

Too much water in cities: a growing concern for security, and how to understand it.

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Fabien Nathan

Doctoral Student

NCCR-NS/IP8

IUED, Geneva

GMOSS and AFES-PRESS, Mosbach

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Introduction

Cities are increasingly affected by hazards, inducing tremendous damages to human beings in many ways. For many reasons, natural disaster risk is growing worldwide, realizing in so-called « natural disasters ». These constitute a serious threat for cities, which may be destabilized and even destroyed by their impacts. As an increasing number of people are living in cities, security studies and practitioners must take into account these challenging risks in order to spare the world of the enormous and increasing potential for harm and suffering they constitute.

Unfortunately, this has yet to come. Urban disaster studies are extremely scarce, and there is a clear lack of data : disaster statistics do not distinguish the urban and the rural realms. And there is almost no theoretical study specialized on urban water-related disasters other than droughts, although they are clearly some of the most damaging and affecting disasters in the world.

Another difficulty comes from the professional sectorization of the field : hazard/disaster, urban and water professionals do not communicate with each other and even share different « cultures ». As Mitchell advocates, hazards specialists community and urban specialists

« must proceed like 2 well-founded cultures that are coming into contact for the 1st time¹. »

The paper will nevertheless propose a reflexion on water-related urban risks, restricting to the problem of « too much water » in cities (floods, storms, mudflows, etc). It has been chosen deliberately to put aside the « not enough water » side of the problem, being qualitatively very different. It aims at showing and explicating the growing security threat posed by these risks, first by exploring the scope of the problem, and then by proposing a model of explanation of urban vulnerability that will ultimately be applied to water-related risks.

I. Scope of the problem: too much water

A. Types of water-related hazards/disasters considered

Water is an ambivalent element: it gives life and allows its permanency, but it also kills and destroys massively. To be sustainable, life thus needs to find an equilibrium between “not enough” and “too much” water. As far as human beings are concerned, when the structural equilibrium between sociosystems and ecosystems is not guaranteed, disruptions occur under the form of disasters. Urban water-related disasters can therefore be interpreted as the result of a disharmony in the interaction between the urban metabolism and the hydrologic cycle.

We shall now consider hazards that generate a potentially devastating excess of water.

1. Floods

There are three types of floods. Firstly, river overflowing is caused by long periods of rain or snow melting. They generally have different return-periods for different flood intensities which may be predicted. The physical extent of the maximal possible flood, the flood plain, may also be known. Second, flash floods are water flows that constitute rapidly, raise highly very quickly and

¹ Mitchell, J.K. (1999), “Natural Disasters in the Context of Mega-Cities”, p 46, in *Crucibles of hazards: mega-cities and disasters in transition*, UNU Press, pp 15-55.

have a high circulation. They are generally resulting of intense but short-time storms. They are therefore extremely difficult to anticipate. Third, floods can result from storm surges when the sea invades coastal lands. This generally accompany extreme meteorological conditions, such as hurricanes, typhoons, and cyclones.

Floods also can induce other hazards/disasters, such as famine, diseases, water contamination, insect proliferation, and sewage spread.

2. Other coastal water-related hazards

There are other coastal water-related hazards, like the extreme meteorological conditions themselves (storms, cyclones, hurricanes, etc) which generate high precipitations and high winds. They result from climatic processes such as temperature distribution, air circulation, pressure, and the like. They can be exacerbated by the El-Niño / La Niña phenomenon.

Tsunamis are seawater waves generated by geologic processes (such as earthquakes, mass movements, etc) which penetrate into the coastal land with a high destructive force.

Sea-level rise is also threatening coasts, in particular flat low-altitude lands, such as Pacific islands, Bangladesh, Holland, etc. It is facilitating all other types of coastal floods.

