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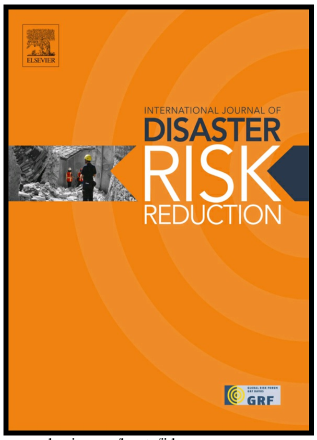

www.elsevier.com/locate/ijdr

PII: S2212-4209(18)30165-1
DOI: https://doi.org/10.1016/j.ijdrr.2018.07.005
Reference: IJDRR934

To appear in: *International Journal of Disaster Risk Reduction*

Received date: 5 February 2018
Revised date: 5 July 2018
Accepted date: 5 July 2018

Cite this article as: Jorge Osvaldo Gentili, María Eugenia Fernández and Alicia María Campo, Vulnerability in Bahía Blanca. Estimating technology-related risks, *International Journal of Disaster Risk Reduction,* https://doi.org/10.1016/j.ijdrr.2018.07.005

Vulnerability in Bahía Blanca. Estimating technology-related risks☆

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ABSTRACT

Since the 1980´s Bahía Blanca has become a center for important agro-industrial and petrochemical companies. Toxic leaks or spills, fires and explosions are the main threats related to the industrial activities. Due to its closeness to populated areas, risk management is essential to develop integral actions to address disaster scenarios. In order to assess economic, social and technical vulnerability, variables from the most recent census data were selected through the REDATAM database. A multivariate analysis methodology based on the standardization of variables was applied. Thematic cartography was developed, which summarized situations of vulnerability for each spatial unit analyzed. Likewise, a qualitative approach was used to study the institutional vulnerability as a dimension of technological risk in the city of Bahía Blanca. Vulnerable areas surrounding industrial activities were identified. From the institutional perspective, the lack of an adequate sanction enforcement policy is one of the most extreme vulnerabilities existing related to risk in Bahía Blanca.

Keywords: Vulnerability, Risk Management, GIS, Bahía Blanca

☆ The present research was carried out within the framework of the research project "XXX" led by Author and subsidized by the Secretaría General de Ciencia y Tecnología of the Universidad Nacional del Sur. (24/G078)

1. Introduction

Technological-scientific developments in modern societies have led to socially conflicting situations, which imply risks related to nuclear energy, industrial processes and the use of chemical compounds, among others. Catastrophic situations represent a complex issue in a capitalist society, in which risk is a characteristic feature (Beck, 1993, González, 2001, Barrenechea et al., 2003). According to Beck (1996a) risk society is a consequence of innovation processes where risk production shirks controlling and protecting civil society institutions.

Technological risk is defined as the probability of suffering damage or economic, environmental and human loss because of technology failures or accidents arising from a human activity (Bosque Sendra et al., 2004, Fábrega and Sánchez, 2010). The United Nations Assembly on the Environment in 2017 addressed the importance of strengthening environmental governance and the implementation of measures aimed at reducing aggressive pollutant emissions through risk assessment (United Nations Organization, 2017a, 2017b). Within the Sustainable Development Goals (United Nations Development Program), it is argued that reinforcing legal and institutional systems, providing access to information on risks and early warning systems and consolidating preparation and response measures will strengthen the resilience of urban and rural communities. Vulnerability study is an important factor in risk assessment, as a process by which a human group becomes aware of a potential risk, considers the options and resources available to address it and achieves the most appropriate solution (Natenzon et al., 1995, Blaikie et al., 1996, Lavell, 2001, Natenzon, 2004).

According to Cornejo de Grunauer (2012), vulnerability analysis becomes a platform to understand the information usefulness collected by various institutional sources and its application to risk management. At the same time promotes institutional multidisciplinary work for territorial management agents. This is why many researchers analyzed vulnerability as a risk dimension and a first approach for a comprehensive analysis (González, 1999, Reyes Sandoval, 2003, Resnichenko, 2006, Barrera et al., 2007, Monti and Escofet, 2008 De las Cuevas Suárez and Escobar Martínez, 2009, Maldonado and Cóccaro, 2011, Fernández et al., 2013, Pérez, 2014).

Delimiting the risk dimensions allows describing and showing the exposure extension, conducting inventories on hazard points, analyzing vulnerability and simulating risk scenarios, among others (OEA, 1993, Díaz Muñoz and Díaz Castillo, 2002, Isidro et al., 2009). There is extensive material on the application of Geographic Information Systems (GIS) to the study of vulnerability (Lowry et al., 1995, Minaya, 1998, Álvarez, 2001, Zavala and Chuvieco, 2003, Vías Martínez et al., 2003; Rashed and Weeks, 2003; Rivera Masgrau, 2004, Correa and Granda, 2013).

