ICUR2016

International Conference on Urban Risks

LISBON 30 JUNE-2 JULY

ICUR2016 Proceedings

Atas ICUR2016

Conferência Internacional de Riscos Urbanos

LISBOA 30 JUNHO-2 JULHO

Vulnerability Identity (V.ID) for coastal territories subjected to oil spill accidents

Rui GRAÇA[1], Emília REBELO[2], Flávio MARTINS[3]

[1]Faculdade de Engenharia da Universidade do Porto, Porto, Portugal, ruibgraca@gmail.com
[2]Faculdade de Engenharia da Universidade do Porto, Porto, Portugal, emalcata@fe.up.pt
[3]CIMA, Universidade do Algarve, Faro, Portugal, fmartins@ualg.pt

Abstract: Portugal has a 942 km length coastline and approximately 1.72 million km^2 of territorial waters (about 18 times the area of the country), including territorial sea and Exclusive Economic Zone (EEZ), representing the 11th largest area in the world. Within the EU, Portugal is the country with the largest area of territorial waters, excluding the overseas territories of France and the United Kingdom.
The Portuguese EEZ is crossed daily by approximately 200 vessels larger than 500 tons, of which 40 are tankers, in addition to about 220,000 ships entering the Mediterranean. This traffic is hazardous, representing a high economic, environmental and social risk to the region.
In this article, a multi-indicator index for costal oil spill vulnerability, the V.ID (Vulnerability Identity) is proposed. Unlike traditional single indicator indexes, V.ID considers different vectors of oil spill vulnerability to create an "Identity Card" of each Unit in the Study Domain, associating a graphical image to it, providing easy and immediate reading.
The vectors considered include various socio-economic and environmental statistical indicators associated with each of the municipalities. These vectors integrate information regarding the length and type of coast of each municipality, natural areas and Natura 2000 areas, population, importance of hotel business and fishing on the economy of each municipality. The explicit visualization of different vectors will allow the analysis of different independent aspects of vulnerability, easily masked when aggregated in a single index. It is a key step to expand the results of previous studies concerning the risk of oil spills on the Algarve coast. Institutions with responsibilities in oil spill response can also use V.ID to plan its actuation. The methodology proposed is fully generic and scalable, allowing its application in other regions of the world.
Keywords: Oil Spill, Risk Assessment, Vulnerability Identity, Algarve

1. Introduction

Since oil has become a cornerstone in the development of civilization (due to its use in transportation, in heating, as raw material in manufacturing and in many other applications) it became one of the main concerns of present day.
This concern is divided into several sectors: part of the society cares about its extraction; the other part with its price, another part is still concerned to combat their exploitation. Additionally, there is a part of society which is concerned with the effects of oil spills on the environment around us.
The report (ITOPF 2015) states that 19 of the 20 largest spills recorded occurred before the year 2000. A number of these incidents, despite their large size, caused little or no environmental damage as the oil was spill some distance offshore and did not impact coastlines (ITOPF 2015).
According to this publication the value has been substantially reduced, as in the 70s, 24.5 spills per year on average were observed, and in 2014 only 1.8 oil spill on average was recorded.

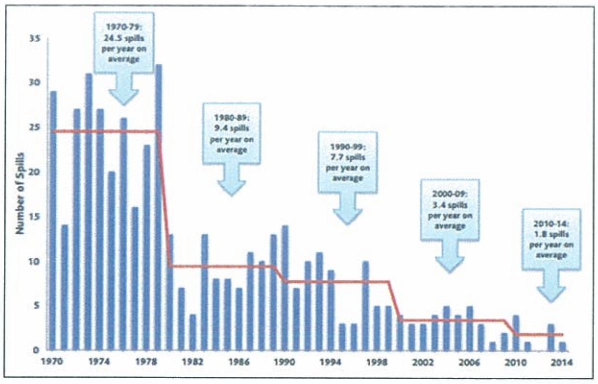

Figure 1 - Number of large spills (>700 tonnes) from 1970 to 2014 (ITOPF 2015)

Notwithstanding the number of large spills is decreasing in the last 40 years, what is certain is that currently the volume transported (either in terms of capacity of tankers and the number of tankers in circulation) is much higher than in the 70s. Ship-borne transportation and the size of tankers have been increasing and this trend is likely to persist (O'Rourke & Connolly 2003). The volume of oil transported per tanker is rapidly increasing due to changes in transportation strategies, including the widening of the Panama channel and the increase in efficiency of larger vessels. This also increases the risk of an oil spill accident.

