Vulnerability to Natural Hazards in Population-Environment Studies

Background paper to the
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"Every year, more than 200 million people are affected by droughts, floods, cyclones, earthquakes, wildland fires, and other hazards. Increased population densities, environmental degradation, and global warming adding to poverty make the impacts of natural hazards worse."

United Nations, International Strategy for Disaster Reduction,
Hyogo Framework for Action 2005-2015.

Natural Hazards and Global Environmental Change

Risks and natural hazards have always intervened in the population-environment (P-E) relationship. Given that the risk of hazards has always influenced to some degree the settlement patterns of human populations (Hogan and Marandola Jr. 2005), they are part of the mediation between people and their environment. A specific population perspective on natural hazards, however, has been slow to evolve. This background paper to PERN's Population and Natural Hazards Cyberseminar will argue that such a perspective is needed, especially in the context of the shift of natural hazards research from its technical/operational focus to a more interdisciplinary endeavor. The paper will also suggest that the concept of **vulnerability** opens the door for a more explicit demographic contribution.

Vulnerability Science has evolved considerably in recent years, spurred by both theoretical and methodological advances and the new issues created by the interweaving of natural, technological and social hazards in contemporary society. As human interventions in physical space produced more complex socio-spatial relations, risks were transformed from localized events into phenomena whose roots are to be found in the very essence of contemporary life, in what sociologists have called **risk society** (Beck 1992). The multidimensionality of contemporary hazards has made such **hybrid hazards** (with natural, technological and social causalities) a challenge for today's hazards researchers (Jones 1993).

[1] http://www.populationenvironmentresearch.org/seminars.jsp

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The principal catalyst of these efforts was the environmental question, which focused both public concerns and theoretical efforts on the investigation and understanding of these events in an integrated and complex manner. Natural hazards, traditionally studied as earthquakes, droughts, floods or intense rains (White 1974), took on a new dimension to the extent that they came to be considered as inserted in societal dynamics and in the more encompassing perspective of environment. Natural hazards became environmental hazards (Smith 1992).

In the ensuing process, several disciplines have turned their attention to the issue; scientists, governments and NGOs have all been active participants; and the conceptual focus shifts among disciplines and participants. The result is a theoretical universe in which uniformity of usage is rare. In **Box 1** in the following section, we offer a simple scheme, drawn from current literature, though not yet fully laid out by participants in this debate.

Over the last two decades, much has been done to overcome the pragmatic focus which limited studies to isolated events, an inherent obstacle to establishing transcalar connections. Since the 1990s, declared by the United Nations as the "International Decade for Natural Disaster Reduction" (UN/ISDR 2005), studies have gone beyond the technical and natural causal dimensions of events, now also emphasizing response and capacity for absorption and adaptation of population and places in the face of such events. In this context **vulnerability** has emerged as a key concept, revealing the other side of the event – the conditions and the resources available for response. Hazards came to be studied not only in terms of risk factors and damage (human and material consequences), but above all in their relational, circumstantial and spatial dimension: each place, society and individual, exposed to the same hazards, may be affected differently (Marandola Jr. and Hogan 2006).

The IPCC Fourth Assessment Report, especially the first part, "The Physical Science Basis," released in the beginning of this year, all but eliminated any possibility of doubt about the reality of climate change (IPCC, 2007:5). The unambiguous conclusion regarding the increasing frequency and intensity of extreme weather events related to temperature extremes, wind, and rain[2] both reinforces the importance of the phenomena we are discussing and changes the context of public policy and public opinion. Unprecedented media coverage, accompanied by greater governmental priority, has also affected the academic community. Many scientists, including social scientists for whom climate change was a remote concern, now recognize that the issue has serious consequences which require the engagement of disciplines not generally present in climate research. From a specialized area of Geography, natural hazards research has assumed an important position on multiple research agendas. This circumstance will require not only empirical work, with better data bases, but serious conceptual work. This work is underway in Geography and in Global Environmental Change (GEC) science, but has yet to make its way into many disciplines.