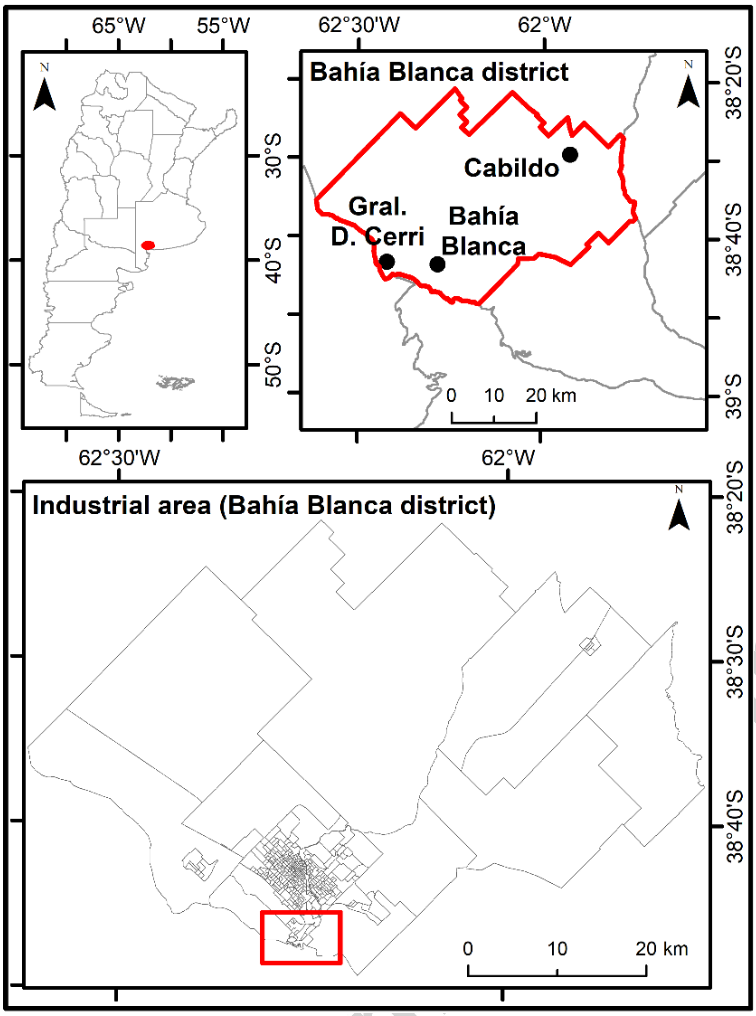
Bahía Blanca has been consolidated as the center of important agro-industrial and petrochemical corporations since 1980’s. These activities, so relevant to the economic development of the region, have gradually became a danger for the population and the environment. The main threats related to this type of industry are toxic leaks, fires and explosions. Due to the proximity of populated areas to the industrial site is essential to take integral action to address a disaster situation. Therefore, the aim of the present work is to evaluate the population vulnerability as a first approach in order to outline technology risk mapping in Bahía Blanca. The originality of this research is based on the approach to vulnerability as a risk dimension.

2. Area of study

Bahía Blanca district is located in the southwest of the Buenos Aires province (Argentina). It has a population of 301,572 inhabitants (INDEC, 2010). It covers up the areas of Cabildo, General Daniel Cerri and Bahía Blanca as the head of the district (Fig. 1). Bahía Blanca district has been consolidated as an important regional center since it is a leading transport and communications node with a broad terrestrial, maritime and airport infrastructure.

Bahía Blanca port area covers a set of facilities that spread out along 25 kilometers on the north coast of the homonymous estuary (Fig. 1). Located in the south of the Buenos Aires province and 650 kilometers away from the city of Buenos Aires (Federal Capital of the Argentine Republic), the port of Bahía Blanca is a privileged placement in relation to important production and consumption inland centers. Located in the south of the Pampa Húmeda, this deepwater port receives part of the agricultural and agro-industrial argentinian production by road and railway networks. Its location on the south Atlantic coast represents an important competitive advantage to trading with the greatest world centers such as Northwestern Europe, the Mediterranean area, Southeast Asia, South Asia, and the Middle East and China, among others. The port complex is run by the Consorcio de Gestión del Puerto de Bahía Blanca, a non-state public entity that implements a self-sustaining economic and financial policy. The maintenance tasks of the port dredging or the maritime traffic control system are examples of its economical self-reliance.