According to (Neves 2015), the risk of an oil spill accident in each coastal sector n follow the equation (1):

$$R_n = (P_{cc})_n * I_n \tag{1}$$

where $(P_{cc})n$ is the probability of oil beaching for the segment n and I_n are the impacts of the spill once it reaches land

The impact of the spill on land depends on the vulnerability of the stretch of coast affected by the oil spill. The main objective of this paper is to develop a Vulnerability Index, the V.ID, associated to a graphic image through which the oil spill vulnerability of an area can be readily assessed.

With V.ID it is intended to create an image that agglutinates four key vectors in the analysis of a territory: Social, Economy, Heritage and Environment and Nature.

Being able to demonstrate the vulnerability of a certain region through a graphical representation makes its reading more immediate, thus facilitating the analysis of this region to environmental managers for decision makers, for companies in the sector (producers and transporters) to NGOs, etc.

The paper is organized as follows. In Section 2 we revised other methodologies developed. In Section 3 we described how to calculate and normalise each of the vectors. The proposed case study – Lagos Coast - is presented in Section 4. Finally, Section 5 is dedicated to the discussion and presentation of the main conclusions.

2. State of the art

2.1 Other methodologies developed

One of the first forays into the establishment of methodologies for estimating the vulnerability of coastal areas facing the oil spills was made by (Gundlach, E.R., Hayes, M.O. 1978), where this vulnerability was only estimated taking into account the physical and geological characteristics of the coast.

From 1978 to the present day, several approaches have been developed trying to include the concerns an oil spill poses upon nature as well as upon socio-economic activities in a given geographical area.

Castanedo et al. (2009) developed an integrated oil spill vulnerability index for coastal environment, V, and implemented it to the Cantabrian Coast. This index takes into account the main physical, biological and socio-economical characteristics by means of three intermediate indexes.

(Frazão Santos et al. 2013) developed a methodology to assess the spatially differential degree of vulnerability to oil spills that consisted on the creation of a composite indicator, formed by a series of individual, relevant and multidimensional indicators compiled into a unique index.

According to (Lee & Jung 2015), the oil spill risk assessment is carried out by using two factors: 1) The impact probability of the oil spill, and 2) the first impact time of the oil that has been spilt. The risk assessment is conducted for environmentally sensitive areas, such as the coastline and aquaculture farms in the Garorim Bay area.

Oil Spill Risk Assessment (OSRA) methodologies often fails in fulfilling basic requirements necessary to support decision making: i) uncertainties in the risk estimates neglected, ii) operational oil spills (i.e. intentional small, but frequent, spills associated to vessel operations such as tank washing) have not been addressed and iii) the risk analysis outputs are not appropriate for communication with stakeholders (Neves 2015). Therefore, this author developed a new OSRA approach based on a critical analysis of the ISO 31000:2009 on risk management principles and guidelines, addressing the limitations observed in previous OSRA and including Information Technology tool, the so-called IT OSRA.

2.2 – Critical analysis of multi-indicator indexes

Multi-indicator indexes have clear advantages over single (composite) indicators, but also some disadvantages, as described. When an assessment is made using a composite indicator, the individual values of each variable composing the indicator are hidden in the final value, i.e. the indicator can have the same value with different combinations of individual variables, so the real characteristics of the vulnerability remain camouflaged in this reduction. In opposition to this a multi-indicator index reveals the true nature of vulnerability, making it possible to distinguish between different types of vulnerability.

The multi-indicator index proposed in this article (the V.ID) results in an identifying image of each municipality in the form of web graphic as regards to oil spill vulnerability, working as an "ID card" of each sub-region allowing an easy visual identification of its vulnerability value as well as its nature. The methodology can be easily applied in other regions, and scaled to other dimensions to analyse countries or regions. The graphical nature of the index helps the communication with the decision makers and is a valuable tool for aiding oil spill response in their three aspects (strategical, mapping and operational) as systematized in (IPIECA 2012). For being a graphic identity, the strengths and weaknesses of a Study Unit can easily be checked without having to rely on tabulated values.

A disadvantage of this kind of indexes is that it produces a set of numbers which must be converted into a single objective function when developing optimization algorithms or computing absolute risk.

Despite the advantages associated with the concept here presented, the fact of some indicators not being included (such as intangible heritage and biological data of biodiversity) can be a negative point. However, taking into account that V.ID will be helpful in urban and territorial planning, these points can be considered in later work.

