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CONCEPTUAL BASIS OF SCIENCE OF RISKS IN THE GEOGRAPHY: A BRIEF DISCUSSION*

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ABSTRACT

The main purpose of this article is to contribute to a theoretical and conceptual discussion about the notion of risk and vulnerability, notably the establishment of a geography of the risks and vulnerabilities of social and environmental issues. To this end, this is a reviewing of some major theoretical and methodological principles of science on the risks and vulnerabilities, contributing alternative operationalization of these concepts.

Keywords: Risk, vulnerability, , hazard, geography.

RESUMO

Base teórico-conceitual da ciência dos riscos na geografia: uma breve discussão - O principal objetivo deste artigo é contribuir para uma discussão teórico-conceitual sobre a noção de risco e de vulnerabilidade e, notadamente, o estabelecimento de uma Geografia dos riscos e das vulnerabilidades sociais e ambientais. Para isso, fez-se uma análise de alguns dos principais referenciais teórico-metodológicos sobre a ciência dos riscos e vulnerabilidades, contribuindo com alternativas de operacionalização desses conceitos.

Palavras-chave: Risco, vulnerabilidade, perigo, geografia.

RESUMEN

Fundamento teórico y conceptual de la ciencia de los riesgos en la geografía: una breve discusión - El propósito principal de este artículo es contribuir a una discusión teórica y conceptual sobre la noción de riesgo y vulnerabilidad, en particular la creación de una geografía de los riesgos y las vulnerabilidades de los temas sociales y ambientales. Con este fin, se trata de una revisión de algunos grandes principios teóricos y metodológicos de la ciencia sobre los riesgos y vulnerabilidades, contribuyendo operacionalización alternativa de estos conceptos.

Palabras clave: Riesgo, vulnerabilidad, amenaza, geografía.

RÉSUMÉ

Fondement théorique et conceptuel de la science des risques dans la géographie: une brève discussion - Le but principal de cet article est de contribuer à une discussion théorique et conceptuelle de la notion de risque et de vulnérabilité, notamment la création d'une géographie des risques et des vulnérabilités des questions sociales et environnementales. À cette fin, il s'agit d'une revue de quelques grands principes théoriques et méthodologiques de la science sur les risques et les vulnérabilités, ce qui contribue opérationnalisation autre de ces concepts.

Mots-clé: Risque, vulnérabilité, aléa, géographie.

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Introdução

The omnipresence of risk is undeniable. From the moment that human life was conceived, it's been running after several risks. Risk is, thus, inherent in life.

With the human presence, risk never ceases to exist (there is no "*zero risk*"); it only varies in time and space. It is, however, in modernity that this omnipresence is exacerbated. Among the marks of recent human evolution - the emergence of capitalism, the progress of science and technology, the dissemination of democratic relationships - the revolutionary idea that defines the boundary between modernity and the past is the search for the "domain" of risk, or the notion that the future is more than the whim of the gods and that man isn't passive in the face of nature (Bernstein 1998).

From the time of the "*Revolutions*" (Scientific, Industrial, French and Renaissance, among others) and for a long time after, catastrophes, whether natural or caused by man, were believed to be "*acts of God*" (The 1755 earthquake that affected Portugal is considered the 1st natural catastrophe to be managed in a modern style).

This so called "dominance" of the future seems paradoxical in light of the relatively recent major transformations in society and nature on a planetary scope.

On one hand, the number of people concentrated in surban areas is reaching nearly half the worldwide human population. This shows a tendency to generalize risks and hazards as they increase with population density and population growth in environmentally unstable and socially vulnerable urban areas (Urban areas cover approximately 1% of the total surface of the Earth, and at least 2% of its land areas).

On the other hand, global environmental changes (climate change due to the increase of greenhouse gases, rising sea levels, the increased frequency of extreme weather etc.) impose much vulnerability and a growing sense of insecurity in the whole of humanity.

For many authors, these facts – along with the risks and uncertainties associated with them – are considered a keynote of Modernity, or Post-Modernity.

Giddens (2002) speaks of modernity by referring to the institutions and modes of behavior initially engendered in Europe with the end of feudalism, and which throughout the twentieth century have become global in their influence. Modernity refers to the "*industrialized world*" and the social implications involved in the widespread use of techniques and machines in the production process.

The Twentieth Century, as conceived by Ulrich Beck (1998) in his classic work Risikogesellschaft (The Society of Risk), was not low in the number of historical catastrophes. At this time, they were generalized as '*technological*' hazards, some examples being: Hiroshima and Nagasaki (Japan, 1945), Minamata (Japan, 1956), Seveso (Italy, 1976), Three Mile Island (U.S.A., 1979), Bhopal (India, 1984), Chernobyl (Ukraine, 1986) and Goiania (Brazil, 1987).

As for natural hazards, they are no less important and catastrophic if they are often repeated and have devastating magnitudes in terms of environmental changes undertaken by man, by the growing concentration of populations in increasingly vulnerable cities, by population growth in general, and by the globalization of social inequality and segregation.

The tsunami in the Indian Ocean in December of 2004 caused thousands of deaths, destroyed thousands of homes and brought chaos and destruction to countless families in Asia and Africa, especially to the socially vulnerable populations. Likewise, the aftermath of Hurricane Katrina hit more severely poor and black communities in New Orleans, in 2005.

Thus, one can say that risks and disasters are typical of Modernity. At the same time, this is a historical moment in which all of humanity feels vulnerable. Even the economic powerhouse and global hegemony that is the United States felt vulnerable in the presence of the terrorist attacks on the World Trade Center in New York, and on the Pentagon in Washington, on September 11, 2001.

In this context, the main aim of this paper is to contribute to a theoretical and conceptual discussion about the notion of risk and vulnerability and, principally, the establishment of a science of risks and vulnerabilities in geography. The methodology used in this paper was the review the literature related to the topic of risks, vulnerabilities and natural disasters along with a presentation of some cases of operationalization of concepts.

