AN URBAN TECHNOLOGICAL RISK CHARACTERIZATION AND MANAGEMENT EXPERIENCE IN MERIDA CITY (VENEZUELA)

Alejandro LIÑAYO
Disaster Risk Management Research Centre (CIGIR)
Network for Social Studies on Disasters Prevention in Latin-American (LaRED)
Mérida - Venezuela

ABSTRACT:

Adverse events of human or natural origin (that have affected industrial facilities) during the last decades reveals that many cities have a limited capacity to estimate and to respond in an integral way to technological risks scenarios[1].

Although some industrial accidents (Séveso 1976, Bhopal 1984, etc.) have promoted in the past years the adoption of methodologies for urban technological risk characterization and treatment, today some elements suggests that it is necessary to understand that growing complexity of urban spaces demands from city disaster and emergency planners some technological risk management efforts, even in urban spaces where industrial facilities cannot be located.

Additionally, almost all technological risks management initiatives today (training programs, software, legal frameworks, etc.) are focused in the existence of industries that store or process important amounts of hazardous materials. In those cases, the classic approach promotes the elaboration of geospatial risk diagnostics that are used latter to supports the implementation of rigorous safety policies and/or contingencies response protocols that usually are limited to cover facilities and personnel located inside the companies or industries boundaries, leaving away near human establishments that ignore that are located in spaces with very high levels of technological risk.

This article describes some advances and experiences accumulated by the Disaster Risk Management Research Centre (CIGIR by its Spanish acronym) about identification and integral treatment of urban technological risk for the city of Mérida (Venezuela). It also emphasizes the application of tools and new technologies for the geospatial characterization of risks scenarios and calls for efforts to strengthen the institutional and community aspects in the local administration of urban technological risk scenarios.

KEY WORDS: ***Technological risk, Urban Risk Administration, Urban Development, Hazard Materials***.

1. INTRODUCTION

Any reference to the importance of efforts to reduce the impact of disasters in our societies today seems unnecessary when we consider the crushing reports about the actual impact of disasters in the world[2]. These impacts seem to follow a clearly tendency defined by the fatidic prediction made by Quarantelli (1988) when he suggested that we are invariably moving toward a global scenario of "more and worse disasters in the future".

While disasters risks and events of natural origin remains the focus of disaster prevention, different elements have been arising that tempt us to judge technological risks as an important element that needs to be considered in any initiative dedicated to the integral administration of urban disaster risk.

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[1] Without ignoring the extent number of situations that involve the notion of "urban technological risk ", we will refer this term to the analysis of potential scenarios of urban affectation associated to failures that may occur in facilities where hazard materials are stored (flammable, explosive, toxic or radioactive)

[2] Reports of the Centre for Research on the Epidemiology of Disasters (http://www.cred.be) and Munich RE (http://www.munichre.com) suggest an exponential growth in the economic and social repercussions associated to the impact of disasters during the last decades, especially in developing countries