3. Methodology

3.1 – Vectors for implementing the V.ID

After an oil spill, several resources and activities may be affected in the region. In this study, four different vectors are identified to characterize an area or region. For the purposes of nomenclature simplification "Unit" is hereafter referred as the area intended to be characterized as a subsystem of a larger territory and "Study Domain" the region in which that subsystem is included. The methodology to attribute numerical values to each of the four different vectors is described below.

3.1.1 – Social Vector

When an oil spill happen in a certain area the direct and indirect impacts will affect the area for a long period. One of the possible aftermaths of an oil spill can be the unemployment of the affected territorial area, mainly in the economic areas related to tourism and fisheries. Observing this, three subvector are considered, characterizing the Unit relatively to the Study Domain regarding: i) Resident population in the Unit; ii) Employed population in Hospitality in the Unit and iii) Employed population in Fisheries and Aquaculture in the Unit.

3.1.2 – Economic vector

The economic vector analyses the vulnerability of an area in terms of income losses resulting from interrupting activities related to the coastal uses. The number of the variables to consider in the economy vector after a possible oil spill can be very high as stated in (Chang et al. 2014). For the sake of simplicity, this work considers only the more relevant three: i) Economic value generated by ports and marines in the Unit; ii) Economic value generated by the Tourism sector in the Unit and iii) Economic value generated by the Fisheries and Aquaculture sector in the Unit;

3.1.3 – Heritage Vector

In every domain, the built heritage is present all along the coast. Given its historical, cultural or aesthetic value, these factors should be considered in the decision making process in the event of an incident involving the oil spill.

Despite the built heritage not be directly affected by the oil spills, response operations to an incident of this type, may interfere with this (NOAA et al., 2010).

According to the classification given by the Portuguese General Directorate of Cultural Heritage in SIPA - Information System for the Architectural Heritage (DGPC 2015), a classification from 1 to 8 is considered, depending if it is an heritage of Municipal Interest or World Heritage Monument.

3.1.4 – Environment and Nature Vector

3.1.4.1 – Protected areas

According to ICNF, the Portuguese Network of Protected Areas is divided in 3 classes: National Scope (38 areas), Regional/Local Scope (13 areas) and Private Scope (1 area) making a total of 52 protected areas. Are classified as protected areas those where biodiversity or other natural occurrences present, for their rarity, scientific, ecological, social or scenic value, a special importance that require specific measures for the conservation and management in order to promote rational management of natural resources and the enhancement of natural and cultural heritage.

3.1.4.2 – Natura 2000 areas

According to (ICNF 2016), Natura 2000 is an ecological network for the European Union Community space resulting from the application of Directive 79/409 / EEC Network of April 2, 1979 (Directive Birds) - repealed by Directive 2009/147 / EC - and Directive 92/43 / EEC (Habitats Directive), which aims to ensure the long-term conservation of species and most threatened habitats in Europe, helping to stop the loss of biodiversity. It is the main instrument for the conservation of nature in the European Union.

The Natura 2000 network, which also applies to the marine environment, consists of:

- Special Protection Areas (SPA) - established under Directive Birds, which are intended primarily to ensure the conservation of birds and their habitats;
- Special Areas of Conservation (SACs) - set up under the Habitats Directive, with the express purpose of "*contribute to ensuring biodiversity through the conservation of natural habitats and species of flora habitats and of wild fauna considered threatened in the European Union space*."

Once these areas represent such important conservation issues, they shall be represented and studied carefully.

3.1.4.3 – Coast type classification

According to (IPIECA 2012), for the various types of shoreline (and riverine or lacustrine ecosystems), the widely accepted Environmental Sensitivity Index (ESI) can be adapted for each country. The ESI, ranging from 1 (low sensitivity) to 10 (very high sensitivity), integrates the shoreline type (grain size, slope), the exposure to wave (and tidal energy) and the general biological productivity and sensitivity.

The 10 levels referred above are subdivided in 23 sublevels. To implement this methodology the levels and sublevels were simplified as shown in the Table 1.