In terms of their spatial distribution, natural hazards affect socioeconomic groups differentially. Some are widespread and affect all groups (snowstorms, earthquakes,

[2] The report states "There is observational evidence for an increase of intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures" (IPCC, 2007:8).

droughts and storms), whereas others occur in areas in which the primary population group exposed tends to be poorer because residence in these hazard-prone areas is tied to privation and poverty (floods and landslides). With increasing frequency and intensity, these events are likely to affect growing numbers of persons, requiring societal – no longer merely sectoral – interventions.

In such a scenario, we must go beyond the identification of areas with greater or lesser risk. It is necessary to deepen our knowledge of both the possible modifications of the environment (especially climate) and of the elements which intervene in the vulnerability of persons, places and countries. Events of the last few years, such as the North Atlantic hurricane season and the Asian tsunami, clearly showed that preparation and response capacity are central elements in the effort to avoid large-scale natural hazards turning into disasters, with great human and material loss. Knowing when and where events may occur proved to be insufficient to limit the size of the disaster of Hurricane Katrina, for example. (Cutter and Emrich 2004; Cutter et al 2006)

These two disasters are textbook cases of the social inequities of natural hazards and clearly demonstrate our limited understanding of the vulnerability dimension. Not only are poor, developing countries, with weak institutional mechanisms for predicting and responding to natural hazards more vulnerable, but poorer, unprotected social segments of rich countries, in spite of sophisticated prediction technology and elaborate civil defense systems, are also vulnerable. Institutional, political, economic, cultural and geographical factors all contribute to vulnerability, with distinct differences among persons and places.

While a more encompassing understanding of the relations between the components and dimensions of vulnerability is necessary, it is just as important to continue efforts to understand the specific causal nexus in specific places, because it is in specific places that the different dimensions of vulnerability materialize, giving us clues as to the nature of such interactions. The hazards-of-place approach (Cutter 1996; Cutter et al 2003) permits the observation of hazards at this scale, allowing us to make the transcalar connection, starting from the place and moving toward greater understanding in regional and global terms.

Cultural dimensions of hazards are fundamental. While the anthropological approach has a long tradition of studies on hazards and disasters, it has been largely ignored in more recent efforts at understanding vulnerability and extreme natural hazards. Even in GEC science, ethnographic studies have been only minimally incorporated, perhaps because of the implied scale problem (the ethnographic micro scale versus the global macro scale). It would be a mistake, however, to underestimate the importance of local strategies and community-based experience in vulnerability reduction (Delica-Willison and Willison 2004). Strategies and actions at the local scale are meaningful cultural responses which produce lasting and important effects on the capacity of people and places to adapt and respond to risk. The self-reliance of local communities themselves has been responsible for many successful cases of vulnerability reduction, especially in less favorable economic settings (Heijmans 2004). In these cases, the territorial and cultural link may be the catalyst for social strategies which permit significant advances in protection and increased security, even in the absence of significant economic investments or direct state interventions.

Risk perception has also been present in hazards studies since their inception. Most of theses studies, however, are based on a rather limited dimension of perception, focusing on a functionalist approach which does not do justice to the complex cultural and symbolic dimension of individual response to risk. Perception is seen as separate from the life history and personal involvement with the place, which are sources of an individual's world-view. Rational action theory still prevails in these studies, identifying a single way of reacting in the face of disaster or risk. People who refuse to leave their homes in areas of permanent or imminent risk are seen as uninformed or unaware of the risk involved.

It would be more productive for natural hazards studies, however, to pose the question: Why do such people stay and confront danger instead of leaving high risk areas? Is it that they do not fully understand the risk or that they have different strategies for confronting it? Are such people more vulnerable? Should we impose on them a vision of scientific certainty at a time when science itself is forced to recognize its own imprecision and fallibility?