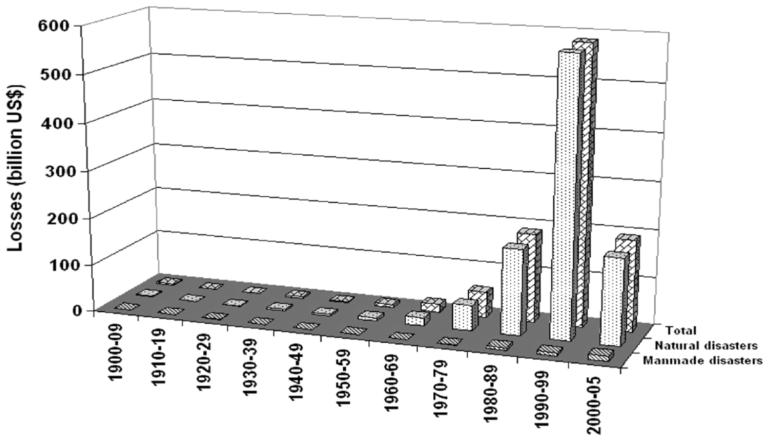
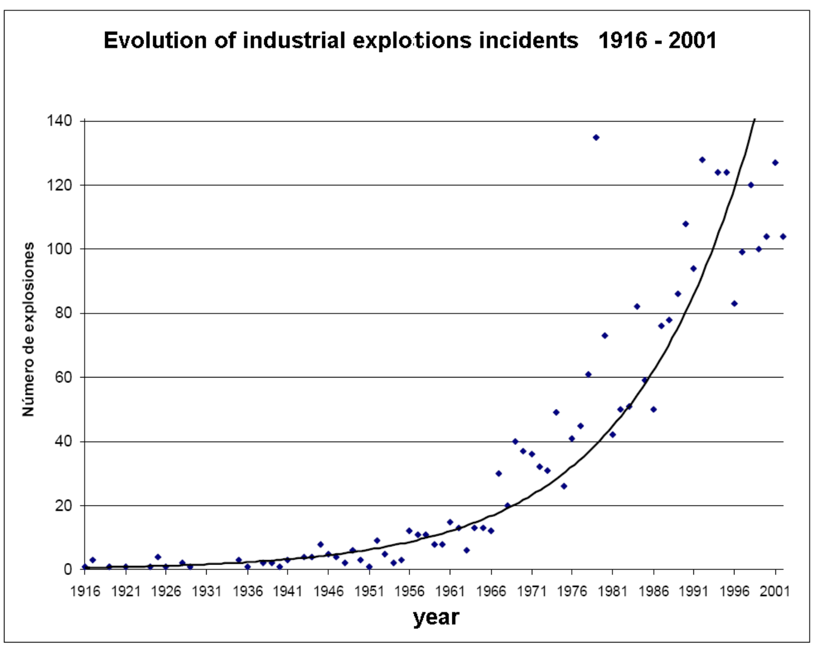


Image 1: Tendencies of economic losses associated to the occurrence of disasters of natural and man-made origin during the last century

Source: CRED database of EM-DAT; http://ww.em-dat.net

For example, let us assume that the 1998 Chernobyl catastrophe marked a turning point in the consideration of the destructive potential of a technological-based disaster. In fact, the Chernobyl accident shows that we have reached a point in which an industrial accident can have human and environmental consequences similar and even worst to those disasters associate with earthquakes, tsunamis, hurricanes or any other kind of natural events. Additionally, in terms of frequency, several works suggest that, although it is certain that the levels of human and economic losses from natural disasters still surpasses those of technological origin, the frequency of this type of events has grown continuously throughout the last century (Figure 2).

Figure -2: Historical evolution of industrial explosions incidents (source: "Analisis Historico de Accidents: Explosions; University of Cataluña; available in http://elgasnatural.files.wordpress.com/2008/07/unipolcata.pdf)



Another fundamental aspect to keep in mind when justifying the necessity to address urban technological risks arises by simply counting the frequency of situations in which events of natural origin (earthquakes, floods, mass movements, etc.) set off emergencies of technological type (fires, toxic materials leaks, explosions, etc.) that can end up, at local urban level, in consequences as serious than those associated to the initial "trigger" event.[3] These kinds of situations are usually referred to as *NATECH*.

The level and complexity of technological risks inside urban spaces, as in the case of natural origin disaster risks, can change a lot from one city to another. Additionally, effective solutions to this problem are usually difficult to implement because they concern intrinsic aspects of economic, social, political, cultural, and institutional realities of each community. Any proposal to manage this kind of urban risk, far from being bounded to the analysis of the industrial facility where an adverse event could generate, should consider social-environmental elements and should also involve all actors that could be potentially affected, direct or indirectly, by the occurrence of the considered event.

Those ideas invite us to consider that if we accept risk administration is based on the idea that disasters are a symptomatic manifestation of our inability to coexist with the territory we occupy, and if we understand that disasters are in essence a toll we have to pay due to our incapacity to negotiate properly with the territory we occupy, it is fundamental to recognize within the urban risk equation the component of technological risk as an element whose threats and vulnerabilities should also be dealt with.

2. A GLANCE TO URBAN TECHNOLOGICAL RISK EVOLUTION AND ITS CHALLENGES.

It is accepted that urban technological risk construction began with the sudden and uncontrolled way in which dangerous industrial infrastructure invaded spaces formerly occupied by cities, particularly during industrial revolution (18^{th} century). With time nature of this problem has change and today the uncontrolled size and complexity of our urban spaces has made it more and more difficult to single out industry as the only culprit of a problem that results from the coexistence of dangerous technological infrastructure with human establishments.