The notion of risk permeates many nuances of society, from the academic to the corporate world. It's an object of use in the economy (analyzing a country's risk, the risk of falls in stock exchanges), in engineering (the risk assessment of construction accidents, workplace safety), and in the insurance and health industries, among others. Basically, risk is a fairly widespread concept. It is a recurring component of modern society. The complexity of this concept comes essentially from being an inherent characteristic of contemporary society, permeated by uncertainty, fear and insecurity.

The term risk is often accompanied by an adjective, which qualifies and associates it with the everyday life of society: environmental risk, technological risk, natural risk, social risk, biological risk and economical risk, among others (Castro *et al.*, 2005).

Given this diversity in the conceptual approach to risk, there are common inaccuracies, ambiguities and

even confusion as to the establishment of concepts. Therefore, a review of basic concepts is proposed, with the main purpose being a legitimate semantic precision of this approach.

Etymology of the term "risk"

The origin of the term "*risk*" is considered by some authors as uncertain, but it is present in all European languages: risk (English), *rischio* (Italian), riesgo (Spanish), *risque* (French). Some linguists relate the referred term to the ancient Castillian "*resegue*" (to dry/to cut), which was most commonly used in the middle ages and was synonymous with struggle, conflict and division (Aneas de Castro, 2000).

There is also the Latin word "*rixare*" (fight) and "*resecare*" (excise, delete), which has a double meaning - division, discord and a rugged place; in Greek "*rhizikon*" and Arabic "*risk*". In Aneas de Castro (2000) and Veyret (2007), etymological risk comes from the term "*Risico*" or "*rischio*", while the Castilian "*risk*" means: I choose, cliff, promontory, or sinking. "I*n fact, the word means, at the same time, a potential hazardous perception and indicates a situation perceived as hazardous in which it is or whose effects can be felt*." (Veyret, 2007, p. 25).

However, according to the UNDRO (United Nations Disaster Relief Organization), which contributes to the definition of various concepts related to the study of natural disasters, risk is "*the degree of loss expected due a natural phenomenon and determined as a function of both the natural hazard and vulnerability.*" (Aneas de Castro, 2000, p. 2).

A specific bias can be seen in the previous concept, mainly in defining the type of risk (natural risk – to be discussed later). In general, however, the concept of risk can be taken as a category of analysis associated with the notions of uncertainty, exposure to hazard, loss, and material and human damage, not only linked to natural processes, but also to processes resulting from human activities. Broadly, risk "*refers to the probability of the occurrence of time and spatial processes, inconstant and undetermined, and how these processes affect (directly or indirectly) human life.*" (Castro *et al.*, 2005, p.12)

The use of the term risk

Even as an analytical category clearly related to industrial development and the use of science as a way of "*controlling*" uncertainty, the notion of risk and its origin, analysis and management has been reported by several authors to have started in ancient Babylon, in the Tigris-Euphrate valley (3,200 BC), marking the beginning of spatiotemporal risk analysis (Cutter 1993; Castro *et al.*, 2005).

Threats associated with lead poisoning were reported for centuries, and are described in the Bible and the Talmud. Wines produced and stored in barrels of lead were considered responsible for the fall of the Roman Empire (Cutter, 1993).

The origins of the concept of risk also date back to pre-Modernity, to the beginning of navigation, military activity and commercial practices. For most pre-modern cities, fires and plagues were categorized as the two main urban disasters for centuries, linked to the precarious existence of the townspeople at that time.

Moreover, given the modest size of ancient cities, geological (earthquakes, volcanic eruptions etc.) and hydrological (floods, storms etc.) disasters caused contingent and limited harm and loss, compared to the fires that ravaged cities like Toulouse in 1442 and 1551, Berlin in 1405, Amsterdam in 1451 and 1452, Moscow in 1626 and London in 1666 (cf. Chaline and Dubois-Maury, 1994).

Currently, risk was considered a neutral category which produced both positive and negative consequences. During the Italian Renaissance, the definition and perception of risk acquired a prominent place in European society, as well as a strong sense of something negative, to be feared and avoided (Veyret, 2007; Marandola Jr., 2004).

In modern times, associated with industrial activity and scientific advances, Cutter (1993) listed some activities that began to trigger the so-called "*technological risks*", for example the risk of cancer associated with the transmission of high voltage electrical energy, the risks of nuclear power, and the risks attributed to the use of chemical and biological weapons (biohazard) in wars and conflicts.

As to the first modern studies on risk, Castro *et al.* (2005) attributes the first use of the terms "*risk*" and "*uncertainty*" to Frank Knight's classic 1921 work, "*Risk, uncertainty and profit*", when they took the role of technical terms in academic literature.

Risks and hazards: a tradition of social science and Geography

Given the historical tradition of studying geographical areas based on their natural and social elements, it was Geography that emerged in classic works on "*natural hazards*". For a long time, geographers (mainly physical geographers) remained strictly imbued with the research of the physical-natural, its processes, its chronology and its measurement.

This was maintained until the 1950's/60's, when there was an awakening in the growing interest in the relationship between human activities and the environment. One

aspect that helped to narrow the gap between studies of nature and studies of society was research on "*natural hazards*", highlighted by Gregory (1992).

Also, according to Gregory (1992), there were always frequent allusions to human-environment relations by geographers, but they opted for ignorance of the indicators already evidenced in the mid-nineteenth century. Thus, Physical Geography has developed almost in isolation and without consideration of human action in its theoretical and methodological scope. Pioneering work, such as George Perkins Marsh's Man and Nature, 1864, had a strong influence on subsequent research, for demonstrating the ways in which the Earth was seen and used by man.

It was in the late 1950's, however, that a study of human-environmental trends and their insertion into Physical Geography emerged, mainly the study of "*land coincidences*" from a socioeconomic perspective.

The search for what are called "*natural hazards*" is attributed to the inclusive tendency of human influence in environmental studies and Physical Geography. In this regard, the pioneering work of American Geographer Gilbert F. White became a reference in the studies of natural risks and hazards, and therefore deserves more distinctive attention.