Figure 1. Area of study



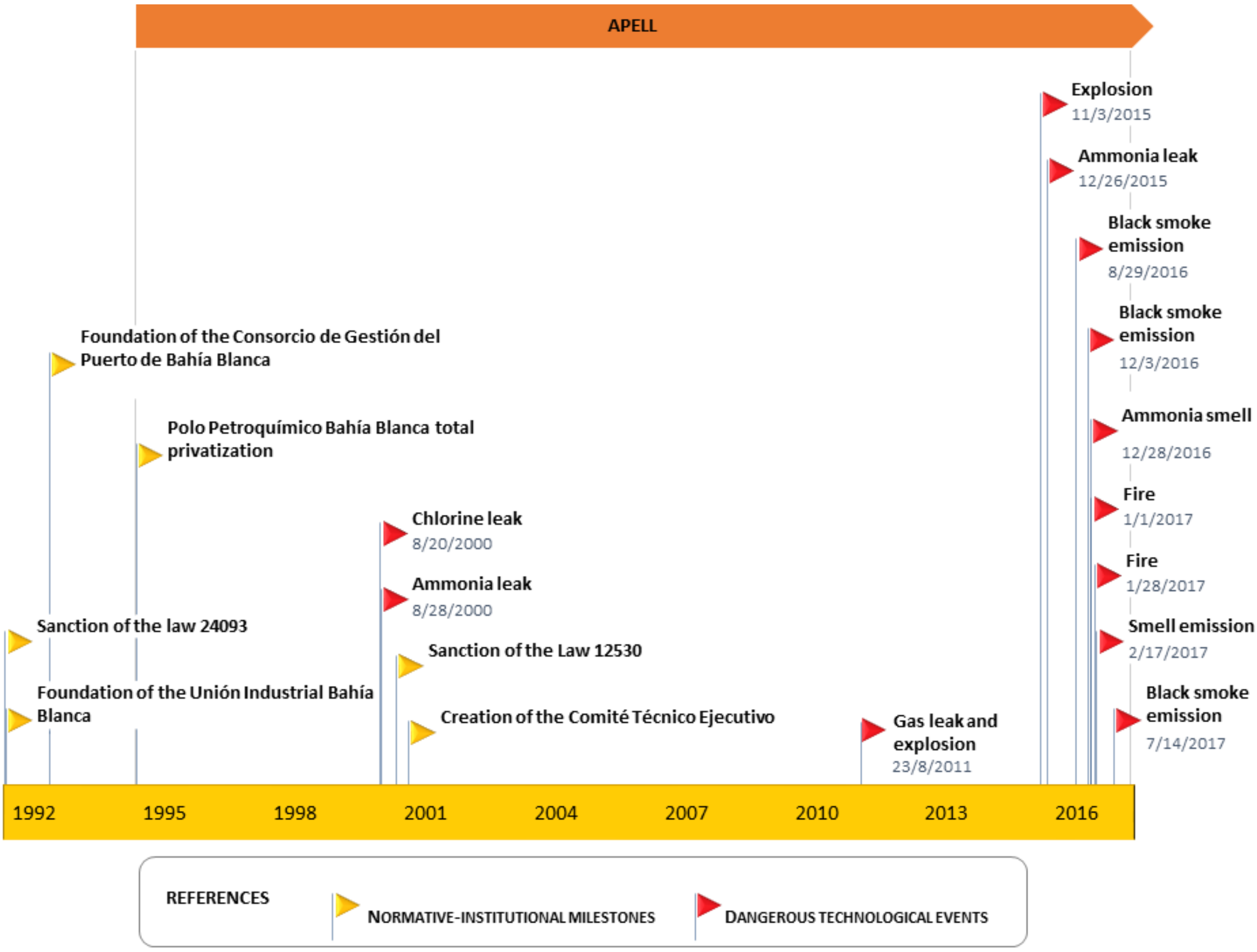
Source: Authors (2018)

In 1992 (Fig. 2), the Government enacted National Law No. 24093, known as the Port Activities Act, which authorized the ports transfer of state ownership to the provinces they belong to. According to the Act, before the transference private-law companies or non-state public entities should be established. These companies would be in charge of the administration and operation of each of those ports. In 1993, the Consorcio de Gestión del Puerto de Bahía Blanca was created and became the first autonomous port of the Argentina.

Conversely, the port complex is integrated with a dynamic industrial environment, i.e. the petrochemical pole of Bahía Blanca, one of the most important in the country. Oil (ethane, naphtha, LPG, fuel oil, gas oil, gasoline, among others), petrochemical (pure ammonia, ethylene, VCM, PVC, polyethylene, urea) and chemical industries (caustic soda, chlorine) generate approximately 65% of the Argentine petrochemical production and 25% of Bahía Blanca's gross proceeds. It is expected that port activities and associated industries will merge into an industrial-port cluster (Consorcio de Gestión del Puerto de Bahía Blanca, 2017).

Although the activities of the industrial-port complex are relevant to the economic development of the region, they represent a latent threat to the entire population and their environment. In 2000, the Secretaría de Política Ambiental de la Provincia de Buenos Aires closed industrial plants due to chlorine and ammonia leaks (Fig. 2).

Figure 2. Timeline of the main industry-related events in Bahía Blanca



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These events caused great sensitivity on local population. This was reflected in popular assemblies and social demonstrations in the main industrial park access roads (Clarín, 21.08.2000, La Nación, 25.08.2000, Clarín, 10.11.2000; La Nación, 14.12.2000, La Nación, 29.08.2000, Clarín, 05.06.2001, La Nueva Provincia, 20.08.2016).