To move in the direction of a conjunctive and multidimensional approach, it is also important to incorporate population dynamics more directly. P-E studies still have far to go in terms of their strictly demographic content. In studies of hazards and vulnerability the population dimension was always present, but very much tied to immediate perception, to response capacity and to adaptation (Hewitt and Burton 1971). Little or nothing appeared in this literature on variables other than population size and the number of victims. The long-term demographic impacts of hazards such as the tsunami, in terms of fertility and dependency ratios, for example remain little more than speculation.

Demographic Dynamics and Vulnerability to Natural Hazards

It is within the vulnerability perspective that demographic factors such as gender, race, family structure, life cycle, migration, mortality, morbidity and fertility may usefully be considered (Wisner et al 2004). This is relatively virgin territory. It became a more significant issue when natural hazards research evolved from the analysis of isolated events, or even series of events (such as annual floods or the North American hurricane season), to include processes prior to the event (those factors which place people in greater risk and compromise their response capacity); and the later consequences of the event. Antecedents and consequences have not been absent from hazards research, but only with the growing seriousness of hazards have the different acts of the drama come to be seen as part of a single story. This partly explains the conceptual fuzziness which characterizes this issue, especially when different disciplines have contributed more to the understanding of one act than of another, often using the same terms to describe different aspects of the process. In the effort to treat not only the moment of the event, but the overall process, it will be helpful to invest in greater conceptual clarity. On the basis of the literature cited below, which is not, however, entirely consensual, we propose the scheme presented in **Box 1.**

In the different moments of this overall process, different demographic factors may play different roles. We suggest that the factors which determine risk and vulnerability are a fruitful place to concentrate research. It is true that many natural hazards may actually be provoked by population density or patterns of population mobility and distribution: soil

degradation and deforestation (factors in causing floods) have been studied in this way. Even earthquakes may be affected by the construction of large reservoirs or pumping waste into the ground and oil and water out of it. But these factors only skim the surface of a truly demographic contribution and, in any case, already receive some attention.

BOX 1
A glossary of natural hazards vocabulary

- ***Hazard*** *is the danger, the event itself;*
- ***Risk*** *is the probability (not always expressed as a mathematical function) that an individual, a household or a community will be exposed to the hazard;*
- ***Vulnerability*** *subsumes those conditions (social, economic, demographic, geographic, etc.) which affect the capacity to respond to exposure;*
- ***Adaptation***, ***resilience*** *and* ***failure*** *are outcomes of these three factors:*
  - ***adaptation*** *is the transformation of one or more system features which permits the reestablishment of equilibrium so that the individual, household or community is able to respond to hazard in the short, medium and long term;*
  - ***resilience*** *is a system's capacity – on the basis of natural conditions or the result of human intervention – to return to an original state (without the need for adaptation), after experiencing a hazard;*
  - ***failure****, seldom recognized as a final outcome, is the incapacity to respond to hazard.*

While most population elements are still only timidly incorporated into analyses, **migration** has been object of much more attention, along with the **spatial distribution** of population. Migration is a response to hazards which produces significant impacts in both places of origin and destination (Ezra 2002; Hunter 2005). Moved by a certain perception of risk, people migrate for protection, creating the new category of environmental refugees. Droughts (in the Sahel and in Brazil's Northeast, for example) represent classic cases of such migration.

Other forms of population mobility are also important in understanding vulnerability. Short distance migration is also a response to natural hazards; people move – when they have the means – out of floodplains and away from steep slopes, to safer places. Commuting may also be a protection strategy, especially in metropolitan areas, with people choosing to live in less polluted areas with less risk, at the price of long daily movements between home and the job (Hogan 1994, 1995; Marandola Jr. 2006). The choice of where to live may be a prior decision for individuals or families, eliminating from the beginning a recourse to migration or other forms of mobility as response to hazard.