White's research was guided by Human Ecology, a sub discipline of Sociology and Geography developed at the University of Chicago in the mid-nineteenth century (Mileti, 1999). Recognized internationally as the "*father*" of research and management of "*natural hazards*", White based his research on the idea that natural hazards are the result of the interaction of natural and social forces, and those hazards and their impacts can be reduced by individual and collective adjustments (Mileti, 1999).

White himself has indicated in an article produced with Robert Kates and Ian Burton (White *et al.*, 2001), that research on "*hazards*" was born from a demand for studies and analysis for the purpose of application to practical situations of reality.

Despite the collaboration of many professionals in delivering solutions to these problems (dikes, reservoirs, riverbanks, etc.), many Geographers have questioned the emphasis on strict solutions to engineering projects and, appropriately, have outlined the possibility of alternative solutions.

This is the case in an article by White and colleagues (1958) on the changes resulting from human activities on flood plains in the U.S.A. Managed in accordance with administrative guidelines at the time, they expressed an important paradox: The occasional losses of any kind caused by floods were increasing significantly, instead of being reduced as a result of containment procedures (Garcia-Tornel, 1984).

In the late 1960's, the Human Environment Commission of the International Geographical Union (IGU) promoted research on natural hazards and their consequences for man. The studies, carried out from 1968-1972, were subsequently edited by Gilbert White, then president of the commission, and published in 1974 (White 1974), entitled "*Natural hazards - local, national, global*".

In the mid-1970's, a more constructive approach to "*natural hazards*" began building. At the time, there was an approach to hazards, in Geography, based on its legacy in Human Ecology, with an emphasis on the relationships between natural hazards and the social responses to these, as well as a reduction of losses (Mileti, 1999).

There was an approach already coming from Sociology whose perspective was the analysis of collective behavior, emphasizing the responses to disasters and the prevention of them. This theoretical orientation became known as "*disaster research*", noted for its stance on the study of disasters and the formation of a "*school*" of research on this topic.

The search for more integrative approaches began to materialize in 1972, when two previous proposals, the geographical, based on analysis of hazards, and the sociological, focusing on the study of disasters, were lumped together with different views of Climatology, Engineering, Economics, Law, Planning, Psychology, Meteorology and Public Planning, among others.

In another study by White's group (Burton, Kates, and White, 1978), the authors sought to outline a history of the advances in research on the topic of "*hazards*". Such work became one of the main references for researchers and professionals of risks and hazards, as the authors concluded that the frequency and magnitude of catastrophic events was increasing, as well as the losses and costs that occur in relation to various countries.

The authors also highlighted the strong independence between the physical and natural dynamics of the Earth and the processes of land occupation, which had grown to be primarily responsible for the uncertainties and damage people faced, especially those most vulnerable.

A discussion of the concepts of risk, hazard and disaster

Risk is an eminently social construct, that is, a human perception. Risk is the perception of an individual or group of individuals in the likelihood of a potentially hazardous and damage-causing event. The consequences are a function of the intrinsic vulnerability of this individual or group.

Observe that, in general, it merges the concept of risk with the notion of the event itself that causes hazard or

threat, which hinders its perception and its management. Thus, the notion of hazard, which is different from the idea of risk, is related to the possibility or the actual occurrence of an injury causing event.

For Smith (2001), hazard is an inescapable part of life and is a component of risk. Hazard is a potential threat to people and their property, while risk is the likelihood of a hazard to generate losses. Explaining, Smith cites the example which considers two people crossing an ocean, one in an ocean liner and another in a rowboat. The main hazard (deep water and big waves) is the same in both cases, but the risk (the probability of sinking and drowning) is higher for the individual in the rowboat.

Two other concepts that deserve clarification are disaster and catastrophe. According to Quarantelli (1998), a disaster is an event focused on the time and space in which a community experiences severe hazard and destruction of essential services, accompanied by a scattering of human, material and environmental losses, which often exceeds the capacity of a community in dealing with the disaster without outside assistance. Thus, the concept of catastrophe is similar to disaster. What differentiates them is the scale and magnitude of the consequences and, if so, the disaster has wider dimensions and can be quantified as human, financial and ecological loss.

The second part of the concept of risk is vulnerability. In this context, risk is a function of two components: f(R) = H x V, where H is the hazardous event itself (H) or its potential for occurrence, and V is the intrinsic vulnerability of an individual or group of individuals. Other concepts embedded in the science of vulnerability, such as resilience, adaptation, insecurity, adjustment, exposure and susceptibility can be analyzed in the vast bibliography on the topic.

According to Veyret (2007), there are several types of risks, but not all are treated by geography. Risk perception and management, which are accompanied by a spatial dimension, are therefore covered by the geographical science and are classified according to the processes that engender them. Thus, classifying risks (which presents spatial expression) can be established as follows: environmental hazards (natural hazards and natural hazards aggravated by man), technological risks, economic risks, geopolitical risks and social risks, along with other types of risks (e.g.: major hazards - earthquakes, tsunamis and urban risks).

The 1980's and the emergence of the science of vulnerability

The concept of vulnerability, as well as the concept of risk, expressed on a large international literature, is quite complex and multifaceted, and several authors, cited by Birkmann and Wisner (2006), highlight the fact that vulnerability is:

- Multidimensional and differential (varies over space and between and within social groups);
- Dependent on the scale (with respect to time, space and units of analysis such as individual, family, region, system), and
- Dynamic (the characteristics and driving forces of vulnerability change all the time).

Since this concept is polysemic, the researcher must choose the one most appropriate for their research.

By analyzing the worldwide socio-spatial distribution of victims of natural disasters between 1973 and 2002, the differences become clear with regard to the consequences between the states of poverty in the affected countries. The poorest countries, i.e. those with a Human Development Index (HDI) of less than 0.8 (=Mexico) registered in this time period 96% of deaths related to natural phenomena. This fact explains that poverty is arguably one of the root causes of vulnerability (Leone and Vinet, 2006).

The growth of social inequalities, poverty and segregation arising with trinomial capitalism - industrialization - urbanization, in correlation with the consequent environmental degradation of its various facets, opened in the mid-1980's a theoretical and methodological approach that sought to focus disaster's (natural or technological) point of view not only on their physical triggering factors, but based on the prism of the affected populations.