Even though Eastern and Northeastern wind direction prevented contaminants from affecting the residential area, these events led to the redefinition of the legal framework. The Provincial Law Nº12530 created the "Programa Especial para la Preservación y Optimización de la Calidad Ambiental" for Bahía Blanca (Fig. 2). In order to put into practice this program, the Comité Técnico Ejecutivo (CTE) was created to constantly monitor the industrial emissions. Its actions are structured within the framework of the Programa Integral de Monitoreo (PIM). Nevertheless, the local and national media has repeatedly referred to industrial accidents such as leaks and explosions in Bahía Blanca. In view of these events, a large part of the population openly expresses dissatisfaction with industrial activities in the city (La Nación, 25.08.2000; La Nación, 14.12.2000; Clarín, 05.06.2001; La Nueva Provincia, 20.08.2009; Clarín, 23.08.2011; La Nueva Provincia, 13.03.2016; La Nueva Provincia, 28.12.2016; La Brújula, 20.02.2017). Figure 2 shows the main industrial accidents reported by the local and national press. Bahía Blanca´s Municipality official website (www.bahia.gob.ar/cte/actas) has 189 industrial pole corporations registered infractions presented to

the provincial environmental control agency in the 2010-2017 period (Organismo Provincial para el Desarrollo Sostenible).
Since 1995, petrochemical pole companies and the city hall have been working according to the APELL Program guidelines (Awareness and Preparedness for Emergencies at Local Level) which aims to improve the technological accidents prevention and emergency preparedness (Fig. 2). Developed by the United Nations, this methodology has specific recommendations to create a cohesive and resilient community to technological hazards and to develop measures for preparedness and emergency response. Consequently, the Plan de Respuesta a Emergencias Tecnológicas (PRET) is developed in order to guide the immediate actions during the first critical hours when an emergency arises. Such procedures operate as risk management tools and show that industrial accidents are part of public management concerns. In essence, it is of particular interest to assess the city's population vulnerability as a management resource against technological risks.

3. Methods and materials

Vulnerability is a complex concept, which implies social, economical, political, technical, ideological, cultural, educational, ecological and institutional dimensions and might be approached from very diverse epistemological perspectives (Wilches-Chaux, 1993). This wealth of nuances is what poses a challenge when finding appropriate measures to carry out an operational study of vulnerability (Díaz Muñoz and Díaz Castillo, 2002). Descriptive indicators express situations, causes, susceptibilities or weaknesses of particular social groups to which risk-reduction actions must be oriented (Carreño Tibaduiza et al., 2005). A quantitative analysis of the economic, social and technical vulnerability was carried out. Also a qualitative approach referred to the institutional vulnerability as a dimension of the technological risk in the city of Bahía Blanca. Likewise, a map of actors is included to analyze how they articulate, relate and manage in the local framework (Wilches-Chaux, 1993, Tapella, 2007).

In order to assess the economic, social and technical vulnerability, variables associated to response and recovery capacity towards the hazard materialization were selected. The variables selected refer to demographic characteristics, standards of living and employment situation (Table I). The most recent official data from the Censo Nacional de Población, Hogares y Vivienda of 2010 (INDEC, 2010) were used. REDATAM database provides disaggregated information at the census radius level (minimum spatial unit in the official census data publications) and allows seeing its spatial distribution. The digital cartographic database was downloaded from the official INDEC website (www.indec.gov.ar).

Table I. Indicators selected for vulnerability assessment

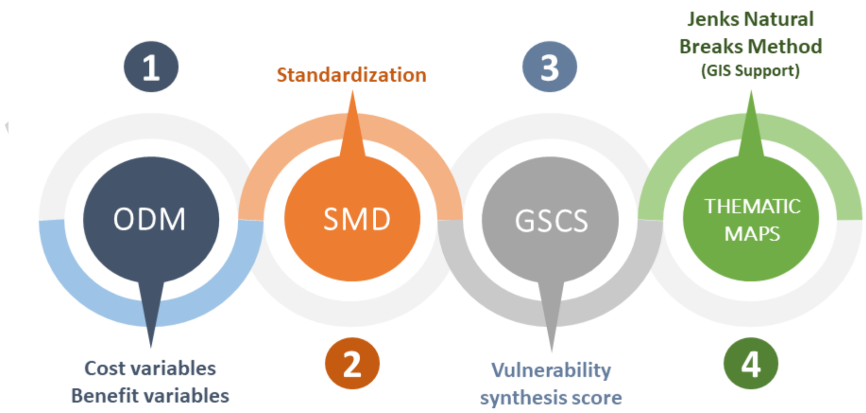
Vulnerability	Indicator	Classification	Unit	Cost/ Benefit
Social	Total population		N° of people	Cost
	Total dependency rate		N° of people	Cost
	Single-person household (over 65 years of age)		N° households	Cost
	Illiteracy rate		%	Cost

Technical	Constructive housing quality	Insufficient: without resistant and solid materials or adequate insulation; no built-in plumbing or flush toilet (INDEC, 2013).	N° housing	Cost
		Basic: without adequate insulation elements or with sheet-metal or fiber cement roofing. With built-in piping and flush toilet (INDEC, 2013).		Cost
		Satisfactory: sound and resistant materials with adequate insulation (INDEC, 2013).		Benefit
	Computer use and telephony access		N° households	Benefit
	Overcrowding rate	Critical overcrowding: over three people per room (INDEC, 2013).	N° households (%)	Cost
		Overcrowding: over two people per room (INDEC, 2013).		Cost
		No overcrowding: two or fewer persons per room (INDEC, 2013).		Benefit
Economic	Total unemployment rate		%	Cost

Source: Authors (2018)

The Data was organized in a matrix structured in rows (spatial units) and columns (variables), called Original Data Matrix (ODM) (Fig. 3). An ODM analysis allows to identify more than one set of variables. This structure is consistent with digital processing by using spreadsheets and GIS databases. The data was classified into variables of cost or benefit (Buzai and Baxendale, 2012). Cost variables are those whose maximum scores show disadvantageous situations and are related to a greater vulnerability. The cost variables are: total population, single-person households inhabited by individuals over 65 years of age, total dependency rate, illiteracy rate, basic and unsatisfactory housing quality construction, overcrowded and critically overcrowded households, and unemployment rate. Instead, benefit variables are those that in their maximum scores show favorable situations and are associated with a lower vulnerability. The benefit variables are: satisfactory housing quality construction, no overcrowded households and the use of computer and telephony access.