Table 1 - Simplification of ESI sensitivity rankings ESI (Adapted from (IPIECA 2012)

ESI (from 1 to 10)	Simplified ESI
Index 1 and 2	1 (very low)
Indexes 3, 4, 5 and 6	2 (low)
Index 7	3 (medium)
Index 8	4 (high)
Index 9 and 10	5 (very high)

3.1.4.4 – Beach Importance Index (BII)

The formulation defined by Leal (2011) is followed is this study. Accordingly, IIB is the result of the formula (2):

$$BII = (VCP + VCC) + VA1 + VA2 + VA3 \quad (2)$$

In order to systematize all the information regarding the IIB, the following table (adapted from (Leal 2011)) presents the variables identified in IIB:

Table 2 - Variables and Values of BII

Variable	Classes		Value
VCP	Beaches Type IV, V and suspended or	beach not equipped with conditioning use;	4
	Beaches Type III	beach with conditioning use	6
	Beaches Type II	not urban beach with intensive use	8
	Beaches Type I	urban beach with intensive use	10
VCC	VCC < 3200 users or no information		2
	3200 ≤ VCC <6400 users		4
	6400 ≤ VCC <9600 users		6
	9600 ≤ VCP <12800 users		8
	VCC ≥ 12800 users		10
VA1	Aptitude to water sports: surfing, kite surfing and diving	No	0
		Yes	2
VA2	Existence of concession	No	0
		Yes	2
VA3	Beaches with Blue Flag	No	0
		Yes	2

3.2 – Methodology application

In this section, the application of the proposed methodology is explained.

3.2.1 – Social Vector (S)

The Social Vector is a combination of three subvectors, which calculation is made using (3), (4) and (5).

$$S1 = \frac{Resident\ population\ in\ the\ Unit}{Population\ of\ the\ Study\ Domain} \tag{3}$$

$$S2 = \frac{Employed\ population\ in\ Hospitality\ in\ the\ Unit}{Population\ of\ the\ Study\ Domain} \tag{4}$$

$$S3 = \frac{Employed\ population\ in\ Fisheries\ and\ Aquaculture\ in\ the\ Unit}{Population\ of\ the\ Study\ Domain} \tag{5}$$

After obtaining the values of S1, S2 and S3, using a convex linear combination (6), in which the sum of the parts is equal to 1.

$$\alpha 1 + \alpha 2 + \alpha 3 = 1 \tag{6}$$

The normalization of the Social Vector (S) can be done as shoed in (7):

$$S = \alpha 1 * S1 + \alpha 2 * S2 + \alpha 3 * S3 \tag{7}$$

3.2.2 – Economy Vector (E)

The Economy Vector is a combination of three subvectors which are calculated using (8), (9) and (10).

$$E1 = \frac{Economic\ value\ generated\ by\ ports\ and\ marines\ in\ the\ Unit(€)}{Economic\ value\ generated\ by\ ports\ and\ marines\ in\ the\ Study\ Domain} \tag{8}$$

$$E2 = \frac{Economic\ value\ generated\ by\ the\ Tourism\ sector\ in\ the\ Unit(€)}{Economic\ value\ generated\ by\ the\ Tourism\ in\ the\ Study\ Domain} \tag{9}$$

$$E3 = \frac{Economic\ value\ generated\ by\ the\ Fisheries\ and\ Aquaculture\ sector\ in\ the\ Unit(€)}{Economic\ value\ generated\ by\ the\ Fisheries\ and\ Aquaculture\ in\ the\ Study\ Domain} \tag{10}$$

The normalization of the Economic Vector (E) can be done as showed in (11), respecting the convex linear combination and assigning the different weights to the value β:

$$\boldsymbol{E = \beta 1 * E1 + \beta 2 * E2 + \beta 3 * E3} \tag{11}$$

3.2.3 – Heritage Vector (H)

According to point 3.1.3, 8 classifications were given to the different types of heritage. The eight classifications are then simplified in five classes, assigning a different weight δ to each class.

Table 3 - Heritage classifications, classes and weights

Classifications	Weight (δ)
1. CM - Municipal Rating	1
2. VC - In the process of classification	2
3. SIP - Public Interest Site	3
4. CIP - Public Interest Set	4
5. IIP - Public Interest Building	5
6. MIP - Public Interest Monument	6
7. MN - National Monument	7
8. PM - World Heritage – UNESCO	8

To calculate the value H the formula (12) can be used, where the sum of δ1, δ2, δ3, δ4 and δ5 is equal to 1, *n* is the number of heritage classified and affected by the oil spill in the Unit and *m* is the total of heritage in the Study Domain:

$$H = \frac{\sum_1^n \delta}{\sum_1^m \delta} \quad (12)$$

3.2.4 – Environment and Nature Vector (EN)