Until the 1970s, the focus of research on risk was based on the analysis of natural hazards and threats. This work sought technical responses to situations or practical problems of everyday life (as seen above)

Investigations on natural hazards and technical interventions to mitigate human and material consequences (usually coming from engineering work) took the form of a paradigm called "*Risk analysis*", and began conducting research and evaluation inside and outside the academic community, supported by economic analysis from insurance consultants (Marandola Jr. and Hogan 2004).

The assumption that disasters are direct consequences of events or physical threats of different types, based on the paradigm of risk analysis, and various publications under the egis, are defined by Hewitt (1997) as "*physical*" approaches when confronted with the approaches that depart from a vision of disaster as a social problem, or as "*unresolved problems of development*" (Maskrey, 1996).

This perspective of understanding of catastrophes and natural disasters caused by phenomena such as

earthquakes, cyclones, hurricanes, volcanic eruptions, landslides, avalanches, tsunamis and floods began to incorporate more integrative and holistic approaches in understanding the complex networks of social, natural, cultural and environmental relations, which constitute the basis for the genesis of disasters. It is in this context to include the socio-cultural dimensions in environmental problems that create the concept of vulnerability. White et al (2001) express the theoretical and methodological trends of research on natural hazards and disasters, and highlight the growing attention given to addressing the vulnerability.

Over the past 50 years, researchers of risks and hazards have focused their attention on finding answers to a series of fundamental questions: How can the human occupation of hazardous areas work?; How do individuals and societies respond to environmental hazards and what factors influence their choices of adjustment (adaptation)?; and how can risks and natural hazards be mitigated? In the 1980's, however, another question was added to the previous list: Why are societies becoming more vulnerable to environmental hazards? (Cutter, 1996)

Roughly defined as the potential loss of a system (Mitchell, 1989), vulnerability has become an essential concept in addressing risks and hazards, and is central to the development of strategies to reduce and mitigate the consequences of natural disasters on different scales of analysis (local, regional, national, and global).

According to Cutter (1996), the science of vulnerability focuses on three principal areas: the contradictions and confusions in the meaning of the term, its measurement, and the causes of the resulting gaps associated with vulnerability studies. Both to White *et al.* (2001), and to Cutter (1996), there are three main fields of research for the science of vulnerability: the search for a meaningful consensus, the concept of vulnerability as a measure of risk, and the incorporation of the concept in analyzing the vulnerability of specific groups and their characteristics. The author also adds a new proposal, or a new conceptual model, of vulnerability, defined as the hazards of place. For White *et al.* (2001), corroborating the analysis of Cutter, vulnerability has become, in recent decades, a central concept used by many authors. Of 12 books on "*natural hazards*" analyzed by the authors, seven of them used the term vulnerability in their respective indexes, and other works highlight the definition of the concept and its applicability (see Table I).

Among the environmental sciences, the science of vulnerability may contribute to understanding the circumstances that put people at risk and the limitations

Table I - A selection of the most representative publications on natural hazards from the 1990's.

BLAIKIE, P. M.; CANNON, T.; DAVIS, I. e WISNER, B. At risk: natural hazards, people's vulnerabillity, and disasters. London: Routledge, 1994. 284p.

BRYANT, E. Natural hazards. Cambridge: Cambridge University Press, 1991. 312p.

BURTON, I.; KATES, R. W. e WHITE, G. F. The environmental as hazard. 2nd. Ed. New York: Gilford Press, 1993. 290p.

COCH, N. K. Geohazards: Natural and human. Englewood Cliffs (NJ): Prentice Hall, 1995. 481p.

HEWITT, K. Regions of risk: a geographical introduction to disasters. Harlow: Longman, 1997. 389p.

KOVACH, R. L. Earth's Fury: an introduction to natural hazards and disasters. Englewood Cliffs (NJ): Prentice Hall, 1995. 224p.

LINDELL, M. K.; PERRY, R. W. Behavioral foundations of community emergency planning. Washington: Hemisphere Publishing Corp., 1992. 320p.

PALM, R. Natural Hazards: an integrative framework for research and planning. Baltimore e London: Johns Hopkins Univ. Press, 1990. 184p.

QUARANTELLI, E. L. What Is a Disaster?: Perspectives on the question. London: Routledge, 1998.

SMITH, K. Environmental hazards: assessing risk & reducing disaster. London: Routledge, 1992. 324p.

TOBIN, G. A.; MONTZ, B. E. Natural Hazards: explanation and integration. New York: Gilford Press, 1997. 388p.

ZEBROWSKI Jr., E. Perils of a restless planet: scientific perspectives on natural hazards. Cambridge: Cambridge University Press, 1997. 306p.

Source: White *et al.*, 2001.

that reduce the ability with which people and places respond to environmental threats, or reduce their resilience (Cutter, 2003). Vulnerability has become the basis for policies to reduce risks, hazards and disasters, such as the IDNDR - International Decade for Natural Disaster Reduction - which is an important program to reduce losses from natural hazards, adopted by the General Assembly of the United Nations in December, 1989, which proclaimed the year 1990 as the international decade for natural disaster reduction (Munasinghe and Clark ,1995; Smith, 2001).

Categories such as risk analysis (exposure), hazards, resiliency, differential susceptibility, and recovery / mitigation also include in their theories the concept of vulnerability. This also appears in the same way in research applied to development studies and poverty (academically in Anthropology and Sociology), public health, studies of climate change, Engineering, Geography, Political Ecology, and especially among researchers of risks, hazards and disasters (Birkmann and Wisner, 2006).

Despite the current emphasis on the science of vulnerability, the concept still needs better definition and consensus on it, as shown by several authors (Bogardi, 2004; Cutter, 1996 and 2003, White *et al*. 2001). The confusions and contradictions in the establishment of an agreed definition of vulnerability cause great difficulties in operationalizing the concept. The fact that a branch of research has so much debate about the meaning of the term can serve as justification for the above assertion.