We can expect that climate change, provoking greater frequency and intensity of natural hazards, will redesign risk and vulnerability maps, affecting population mobility. Places marginally vulnerable to flooding, for example, may be more exposed to the effects of more intense storms, with consequences for patterns of population distribution at the local scale. While measures to increase resilience will be needed to afford greater protection, it may often be more rational to relocate residences. It is an open question, for example, whether the elaborate water-diversion technology present in the New Orleans disaster, should be reinforced to permit the social and cultural continuity so much desired by many residents. Natural hazards often have disastrous impacts because man has tried to

control nature rather than adapt to it (McPhee 1989). From this perspective, the question is Why not move New Orleans to safer ground? It is clearly possible that a sense of place may develop in situations created by ill-advised technological intervention. The contradictions inherent in such cases are a challenge to science and to public policy.

Besides population distribution issues, how do population dynamics in fact influence response capacity of persons and places in the wake of natural hazards? And which demographic aspects? How might P-E studies, as an interdisciplinary field, contribute more broadly to the understanding of vulnerability, especially in global environmental change scenarios?

The demographic factors for which more reliable evidence is available are mortality and morbidity. While this concern is central for natural hazard studies (the causal arrow here is E→P), they seem unlikely to have major consequences for long-term mortality trends, which will be determined by other factors. Health consequences of natural hazards, though, are likely to increase as the number of people affected by disasters increases (Guha-Sapir et al 2004). The most promising starting point for demographic research, though, may be the P→E relation.

As mentioned above, there is growing attention to the social factors involved in the risk of exposure to hazard, which later compromise the ability to cope with the hazard. It is in this field that population researchers may have important contributions. Both population **characteristics** and **processes** are important to examine. **Age structure**, for example, is important because infants, children and the elderly are often at greater risk, and nearly always have fewer resources to cope with disaster. In an age of rapidly changing age structure, it will be necessary to plan for the numbers of elderly requiring assistance in fleeing storms; in seeking relief from heat waves; and in coping with sudden events like earthquakes or tsunamis. Infants and children, while their share in total population may be declining, have different needs both for diminishing risk and for reacting to natural hazards.

The United Nations' International Strategy for Disaster Reduction (UN/ISDR) has promoted projects in many countries to elaborate alternatives and solutions for the empowerment of local populations, with a view to increasing community resilience.3 A recent publication relates experiences from a gender perspective, with examples of training women and preparing them for disasters, with measures ranging from adapting housing and building materials to learning about the dynamics of the events themselves. Some cases also treat struggles for women's rights, often involving cultural patterns which increase risks and gender vulnerability (UN/ISDR, 2007). While gender issues have received some attention, demographers could make significant contributions with their knowledge of woman's health and the different moments in her life cycle when she may be more exposed to risk and less prepared to cope with disaster.

Studies of **family structure**, and especially the changes seen in contemporary society, have not often incorporated the differential abilities of different structures to withstand and overcome natural hazards. Declining family size and population aging create families with fewer alternatives for support in times of crisis. In the limiting case of

[3] See http://www.unisdr.org/.

the Chinese one-child regime, family structure is streamlined. There are no siblings, aunts, uncles, cousins, brothers- or sisters-in-law to rely on in times of crisis. What does this mean for households' ability to recover from natural hazards?

Urbanization is also an important phenomenon. In 2008, more than half the world's population will live in cities and the next half-century will witness the intensification of urbanization (UNFPA 2007). This is another of the demographic processes which actually creates and magnifies natural hazards (heat islands, channelizing of rivers, paving over of green areas). But such consequences are already the subject of research by geographers and others. What is still missing is an analysis of the profound shifts in vulnerability to natural hazards which are provoked by intra-urban mobility and residential patterns; by household density; by the presence or absence of family ties in times of emergency; by smaller families (no older siblings to help); by single-earner households whose economic resources may limit their ability to respond to disaster. Changes in family structure have been a mainstay of demographic research in the last half-century, but rarely has this wealth of knowledge and understanding been brought to bear in the effort to evaluate the vulnerability of urban women to natural hazards.

