with several sub-steps (Table 1). Risks are identified, analysed, evaluated and mapped based on the procedure defined for each step and sub-steps. The analysis is based on historical records, statistical data, and information on consequences for each hazard, questionnaires, vulnerability assessments, expert judgment and testing scenarios.

Table 1: Risk Assessment methodology steps and sub-steps

Steps	Sub-Steps
1. Context analysis	1.1 Establish the analysis context at national level
	1.2 Establish risk criteria and indicators
2. Risk identification	2.1 Identify risk sources
	2.2 Identify risk sequence and plausible single & multi-risk scenarios
3. Risk analysis	3.1 Hazard analysis
	3.2 Vulnerability analysis
	3.3 Loss estimation
4. Critical infrastructure assessment	4.1 Define asset and system parameters
	4.2 Collect and gather information
	4.3 Screen infrastructure assets
	4.4 Assess consequences
	4.5 Assess hazards & threats
5. Risk evaluation	5.1 Risk matrix
	5.2 Determine the acceptable level of risk
6. Risk mapping	6.1 Hazard maps
	6.2 Elements at risk and critical infrastructures maps
	6.3 Risk maps
7. Develop Risk Reduction and Management Strategies	7.1 Capability assessment
	7.2 Strategy development

Risk scenarios are necessary to address the uncertainty inherent in risk assessment. A scenario is a plausible description of how the future may develop. Scenario building is mainly based on experiences from the past, but also events and impacts which have so far not occurred should be considered. Scenarios should be based on a coherent and internally consistent set of assumptions about key relationships and driving forces (EC, 2010).The following paragraphs summarize each step of the national disaster risk assessment methodology.

1. Context analysis

Context analysis is the initial step of the methodological approach (Kendon, 1990). It articulates the objectives, defines external and internal parameters to be taken into account and sets the scope and risk criteria for the remaining process. It involves two main sub-steps:

1.1 Establish the analysis context at national level

This includes establishing the external context (i.e. national and international legal and regulatory requirements, stakeholder perceptions, technological and economic context), the internal context (Civil Protection Department culture and tasks, measures, policies and strategies in place, information systems, information flows and decision-making process, standards and guidelines adopted by the managing authority, contractual relationships) and the context of the risk management process (goals, scope and objectives, responsibilities and accountabilities, organisational structure, products and services to be delivered). The scope is to define general objectives and decision-making criteria as a first approximation, to be refined at a later stage.

1.2 Establish risk criteria and indicators

The established criteria and risk indicators that will be used in steps 3 (risk analysis) and 5 (risk evaluation), will reflect the values, objectives and resources:

- They are directly related to risk acceptability and inherently have a social and political dimension (Slovic, 2000);
- They will be derived from national and European legal and regulatory requirements, using an iterative process that requires feedback from steps 2 and 3.
- The nature and type of causes and consequences and their respective metric, definitions and timeframe(s) for likelihood and/or consequences and the different levels of risk will be analysed. Exposure indicators (e.g. duration, intensity, extent and likelihood), threat and vulnerability indicators (e.g. contextual site factors, vulnerable elements, aggravating factors) and consequence indicators (e.g. costs for repair, deaths) related to each national case will also be defined. Data relevance and availability on the appropriate scale should be verified at this step.

2. Risk identification

Risk identification is the process aimed at identifying sources of risk (hazards in the context of physical harm), areas of impact, their causes and potential consequences. It is a screening exercise and it serves as a preliminary step for the subsequent risk analysis stage. Potential sources of information for the risk identification could include official government reports, papers, publications, newspaper or media articles, or even anecdotal information from long-time residents. Although information collection will be hazard- and threat-specific, structured interviews with experts and analysis of existing documentation will be the primary information collection approaches (EC, 2010).

The goal of the risk identification is to screen risk sources and select those risks that pose a significant threat. The result is a selection of risk scenarios to be further analyzed at the risk analysis stage (stage 3). It includes an overview of the various risks and a description of the single- and multi-risk scenarios to be further analysed during the risk analysis stage.

The risk identification involves the following two sub-steps:

- Identify risk sources: The objective is to generate a list of potential hazards and elements that alone or in combination are likely to generate detrimental consequences; it basically involves the identification of hazards that could threaten the territory of the Maltese Islands;
- Identify risk sequence and plausible single and multi-risk scenarios. The objective is to acquire a good understanding of the risk process, from the event source to the related consequences and identify plausible scenarios for single and combined hazards.