In this sense, the broader definition of vulnerability as "potential loss" does not articulate what "*loss*" is describing, nor does it answer the following questions posed by Cutter (1996): Who is / are vulnerable?; Vulnerable to that process?; and Which socio-spatial conditions does it depend on?

Supporting those questions, you may notice the multidimensionality of the concept that permeates the various dimensions that make up reality - cultural, social, economic, ecological, technological, environmental and psychological, among others. Cutter (1996) listed 18 definitions of vulnerability, showing this multidimensionality, but also an evolution of the concept over time, as Hogan and Marandola Jr. (2006) express.

The lack of consensus on the definition of vulnerability comes as much from the difficulty in understanding the multidimensionality of reality analyzed for the diversity of epistemological orientations (political ecology, human ecology, physical sciences, spatial analysis, etc.), and, consequently, methodological practices (i.e., the operationalization of the concept).

Also in this sense, there is considerable variation in the choice of the hazards and threats to be analyzed (drought, earthquakes, floods, hunger, violence, etc.), each with specific spatiotemporal dimensions, beyond the choice of the region to be studied – developed or developing countries, to cite one example. Cutter (1996, p. 530) concludes: "*the result is a confused lexicon of meanings and approaches to understanding vulnerability to environmental hazards*." Thus, there will be greater operational evolution of the concept if, in its application, it is able to answer how and why people and places are vulnerable to environmental hazards.

The concept of vulnerability, as well as risk, indicates a situation or a future state. In this case, the definition of Blaikie *et al*. (1994) seems appropriate, since, for the authors, being vulnerable means understanding the features of a person or group in terms of its ability to anticipate, survive, resist and recover from the impact of a threat or natural hazard. The authors consider the concept as a combination of factors that determine the degree to which the lives and livelihoods of people are put at risk from a distinct and identifiable event in nature and / or society.

In this regard, Smith (2001) believes that for the most vulnerable, access to resources (e.g. earning a secure living or the ways to recover from disasters) and information, and the availability of social networks that mobilize support and help in the community, are factors of great significance in dealing with the consequences of disasters.

In addition, factors such as poverty, age, gender, ethnicity, disability, class or social status and caste are characteristics that can indicate whether certain groups in society are more susceptible than others to damage, loss and suffering in the context of different threats.

Indeed, around 25% of the world's population lives in areas that are at risk from natural hazards. Anderson (1995) indicates that most of this is in populous, developing countries, where the vulnerability is formed by poverty, segregation / discrimination and a lack of political representation, which hinder the process of development.

Poverty, occupation of areas subject to natural hazards and / or technology, population concentration in cities, the economic impacts of disasters, deficiencies in infrastructure and services, social characteristics (listed above - gender, age, class, etc..), environmental degradation, corruption, policy decisions, and a lack of social programs also add to this.

In developing countries, these broader issues, when combined, create the conditions for the highest degree of vulnerability. Thus, it can be inferred that the scale of the impact of a disaster is a function of human vulnerability and the physical magnitude of the hazardous event (cf. Smith 2001).

Bogardi (2004) speaks of millions of migrants who go every year to cities, due to unsustainable and declining

rural communities, and adds: "*It is widely expected that in 2025 two-thirds of humanity, thus 5 billion people by then, would live in cities*"(p. 362). For the author, the relentless and unplanned urban sprawl creates its own problems: overburdened municipal services and the occupation of marginal, unsafe lands (slopes and areas prone to flooding, mostly).

Thus, the majority of major urban areas are located in coastal zones, deltas and along rivers. The increased concentration of people in these environments amplifies considerably the number of persons likely to be exposed to the consequences of extreme events such as storms, hurricanes, typhoons and subsequent events, such as earth movements, tsunamis and floods, among others (Bogardi, 2004).

Although the concept of vulnerability is one key to the understanding of human security, there is still considerable uncertainty about the potential of its use as a category of analysis of risks and hazards. There are strong challenges to this, and one of them is the order of scale. While the consequences related to the problems described above are of global scale, the occurrence of extreme events and their overlays in relation to environmental degradation are phenomena of local or regional scale. Therefore, understanding the logical sequence and the stochastic nature of the "*hazards-risk-vulnerability*" chain is of paramount importance, also in accordance with Bogardi (2004).

Operationalizing the concept of vulnerability

While there is, however, a relative consensus regarding the concepts of hazard and risk, there are still some uncertainties about the extent and applicability of the concept of vulnerability. As seen by Cutter (1996), there are a range of multiple definitions for the concept, according to a review conducted in the mid-1990's.

From the year 2000 and onwards, the demand for conceptual consensus persists, and one of the simplest and most comprehensive definitions is reported by Wisner (2002, apud Bogardi 2004, p. 362): "*The likelihood of injury, death, loss, disruption of livelihood or other harm in an extreme event, and / or unusual difficulties in recovering from such effects.*"

In the overall review of disaster reduction initiatives (review of IDNDR), the International Strategy for Disaster Reduction (ISDR) defines vulnerability as "*a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of a community to the impact of hazards*" (ISDR 2002 apud Bogardi ,2004, p. 362).

Likewise, the report on disaster-risk reduction by the UNDP (United Nations Development Program) stressed the social connotations of vulnerability and defines it as "*a human condition or process resulting from physical, social, economic and environmental factors, which determines the likelihood and scale of damage from the impact of a given hazard*" (UNDP 2004 apud Bogardi, 2004, p. 362).

Bohle already exposes the multifaceted nature of vulnerability when he conceives the two angles: an "*external*" (environmental) angle and an "*internal*" (human) angle, covering a wide range of potential damage and consequences, which implies a relatively long period, certainly exceeding the time of occurrence of the damaging event (Bohle, 2002). To Bogardi (2004), Bohle's interpretation strongly relates vulnerability to the notion of resilience (see ISDR 2009), which means, in the case of disasters, the ability to return to a state similar to its condition before the disaster.