The spatial **form** of urbanization must also be considered. Cities are more and more dispersed, increasing their land areas due to real estate speculation (in middle-size and large cities, it is common to find more than half the land unoccupied), without taking into account the nature of P-E relations. What generally prevails is the adjustment of the environment to the city, not the contrary, a process which is at the root of many urban hazards, especially floods. It is important to think in these terms because the later identification of risk areas and the removal of populations from these areas is a complex process which involves ethical, social, technical and financial questions not easily solved. In addition to this, these actions are only palliatives. As long as the current model of urbanization continues to ignore the environmental constraints of each city's site, no solution is possible. While we are busy with one risk area there will be another being created in an endless process. Patterns of urbanization and land use must be reexamined, because urban form is a reflection of processes which reproduce risks in new contexts, amplifying their magnitude and intensity, increasing the numbers of vulnerable places and people.

The P-E Relationship and Spatialized Vulnerabilities

With a few important exceptions, the literature records either anecdotal and unsystematic references to demographic factors, or an emphasis on the **number** of deaths, the **number** of people affected or the economic **cost** imposed by a specific natural hazard. These are the most quantifiable and commonly found data which permit the classification of a disaster as catastrophic. By far the most active players in this endeavor are the governmental and non-governmental agencies which provide emergency support to victims of natural hazards (e.g., UN Office of Coordination for Humanitarian Affairs, the Red Cross, etc.). Associated to these institutions, directly or indirectly, is a growing number of research centers dedicated to the often interdisciplinary understanding of the diverse aspects of natural hazards.

For example, the Center for International Earth Science Information Network (CIESIN) of Columbia University has developed a portal for accessing global data sets– the Gridded *Population of the World* (GPW).[4] GPW allows the overlay of population numbers or density with environmental information at the geographical scale desired by the researcher. Since natural hazards, like most environmental events, do not occur in the spatial and temporal framework found in population censuses, an approach which frees the researcher from pre-established geographic boundaries is an important starting point. CIESIN, working together with the Columbia University Center for Hazards and Risk Research, carried out a preliminary study on natural disaster **hotspots** (World Bank 2005, 2006) which involved an overlay of major hazards distributions and populations at risk to understand the distribution of mortality. In particular, variables such as population density and rural-urban differences were incorporated into the analyses. Similar work was carried out by CIESIN for the Asian tsunami and Hurricane Katrina.[5]

A second major center is the Centre for Research on the Epidemiology of Disasters (CRED), established in Brussels in 1973.[6] This center, while dedicated to health issues, has constructed data series on natural hazards beginning in 1900. Focusing on the last three decades, and in spite of their rigorous criticism of the data available, it was possible to establish a baseline on three central issues (deaths, numbers affected and economic costs) (Guha-Sapir, Hargitt and Hoyois 2004). The central conclusion was that while natural hazards were probably not yet increasing significantly, the number of people vulnerable and affected by disasters is definitely on the rise. The study gives the reader orders of magnitude concerning the extent of natural hazards, which reinforce the urgency of predictions based on climate change research. The absence of population data in this report underscores the paucity of demographic analysis.

Other university programs on natural hazards include the Natural Hazards Center at the University of Colorado and the Hazard and Vulnerability Research Institute at the University of South Carolina, as well as climate-focused research centers that address hazards tangentially, such as the Tyndall Centre for Climate Change Research.[7]