To calculate subvector EN1, divide the total amount of protected areas in the Unit that are affected by the oil spill by the total of Protected Areas in the Study Domain, using the formula (13):

$$EN1 = \frac{Area\ of\ Protected\ Areas\ on\ the\ coast\ of\ the\ Unit(ha)}{\sum Protected\ Areas\ in\ the\ Study\ Domain} \quad (13)$$

To calculate subvector EN2 act in a similar way than in (14).

$$EN2 = \frac{Area\ of\ Natura\ 2000\ Areas\ on\ the\ coast\ of\ the\ Unit\ (ha)}{\sum Natura\ 2000\ Areas\ in\ the\ Study\ Domain} \quad (14)$$

In sub vector EN3 five classes are considered, with a correspondent weight μ, as shown in Table 4:

Table 4 – Values of Simplified ESI

ESI (from 1 to 10)	Simplified ESI (μ)
Index 1 and 2	1 (very low)
Indexes 3, 4, 5 and 6	2 (low)
Index 7	3 (medium)
Index 8	4 (high)
Index 9 and 10	5 (very high)

Thus, the sum of multiplication of a given Coastal Segment (CS) of a Unit corresponding to each class by its weight (μ), divided by the sum of multiplication of a given CS of a all the Study Domain corresponding to each class by its weight (μ) corresponds to the value calculated by the formula (15):

$$EN3 = \frac{\sum_1^n CS * \mu}{\sum_1^m CS * \mu} \quad (15)$$

As seen above, the Beach Importance Index (BII) is the result of a sum of different factors, characterizes each beach, and gives a value of importance. In this work, the objective is to characterize a Study Unit and a region so the value must reflect all beaches of the area.

Considering the best situation, a beach with the most valuable characteristics (which is a beach Type I, with more than 12800 users, with aptitude to water sports, with concession and with blue flag) the total value obtained is 26. TO calculate EN4 is used the formula (16):

$$EN4 = \frac{\sum_1^n BII}{m * 26} \quad (16)$$

Where *n* stands for the number of beaches in the Study Unit and *m* for all the beaches in the Study Domain. Finally, the values from the different subvectors of the Environment and Nature Vector are agglutinated in the formula (17), where ρ1+ ρ 2+ ρ 3+ ρ 4 =1:

$$EN = \rho1 * EN1 + \rho2 * EN2 + \rho3 * EN3 + \rho4 * EN4 \quad (17)$$

As referred above, the Vulnerability Identity (V.ID) is a multi-index indicator shown in a graphic way to facilitate the interpretation of a certain region or area and to facilitate the work of decision makers, planners or operational staff. The four subvectors (S, E, H and EN) values must thus be represented in a "radar type" graphic. This graphical description simplifies the comparison of vulnerabilities between territories facing an oil spill, enabling it to be done visually with the "radar" graphic.

4. Case study: Lagos municipality

Lagos is a municipality on the west side of Algarve. With an area of 213 km2 and 30776 inhabitants in 2012 is known by its cliffs and as a holiday's destiny.

Applying the proposal formulas in this work is possible to achieve the Vulnerability Identity (V.ID) of this municipality.

Using the values presented by (Instituto Nacional de Estatística 2015) is possible to know that the resident population in Lagos is 30776, the employed population in Fisheries and Aquaculture is 114 and the Employed Population in Hospitality is 2240. The Social Vector is calculated with these values and presented on Table 9.

To calculate the Economy Vector, a similar procedure was applied using the formulas proposed above.

It was not possible to achieve the real data to calculate the values for E1 and E2, for what the values presented are estimated. The values of 2015 published by DATAPESCAS (Table 5) were used to calculate E3 (Table 9).

Table 5 – Values used to calculate E3

	Estimated Landing			Estimated Landing (ton)			Estimated Landing (€)		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
Lagos	3,44	3,87	4,03	2706,7	2574,7	2983,3	9 311 048 €	9 964 089 €	**12 022 699 €**
Portimão	2,08	2,29	2,44	5464,3	5392,3	4443,8	11 365 744 €	12 348 367 €	10 842 872 €
Olhão	1,89	1,51	1,13	11677,5	12410,4	15967,9	22 070 475 €	18 739 704 €	18 043 727 €
Tavira	3,29	5,24	5,34	1411,8	721,2	627,9	4 644 822 €	3 779 088 €	3 352 986 €
VRSA	7,39	7,54	10,35	1457,3	1170,3	897,4	10 769 447 €	8 824 062 €	9 288 090 €
							58 163 549 €	53 657 324 €	53 552 389 €

Font: DATAPESCAS - Janeiro a Dezembro 2015, nº 107

The third vector is related with the Heritage in Lagos compared with the Classified Heritage in the Domain Unit.