Figure 3. Methodological scheme



Source: Authors (2018)

Subsequently, a multivariate analysis methodology was implemented. It was based on the variables standardization and a synthesis score generation of cost and benefit variables (Unified Spatial

Classification Score). Following Buzai and Baxendale's proposal (2012), thematic cartography summarizes the vulnerability situations for each analyzed space unit (Fig. 3). Data processing included the values standardization of each variable in order to group and compare spatial units (Standardized Matrix Data, SMD). To achieve this, omega standardization was used with the following formula:

$$\Omega = \frac{xi - m}{M - m} \times 100$$

where: xi are the values of a variable, m the smallest value and M the highest value of the total data.

For both variable types, the resulting values are distributed in a range from 0 to 100. For the benefit variables, a value of 100 indicates the best situation and 0 the worst one. The opposite happens in the case of cost variables. In order to make comparable both types, for benefit variables the standardization was based on the following formula:

$$\Omega\ (inv) = \frac{M - xi}{M - m} \times 100$$

where: xi are the values of a benefit variable, m the lowest value and M the highest value of total data.

Subsequently, a Global Spatial Classification Score (GSCS) was calculated with the standardization values of cost (Formula I) and benefit (Formula II) variables (Fig. 3). This score was calculated as follows:

$$GSCS = (vc1 + vc2 + vc3 + \cdots + vb(i)1 + vb(i)2 + vb(i)3 \ldots)/n$$

where: vc are cost variables (omega standardization) , $vb(i)$ benefit variables (omega inverse standardization) and n the number of variables in omega score considered in the global classification.

The thematic cartography resulting from the Global Space Classification Score allowed us to analyze the selected variables distribution and spatial association (Humacata, 2015). The selected data were introduced into a geo-referenced database, linking the census radius to their corresponding information (Fig. 3). According to Barrenechea et al. (2003) Jenks Natural Breaks method (Jenks, 1967) is the most appropriate criterion within the GIS environment to visualize heterogeneities in the selected information.

4. Results

In regard to technical vulnerability, the indicators spatial distribution was analyzed. The housing quality construction is defined according to materials quality, internal installations and basic services (water and sewage network) (INDEC, 2013). Solid and resistant materials and an adequate insulation would do less vulnerable households. Basic and unsatisfactory housing quality construction is considered as a vulnerability factor. Housing without adequate insulation will not be safe enough when it is recommended to stay indoors due to an accidental pollutants leakage (Municipalidad de Bahía Blanca, 2011). Twenty-one census radius had between 24 % and 82.6 % of unsatisfactory housing quality construction. Sixteen of them are located in the industrial zone or its surrounding area. In the same area thirty-five census radius had overcrowded households. The overcrowding index provides information on housing protection, habitability and health conditions. Higher rates of overcrowding will be related to a greater vulnerability. The use of computer and telephonic devices reflects communication and media access and even to social networks (the Internet). Bahía Blanca municipality provides free access to air quality data by its official website. It is used to inform the population about environmental monitoring around the petrochemical sector and industrial premises. Therefore, media access is essential when receiving / transmitting information about what to do in case of a catastrophic event (Reyes Sandoval, 2003). Sixty-one census radius showed high percentages of computer non-access (less than 52.3% of total households' number), mainly located in the most vulnerable area shown in Figure 4.

In regard to economic vulnerability, the total unemployment rate was analyzed (Barrenechea et al., 2003, Reyes Sandoval, 2003). The higher the unemployment rate is, the greater the vulnerability (Cannon et al., 2003). The unemployment highest values rate were reflected in the southwest of the study area, over the coast and Ing. White.

Social vulnerability was evaluated based on population indicators, single-person households inhabited by people over 65 years, dependency index and illiteracy rate (Table I). Concerning to demographic characteristics, the study considered the total population. This indicator shows the concentration or dispersion of people given the occurrence of a dangerous event (Díaz Muñoz and Díaz Castillo, 2002, Barrenechea et al., 2003, Carreño Tibaduiza et al., 2005). Total dependency rate shows dependent population proportion (between 0 and 14 and over 65 years old) in respect to total economically active population. This data shows population age structure and accounts for each group weaknesses and potential capabilities to face dangerous situations. It is assumed that an average adult has the capacity to make decisions and enough physical energy to face such situations. Instead, the older adult and the child may require assistance. Thus, a greater potential dependence will be a sign of greater vulnerability (Barrenechea et al., 2003, Carreño Tibaduiza et al., 2005, Cornejo de Grunauer, 2012). Furthermore, household type was analyzed. Single senior citizen households were selected. Because of their age, health decline and living alone their situation is associated with helplessness and the need for assistance in both emergency and recovery. Single senior citizen household and dependency index showed higher values around the central urban area. This result is consistent with the study performed by Peláez (2006), Bagnulo and Pizarro (2010), Baxendale (2015) and Consuelo et al. (2016). Public services, shops, leisure and cultural spaces and transport offer, encourages senior citizens settling towards the central urban área (Herrasti, 2017). Instead, the illiteracy rate was higher in areas further from the city center. People who cannot read or write will be more vulnerable to an event due to lack of access to information released for prevention, mostly written (Reyes Sandoval, 2003, Cornejo de Grunauer et al., 2012).