Pelling (2003), when dealing with human vulnerability (individual), divides vulnerability to natural hazards into three components: exposure, resistance and resilience (Pelling, 2003 apud Klein *et al.*, 2004). Following the proposal of Blaikie *et al.*, (1994), Pelling describes resilience to natural hazards as the ability of a person to cope with or adapt to the occurrence of a hazardous event.

In Dauphiné (2005), the notion of vulnerability is presented as the second part of the concept of risk (the other category is the concept of hazard, or '*aléa*' in French). In light of the numerous definitions that the concept of vulnerability has, the author groups the sets of definitions into two broad categories, one called analytic and another synthetic. The analytical definition considers vulnerability in a broader sense, as an expression of the level of the foreseeable consequences of a natural phenomenon on the threatened resources, represented by people, their property and the environment in which they live. This approach is taken for analysis, since the vulnerable resources can decompose, for example, in the case of economic goods, when it is possible to calculate the damage to agriculture, industry and services.

After a few decades, however, this definition of vulnerability proved restrictive and opposed to an approach to understanding the vulnerability of societies based on their capacity to respond to potential crises (D'Ercole, 1994). This concept of vulnerability (synthetic) attempts to translate the fragility of a system as a whole and, indirectly, to demonstrate its ability to overcome the crisis caused by a potential hazard. Thus, the more a system is able to recover after a disaster, the less vulnerable it is considered, which leads again to the notions of resistance and resilience.

In estimating the level of operational availability of methods for assessing vulnerabilities to natural hazards, Leone and Vinet (2006) conceived two ways of operationalizing the concept of vulnerability, which are: sectored approaches and global/systematic approaches. In dealing with the sectored approaches (similar to the analytical concept of vulnerability of Dauphiné, 2005), vulnerability can be considered as a concept with endless definitions, but for the purposes of the studies of natural phenomena, it has become what is included below in Table II.

Regarding the global or systemic approach (synthetic, by Dauphiné 2005), there are few authors who describe the difficulties in operationalizing conjunctive approaches, holistics, interrelations, and the multiple disciplines of vulnerability. The failure to establish an overall vulnerability of this science requires researchers of this science to search for means of measurement.

Dauphiné (2005) proposes four ways to unify the measurement of vulnerability: turning all the vulnerabilities into the same unit: e.g., financial losses; to establish an energy accounting of vulnerability: e.g., calories; in terms of turnaround time: e.g. in the case of flooding; and the use of multiple criteria techniques, combining the varied information to produce a single index of evaluation: e.g., cost-benefit analysis. For the establishment of a synthetic vulnerability (global, systemic), one of D'Ercole's (1994) and Dauphiné's (2005) propositions is a tendency to use the system analysis, especially in regard to urban territorial systems (Leone Vinet, 2006).

The work of Chardon (1994) on the vulnerability of the city of Manizales (Colombia) before a set of natural hazards (floods, earthquakes, landslides), is an example of the demand for more global and systemic methodological operationalization, even presenting, at first, sectored studies: the use of indicators classified into two main categories - physical and socioeconomic vulnerability - dealt with the elaboration of a spatial hierarchy of vulnerability and its corresponding mapping.

In this respect, D'Ercole (1994) warns of the difficulty in understanding the vulnerability contained in the plurality of variables that make up urban areas, especially those in developing countries.

"*A classical approach to measuring the vulnerability of potential damage to property and people and its impact on the economic environment, seems to oppose that which considers the vulnerability of societies through their ability to respond to potential crises. This capacity is itself linked to a set of structural factors and quotas that can be analyzed separately, but whose interrelationships are complex. Therefore, any analysis of vulnerability, especially within the urban world, which tends to increase and diversify vulnerabilities, can hardly get rid of a systemic approach*". (D'Ercole 1994, P. 94).

The synthesis of various approaches to vulnerability assessed by D'Ercole (1994) can be seen in fig. 1.

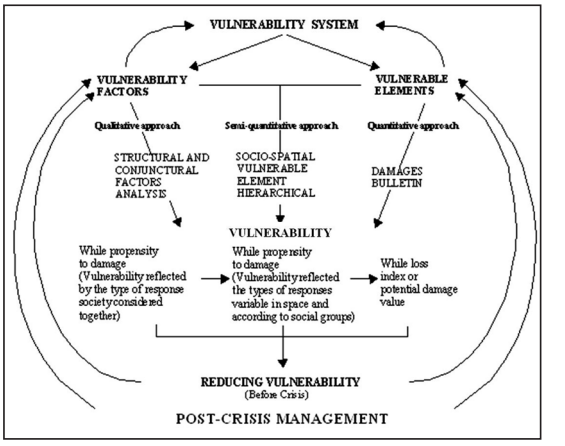

Fig. 1 - Summary of different approaches to vulnerability and relationships. Source: modified from D'Ercole, 1994.

Table II - A selection of the most representative publications on natural hazards from the 1990's.

Type of Vulnerability	Characteristics
Physical vulnerability (structural/body)	Concentrated on the analysis of structures, infrastructure networks and the potential loss of life.
Human or Social vulnerability	Evaluates response capacities, adaptations, and behaviors and their socioeconomic and territorial consequences. It also evaluates the perception of threat or the memory of risk, the knowledge of the means of protection, and the potential behaviors.
Institutional vulnerability	The responsiveness of institutions before a crisis. This acts as an indirect factor of social vulnerability
Environmental and Patrimonial vulnerability	Examines environmental damage: vegetation, soils, water resources, wildlife, and cultural aspects caused by natural phenomena
Functional and Economic vulnerability	Evaluates the dysfunctions in relation to economic activities, breakdowns in communication networks and transportation, among others.

Source: Leone and Vinet, 2006.

There are examples of work that evoke the use of system analysis in the evaluation of vulnerability in urban areas. Leone and Vinet (2006) cite the work of the IRD - Institut de Recherche pour le Développement, in the metropolitan area of Quito (Ecuador), in the context of developing a system of information and risk (mostly volcanic), the vulnerability of urban systems before natural hazards, technological and social studies were the subject of other systems such as the work of Chardon (1994) previously cited.