After consulting the Portuguese General Directorate of Cultural Heritage in SIPA - Information System for the Architectural Heritage, it was possible to calculate the sum of the different weights of each classified heritage located by the coast not only in Lagos but as well in the entire Region (Table 6).

Table 6 – Heritage Classification

Study Unit	Name	Localization	Classification	δ	Σ
Lagos	Forte da Ponta da Bandeira	Lagos	IIP	5	26
	Castelo da Senhora da Luz	Luz	IIP	5	
	Estação Arqueológica Romana da Praia da Luz	Luz	IIP	5	
	Igreja de Nossa Senhora da Luz	Luz	IIP	5	
	Forte da Meia Praia	Lagos	MIP	6	
Algarve					208

The value the H Vector is presented on Table (10).

The last Vector to be studied is the Environment and Nature Vector. According to Portuguese Forests and Nature Conservation Institute (ICNF), in Table 7 are listed the areas of each county which are classified as Protected Areas and Natura 2000 Areas.

Table 7 – Protected and Natura 2000 Areas

	County	Protected Areas (ha)	Natura 2000 Areas	
			Area	Area in the Coast
Study Unit	Albufeira	---	2282	---
	Aljezur	18239,21	23615	18239,21
	Castro Marim	1148,79	3879	1148,78
	Faro	8009,16	8009.16	6380
	Lagoa	---	279	279
	Lagos	0	3406	3406
	Loulé	3405,29	40178	3405,29
	Olhão	4839,15	4839.15	3838
	Portimão	---	1377	1377
	Silves	---	22068	---
	Tavira	4517,18	6513	4517,18
	Vila do Bispo	14383,81	16393	14383,81
	Vila Real de Santo António	1301,27	1500	130,27
Study Domain	Algarve	---	121490	57104,54
	TOTAL	**55843,86**	---	---

Observing the formulas (13) and (14) the subvector EN1 = 0 and EN2=0.06.

To calculate EN3 it is necessary to observe all the stretches of all coast and compared them to the proposed table to apply the different weights to each Coastal Segment. Once it was not possible to found available data for the entire coast, the presented value is estimated.

To calculate EN4 – Beach Importance Index it was necessary to compile information from different sources, as the Coastal Zone Management Plan (POOC) from Sines – Burgau, Burgau – Vilamoura and Vilamoura-Vila Real de Santo António, the data presented by the European Blue Flag Association (ABAE 2016) and the work developed by (Leal 2011). It was considered 115 beaches in the Algarve coast (Table 8).

Table 8 – Values for the beaches in Lagos Municipality

County	Beach	VCP	VCC	VA1	VA2	VA3	IIB
Lagos	Batata	8	2	2	2	2	**16**
	Balança	4	2	0	0	0	**6**
	Canavial	4	2	0	0	0	**6**
	Camilo	6	2	0	0	2	**10**
	D. Ana	8	2	2	2	2	**16**
	Luz	10	4	0	2	2	**18**
	Pinhão	4	2	2	2	0	**10**
	Estudantes	4	2	0	0	0	**6**
	Meia Praia	8	8	0	2	2	**20**
	Porto de Mós	8	2	0	2	2	**14**

Table 9 – Values of the four vectors (EN)

Social Vector			Economy Vector			Heritage Vector		Environment and Nature Vector		
	Value	Weight		Value	Weight		Value		Value	Weight
S1	0,07	0,3	E1	0,19	0,3	Study Unit	26	EN1	0	0,1
S2	0,07	0,5	E2	0,35	0,5	Study Domain	208	EN2	0,059645	0,4
S3	0,06	0,2	E3	0,22	0,2			EN3	0,04	0,1
								EN4	0,0408027	0,4
S	**0,07**		**E**	**0,28**		**H**	**0,125**	**EN**	**0,03**	

Resuming the work developed:

V.ID Lagos

V.ID Lagos	
S - Social	0,07
E - Economy	0,28
H - Heritage	0,125
EN - Env & Nature	0,03