3 Risk analysis

Risk analysis involves an understanding of the risks in depth. It provides input to risk evaluation and serves as a decision basis for determining whether risks need to be considered. For every risk and risk scenario identified in the previous identification stage, the risk analysis process carries out a detailed estimation of the probability of its occurrence and the severity of the potential impacts. Quantitative data are sought, were available. Where quantitative data are unavailable, scenario analysis is based on qualitative information. The EC Risk Assessment and Mapping Guidelines require that national risk analysis incorporates at least hazard and vulnerability analysis. Therefore, risk analysis involves three sub-steps: hazard analysis, vulnerability assessment and loss estimation.

3.1 Hazard analysis

Once the hazard, threat and risk identification is completed, a hazard profile will be built by addressing the following information for each hazard (Godschalk et al., 1997; Brower & Bohl, 2000):

- Delineate the location and boundaries of hazardous areas;
- Delineate the magnitude of potential hazards. Magnitude is measured in a different way for each hazard;

- Delineate the likelihood of occurrence of hazardous events. The probability of occurrence of hazard is generally difficult to determine; at minimum, a repetitive probability scale will be used (Karagiannis et al., 2013); and
- Describe and analyze the separate characteristics of potential hazards and threats.

3.2 Vulnerability analysis

The objective is to identify the characteristics and circumstances of the community that make it susceptible to the damaging effects of a hazard (UNISDR, 2009). Vulnerability is analysed against a hazard; therefore, once a hazard has been profiled, vulnerability can be analysed by looking into the following questions (Godschalk et al., 1997; Brower & Bohl, 2000):

- Assess the number of people exposed to hazards and threats, including special populations (e.g., elderly, hospitalised);
- Assess the value of property exposed to hazards;
- Assess critical infrastructure (e.g. hospitals, bridges, water and sewage treatment plants, schools, power plants, and police and fire stations) exposed to hazardous forces, using the criteria established in the European Critical Infrastructures (ECI) Directive;
- Assess the danger from secondary hazards (e.g. dam breaking);
- Assess the danger from hazardous facilities (e.g. chemical plant) in hazard areas;
- Assess the danger from exposure to hazardous materials in wake of natural disaster; and
- Assess environmental impacts of a disaster.

Various techniques can be used to inventory the people and assets (property, critical facilities, hazardous facilities etc.) that could be exposed to hazards. Data from urban planning data, national cadaster data, population census data, fiscal data, industrial data and other sources can be used as required and appropriate. The overall objective at this point is to determine as accurately as possible which parts of the community can be exposed to the hazards that have been previously identified and analysed.

3.3 Loss estimation

The purpose is to estimate the consequences of disastrous events (hazards) to people, buildings, and other important assets identified above. Consequences are estimated in terms of potential losses using a deterministic approach that can directly yield the risk severity (Karagiannis, 2012). The potential losses from the occurrence of a hazard are actually a function of the intensity of the hazard and the community's vulnerability to that hazard.

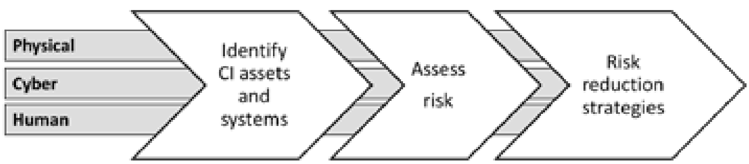
Therefore, one needs to analyze the information gathered during risk identification, hazard analysis and vulnerability analysis. Loss estimation is a two-step process:

- The first step is to calculate the extent of damage from any given hazard. Damages from a hazard are calculated in terms of losses to structures; losses to contents of buildings; losses of structure use and function; and human losses; and
- Then, the total losses due to a specific hazard event can be estimated by adding the losses to structures, to building contents, to structure use and function, and human losses for all assets identified within a community (FEMA, 2001).

4 Critical infrastructure assessment

The loss or disruption of critical infrastructures, such as power, water, transportation and communications, is particularly important in the framework of multi-risk scenarios addressing natural disasters, e.g. earthquakes and tsunamis, and terrorist events (ENISA, 2013), including cyber-threats. However, the new and emerging threats faced by critical infrastructure assets and systems, in conjunction with the interdependencies among them at national and European level, makes it virtually impossible to keep addressing critical infrastructure safety in the traditional, hazard-based way. A systems approach has therefore been used for the assessment of critical infrastructure assets and systems (Figure 2) .