Leone and Vinet (2006) also address other challenges associated with operationalizing the concept of vulnerability, as regards the choice of the areas studied and their socioeconomic contexts (e.g., developing countries), the spatial scales of analysis (e.g. local scale - urban basin of risk; regional scale - volcano, basin, region), the assessment tools used (e.g., GIS, surveys, mapping), and mobilized and professional disciplines (e.g., architects, geologists, engineers, seismologists, volcanologists, geomorphologists and especially geographers).

As for geographers, the authors emphasize the importance of these professionals for their multidisciplinary training and their view of hazardous phenomena and vulnerable resources, managing spatial approaches and mapping tools, which meant that it perceived a tendency to develop a new sub discipline: The Geography of Natural Hazards.

Measuring vulnerability - challenges and opportunities

One of the most important challenges in operationalizing vulnerability, however, relates to its measurement. After the recent major natural disasters - the tsunami in the Indian Ocean in 2004, and Hurricane Katrina in 2005 - there was a strong exposure of the vulnerabilities of various societies to the impact of natural hazards.

Since then, the development of methods for measuring vulnerability has become a prerequisite for the promotion of risk reduction and preparedness against disasters. During the WCDR - World Conference on Disaster Reduction, held in Kobe, Japan, in 2005, it was noted that the development of indicators to measure vulnerability, risk and its reduction have become major challenges for the future (Bogardi, 2006) ("O*ne of the most important goals of developing tools for measuring vulnerability is to help bridge the gaps between the theoretical concepts of vulnerability and day-to-day decision making. Therefore, it is important to view vulnerability as a process.*" Birkmann, 2007, p. 30).

"*In this context the term 'measuring vulnerability' does not solely encompass quantitative approaches. It also seeks to discuss and develop all types of methods able to translate the abstract concept of vulnerability into practical tools, classifications and comparative judgments to be applied in the field*" (Bogardi, 2006, p. 05).

However, according to Birkmann (2007), in contrast to the significant development of mechanisms for disaster response within the international community, developing a common methodology to identify and measure risks and vulnerabilities to disasters to define forms of risk management / disaster management and priorities has not yet been sufficiently developed. Accordingly, to strengthen the process of measuring risk / vulnerability, we must enhance knowledge of the most vulnerable areas exposed to the risk, and the factors that influence and produce vulnerability / risk (Birkmann, 2007).

In Birkmann's study (2007), the main objective was to conduct a review of four studies that had, among their goals, the measurement of risk and vulnerability, through the use of indicators, applied in various spatial scales. Thus, all approaches considered view that the risk of disaster is the result of exposure to hazards, the frequency and magnitude of the hazards, and vulnerability.

In a report similar to previous research, Birkmann and Wisner (2006) emphasized that case studies showed that the measurement of vulnerability requires different approaches depending on the threat in question (risk), as well as the socioeconomic and cultural context of the analyzed area. The work of Birkmann and Wisner (2006) resulted from discussions held at the WCDR meeting hosted by the Expert Working Group on Measuring Vulnerability from the United Nations University (UNU-EWG). According to the synthesis that was carried out after the presentation of the various methods applied to case studies, there are major emerging themes related to the measurement of vulnerability, such as social, economic, environmental and institutional issues.

Among the studies analyzed, the authors highlighted the work of Birkmann and his colleagues on the production of a model of '*fast*' application and multidimensional analysis of the vulnerability of Sri Lanka to the occurrence of tsunamis in the Indian Ocean. The research was based on the conceptual BBC model (BBC framework - fig. 2; see Birkmann and Wisner, 2006) and used four methods to identify and measure vulnerabilities, response capabilities and appropriate tools of intervention.

Also in the international context, we highlight the work of Baettig *et al.* (2007) whose aim was to develop an index that is a measure for projected climate change (Climate Change Index - CCI); even in relation to the consequences of global climate change, the IPCC produced in 2012 the Special Report of Working Groups

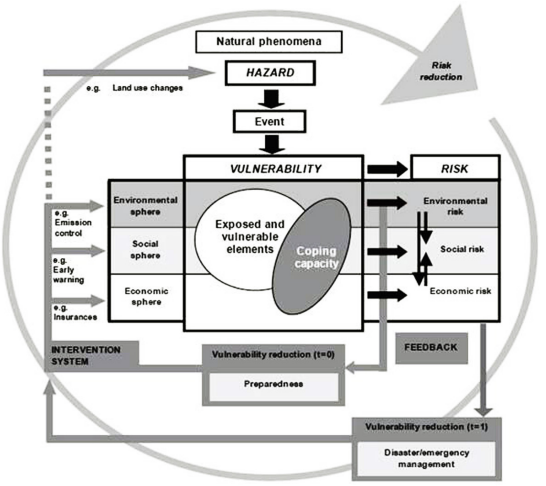

Fig. 2 - Conceptual model of vulnerability (BBC conceptual framework), by Bogardi and Birkmann, 2004, and Cardona 1999/2001. (Source: extracted from Birkmann and Wisner, 2006).

I and II, which dealt about managing the risks of extreme events and disasters in the sense to advance to climate change adaptation; also in a global context, the WorldRiskReport (UNU-EHS, 2011) consists of an index, a main topic and case studies. The index describes the disaster risk for various countries and regions. The main focus of the report is on exposure to natural hazards and climate change, as well as social vulnerability. The index consists of indicators in four components: exposure to natural hazards such as earthquakes, storms, floods, droughts and sea level rise; susceptibility as a function of public infrastructure, housing conditions, nutrition and the general economic framework; coping capacities as a function of governance, disaster preparedness and early warning, medical services, social and economic security; and adaptive capacities to future natural events and climate change.

