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Socio-Economic Factors in the Event of an Oil Spill in the North Adriatic

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ABSTRACT: Should an oil spill of tier III magnitude occur in the Northern Adriatic, there is a high probability that the oil will reach and pollute the surrounding coastline. Therefore, it is vital to conduct coastal vulnerability studies to develop priority plans and coastal vulnerability maps to help first responders protect the coastline. As there is no common contingency plan for oil spills in the Northern Adriatic, three countries, Italy, Slovenia, and Croatia, which share the area, decided to participate in the North Adriatic Incident Response System (NAMIRS) project. Part of the project was to conduct a coastal vulnerability study in the area. One of the three pillars for determining vulnerability, in addition to the ecological and geomorphological factors, is the socio-economic aspect, which was studied as part of the research. As there are no clear scientific methods to determine the vulnerability of the socio-economic factors, a survey was conducted where the participants gave their subjective opinion on its value. This was done through three workshops organised in each participating country, where professional stakeholders familiar with the state of socio-economic activities assessed their vulnerability. The values obtained were combined with the assessments of the geomorphological and environmental factors and gathered in a coastal vulnerability layer, which was incorporated into a GIS as a standard coastal vulnerability map that will help first responders prioritise coastal protection. The research results will also be useful globally and not just in the area studied by NAMIRS, since the method used is readily applicable to any part of the world.

1 INTRODUCTION

Socioeconomic factors can refer to any activity or structure that economically benefits a country, a municipality, and a community or a great social value to the people in an area where these factors are located. Many of these factors are found in coastal areas, as the sea provides many opportunities for pleasure, tourism, recreation, fishing, and other similar activities. In the northern Adriatic, there is a high probability that an oil spill will reach the surrounding coastline because the area is located in a closed bay. The coast, shared by the three countries of Italy, Slovenia, and Croatia, has a high socio-economic value. Therefore, an efficient emergency plan should be established to prevent the oil spill from spreading further and protect the most vulnerable parts of the coast. If emergency responders have hazard maps available, they can prioritise certain sections of the coast over others because they prove to be particularly vulnerable to oil. They would be unable to protect the entire coast because, in the initial period after an oil spill, no one had sufficient resources and equipment to clean it up. This shows how important it is to map coastal vulnerability to oil.

When discussing the vulnerability of coastal areas to oil, it is essential to consider more than environmental sensitivity. For example, an oil spill contaminates mariculture fields could affect food supplies and lead to food shortages. Another example would be the significant pollution of a resort and its beaches. In this case, revenue from the tourist season would be jeopardised for years to come, affecting the local community and possibly the economy of an entire country if the country in question is highly dependent on tourism as a source of revenue for its GDP. Therefore, any coastal activity with social and economic value must be considered.

Following this train of thought, two groups of hazard factors are formed: environmental and socioeconomic factors. However, since each beach or shoreline is composed of different materials that react differently to oil, geomorphology must also be considered. To do this, all shorelines in a given area must be identified and ranked according to their oil sensitivity, using Environmental Sensitivity Index (ESI) values determined by NOAA or other scientific means, since many different shorelines around the world don't occur in the U.S. and therefore aren't included in the ESI ranking [9]. Once all three groups of vulnerability factors are identified, they can be divided into subsections that provide information on what types of factors belonging to each group are present in that area or, as in the case of NAMIRS, in the northern Adriatic. But why is coastal vulnerability mapping necessary for oil spill emergency planning or other hazard mitigation, and how can vulnerability be qualified or quantified? This problem can be addressed in several ways.

2 COASTAL VULNERABILITY ASSESSMENT

Today, the term "coastal hazard" is ubiquitous in oil spill emergency planning. However, the term refers to different types of hazards. Over the years, scientists around the world have described coastal vulnerability as either a factor highlighting the susceptibility of the coast to natural or man-made processes, such as erosion from flooding and the construction of coastal infrastructure, or as a factor highlighting the susceptibility of the coast to pollution from oil or other hazardous chemicals [6]. Therefore, this aspect must be considered in developing an oil spill contingency plan for several reasons.