Today, beyond the existence of industrial areas within urban spaces, the economic processes currently occuring in our cities call for the consumption and storing of very dangerous materials that, apart from degrading the environment, frequently cause very high exposure levels for their inhabitants. The importance of this fact discredits the idea that the treatment of urban technological risks should be directed exclusively towards the actors linked to the industrial activity. It is fundamental to recognize that in our cities exists a very important flow of materials that, without admitting its danger, are vital inputs for some economic processes. Therefore, there is a need to develop permanent efforts dedicated to identify the characteristic levels of technological risk for each urban space and to define socially pertinent mechanisms that should be implemented in order to inform and to reduce these risks.

The dominant paradigm that associates the technological risk with the industrial activity has promoted the existence of important efforts to characterize and to reduce the technological risks of industrial processes. However, as we said before, these studies and methodologies have been, in general, strictly limited to the actors inside the industries. Risk diagnoses, contingency plans, and training programs are directed at industries while, in most cases, the communities and institutions that surround those facilities (to which the industry commonly referrers as "third parties"), are frequently denied the right of knowing the implications that, from the risk point of view, has to live close share space with those facilities.

3. ENVIRONMENTAL IMPACT STUDIES: VIRTUES AND LIMITATIONS

[3] This reality makes more and more difficult to distinguish the commonly established frontier between disasters of natural origin and disasters of technological origin and invites to be involved deeper in the treatment of multi-threat urban scenarios.

An interesting aspect that deserves to be addressed is the excessively normative logic with which the institutional regulators of the industrial activity tend to approach technological or industrial urban risk problems. We refer here specifically to the commitment of these controlling entities to making the environmental impact studies a control mechanism for long term urban industrial risk.

Commonly, when any industrial infrastructure is planned, environmental impact studies and security approaches are taken into consideration to guarantee that the final location will be suitable. This suitability results in, among many other things, all industry components being located a sufficient security distance from human establishments and being preserved from any intervention outside the industry itself.[4]

Unfortunately, reality demonstrates (particularly in less structured societies) that there are socio-economic elements that have not been appropriately considered. This has allowed important technological disasters associated to the explosion-fire-toxicity trilogy inside several urban scenarios (Table 1). The trick question here is: ¿How did these events occur in spite of existing provisions and regulations? ; ¿Is it possible that the security measures designed to maintain separation between industrial facilities and affected urban spaces were not enough?

Surprisingly the answer that we have found after evaluating the circumstances in which some of Venezuelan most important technological disasters suggests that there are very few cases in which one could suspect the inadequacy of the norm. In their original design, the involved industrial spaces were sufficiently afar from human establishments. However, diverse social and economic pressures decreased, and in many cases eliminated, the security distances. Two of the main circumstances that seemed to propitiate this phenomenon are:

1. Even though the original design located the industrial facilities in the urban periphery, the commonly anarchical growth that characterizes these cities results in urban spaces occupying security distances[5]. We should highlight that these occupation processes are frequently undertaken by low income human groups that, in their search of alternative urban survival ways, ignore the territorial and environmental regulations and limits on which city planners and administrators place their highest hopes[6].

2. A second aspect that is especially important to highlight is that, on multiple occasions, once a new industrial infrastructure is settled (following all the technical approaches and keeping the regulated security distances), that same industry becomes an immediate attraction for the development of marginal economic activities in its proximities that favour the establishment of uncontrolled shanty towns. With the passing of time, these shanty towns consolidate into small citadels surrounded by all types of technological risks.

In any case, these facts should encourage us to consider that - recognizing the importance that promoting normative mechanisms to prevent the coexistence of human establishments with technological infrastructure has - this coexistence becomes practically unavoidable. Under these circumstances, it is imperative to promote mechanisms that allow the inhabitants to learn how to live and how be aware of the environment that surrounds them here be should recognize the fundamental role that the educational and communicational sectors should play.

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[4] Maybe that is why everything made in function of how to cohabit with industrial risk (emergency cases training, contingency plans, evacuation exercises, etc.) essentially goes to the people inside of those facilities.

[5] It is a very similar process to that of most Latin American airports whose initial location was at a prudent distance from the cities and today seemed to be set deep in the center of them, bringing an important risk associated to the air operations.

[6] Here underlies the drama that has been outlined by the Network for Social Studies in Disasters Prevention in Latin-America LaRED whose sustains that the so called " urban development " is restricted only for those who can pay it and is increasingly far from satisfying the basic necessities of the most deprived ones, and this situation inevitably will be promoting a permanently appearance of old and new kind of urban vulnerabilities (www.desenredando.org).