Figure 4 shows the synthesis score spatial distribution of the indicators in order to assess Bahía Blanca´s economic, social and technical vulnerability. The central urban areas showed the lowest values of vulnerability in the area. The peri-urban areas registered mostly medium and high vulnerability. The areas near the port are the most vulnerable, with a higher category in the analysis scale used. The rural areas located in Bahía Blanca´s north and northeast shows medium vulnerability. Those located in the southwest registered high vulnerability indexes, mainly in the area bordering industrial and port activities. Cabildo presented medium vulnerability and General D. Cerri (near the industrial pole) showed medium and high vulnerability in all its census radius. This analysis shows that, in case of an industrial accident, the most exposed census radius are those with the worst conditions regarding housing quality, information access and job stability, among others. These findings are consistent with the analysis performed by many researchers in Bahía Blanca and other Latin-American cities (Sabatini et al., 2001, Rodríguez and Arriagada, 2004, Tecco and Fernández, 2009, Prieto, 2011). This unequal urban population distribution is defined as segregated housing. It is defined by the social groups concentration in specific urban areas. (Rodríguez Vignoli, 2001, Sabatini et al., 2001, Rodríguez and Arriagada, 2004). The observed distribution is produced in terms of socio-economic strata from a concentric nature, with a negative gradient from the center to the peripheral urban areas (Buzai, 2003). The poorest groups are located in the periphery, where the land value is lower. This is consistent with Latin-American cities modelation (Janoschka, 2002) and with intermediate Argentinian cities such as Trelew (Baxendale, 2015), Tandil (Linares y Velazquez, 2015), and Mar del Plata (Lucero, 2015), among others. Nevertheless in the last few years the targeted investments broaded the suburban zones (Molinatti, 2013), in Bahía Blanca has taken place towards the most distant áreas from the industrial pole (Urriza, 2016).

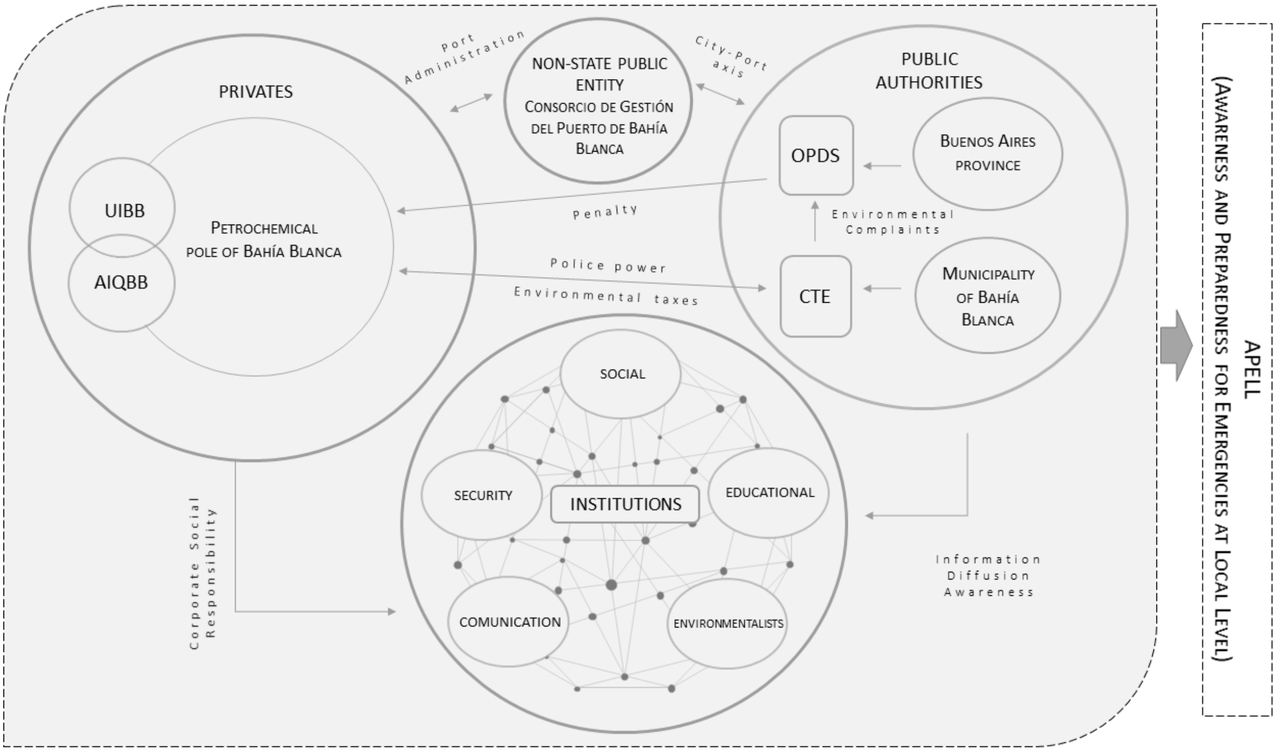
This analysis facilitates decision-makers since it makes possible to identify specific problematic areas. Beck (1996a, 1996b, 2006) asserts that decision-maker's self-criticism and thinking might possibly prevent risk. Public policies should ensure telephonic and computer access, especially in areas of greater danger exposure. In addition, credit policies for housing expansion will be necessary in order to grant solid, resilient and adequately insulated buildings, as well as decent and habitable housing spaces. It should be noted that the greater variability areas have less population, which means that the aforementioned policies can be fully enforced.