3. Mudflows

« A mudflow is a process in which gravel, boulders and rocks, mixed with clay and water, move readily, almost like a liquid, down a slope².» They are generally triggered by volcanic activity, heavy rainfall, landslides, earthquakes, snow and ice melt, breaches of man-made or natural dams, or underground water. When resulting of volcanic activity it is known as *lahar*.

Three pre-requisites are needed for a mudflow to happen : a minimal gradient of slope, a water content, and some potentially mobile material³.

4. Storms

Finally, storms do not only happen in coastal lands. For example, snow- or hailstorms affect many continental lands and can generate huge losses. Cold waves can also be accompanied by water-related hazards, like ice storms, or freezing rain.

Let us consider now the damages and risk generated by urban water-related risks and disasters.

B. Water-related risks and disasters

² DHA (1996), *Mudflows. Experience and Lessons Learned from the Management of Major Disasters*, Prepared in Support of the International Decade For Natural Disaster Reduction, United Nations, New York and Geneva, p 7

³ Ibid., pp 7-8

As highlighted in the introduction, there is no consistent data on urban water-related disasters. That is the reason why we must split the analysis and rely on the one hand on general data about water-related disasters, and on the other about urban disasters.

1. Water-related disasters

According to the World Water Assessment Programme,

« more than 2200 major and minor water-related disasters occurred in the world during the period 1990-2001 »

Of these disasters, 50% were floods, 28% were water-related epidemic, 11% were drought, 9% were landslides and avalanches, and 2% were famines⁴.

The deadliest natural disasters of the 20th century were epidemics, droughts with famine, and floods (in Asia). However, when considering the average number of deaths per disaster, cyclones and floods were coming first.

Among the 234 biggest disasters of the second half of the century, 90% of them are constituted of storms and floods, amounting to about 1.4 million deaths⁵.

Asia is disproportionately affected, concentrating 94% of the victims of natural disasters between 1964 and 1998⁶. Bangladesh, China and India, gather 85% of the affected people in the world, 90% of which because of floods and landslides.

Floods thus account for a high proportion of damages and suffering throughout the world, accounting to 49% of the deaths of natural disasters from 1985 to 1999⁷. In absolute numbers,

« between 1973 and 1997 an average of 66 million people a year suffered flood damage, making flooding the most damaging of all natural disasters.⁸ »

In terms of economic losses also:

« global economic losses to floods alone average US\$3 billion per year, equivalent of 20% of new investment in the water sector in developing countries⁹. »

Moreover, forty-six million people per year in coastal areas are at risk from storm surges and sea-level rise¹⁰.

⁴ UNESCO- WWAP (2003), « Mitigating Risk and Coping with Uncertainty », p 272, in *Water for People, Water for Life*, UNESCO and Berghahn Books, Chapter 11, pp 268-290. In comparison, the IFRC computes 2557 natural disasters between 1991 and 2000, of which 2,292 were hydro-meteorological, of which 888 (34,7%) were floods.

⁵ MunichRe, *Topics 2000*, p 43.

⁶ Michellier, C. (1999), *L'évaluation des risques aux catastrophes naturelles en vue de leur prévention: l'utilité et l'utilisation de EM-DAT à une échelle mondiale et infra-nationale*, mémoire de maîtrise, CRED/Université de Savoie, Septembre 1999.

⁷ Abramovitz (2001), *Unnatural Disasters*, Worldwatch Paper 158, p 11. www.worldwatch.org

⁸ UNESCO-WWAP, *Ibid.*, p 274

⁹ World Water Assessment Programme (2001), *Water security : A Preliminary Assessment of Policy Progress since Rio*, Bonn, p 22

¹⁰ UN/ISDR (2002), *Living with Risk. A global Review of Disaster Reduction Initiatives*, Preliminary version, Geneva, p 57.

These figures highlight the tremendous importance of water-related disasters. It is interesting to know, that about 70% of the sum of all natural disasters are already induced by climatic processes¹¹. But climate change will probably increase this figure, contributing to more extreme precipitation patterns, accelerated sea-level rise, and the like.