Table 1: Main accidents with dangerous substances between 1974 y 1988
(Source: "Industrial facilities risk Analysis"; Casal et all, 2001)

EVENT - PLACE	YEAR	DEATHS	INJURED	EVACUATED
Chlorine leak in Yokkaichi – Japan	1974	0	521	0
Ammonia leak in Cuernavaca - Mexico	1977	2	500	2000
Explosion en Iri – South Korea	1977	57	1.300	0
Polypropylene Explosion in Els Alfacs-Spain	1978	216	200	0
Butane Fire in en Xilatopec – Mexico	1978	100	200	0
Three Mile Island nuclear Reactor– USA	1979	0	0	200.000
Train Accident (chlorine y propane) – Canada	1979	0	200	220.000
Chemical toxics in Novosibrinski – USSR	1979	300	NA	NA
Phosphorous Trichloride leak in Somersville USA	1980	0	418	23.000
Butane Intoxication in Danaciobasi Turkey	1980	107	0	0
Chlorine leak in San Juan – Brazil	1981	0	2.000	0
Chlorine transport Accident in Mexico	1981	28	1.000	5.000
Butadiene leak – Melbourne; Australia	1982	0	1.000	0
Hydrocarbon Explosion–Tacoa; Venezuela	1982	+200	1.000	40.000
GLP Fire in Nile – Egypt	1983	317	0	0
Polyduct Explosion in Cubatao; Brazil	1984	508	NA	0
GLP leak in Sn. Juan Ixhuatepec; Mexico	1984	503	7.000	60.000
Methyl Isocyanate leak in Bhopal; India	1984	2800	50.000	200.000
Chemical leakage in Rumania	1984	100	100	NA
Phosphoric Acid leakage Miamisburg; USA	1986	0	140	40.000
Reactor Explosion Chernobyl – USSR	1986	32	299	135.000
Arsenal Explosion in Alexandria; Egypt	1987	6	460	¿?
Water Contamination in Shangai; China	1987	0	1.500	30.000
Base piper alpha Explosion North Sea	1988	167	NA	0
Chemical Leakage in Tours; France	1988	0	3	200.000
Polyduct explosion in Guadalupe; Mexico	1988	20	NA	200.000
Arsenal Explosion in Islamabad; Pakistan	1988	+ 100	3.000	NA
Gas Explosion in Chihuahua; Mexico	1988	0	NA	150.000
TNT Storage Explosion in Arzamas; USSR	1988	73	720	90.000
TNT Storage Explosion in Sverdlovsk; USSR	1988	4	500	0
Contamination fertilizers in Sibenik; Yugoslavia	1988	0	0	60.000

4. TOWARDS AN APPROACH BASED IN THE "*RIGHT TO KNOW*"

If something has become evident from the investigation processes developed in order to determine the causes of the most important technological disasters registered in Venezuela in the last years, it is the absence of information among the affected populations. For example:

Image 3: Original photography shows part of the devastation left by the FIRE occurred 13/11/1939 in Lagunillas del Zulia (Source: Profesor Julio Portillo Rosales archives)

The first big technological disaster in Venezuela was registered on 1939, when a mishap in the Venezuela Gulf Oil Well Nº1 caused the leakage of great quantities of petroleum and flammable gases over Maracaibo's lake, in place where today is located the town of Lagunillas del Zulia. This area was historically occupied by ***palafitos***[7] that, during the uncontrolled national oil boom registered in the first third of the twentieth century, were suddenly forced to coexist with an important and locally unknown industrial petroleum infrastructure.

As result of this encounter a fire started the night of November 13, 1939, (different relates sustain that inhabitants detected several hours before the fire a strong smell and a thick black *cream* floating over the waters) burning near 300 ***palafitos***, killing around 2,500 people and burning over 5,000 victims.

Another much more recent case occured in the town of Catia La Mar, located on the coasts of Vargas State (Venezuela).In December, 1982 a fire broke out in the fuel tanks of Tacoa Thermoelectric Station. On Sunday December 19, 1982, at quarter past six in the morning, an explosion occurred in tank nº 8 of Tacoa Electric Generation Complex, in Arrecife, where 16 thousand liters of fuel oil were being unloaded from the tanker "Murachí".