Figure 2: Critical infrastructure assessment core methodology



Source: (adapted from Department of Homeland Security (DHS), 2013)

It is important to note that the assessment of critical infrastructures was not conducted as a separate exercise from the remainder of the risk assessment. Rather, the identification of hazards and threats, and the analysis and evaluation of the risks thereof, have been conducted simultaneously with the assessment of critical infrastructure assets and systems. This combination of the contingency and systems approaches has proven highly useful and has been a major improvement to the overall outcome compared with traditional risk assessment approaches.

The identification of critical infrastructure is based on the guidelines established in Annex III of EU Directive 2008/114/EC on the identification and designation of European Critical Infrastructures (ECIs) and assessment of the need to improve their protection. Specific criteria will be determined in consultation with the Critical Infrastructure Protection (CIP) Directorate. Therefore, the list of criteria is likely to include:

- the necessity of the infrastructure for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people;
- severity of impact;
- the availability of alternatives;
- the duration of disruption/recovery; and
- the potential impact of the disruption to other EU Member-States (ECI).

Critical infrastructure can include, but not be limited to, the following:

- Energy (electricity, oil, gas, renewable energy)
- Transportation (road, rail, air, water – inland and ocean)
- Communications and information technology
- Emergency services
- Healthcare and public health
- Water, wastewater services and dams
- Food and agriculture
- Commercial, critical manufacturing and chemical facilities
- Financial services
- Government facilities
- Defense facilities

5 Risk evaluation

Risk evaluation involves comparing the level of risk found during the analysis process with the risk criteria established when the context was considered. It involves two main sub-steps: the risk matrix and the level of acceptable risk.

5.1 Risk matrix

The Contract, and the EU Risk Assessment and Mapping Guidelines and the Standard on Risk Management (ISO 31000:2009) require that each risk must be assessed on the basis of its likelihood and its consequences, using a risk matrix that is appropriate to the country level of risk. From the matrix, there emerges a measure of the severity of the risk, and a recommendation on how to proceed. A system for assessing the severity of a risk requires three components:

- A multi-level scale for rating the likelihood (or the probability of occurrence) of a risk;
- A multi-level scale for rating the consequences (or the severity of impacts) of a risk; and
- A matrix for scoring each possible combination of likelihood (probability) and consequences (impacts).

The ISO standard requires that the three components be realistic within the context of the analysis and reflect the perception of risk within the specific country.

Risk matrices are commonly used in risk assessments, as they help illustrate the relative prioritisation of each hazard according to the combination of their probability of occurrence and severity of impact. A 5×5 risk matrix (Table 2) can be used in risk assessments (EC, 2010). Each risk is represented by a point on a risk matrix. This point corresponds to a defined degree of probability of occurrence and severity of impact (Cox, 2008).

Table 2: A 5×5 risk matrix

		Probability of occurrence				
		Highly Likely	Likely	Unlikely	Highly Unlikely	Extremely Unlikely but yet possible
Severity	Catastrophic					
	Significant					
	Moderate					
	Minor					
	Limited					

Source: (EC, 2010)

Determining the probability of occurrence of a hazard is a key step in a risk assessment. The probability of occurrence for a known hazard will normally have been determined during the risk analysis phase. A qualitative or quantitative (depending on available data) scale should be used. The qualitative and quantitative scales illustrated on Table 3 will be used to provide a relative likelihood of the occurrence of a hazard.

Table 3: 5-class probability scale

Probability class	Quantitative	Qualitative
A	More than 10^{-2}/year	Highly likely
B	10^{-2}-10^{-3}/year	Likely
C	10^{-3}-10^{-4}/year	Unlikely
D	10^{-4}-10^{-5}/year	Highly unlikely
E	Less than 10^{-5}/year	Extremely unlikely but yet possible

A hazard's severity of impact on a given community also needs to be determined if the risk from the hazard to that community is to be estimated. The severity of the impact of a hazard is actually a function of the intensity of the hazard and the community's vulnerability to that hazard. It is therefore determined by analyzing the hazard's own characteristics (e.g. location, boundaries, magnitude, intensity etc.), which have been determined during the risk identification and analysis phases. The result of the combined analysis of hazards and vulnerabilities is the estimation of potential losses. A deterministic approach is used to estimate losses from the occurrence of a hazard.

The estimated losses can be directly used as an indication of the hazard's severity of impact in a risk assessment. Severity ratings need to be consistent for all hazards; otherwise the purpose of performing a risk assessment is defeated. Table 4 illustrates the scale of severity ratings that will be used.