Figure 4. Economic, social, and technical vulnerability in Bahía Blanca district

Source: Authors (2018)

Vulnerability reduction in urban environments compels an institutional framework with political commitment. This requires appropriate policies and legal control instruments. Effective emergency operating committees, relief personnel training, contingency testing plans, regulations updating and community information are elements that account for institutional vulnerability (Wilches-Chaux, 1993). Figure 5 summarizes main social actors involved and their interactions in the analyzed framework.

Figure 5. Social actors map involved in the industrial area of Bahía Blanca



Source: Source: Authors (2018)

In 2000, toxic substances escaped from two industrial plants in the petrochemical sector (Fig. 2). The community demanded greater control over the companies of the industrial pole. It was reported that the emergency alarms did not go on, people were hospitalized and the public health system collapsed. These events marked a turning point in the population environmental awareness, mainly in Ing. White and the port bordering area. Consequently, social organizations (Asociación Ambientalista Unión 20 de Agosto, Asociación de Vecinos por la Vida, Asociación Conservacionista del Sur Tellus, Asamblea Ambiental AUKAN and Asociación Vecinal en Defensa del Ambiente General Daniel Cerri, among others) uncovered these irregularities (Dobal, 2015). They all have an active role gathering and releasing information, promoting debates and lodging complaints when necessary. Nevertheless, these organizations have dissenting positions. The Asociación Vecinos por la Vida has the most critical attitude, since it requires the definitive eradication from the industrial pole. The Asociación Vecinos de la Costa has a moderate posture, demanding most rigorous controls over company's activities. Unión 20 de Agosto demands compensation for those neighbors whose desire is to abandone Ing. White after the emissions (Heredia Chaz, 2014). This heterogeneity matches the Latin- American environmentalism (Gudynas, 1992). Multiple social and popular actors come together towards these movements. In Bahía Blanca a community associations increasing role was evidenced. The crisis in governmental representativity and choices absences promoted environmentalists not only on a local level, but also in a Latin-American. The distinction between Latin-American environmentalists and developed countries is shown in the ideological perception that considers economic growth as a progress engine, or as a social concern (Gudynas, 1992).

Following these incidents, petrochemical pole companies and local and provincial authorities adopted measures to respond to population concerns. Provincial Law No. 12530 was enacted (Fig. 2) and established the Programa Especial para la Preservación y Optimización de la Calidad Ambiental in order to monitor and control gaseous emissions and liquid effluents from industrial origin. In this legal framework, the petrochemical pole and port area environmental control was fully delegated from the Organismo Provincial del Desarrollo Sostenible (OPDS) to the Municipality of Bahía Blanca. The Comité Técnico Ejecutivo (CTE) was created. The CTE participates in the contingency, surveillance, control, education and citizen awareness plans development and assesses its implementation. The CTE police power is granted by law, while the provincial organism OPDS has the power to assess and process the infringements pointed out by the municipality. In Bahía Blanca, the OPDS delegation operates within the headquarters of the Industrial Union of Bahía Blanca after reaching an institutional cooperation agreement in July 2014 (Dobal, 2015). It should be pointed out that Law Nº 12530 establishes environmental taxes for third-category companies and grain and oilseed companies located within the scope of the CTE application in order to provide control, monitoring and prevention services.

The APELL process (in force since 1995) is a technological emergency response plan that involves all the actors in the scheme (Fig. 5). APELL is a municipal implementation of a United Nations program. Its aim is to prepare local people for an industrial accidental event. It is made up of the Coordination Group, which involves oil, chemical and petrochemical corporations, security agencies, environmental entities (as the Asociación Ambientalista Unión 20 de Agosto), neighborhood development companies, and educational institutions (as the Universidad Nacional del Sur). This kind of plans are essential when coordinating actions during an emergency. Since the pollutants leakage reported in 2000, the APELL process began to deploy more actions in the local port area, especially in schools. The necessary elements to cope with an industrial accident were provided, training courses were teached and confinement exercises were carried out (Heredia Chaz, 2014). As Ulrich Beck (1996a, 1996b, 2006) claims in his Risk Society theory, risks result from the modernization processes are forces of change. Society self-confronts undesired modernization consequences, thinks about the causes and creates reflective modernization. Risks threat, determine thoughts and actions and require decision-making responsibility.