During the morning of that day, more than one hundred firemen and volunteers fought the fire. At 12:35 pm, when the fire in Tank nº 8 was practically controlled, a boilover phenomenon generated in Tank nº 9 killed more than two hundred people, including firemen, journalists and inhabitants of the area that, ignoring the danger, were observing the action.

Image 4: Tacoa Fire on December 19, 1982 (Source: El Nacional)

[7] ***Palafitos*** are primitive housing built over an aquatic surface upon a frame of stakes dating from the Pre-Hispanic era. It is said that when Américo Vespucio saw this houses over the waters of the Lake remembered the city of Venice (Italy) and suggested the name of Venezuela (Small Venice) for the new territory.

These examples, as well as other events that have happened in the country, are as much a product of the occupation of urban spaces by industrial infrastructure as the occupation of industrial areas by urban settlements. They suggest the need to develop efforts to allow potentially exposed people to know their exposure levels and to know in which circumstances they should take certain measures in order to safeguard their life.

Unfortunately, in spite of experiencing events like those described, in many contries we are far from recognizing the citizen´s right to know the technological risk they are exposed to and this is contradictory becouse, If we accept that risk management is based on the idea that disasters are a symptomatic manifestation of our inability to coexist with the territory we occupy, and if we understand that disasters as a toll we have to pay due to our incapacity to negotiate properly with the territory we occupy, it is fundamental to recognize within the urban risk equation, the component of technological risk.

Image 5: Aerial view of the Lake of Maracaibo west coast that illustrates the coexistence of urban spaces with industrial infrastructure (Source: A. Liñayo).

5. STEPS TOWARD A BETTER URBAN TECHNOLOGICAL RISK MANAGEMENT: THE EXPERIENCE OF MERIDA CITY (VENEZUELA).

The lessons left in Venezuela by previous disasters have led to the promotion of diverse initiatives to improve the risk administration approach of socio-natural and technological disasters. As part of the characterization of urban technological risk, some efforts have been made in Mérida city since 2007 (Venezuela) to consolidate and inventory of different types of urban risks associated to the occurrence of fires, explosion-deflagrations and toxic materials leakages and to calculate the potential impacted urban scenarios that could generate these events.

A first interesting aspect of this project is that, being Merida city a place in wich no industrial areas can be found, different innovations have beeen applied to adapt available methodologies (focused on technological risk management in urban spaces located near industrial infrastructures and/or factories) to deal with risks characterization for much more common facilities such as gas stations, deposits and domestic GLP transmission lines, water-treatment plants, swimming pools, refrigeration plants, hardware stores, paint stores, dry cleaner's, agricultural products deposits, pyrotechnic stores and any other tipical urban comertial establishment in which explosions, fires or toxic materials leakages could be generated.

Another interesting aspect of this work is that, results has been linked with other microzone studies of natural origin threats (seismic, movements of masses, floods), by means of geographical information technologies, and allowing the elaboration preliminar urban multiple threats maps. Based on these diagnoses, institutional and community strenghening strategies (based on education and public information efforts) have been promoted to improve either local urban risks prevention-mitigation capacities and local preparing and responding capacities to potential disasters.

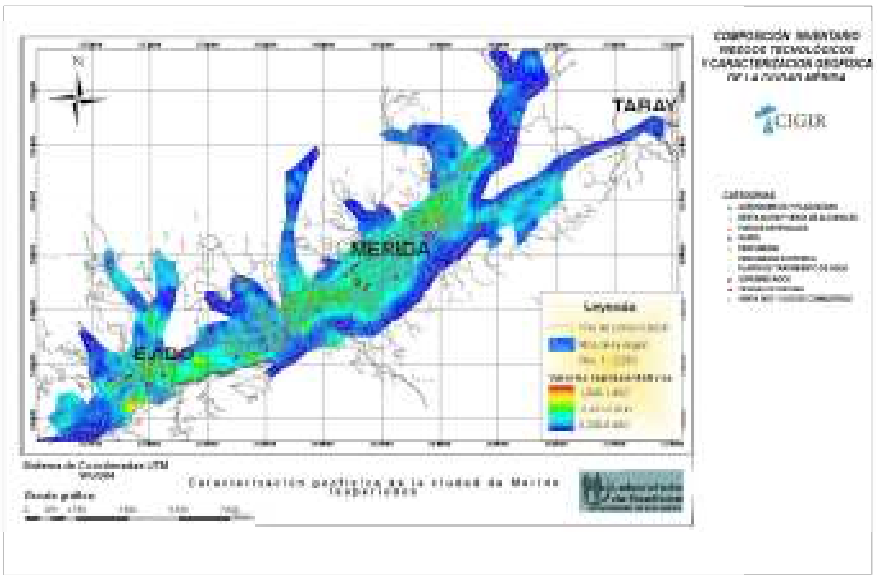

Image 6: Geographic information system output for the city of Mérida showing results of different urban risk micro zone studies. In here the expected seismic soils acceleration map (prepared for Geophysics Laboratory of Universidad de Los Andes) and location of some HAZMAT location and potential affectation in the city can be overlapped.