Gundlach, Hayes, and Michel et al. were the first to classify coastal vulnerability to oil spills. Twenty years later, their work was improved by Jensen et al. and then further developed by the National Oceanic and Atmospheric Administration (NOAA) into one of the most efficient coastal vulnerability assessment tools, the Environmental Sensitivity Index (ESI) [7, 14, 15, 16]. There are no tools like the ESI in Europe since they can be applied worldwide, and most do not need to be redeveloped. Nevertheless, some studies have been conducted to create a similar coastal vulnerability index [8]. For the Adriatic Sea, only one tool, an atlas, is proposed in the SHAPE project: the oil spill vulnerability assessment. Since the lack of clear coastal vulnerability maps is a significant gap in international oil spill emergency planning, the three countries sharing the northern Adriatic area decided to try to create their coastal vulnerability index to develop a tool that can be applied in other areas of the Adriatic and worldwide, taking into account not only the geomorphological aspect defined by the ESI but also environmental and socio-economic factors.

Coastal regions such as the northern Adriatic are remote and landlocked. Therefore, there is a high probability that oil spills will reach the surrounding coastal areas. In the event of a major oil spill, first responders are unlikely to have sufficient resources and equipment to protect the entire coast from pollution. Therefore, they would need to decide which sections of the coast they should protect rather than others. For responders to decide which coastal sections to prioritise for protection, coastal vulnerability maps must be developed.

Globally, coastal vulnerability has been assessed separately for each hazard factor and combined into a standard vulnerability index. Geomorphological factors are now scientifically assessed using Environmental Sensitivity Indices (ESI) produced by the National Oceanic and Atmospheric Administration [7]. Environmental factors are scored differently or, in some cases, need not be scored at all. These factors, represented by various legally protected areas, would take precedence over anything else in the event of an oil spill, at least in those countries that enforce such laws. However, in assessing the socioeconomic factors of vulnerability, there are several approaches to this problem.

2.1 *Socio-economic factors assessment*

In addition to the costs that arise in oil spill clean-up operations, financial losses are sometimes experienced by sectors that rely on clean seawater and coasts. The most significant economic impacts are typically felt in fisheries, mariculture, and tourism, although a great number of other sectors can be affected, such as cooling water stations, cultural heritage sites etc. [5]

Tourism, which is one of the main socio-economic factors that bring great income to countries with rich coastlines, can be disrupted by the presence of oil in water or onshore. Consequences likely to arise include disrupting traditional coastal activities like bathing, boating, diving etc. However, this affects not only the coastline but also hotels, restaurants, bar owners, sailing schools, campsites, caravan parks, tourist marinas and the many other businesses and individuals who gain their livelihood from tourism. Some holidaymakers may cancel bookings in the affected area and transfer their holidays to alternative locations. The problem, however, lies in visitors' conscience, as they are unlikely to return to the affected site for years because they would deem it tainted from oil, even if the area was sanitised and cleaned. The same could be said for various recreational sites, often tourist sites [5].

Ports can suffer similar consequences as tourist marinas, but on a grander economic scale for the country rather than a specific tourist area. However, these consequences may only last for a short time since ports have environmental protection services that can quickly limit them. Losses in the case of ports are related to the loss of business the port could make when it is closed because of oil spill clean-up operations [5].

In many countries, mariculture and fisheries represent a big part of their population's food chain, which can be seriously depleted if affected by oil. The importance of mariculture varies from country to country, but it's nevertheless always worth considering [5].

Another factor worth considering from a socio-economic point of view is cultural heritage, which represents excellent value to history and even tourism. Damage caused to cultural artefacts may either result from the oil itself or negligent clean-up operations. The surfaces of heritage sites which have weathered can become porous or crumbling. Therefore, oil can penetrate deeply into them and cause major difficulties. Specialist restoration techniques may be called for, which can be very costly, depending on the scope of pollution [5].

Worth considering are also various industrial water intakes used for cooling water or other purposes. The sanitation costs would depend on the scale of pollution [5].

Knowing the presence of the above factors in the area in question, the vulnerability to determine the vulnerability to oil by various methods, sometimes more and sometimes less appropriate.