The trend followed by these types of disasters is the same as the general trend in disasters: a tremendous increase¹².

It is the same for urban disasters.

2. Urban disasters

Urban disasters have occurred since there are cities in the world. But as half of the population now lives in cities, and as that figure is increasing, the problem is becoming more and more serious.

Examples of big recent water-related disasters include the 1985 Colombian Armero volcanic mudflow (21.800 deaths); the 1988 floods in Rio de Janeiro affecting nearly 20% of the population (and amounting to almost 1 billion \$ damages), the 1988 and 1991 floods in Cotonou, Benin (56% of the houses flooded), the 1991 Ormoc City mudflow, Philippines (5.000 killed), the 1999 Venezuelan mudflows in a densely populated area (20.000 deaths, 2 billion \$), the 2001 Algiers and Bab El Oued floods and mudflows (Algeria, 750 deaths), etc.

These are big disasters usually recorded and well mediatized. But there are plenty of neglected small events that affect many people locally. For example,

« In Sao Paulo, localized environmental degradation was associated with 220 floods and 180 landslides in 1996 alone¹³ »

These small disasters reveal a high risk situation in many third world cities. In Bogota, 60% of the population lives on steep slopes at risk from landslides; in Calcutta, 66% of the population live in squatter settlements exposed to flooding and cyclones ; In Rio de Janeiro,

« 1.6 million people have settled on peripheral hill-slopes, around garbage dumps and in flood-prone lowlands¹⁴ »

In general, the trend of risk and disaster in urban areas is on the rise.

C. Urban disaster : a disruption/crisis

Disasters are now usually defined as follows:

« a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community/society to cope using its own resources¹⁵. »

¹¹ UN/ISDR (2001), *Lutter contre les catastrophes, cibler la vulnérabilité*, Kit d'information, Campagne mondiale 2001 des Nations Unies pour la prévention des catastrophes, p 16.

¹² When encompassing technological disasters, the Em-Dat database reports 1366 events in the 1970s, 2969 in the 1980s, and 4777 in the 1990s. www.cred.be

¹³ Pelling, M. (2003), *The Vulnerability of Cities. Natural Disasters and Social Resilience*, London, Earthscan, p 27.

¹⁴ (Ibid., p 29.

In that sense, urban disasters are disruptions in the patterns of “normal”, daily life, generating a crisis and a societal response to come back to order.

But the evaluation of the normal vs. crisis state is highly social. It depends on the perceptions of the people who can qualify a state of disaster/crisis. For instance, that several million people die out of malaria in the world, or that several thousands people are dying in car accidents in every country and city every year, or in work accidents, or prematurely in slums because of their terrible living conditions, is not considered a disaster. But that the stock market is interrupted (such as the London 1987 stock market, closed after the heavy windstorm, and contributing to the most important financial crash since 1929), or that the electricity supply is ceasing, is considered as such and do generate a crisis.

Disasters are thus also perceptions of disasters. They are a question of measure and proportion: human beings must evaluate that the situation is disastrous; the damages must overtake a certain critical threshold to trigger that evaluation.

It is known that the Bangladeshi people have adapted to recurrent floods, considered as beneficial (“barsha”). But the distinction is made with devastating floods, the “bonna”.

In capitalist cities, the threshold consists generally in the loss or damage of a certain proportion of human beings, goods, infrastructures, and services, all critical elements that contribute to social order. In ancient times, the destruction of a temple for instance may have been interpreted as a huge disaster generating a social crisis and disruption.

In terms of security, it is thus easy to understand that multiplying urban water-related disasters constitute a serious challenge.

Now we must consider how to understand and explain these risks and disasters, i.e. construct a model of urban vulnerability.

¹⁵ UN/ISDR (2002), *Living with Risk*, op.cit., p 338.