In 2001, after chlorine and ammonia leaks, the AIQBB (Asociación Industrial Química de Bahía Blanca) was created. AIQBB is made up by four of the main chemical corporations of the industrial pole. Its purpose is to implement liability policies under the paradigm of sustainable development (Fig. 2). This actions are part of Corporate Social Responsibility (Fig. 5), which includes parks financing, bike paths, training workshops in schools, urban forestation programs, among others. The Unión Industrial de Bahía Blanca (UIBB) (Fig. 2) has a department that promotes social development, through the creation of alliances and cooperation programs with civil society. The group is made up by professionals and entrepreneurs from different fields and types of organizations. A work team, which promotes a voluntary space for training and undertaking projects. All members participate in programs management and execution. In addition, in recent years the Consorcio de Gestión del Puerto de Bahía Blanca and the Municipality of Bahía Blanca have promoted a mutual development policy (the City-Port axis) in order to improve the port integration in the social environment (Consorcio de Gestión del Puerto de Bahía Blanca, 2017). Thus, as for Latin-America, environmental matters ceased to be merely treated by environmentalists. New rules and institutions were created in order to harness and control industrial activities (Gudynas, 1992).

Despite the legal framework enhancement, the greater deployment of the APELL process in the local port and the actions of the Corporate Social Responsability, local and national media have expressed the social discontent regarding industrial activities. Part of the population asserts that serious accidents have been minimized and insure the existence of tremors, cracks in the houses, odors and yellowish clouds. Some people believe that the only way to guarantee the inhabitants future is the industry eradication (Heredia Chaz, 2014). On the other hand, the petrochemical pole in Bahía Blanca is a key element in the development and the gateway of the city toward the international market.

Therefore, it has been shown a discourse polarization related to the industrial activities and their political, social, economic and environmental implications. During social mobilizations (which mostly took place in the year 2000) the inhabitants of the port area (Ing. White) were those who actively participated. Meanwhile, Bahía Blanca´s inhabitants (in the central and remote areas of the port) followed these events mainly from the media, as if it was a distant issue (EcoDías, Year I, n ° 4). Awareness activities and emergency plans were mainly focused on the port area, Ing. White schools and hospitals. This is an important element to observe, since in an accidental pollutants leakage the dispersion could affect the entire city, the district and the surrounding regions. It should be noted that within the APELL process, the PRET is only activated when companies give notice of the emergency. So, companies define which situations represent a risk and when it is necessary to make it known (Municipalidad de Bahía Blanca, 2011).

Some measures may be suggested: maximize the use of mass media to disseminate risk information, increase the promotion of participatory workshops, infographics realization and public streets signs to inform the population what to do in case of an industrial accident. Lack of knowledge about threats and necessary actions in case of an event, are the most acute vulnerabilities. Although the open environmental data provided by Bahía Blanca municipality, its access depends on the availability of a computer and the Internet. This information might be available on public spaces through specialized environmental signage. In regard to control, supervision and penalties, the proceedings delay occasionally originates their prescription (one year after the event). This means that companies are sometimes acquitted of paying the fines given by the CTE (La Brújula, 20.02.2017, La Nueva Provincia, 13.03.2016). The lack of an adequate sanction policy is still one of the most extreme risk-related vulnerabilities in Bahía Blanca. As a result, a section of the population creates a negative perception of the industrial activities and in those agencies responsible for management and control. It has been underlined self-criticism as a key element in reflective modernization (Beck, 1996a, 1996b, 2006). A self-critical society is forward-looking, since it leads to mindful actions regarding modernization negative impacts.

5. Conclusion

It is proposed the use of mass media to impart information, the promotion of participatory workshops and the infographic and public streets signs realization in order to inform the population what to do in case of an industrial accident. With regard to public policies, specific areas were identified to concentrate these measures. They should provide media access, design credit policies for necessary expansion and improvement of housing conditions to guarantee solid, resilient and adequately insulated buildings, as well as decent and habitable housing spaces. These are fundamental assets at the moment of the materialization of the threat. Regarding to data availability, the study used census variables to acknowledge population's vulnerability. As been mentioned, census radio is the minimum spatial unit in which this type of information is disaggregated. Census radio size is not always uniform and limits indicators used in this analysis. For certain variables and in the peripheral urban area, census radio might be unusually vast. However, this data is obtained systematically and covers the whole study area. For most accurate results in vulnerable zones, specific low spatial coverage statistical instruments are needed. This research has both complemented those studies made at a local level that aware social protests over this events, and identified involved actors. Institutional vulnerability analysis contributes to a holistic vulnerability approach, and therefore to a most precise evaluation in technological risk management in Bahía Blanca. Local findings have an applicability in other sites. Information access during a potential technological dangerous event, good living conditions, and a versatile legislative and institutional framework that guarantees control agencies independence from industries, are fundamental to reducing population's vulnerability. Vulnerability analysis and its dimensions contribute to assess technological risk management scenarios as a fundamental tool in order to settle resilient urban environments.

ACKNOWLEDGEMENTS

The present research was carried out within the framework of the research project "Physical Geography Applied to the study of the interaction between society and nature. Problems at various tempo-spatial scales" (24/G078) led by Dr. Alicia M. Campo and subsidized by the General Secretary of Science and Technology of the Universidad Nacional del Sur.

DECLARATIONS OF INTEREST: NONE

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