Qualitative descriptions or quantitative values can determine the coast's vulnerability from a socioeconomic point of view. The economic part of the socioeconomic factors can be determined in two ways: by calculating the impact on the GDP of the affected countries or by obtaining estimates of the value from stakeholders working on the ground. The v). The POLMAR plan was established in 1978 after the Amoco Cadiz disaster. In 2004, the POLMAR plan was renamed the ORSEC-SEA plan. The plan was developed to assess vulnerability from an environmental and socioeconomic perspective in counties in the Northeast Atlantic. It includes the following socioeconomic factors [2, 3]:

– recreation and tourism,
– fisheries and aquaculture,
– shipping,
– ports,
– oil and gas industry, and
– offshore renewable energy.

Apart from recreation and tourism factors, the plan determines the vulnerability of other factors from their impact on each participating country's GDP, highlighted in added gross value in a million euros per year. However, the assessment of former factors also considers the number of people visiting each country for recreational or touristic purposes. The areas which add the most to the OSPAR region's GDP are given the highest vulnerability grade. In contrast, those with the lowest added gross value are given the lowest vulnerability value [2, 3].

Another way to assess the vulnerability of socio-economic factors is the analytical hierarchy process method (AHP), used by Vafai et al in the coastal areas of the Caspian Sea in the north of Iran. The AHP is a popular method, first proposed by Saaty, which is used for solving multi-criteria analysis problems described by qualitative factors. The method incorporates a decision matrix to transform qualitative data into numeric ratios, enabling us to easily compare different factors, such as geomorphological, environmental, and socio-economic factors. By gathering data on the type and number of subfactors from each vulnerability factor group, Vafai et al executed a workshop where experts from each field compared the vulnerability of one factor with another (for example, the importance of socio-economic factors related to environmental factors). After obtaining these results, comparative ratios of the three-factor groups are calculated. A model connecting the three-factor groups must be chosen to determine the coastline's vulnerability. The Iranian scientists also calculated vulnerability with FAHP or fuzzy analytical hierarchical process, which proved more accurate because it eliminates probable uncertainties in the comparison process [4, 17].

The final known efficient method to assess the vulnerability of socio-economic factors is an execution of a coastal vulnerability assessment workshop, where invited stakeholders give their subjective opinion on the importance of each factor. Stakeholders in such workshops should be representatives from each socio-economic area. The final results can be merged with environmental and geomorphological vulnerability factor grades by applying AHP or FAHP ratios.

2.2 *Socio-economic factors assessment in NAMIRS*

Intensive human activity in the Northern Adriatic contributes to a high density of various tourist resorts, recreational areas, and other activities with socio-economic value. The area also includes extensive protected areas of natural and historic sites. Protected natural areas include lagoons, underwater habitats of protected species, cliffs, salt marshes and pans, nature reserves of Mediterranean terrestrial flora and fauna, and freshwater lakes. Considering all these factors, the area will remain highly vulnerable as it grows. Individual countries cannot rely on their resources to deal with a probable major marine pollution incident. Regional cooperation and mutual assistance are, therefore, essential. The first attempt to form a sub-regional contingency plan between Italy, Croatia and Slovenia for oil spill preparedness and the response was made in 2004. At the time, the first coastal vulnerability mapping studies, which represent the first step needed to be undertaken when forming a pollution contingency plan, were conducted. Figure 1 depicts cumulative sensitivity scores of the Slovenian Coastline according to the data available in early 2000 [1].

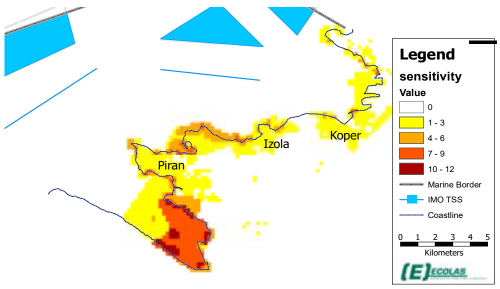

Figure 1. Cumulative sensitivity values of the Slovenian coastal area. Higher scores represent higher vulnerability.

Twenty years later, the NAMIRS project is continuing its research into the vulnerability of the Northern Adriatic to potential marine pollution. This time, the approach to mapping vulnerability was different and consistent for all project team members [1].