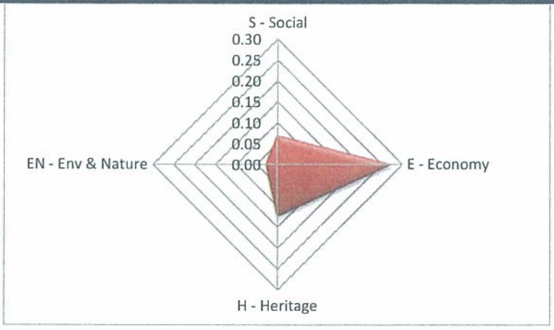

Figure 2 – Values and graph of V.ID for the municipality of Lagos

5. Discussion and conclusions

This new tool presented in this work intends to serve as support in the elaboration of Spatial Plans elaboration, in the Planning and Management of Protected or Classified Areas or in Environmental Assessments.

Once V.ID is a graphical tool with four important vectors totally characterized and not hidden behind just a value, it can be used by anyone who pretends to protect, plan the territory or even the safety forces who need to organized their strengths in a way to be able to identify risky areas.

The presented subsectors are those that were considered the most important for the development of V.ID. However, others may be studied depending on the needs of the teams who use it or, depending on the territorial realities that are installed.

The fact that it has different weights that can be adjusted to the real needs of each area, also gives an innovative character to this proposal, which allows it to be used to characterize small territorial units, or to compare different countries of a particular continent.

6. Bibliography

ABAE, 2016. Bandeira Azul 2015. Available at: http://bandeiraazul.abae.pt/our_news/praias-bandeira-azul-2015/ [Accessed April 13, 2016].

Castanedo, S. et al., 2009. Oil spill vulnerability assessment integrating physical, biological and socio-economical aspects: Application to the Cantabrian coast (Bay of Biscay, Spain). *Journal of Environmental Management*, 91(1), pp.149–159. Available at: http://dx.doi.org/10.1016/j.jenvman.2009.07.013.

Chang, S.E. et al., 2014. Consequences of oil spills: a review and framework for informing planning. *Ecology and Society*. Available at: http://dx.doi.org/10.5751/ES-06406-190226.

DGPC, 2015. Sistema de Informação para o Património Arquitetónico. Available at: http://www.arcgis.com/apps/PublicInformation/index.html?appid=2047c8c660ee42ca84515c9b87964cef.

Frazão Santos, C., Carvalho, R. & Andrade, F., 2013. Quantitative assessment of the differential coastal vulnerability associated to oil spills. *Journal of Coastal Conservation*.

Global Security, Portugal - Exclusive Economic Zone - EEZ. Available at: http://www.globalsecurity.org/military/world/europe/pt-eez.htm [Accessed November 24, 2015].

Gundlach, E.R., Hayes, M.O., 1978. Vulnerability of coastal environments to oil spill impacts. *Marine Technology Society Journal*.

ICNF, 2016. Rede Natura 2000. Available at: http://www.icnf.pt/portal/naturaclas/rn2000.

Instituto Nacional de Estatística, 2015. *Região Algarve em Números*, Lisbon. Available at: www.ine.pt.

IPIECA, 2012. Sensitivity Mapping for oil spill response. , (1), pp.95–102.

ITOPF, 2015. Oil tanker spill statistics 2014. *The International Tanker Owners Pollution Federation Limited*, (January), p.12p.

Leal, T., 2011. *Sensibilidade costeira para planeamento e resposta a emergências de poluição marítima* *causada por hidrocarbonetos*. Universidade Nova de Lisboa.

Lee, M. & Jung, J.-Y., 2015. Pollution risk assessment of oil spill accidents in Garorim Bay of Korea. *Marine Pollution Bulletin*, 100(1), pp.297–303. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0025326X15300023.

Neves, A. et al., 2015. Towards a common oil spill risk assessment framework e Adapting ISO 31000 and addressing uncertainties. *Journal of Environmental Management*, 159, pp.158–168.

Neves, A.A.N.S., 2015. *Oil spill risk assessment and management for the coast of Algarve, Southern Portugal An operational oceanography approach*. UNIVERSITY OF CADIZ.

O'Rourke, D. & Connolly, S., 2003. Just Oil? The Distribution of Environmental and Social Impacts of Oil Production and Consumption. *Annual Review of Environment and Resources*, 28(1), pp.587–617. Available at: http://www.annualreviews.org/doi/abs/10.1146/annurev.energy.28.050302.105617.