6. SOME DIFFICULTIES CONFRONTED IN THE PROJECT:

During the development of this experience, there have been some challenges confronted in order to achieve the identification of urban technological risk scenarios for Merida's metropolitan area. Here are some examples:

6.1. Definitions of riskiness-volume thresholds

The first necessary aspect to deal with was the definition of the thresholds criteria by which a specific city point, in which the presence of some dangerous material was detected, should be incorporate or not within the geospatial database. Venezuelan legislation, unlike other countries, lacks regulation criteria of dangerous materials so it was necessary to establish some criteria that, supported in international regulations and in local calculation of potential urban affectation, allowed the identification of technological threats in the city.

6.2. Lack of criteria for the registration and treatment of non pure substances

One of the most difficult problems confronted was the lack of criteria for the treatment of risks associated with non pure substances detected. This became evident during the field activity, when it was possible to verify only on rare occasions material deposits whose names clearly stood out in the United Nations Guide of Dangerous Materials or in any other similar catalogue. Therefore, in occasions it was necessary to study these materials in the laboratory to establish their composition and some physic-chemical characteristics to identify the active ingredients, and to search for their security sheet (HDSM) in order to infer the characteristics they could have as technological risk generators (MATPEL).

6.3. Estimation and modeling of potential affected areas

Once determinate the urban facilities where dangerous materials were stored and verified the type and quantity of dangerous substances managed in each one, we proceeded to validate different mathematical models and available software to estimate affected areas. It is worth mentioning that we were forced to discard or supplement the use of diverse programs that offer this type of calculations due to diverse reasons. Some programs operated as "black boxes" where some input data is provided and some output diagrams - hardly validated because the dispersion mathematical models used are not known. In other cases, the input parameters requested by the program were not available in the level of precision that the application demanded.

6.5. Transference and subsequent use of these results:

Two of the most sensitive aspects that could determine the effectiveness and applicability of initiatives like this one have to do with the final use of the results and the continuous work that is needed in order to ensure the urban technological risks inventory will be update as frequently as possible. There are numerous examples of the lack of cooperation among the legally institutional entities (often deficiently equipped and qualified) authorized to characterize and management urban risks, and academic and scientific actors that, having important capacities to undertake works on these topics, almost always decide to work isolated, (ignoring their institutional peers and believing that the final result of their work must be an article published in some prestigious scientific magazine).

In order to avoid described situations, a very close communication and coordination link between original academic promoters of the project and the fire department of Mérida State, was established and, as part of this organizational effort, a formal institutional agreement was signed between different institutions. This kind of measures has shown to be fundamentals to guaranty the sustainability of the project, at least until today.

To summarize briefly some of main points presented in this article we could say that:

1. "Technological risk" associated with hazardous materials within urban areas is a significant and growing city problem.

2. Because of interrelated economic, social, political, cultural, and institutional factors, attempting to manage urban technological risk solely by addressing the actors who operate within the boundaries of the industrial facilities today seems unlikely to be effective.

3. Realistically, and particularly in less structured societies, there are strong social-economical circumstances that makes industrial facilities and human settlements coexist in inconvenient close proximity (e.g., due to encroachment that reduces any intended buffer zone).

4. Every citizen coexisting with technological facilities should know the threats he is exposed to, but surrounding communities are frequently denied the opportunity of knowing about the risk to which they are exposed.

5. Some efforts have recently been made in Mérida - Venezuela to better characterize urban technological risk resulting not from industrial facilities but from more common urban facilities.

6. GIS has been used to create maps of urban threats and multi-threats (both technological and natural) and those maps have been used in the design of strategies both for risk prevention-mitigation and for disaster preparation.

7. Important challenges of different kind need to be solved during these efforts, particularly because available methodologies are usually focused only on risks associated to industrial facilities.

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