The coastal vulnerability assessment studies undertaken by research teams from Slovenia, Croatia, and Italy in the scope of the NAMIRS project were conducted in three workshops which produced values of coastal vulnerability to oil spills with the help of workshop participants' quantitative estimations of each highlighted area. The workshops referred to the guidelines of the Delphi method, which defines the IALA PAWSA risk assessment method. Still, because of the different needs of the NAMIRS project, it was rearranged accordingly to them. This mainly pertains to the time in which the workshops were executed. A traditional PAWSA workshop is divided into two or more days. From those two, the first day is dedicated to thoroughly informing participants on each vulnerability and dividing them into groups that tell us how knowledgeable participants are in the studied area. The second day is dedicated to filling in the coastal vulnerability assessment questionnaires to obtain participants' opinions on the value of vulnerability and rearranging it according to their level of knowledge. The process undertaken in NAMIRS went precisely as described. Still, instead of expanding to two days, it was concluded in a single day, meaning that vulnerability factor presentations had to be executed more quickly. However, considering the costs of organising each of the workshops and the time, which was available to the research teams, and, more importantly, to participants, the workshops were deemed to have been executed well because everyone who participated belonged to a group of experts and was therefore considered to have sufficient knowledge in any case.

Such a method of determining coastal vulnerability may be unnecessary since this can be done objectively by conducting scientific research on which types of coasts are the most sensitive to oil spills with the help of ESIs. However, while this is correct from any point of view, the subjective opinion of those who either exploit the sea or coast for any beneficial socio-economic activity and of those who engage in environmental protection or environmental preservation must also be considered since these values cannot be objectively determined in any other way, apart from the ones described in the previous chapter. The format of workshops was chosen because of the tight schedules set by NAMIRS.

The first step towards realising the workshops was relevant stakeholder mapping. A list of services and people who engage in either detection or alerting activities, prevention, preparedness and monitoring activities, cleaning and cleaning-related activities, and post-cleaning operations were formed for each participating country. The research groups also invited every non-governmental or governmental organisation that does not necessarily engage in any of the aforementioned tasks but is known to know the matter in question. This was done to obtain a professional assessment of vulnerability.

The next step included the identification of all factors which have a social and economic value for the community and economy. The socio-economic areas that may be affected by an oil spill include tourist resorts and seaside hotels or camps, cultural heritage sites, cooling water stations, ports, recreational areas (man-made structures built along the coast for sports and other recreational activities), and maricultural areas. Ports were then further divided into commercial ports such as the Port of Trieste, tourist ports represented by marinas dedicated to tourists, and local ports used by local communities and fishermen. Maricultural areas were divided into shellfish, fish, and other havens or farms.

After identifying all socioeconomic factors, the researchers consulted various databases run by project partners or other services to locate them on a map. Locations of mariculture fields were downloaded from the Adriplan data portal. Locations of cultural heritage sites were determined by merging information from maps of archaeological and paleontological sites available on EMODnet Geology, EMODnet Human Activities, and the Bioportal of Croatia. However, gathering data on locations of tourist and recreational areas was more problematic since no maps reporting the recreational and touristic sites were available. A joined map of the recreational-touristic traits of the coast was generated by highlighting intersections between the Northern Adriatic coastline and a 100 m radius buffer drawn around suitable bathing water sites downloaded from EMODnet - Human Activities. Although the number of traits of coast with recreational-touristic activities may be underestimated using bathing water sites, this was the only available information that could be used as a proxy for deriving such vulnerability factor [10, 11, 12, 13].

After all the data was successfully gathered, the researchers formed a questionnaire for the stakeholders to fill out. The invited stakeholders and other organisations met at each of the organised workshops either live in situ or online via the provided link to the digital version of the questionnaire. The workshops proceeded in a completely anonymous manner but with known stakeholders. Participants were asked to assess the vulnerability of each socio-economic factor with a grade on a scale ranging from 1, representing the lowest level of vulnerability, to 9, representing the highest level of vulnerability. When all three workshops were completed, their results were subjected to statistical processing, the outcome of which was later analysed and highlighted in graphs and tables.