The first decade of the 21st century is ending as it began in terms of the struggle against disasters: in spite of greater scientific knowledge, the implementation of local, national and transnational governmental actions and of community empowerment in the face of natural hazards, these events continue to increase in magnitude and intensity, as does consequent loss of life and property damage. Perhaps the greatest gain in terms of better prospects at decade's end is the urgency which the new consciousness about GEC, especially climate change, has brought to the issue. Time will tell whether this attitude change about man's capacity to alter the planetary environment will be long-lasting and whether it will produce the results we hope for in terms of action. What is certain, at this moment, is that conditions are favorable for thinking about natural hazards and vulnerability in a more wide-ranging perspective, in the direction of an integrated

[4] See http://sedac.ciesin.org/gpw/.
[5] See http://www.ciesin.columbia.edu/tsunami2004.html and http://sedac.ciesin.columbia.edu/katrina2005.html.
[6] See http://www.cred.be/.
[7] See, respectively, http://www.colorado.edu/hazards, http://www.cas.sc.edu/geog/hrl/, and http://www.tyndall.ac.uk/.

understanding of their occurrence, distribution and magnitude, not only in physical terms (the environmental change scenario) but also in their social and demographic dimension (in the context of a risk society).

We must advance further in overcoming sectoral and fragmented knowledge of isolated events. This requires a combination of place- or event-specific studies which expand their analytical frameworks (incorporating demographic dimensions of the phenomena) and more overarching studies which seek to connect disparate findings within a global explanatory framework, integrating scales and at the same time allowing us to navigate in both directions (top-down and bottom-up). Examples of such efforts are those of Cutter on Hurricane Katrina (Cutter and Emrich 2004; Cutter et al. 2006) and of de Sherbinin *et al.* (2007:61), who elaborate a vulnerability framework for the study of Mumbai, Rio de Janeiro and Shanghai "to better understand multiple, synergistic stresses and perturbations on one side of the equation, and multiple, interacting physical and social characteristics of the exposed human-environment system on the other side."

The spatial dimension is strategic in that it allows for the analysis of the different dimensions involved, including hazard, risk and vulnerability (adaptation and resilience) in a framework which reveals the nature of the interaction among such phenomena. The spatial basis permits evaluation of the weight and importance of demographic dynamics and their repercussions on places and on the distribution of risks. The objective should not be a typology, but a matrix which helps in increasing our understanding of natural hazards and their social, cultural and demographic aspects.

More complete and permanent data bases are also required, as are more syntheses of individual studies. Here P-E studies have an important role to play, since they operate at an interface which both gives direct attention to these dimensions and allows for the possibility of moving among scales, from micro to macro. Since the IPCC Fourth Assessment Report introduced the repercussions of climate change for all spheres of social life, the conditions are ripe for joining forces in the direction of a wider, interdisciplinary perspective on vulnerability, in natural hazards research as well as in other areas of social life, beyond the field of natural hazards.

In terms of P-E research, there is still much to explore concerning population dynamics and their relationship to the vulnerability of people and places. Some vulnerable spaces are indeed avoided by socially vulnerable people but not by those with more resources. It would be useful to understand when and why this happens, and P-E research may contribute to elucidate such socio-spatial questions.

Cities will play a specific role in this regard. With population increasingly concentrated in urban spaces, and considering their dense nature and disrespect for the natural site and natural phenomena, cities are among the spaces of greatest vulnerability to natural hazards. Every large metropolis constitutes a hotspot where natural hazards are intensified, also congregating social and technological risks, whether or not they are produced at the urban scale. Cities, therefore, constitute a specific focus for vulnerability science, since they are and will increasingly be the principal spaces of vulnerability.

In a hypothetically perfectly resilient (or sustainable) world, the structures – social, material, environmental – we create would be so harmonious with respect to the natural world and its limits, so parsimonious in the use of resources, and so respectful towards our

fellow beings, that the occurrence of natural hazards would not be the disruptive and destructive force which they are today. This is perhaps the direction we would wish to orient our behavior. As culture-bearing animals, capable of understanding and change, adaptation represents our ability to innovate in the search for response to hazard. Together, **resilience** and **adaptation** constitute complementary strategies for responding to natural hazards.

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