II. How to understand and explain urban water-related risks and disasters?

Risk is an on-going process resulting of the combination of dynamic hazards and changing vulnerability. The difficulty of urban risks comes from these constant changes, which renders the process difficult to grasp for human thought. Disasters, as realized risks, follow these patterns:

« ...urban disasters (...) are not just amalgams of disaster and urbanization ; they are the products of a set of changeable relations between both components¹⁶. »

We have seen some characteristics of the water-related hazards. Let us examine the features and changing nature of cities and their vulnerability.

A. Vulnerability

1. Quick conceptual precisions: the concept of vulnerability

a. *What is it ?*

We have described elsewhere¹⁷ the state of the debates on vulnerability and how to understand it. In short, vulnerability can be described on the one side as being a propension to undergo damages, i.e. a state of fragility: a set of conditions, that raise the **susceptibility** of a community to the impact of a damaging phenomenon. On the other side, vulnerability is a **incapacity** to anticipate, cope with, resist to, adapt to and recover from hazards. Of course, both sides are closely related to each other and are constantly evolving.

Gustavo Wilches-Chaux remarks that “secure” means “free and exempt from any danger, damage or risk”. He infers that vulnerability is a synonymous of insecurity

“in the most profound sense of the term: insecurity for the existence; uncertainty in front of the daily history and in front of the surrounding world¹⁸.”

b. *General features*

Vulnerability can be characterized as a **complex** process encompassing multiples intricate dimensions.

As a process it is **dynamic**, i.e. constantly changing through time. Thouret and d’Ercole interestingly talk about « contingent vulnerability », i.e. conjunctural factors of vulnerability, « temporal and unpredictable, in a given locus and at the moment of the impact¹⁹ ».

¹⁶ Mitchell (1999), op. cit., p 22

¹⁷ Nathan, F (2004, to be published), “Natural Disasters and Human Security”, in R. Matthew, N. Gleditsch, and S. Lonergan with support from L. Fraser (eds), *Global Environmental Change and Human Security*.

¹⁸ Wilches-Chaux, G.(1993), “La vulnerabilidad global” p 23, in Maskrey (eds), *Los desastres no son naturales*, La Red.pp 11-44.

¹⁹ Thouret, J.C. et d’Ercole, R. (1996), « Vulnérabilité aux risques naturels en milieu urbain : effets, facteurs et réponses sociales », p 408, in *Cahiers des sciences humaines*, vol 32, n°2, « Croissance urbaine et risques naturels dans les pays en développement », pp 407-422

It is also often **cumulative**, causing disasters that in turn aggravate it, or adding to vulnerabilities to other risks (such as socio-economical risks, etc.).

Furthermore, vulnerability is both **hazard-related** (vulnerable *to* something) and **subject-related** (*one* is vulnerable, be it an individual, a group, a city, a society, the entire humankind, etc.) Therefore, one has to explicit clearly which vulnerability one is talking about, and at which level of analysis (the individual level, the group level, the societal level).

To complexify the analysis, vulnerability is also highly **differentiated** : different subjects, even at the same « level », have different vulnerabilities. Countries are disproportionately affected by disasters, as well as cities, individuals, etc. Generally, the most miserable and isolated suffer most, as well as the less organized.

Finally, one can conclude that vulnerability is **context-dependant**, be it an individual exposed to natural hazards at the household level, or mankind at a global level.

These « transversal » features of global vulnerability apply to each component of vulnerability.

2. Components of vulnerability to natural hazards

Many classifications have been risked, some more happy than others. We are proposing our own, which is an attempt to summarize and logically classify what emerges from the literature on the subject²⁰:

External: exposure

- **physical exposure**: presence and density of the people, habitat, networks, goods and services in risk zones, defining potential losses or damages, both human and non-human (stakes).
- **socio-ecological**: human-induced ecosystemic perturbations aggravating the natural hazard (deforestation, land degradation, street pavement, some engineering practices, climate change, etc.)