3 NAMIRS SOCIO-ECONOMIC FACTORS ASSESSMENT RESULTS

A total of 104 stakeholders participated in the Northern Adriatic Coastal Vulnerability Assessment workshops, either online or on-site.

Results from all three workshops were merged into a single database and subjected to statical processing. Measures of central tendency, including mean, mode and median values, and standard deviation, were calculated for each socio-economic factor. Calculated results are highlighted in a table below, where each socio-economic factor is listed under its question number from the workshops questionnaire:

– Q1 – mariculture,
– Q2 – tourism,
– Q3 – recreation,
– Q4 – cultural heritage,
– Q5 – cooling water stations,
– Q6 – commercial ports,
– Q7 – tourist ports, and
– Q8 – local ports.

Table 1. Joint workshop results

Question	μ	Mode	Median	σ
Q1	7,8	9	8,8	1,799876
Q2	7,6	9	8	1,556356
Q3	6,7	7	8	1,882995
Q4	6,8	7	7	1,752429
Q5	5,7	5	6	1,783609
Q6	6,1	6	7	2,105484
Q7	6,7	8	7	1,952255
Q8	6,4	7	7	1,978037

The stakeholder's input was also exported into grade frequency distribution charts below, which indicate high data dispersion highlighted by standard deviation values from the upper table.

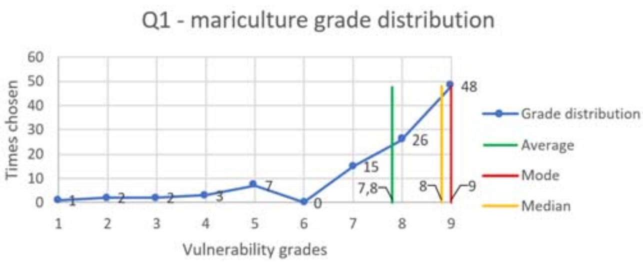

Figure 2. Mariculture grade distribution chart.

Figure 3. Tourism grade distribution chart.

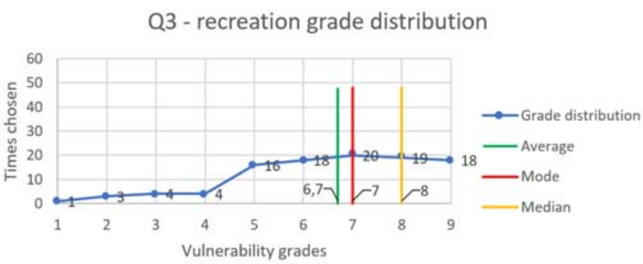

Figure 4. Recreational areas grade distribution chart.

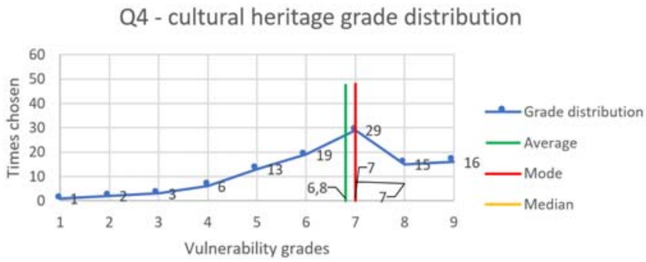

Figure 5. Cultural heritage sites grade distribution chart.

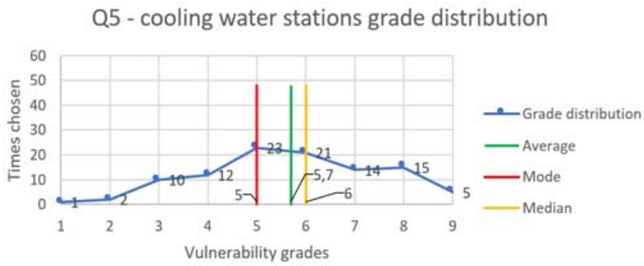

Figure 6. Cooling water stations grade distribution chart.