5.2 Determine the acceptable level of risk

In this step the acceptability of risks is determined based on the risk criteria adopted, risk standards and regulations, tipping points (e.g. technical, financial, spatial or societal/cultural acceptable limits) and uncertainty considered based on the precautionary principle. The choice of probability and severity scales reflects the level of acceptable risk in the nation. Research has shown that risk acceptability depends on psychological factors and has a strong social and political dimension (Slovic, 2000).

Table 4: 5-class severity scale

Severity	Characteristics
Catastrophic	• Multiple deaths • Complete shutdown of critical facilities for 30 days or more • More than 50 percent of property severely damaged
Significant	• Injuries and/or illnesses result in permanent disability • Complete shutdown of critical facilities for at least 2 weeks • More than 25 percent of property is severely damaged
Moderate	• Injuries and/or illnesses do not result in permanent disability • Complete shutdown of critical facilities for more than 1 week • More than 10 percent of property is severely damaged
Minor	• Injuries and/or illness treatable with first aid • Shutdown of critical facilities and services for 24 hours or less • Less than 10 percent of property severely damaged
Limited	• Less than "Minor" effects

Source: (adapted from FEMA, 2007)

Once the probability of occurrence and the severity of impact of a hazard are determined, a risk level can be defined. Generally, the higher the risk level, the higher priority must be given to the prevention measures aimed at that risk. In addition, risks with high probability of occurrence or high severity of impact should be given particular attention.

6 Risk mapping

Maps are useful tools that can be used to support risk assessment. They show information about hazards, vulnerabilities and risks in a particular area and thereby support the risk assessment process and overall risk management strategy. They can help set priorities for risk reduction strategies (EC, 2010). Maps are especially useful for hazards that can be spatially defined.

Risk mapping is being increasingly used with the advent of information technology and aerial photography for civilian purposes, both of which enable the development of Digital Terrain Models (DTMs) and Geographical Information Systems (GIS). A GIS is in essence a digital map (based on a digital terrain model), upon which additional layers are overlaid to describe specific types of information, such as demographic factors, the built environment, networks, topography, geophysical phenomena etc. (Alexander, 2002). In addition, maps can help assess the reliability, validity, spatial specificity, and relevance of the existing hazard data.

A base map will include the following descriptive categories of shapefiles or coverages:

- Built-up areas (by population size/census data)
- Roads and Bridges
- Transportation Grids
- Telecommunication Grid
- Sources of Energy
- Energy Facilities/Utilities and Power Grids
- Environmentally Regulated Facilities
- Forests/Vegetation
- Fire Service locations
- Special Areas of Conservation (SACs) NATURA 2000
- Special Protected Areas (SPAs)
- Watersheds/Dams/Water Utilities
- Land cover/use
- Town Planning Zones
- National Cadastral maps
- Soils
- Digital Elevation Models (DEMs)
- Topography

Based on this base map, three types of maps are developed:

6.1 Hazard maps are used to represent critical characteristics of each hazard;

6.2 Vulnerability maps illustrate the spatial distribution of elements at risk, including but not limited to people (population density maps), property, critical infrastructure or the environment; and

6.3 Risk maps are a combination of the information included in hazard maps and vulnerability maps. They provide an estimation of the level of risk based on the combination of likelihood and impact of a certain event as well as for aggregated hazards (Alexander, 2002)

7 Develop Risk Reduction and Management Strategies

Risk Reduction and Management Strategies are developed based on the knowledge gained throughout the risk identification, analysis and evaluation processes:

- It is perhaps the most important part of the entire risk assessment endeavor.;
- It clarifies the objectives of the policy by determining precise and measurable statements of the intended results to be achieved at different levels; and
- It defines the course of action to be followed to achieve the results, as well as the indicators by which to measure those results.

The development of Risk Reduction and Management Strategies includes the following two steps:

7.1 Capability assessment

The capability assessment and the risk assessment form the "fact basis" of the Risk Reduction and Management Strategies. The capability analysis should outline the strengths and weaknesses of the institutional mechanism to deal with risk mitigation. The capability assessment will review existing prevention policies, as well as any problems associated with current policies; opportunities for and obstacles to new prevention initiatives; the level of present effort devoted to prevention; and intergovernmental coordination of programs (Brower & Bohl, 2000). Capability assessment is a two-step process: Exploring the existing policies, laws and actions that may affect vulnerability and investigating the capability of government departments and agencies.

7.2 Develop strategies

Risk Reduction and Management Strategies should not merely refer to the purposes of the risk assessment as a document (e.g. to fulfill EU requirements). Strategies should instead refer to the ultimate ends of risk reduction that the nation is trying to achieve. Risk Reduction and Management Strategies should be broad in scope and far-reaching in application, and they should be structured as positive statements that are attainable rather than negative observations about the community. Strategies should be cross-cutting in areas of public interest in addition to disaster prevention. For instance, strategies can support such principles as improving water quality, preserving natural areas, and creating open space (Schwab et al., 2007).