Internal: incapacities to prevent, prepare for, face and cope with hazards and disasters

- **physical weakness**: physical incapacity to resist or recover from a hazard's impact.
- **juridico-legal**: weak state of the legislative and judiciary regulations to prevent, mitigate, prepare for, face and recover from disasters.
- **organizational**: weak state of the organizational disposals, at all levels, to prevent, mitigate, prepare for, face and recover from disasters.
- **technical**: inadequate knowledge and/or use of risk management techniques.
- **political**: weakness of the political powers, their legitimacy and control. Inadequacy of the control schemes, policies and planning, or broad political conditions.
- **socio-economical**: socio-spatial segregation, large inequalities of wealth and of access to the security disposals, misery, anomie and social disorganization, poor social position and social isolation of exposed people, existence of higher social risks undergone by people.

²⁰ It is not remote from the classification proposed by Wilches-Chaux, although a bit more synthetical. Cf. Wilches-Chaux (1993), op. cit.

- **psychological and cultural:** inadequate security paradigm or risk perceptions ; cultural anomie or weakness; attachment to risk zones or risky behavior, non-willingness or incapacity to protect oneself.

The overall vulnerability of an element (or stake in the economic language) to one or several hazards is a mix of these particular vulnerabilities. This classification can allow to analytically guide the investigation on vulnerability, but as all these components are linked, such a list is not useful to take a comprehensive picture of the state of vulnerability of an exposed unit, because one needs to establish relations. Moreover, it does not allow to take into account the genesis and trend of these vulnerability, necessary to propose a causal explanation. Therefore, we need a causal model explaining the risk process, in particular the genesis and trajectory of vulnerability, and linking all these components together, but we won't describe the existing models here²¹. We shall nevertheless try to apply our vulnerability analytical scheme to urban risks, focusing especially on water-related hazards. We shall rely on the latest findings of the related literature. For the reasons just mentioned, overlaps in the explaining factors will occur.

B. Vulnerability to water-related urban hazards

The « **external side** » of vulnerability²² is the most evident and documented. It consists on the one hand in a situation of physical exposure, and on the other in the aggravation of this exposure by the increase in the frequency and severity of hazards (socio-ecological vulnerability).

1. Physical exposure

Physical exposure to hazards in cities can be split in three elements: the urban concentration, the urban growth and the urban morphology.

a. Urban concentration and density of population, activities and goods

Cities are characterized by an impressive concentration of human beings, goods, activities, services and fluxes of all kinds in a relatively small area of land : more than 50 % of the world population in only 1% of the earth's land area²³. In 2000, there were 389 cities of more than 1 million inhabitants, and 16 of more than 10 million²⁴.

In economic terms, the importance of cities is tremendous :

²¹ The most useful are the "Pressure and Release model" (in Blaikie and al (1994), *At Risk. Natural Hazards, People's Vulnerability, and Disasters*, London, Routledge) and the access/livelihoods models (Blaikie and al or Cannon, T., Twigg J. and Rowell J. (2003), *Social vulnerability, sustainable Livelihoods and disasters*, Report to DFID Conflict and Humanitarian Assistance Department (CHAD) and Sustainable Livelihoods Support Office).

²² Bohle, H.G. (2001), « Vulnerability and Criticality : Perspectives from Social Geography », in *IHDP Update, Newsletter of the IHDP*, n°2, pp 1 - 5.

²³ Pelling (2003), op. cit.

²⁴ Source : UNESCO- WWAP, op. cit....