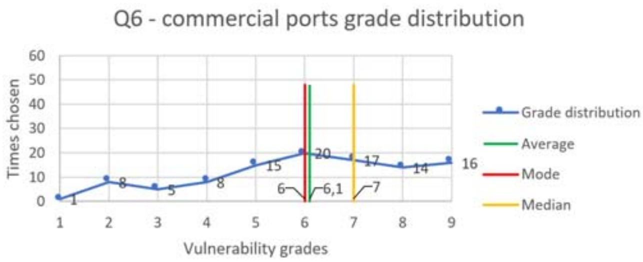

Figure 7. Commercial ports grade distribution chart.

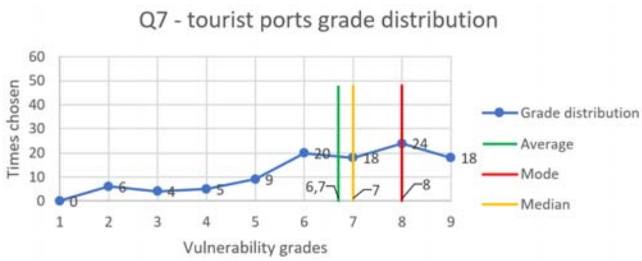

Figure 8. Tourist ports grade distribution chart.

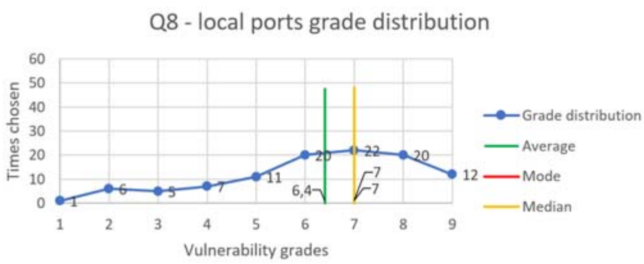

Figure 9. Local ports grade distribution chart.

In this study, it was necessary to use the mean scores as the mode and median scores were, in some cases, too high after calculating all three means of central tendency. Participants generally rated all socioeconomic factors almost equally, except for tourism and mariculture, which were rated more vulnerable. This is mainly because both factors are strongly present in the Northern Adriatic and significantly impact the three countries' economies, especially in Croatia, where tourism plays an important role. Conversely, Mariculture is ranked high due to its direct impact on the food supply of the coastal regions known for their seafood.

After collecting the vulnerability levels from the socioeconomic factors group, the research team merged them with the vulnerability levels of various coastal geomorphological types in the northern Adriatic Sea identified through reassessed ESI, as well as with the estimated vulnerability levels of various legally protected areas that fall under the environmental factors category. The summarised vulnerability levels were exported to a GIS as the Coastal Vulnerability Layer of the Northern Adriatic, which formed the final vulnerability map. The map accurately shows the location of the factors and their coastal vulnerability values under all three viewpoints. The only major difficulty the research team faced in creating the map was finding micro-locations for some factors. While there were no problems locating mariculture fields, harbours, cooling water stations, heritage sites, and recreation areas because there are accurate national and international databases and projects that monitor them, the same is not valid for tourism areas such as hotels, campgrounds, and resorts. In the future, the map will be updated down to the micro-site level in cooperation with the municipalities of each country.

4 CONCLUSIONS

Socioeconomic vulnerability workshops were chosen because they can be conducted quickly and only require a few resources. Workshops are also practical because they provide an up-to-date overview of the views of socioeconomic stakeholders and the general public. People's priorities and policies can change over the years, as can the importance of each socioeconomic area. Therefore, the workshop format seems most appropriate for vulnerability assessment. Another reason why workshops are best suited to address this problem is because of their global applicability and ability to highlight what people see as critical rather than leaving this to the economic sector. While ranking the vulnerability of these factors by their contribution to the economy gives us an idea of which sector needs to be protected first, it does not highlight what is essential to people from a social perspective. For example, a country's commercial ports may significantly contribute to its economy, which would suffer if its work were interrupted due to an oil spill. At the same time, the population may also depend on local fishing ports, as seafood plays a vital role in the country's food chain. Local ports would not have as significant an impact on the country's GDP as commercial ports and would therefore be less vulnerable if the vulnerability were calculated based on income. In such a case, if the vulnerability were determined using socioeconomic factors in workshops, more emphasis could be placed on people's needs. Linking workshop results with AHP or FAHP analyses leads to a globally applicable method for assessing socioeconomic factors.

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