The first step in a risk reduction and management strategy is to define its goals, i.e. the intended effect of the policy. A goal is defined as the long-term results that a policy seeks to achieve, which may be contributed to by factors outside the policy itself. Once defined, goals are broken down in objectives, which define the primary results that the policy seeks to achieve in order to accomplish a goal (IFRC, 2010). A goal may include one or more objectives. Although there is no limitation as to the number of objectives per goal, three or four are usually adequate, otherwise the project could become rather complex.

The difference between goals and objectives can be quite subtle. The goals explain the long-term reasons why the community chooses to undertake a prevention policy (e.g. "to ensure public safety"). The objectives, on the other hand, are more specific, measurable, and intermediate ends which are achievable and mark progress toward the goals (e.g. "reduce population in at-risk areas by fifty percent"). The goals and objectives should be articulated clearly at the start of the disaster prevention planning process to inform the selection of the proposed strategy which makes up the heart of the plan. Individual objectives will vary widely depending on a number of factors, such as the nature of the hazard threat, the level of local and regional resources, and the time frame for implementation of the plan (Brower & Bohl, 2000).

Finally, each objective may be broken down into disaster prevention measures or activities. Activities are the collection of tasks that produce the tangible products, goods and services and other immediate results that lead to the achievement of objectives (IFRC, 2010). One objective may have two or more measures/activities. Although there is no limitation as to the number of activities per objective, more than 7 activities per objective could make the policy too complex to realize in the field.

Malta Test Application

The aforementioned methodology, has been selected to be applied in the country of Maltese Island. The geographical coverage of the NRA includes Malta's territory, territorial waters and air space. However, the analysis was extended outside Maltese territory in some cases, as appropriate. For example, oil spill and marine pollution risk analysis required information about Malta's continental shelf, while the analysis of aviation accident risks will naturally extend throughout Malta's Flight Information Region (Camillieri, 2003 & 2006, Chetcuti, Buhagiar, Schembri and Ventura,, 1992) .

Malta's National Risk Assessment focuses on three types of risks:

- Contingency events with defined beginning and endpoints, such as floods, hurricanes, earthquakes, terrorist attacks;
- Chronic societal concerns, such as illegal immigration, and others not generally related to national disaster preparedness, including traffic accidents and money laundering;
- Loss or disruption of critical infrastructure.

The output of the risk identification phase is the identification of hazards and threats. A total of 33 hazards and threats (with 42 scenarios), and 3 horizontal issues have been identified in the Maltese National Risk Assessment.

Risk analysis involves an understanding of the risks in depth. For each of the 10 risks selected at the hazard and threat identification stage, the risk analysis process carried out a detailed estimation of the probability of its occurrence and the severity of the potential impacts. The end result of the risk analysis is the severity and probability of occurrence of the selected hazard and threat scenarios, which serve as input to the risk evaluation stage. The output of this phase was a detailed risk analysis and evaluation of Malta's top hazards and threats.

The goal of the assessment and mapping of critical infrastructures is to identify critical assets and systems that are essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or loss thereof would have a significant impact in Malta as a result of the failure to maintain those functions.

In addition, throughout the NRA exercise, more than 500 critical and other relevant infrastructure assets and systems have been identified. Based on the results of the assessment and mapping of critical infrastructure, two additional National Planning Scenarios were identified. At the same time a series of GIS-based systems and a GIS application have been developed to support the NRA exercise. Also, a separate Risk Reduction and Management Strategies Report has been prepared. It defines the course of action to be followed to achieve the results, as well as the indicators by which to measure those results. The following table (Table 5) briefly present these strategies that stem from the National Risk Assessment exercise:

Table 5: Risk Reduction and Management Strategies

Title of Strategy
Improve Knowledge and awareness about hazards, threats and risks
Mitigate hazards and threats
Protect Critical Infrastructure and Key Resources
Improve response and recovery capacity

Conclusion

Natural hazards can cause serious disruption to societies and their infrastructure networks. The impact of extreme hazard events is largely dependent on the resilience of societies and their networks. The Disaster Risk assessment methodology which is described above, performs a critical decision support role in maintenance decision making. Malta's test application was conducted as a comprehensive exercise aimed at identifying sources of risk and understanding of the risks and their consequences in depth.

Acknowledgments

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