« at least half of Gross Domestic Product (GDP) in most developing countries is being generated in cities. (...) If cities are unable to maintain their productivity, the whole economic fortunes and futures of countries will be at risk.²⁵ »

Mega-cities in particular follow the concentration pattern to its highest extent, consequence of the reordering of the economical fluxes worldwide :

« 19 megacities together make up a global ‘polycentre’ that directs and controls the international entrepreneurial system. 15 of these places account for 70% of all electronic data flows in the contemporary world.²⁶ »

Such a concentration of important human, material and immaterial elements renders cities particularly vulnerable to perturbations of hazards. It is exacerbated by the fact, that most of the cities are situated in hazardous zones, often for historical reasons:

« 86 of the 100 largest cities in developing countries are threatened. Much of the contemporary exposure of cities (...) stems from their founding or expansion under European colonial control²⁷ »

In fact, 4 cities on 5 are situated on coasts, rivers, slopes and mountain hills, or mountainous corridors²⁸, thus prone to floods, mudslides, storms, and the like. This is easy to understand, as hazardous zones usually provide some of the best resources and advantages, like water access, or fertile soils. For that reason they are often highly strategic, politically and economically. Water-related urban risks are thus partly the result of the societal advantages given by hazardous places : fertile riverbeds, flood plains and volcano slopes ; strategic water communication channels and natural resources such as seas and rivers, etc.

This situation of exposition is increasing with urban growth.

b. Urban growth

This is one of the biggest current demographical trends :

« During 1975-2000, 52 million new urban dwellers were added each year, 87 per cent of these in developing countries. In 2000-2015, 65 million are added annually, 93 per cent in developing countries. (...) Around 60 per cent of urban population growth worldwide is due to natural growth, with migration accounting for only 25 per cent of growth in Africa and 34 per cent in Latin America. In Asia migration remains dominant, providing for 64 per cent of city growth²⁹. »

Migration is thus not the main explanation of urban growth any more ; instead, internal demographical dynamics are at stake. But migrants and their children usually live in poor or even miserable conditions which both contributes to increase their vulnerability to hazards and pushes them on the most dangerous places, as we shall see.

Another component of urban exposure to hazards that shapes vulnerability is urban morphology.

²⁵ “Editor’s Overview”, p 3, in Kreimer, A. and Munasinghe, M. (eds.) (1992) , *Environmental Management and Urban Vulnerability*, World Bank Discussion Papers 168, The World Bank, Washington, pp 1-20.

²⁶ Mitchell, op. cit., p 33

²⁷ Pelling, op. cit. pp 22-23

²⁸ Thouret, J.-C. and D’Ercole, R. (1994), « Les phénomènes naturels créateurs de dommages (=menaces) : diagnostic, inventaire et typologie », p 18, in *Revue de géographie alpine*, n°4, tome LXXXI : « Croissance urbaine et risques naturels dans les montagnes des pays en développement ».

²⁹ Pelling, op. cit. p 21.

c. Urban morphology

Cities are singular social constructions; like human beings, there are no identical ones. Each of them has its morphology or form that creates advantages and disadvantages in terms of exposure and possible responses to hazards. These can be for example dense or sprawling, with or without rivers and coasts, structured around one center or several nodes, with paralyzing bottlenecks³⁰, etc. It is evident, that big hausmanian avenues are easier to reach for relief workers than small medieval streets.

Human/urban perturbations of the ecosystems also exacerbate hazards.

2. Socio-ecological vulnerability

a. Cities often exceed the resource base capacities

“natural events become natural disasters because humankind is preoccupied with the goal of economic growth to the exclusion of sensible precautions for human safety. From this perspective, the city represents the maximum human appropriation of Nature³¹.”

A city needs a quantity of energy and matter drawn from its *hinterland* to transform in different processes in order to keep functioning. This quantity can analytically be converted into a quantity of productive land, which has been called the *ecological footprint*. According to Rees, the city of Vancouver (Canada)

« appropriates itself the production of an earth surface that represents 174 times its administrative surface³² ».

As cities are growing, they need to exploit more and more resources from their surroundings :

« Even as they take over lands which surround them (much of which is cultivable), they also require more food, water, and fuel. Thus, they reach farther and farther into the hinterland for their necessities³³ »

Furthermore, urbanization itself pushes people to change their consumption patterns to the increase:

« the very process of urbanization causes people to increase their consumption of basic resources. As people move to cities, they expect access to city services and adopt « modern » lifestyles (...) The average per capita consumption of water in a Western city is from ten to twenty times greater than the average per capita consumption of rural Africa³⁴ »

³⁰ Mitchell (1999), “conclusion”, in *Crucibles of hazards*, op. cit., p 492

³¹ Puentes, S. (1999), “Social vulnerability to disasters in Mexico City: An assessment method”, p 296, in *Crucibles of Hazards*, op. cit., pp 295-334.