In Brazil, an increasing number of studies are dealing with the spatial hierarchy and the development of vulnerability indices, and to evaluate the social and environmental inequalities and reduce the risks linked to natural and technological events. Cited is an example of the State Social Vulnerability Index, developed by SEADE (State Foundation for Data Analysis) from the State of São Paulo (SEADE, 2008). Recently, concern about climate change led to the production of reports and researches in order to map and measure the vulnerability of social groups most at risk. Thus, we highlight the work of Torres *et al.* (2012) that is on developing a Regional Climate Change Index (RCCI), which can synthesize a large number of climate model projections, and used for the climate analysis, and the Socio-Climatic Vulnerability Index (SCVI) is proposed to aggregate local population vulnerabilities to the climate change information; finally, the report of Nobre and Young (2011) is an interdisciplinary study to identify vulnerabilities in the Metropolitan Region of São Paulo (MRSP), identifying impacts of climate change on the incidence of natural disasters and health, with the backdrop of the continued urban expansion in this vast region.

Almeida (2010) has already developed, in a doctoral thesis, a methodology for measuring social and environmental vulnerabilities of urban rivers in Brazil, which was applied to the Maranguapinho river basin, located in the metropolitan area of Fortaleza, Ceará, in northeastern Brazil. The survey results indicate that there is a tendency of coincidence between the areas most exposed to hazardous natural processes - floods in this specific case - and the areas occupied by the vulnerable population.

The integration or overlay maps produced with retaining the Social Vulnerability Index - SVI and the Physical Exposure to Floods Index – PEFI (fig. 3), allowed the identification and location of spaces where there is coincidence of risks and social and environmental vulnerabilities, resulting in the final product, the Socio-environmental Vulnerability Index– SEVI of the Maranguapinho river basin, represented graphically by the thematic map of socio-environmental vulnerability. Initially a map legend and the respective groups of Socio-environmental vulnerability were defined through the intersection of groups of vulnerability indices produced (fig. 4). It was proposed the crossover between the groups of vulnerability (social and physical) supported in their proportionality, ie, groups with similar hierarchies (eg, high social vulnerability/high physical vulnerability).

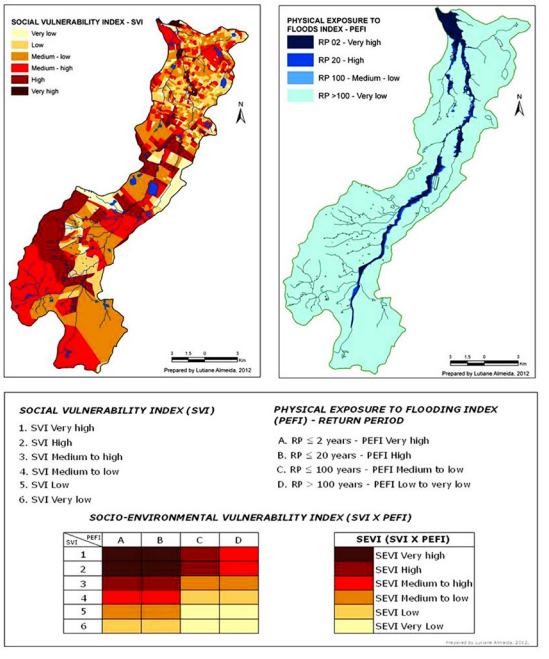

Fig. 3 - SVI and PEFI Maps of Maranguapinho river basin, and methodology for the preparation to the map of Socio-environmentalVulnerability - SEVI.
Source: prepared by Almeida, 2010.

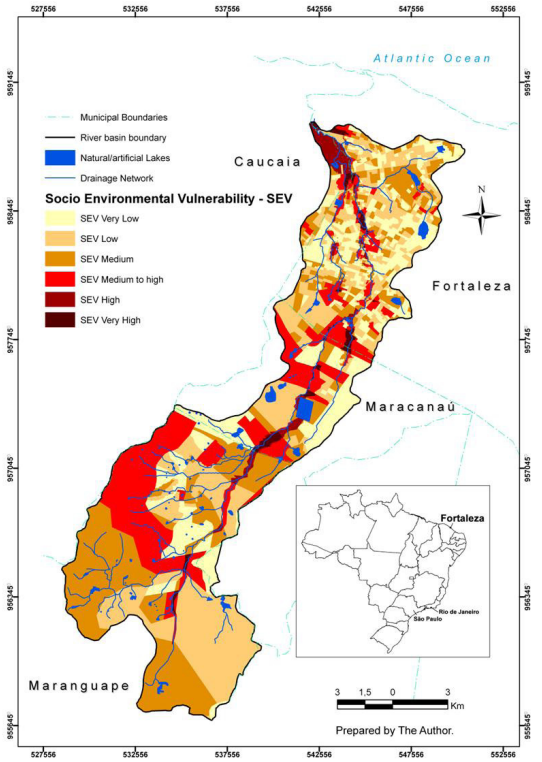

Fig. 4 - - Socio-environmental Vulnerability Index of the Maranguapinho river basin.
(Source: elaborated by the Almeida, 2010).

Final Considerations

Risk and vulnerability are concepts that are becoming "*trendy*". They have been inserted into various government agendas and / or non-governmental organizations around the globe. The International Decade for Natural Disaster Reduction (IDNDR), in 1990, culminated in the creation of the International Strategy for Disaster Reduction (ISDR), and more recently, the 4th Report of the Intergovernmental Panel on Climate Change (IPCC).

In Brazil, the concepts of risk and vulnerability still require further discussion and inclusion in the theoretical and methodological scope of Geography. In this case, it is time to think of a science of risks and vulnerabilities in Geography, creating mechanisms for the dissemination of the main theoretical proposals that lead these key concepts, notably in the English language, given the shortage that is outlined in Portuguese, in comparison to material on the subject in English, French and Spanish.

It is also urgent to think about the challenge in the operationalization of the concept of vulnerability. This difficult task can be used to identify priority areas for investment that can improve the resilience of communities that seem more prone to natural hazards because of social vulnerability. Thus, the use of this concept and its implementation can contribute to decisions that enable the reduction of risks from natural disasters.

Despite the issues of definition, understanding and operationalization, due to the complexity and multidimensionality of this subject, we can guarantee that the concept of vulnerability can help identify the socio-spatial characteristics of certain communities (and individuals) and influence their capacity for response and recovery before natural hazards.

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