³² PNUE (2002), *L’avenir de l’environnement mondial, GEO-3*, De Boeck, Paris et Bruxelles, p 243. Our free translation from the French version.

³³ Mary B. Anderson, “Metropolitan Areas and Disaster Vulnerability: A Consideration for Developing Countries”, p 81, in Kreimer and Munasinghe (1992), op. cit., pp 77-106. The quotation goes on with interesting examples: “For example, Shanghai now uses water for more than 40 km away (...). Forests around urban centers are denuded because of urban fuel requirements. (...) It is estimated that Delhi uses 612 tons of firewood each day (in addition to using kerosene and bottled gas) and much of this wood is from forests as far as 700 km away (...) A city of only 1 million people consumes 9,500 metric tons of fuel ; 625,000 metric tons of water and 2,000 metric tons of food every year (...). » (p 80) « The same city (...) dump over 500,000 metric tons of domestic and industrial waste into the environment yearly. »

³⁴ *Ibid.*, p 80.

Finally, this process of socially-induced ecological degradation creates for the city a situation of dependence and vulnerability even to rural disasters:

“A mega-city is more or less vulnerable according to the degree of its dependence on its hinterland. For example, rural disasters are a potent generator of migrants to urban areas³⁵.”

It also contributes to the perturbation of the ecological cycles, thus aggravating hazards.

b. Perturbations of the water cycle

It is now known, that deforestation, elimination of vegetal cover of slopes, overgrazing and surface covering generate erosion, increased runoff and dam overloading, which cause more flash floods as well as land- and mudslides. Pollution induced by urbanization, in particular inappropriate waste management, increase hazards by contaminating water and congesting drainage systems: in developing countries, 75% of solid wastes are thrown into wild collectors³⁶.

Urbanization thus “affect all phases of the water flux in urban areas³⁷”, aggravating water-related hazards:

« In the quasi-totality of countries, modern development has induced the destruction of forestal coverage, the drainage of natural wetlands zones and the extension of cities in the countryside. These factors and numerous other human interventions have reduced infiltration and increased the speed of the water runoff, which led to more frequent and more important floods³⁸. »

As a result of this ecological degradation and the accompanying increase of hazards, urban disasters tend to multiply :

“[In] Lagos and Manila, filling some swamp and coastal lands for construction resulted in blocking the waters of an extensive river system. As a consequence, large urbanized areas in both cities are now periodically flooded³⁹ »

c. Coastal ecosystemic degradation

Coasts provide natural defenses against storms, and « provide food and shelter to many species”. Sand, “barrier islands, coral reefs, dunes, mangroves, estuaries, tidal marshes and coastal lowland⁴⁰” play a role in the natural regulation of the coastal ecosystems and also protect the coasts against sea invasion. But they are extremely sensible and do not resist to the increasing urbanization of coastal lands. Their destruction is thus an important factor of vulnerability to

³⁵ Mitchell (following Puente), in “Conclusion”, op. cit., p 491.

³⁶ Source: UN-Habitat, 2001 Report.

³⁷ Federovski, S.(1990), "Influencias de la urbanización en un desastre: El caso del área metropolitana de la ciudad de buenos aires", p 33, in IIED America Latina, *Medio ambiente y urbanización*, n°30, Marzo 1990, año 8: "Desastres y vulnerabilidad en América Latina", pp 31-50.

our translation from Spanish.

³⁸ DHA (1997), *Inondations. Personnes menacées - Stratégies de prévention*, Nations Unies, New York et Genève, p 20. Our free translation.

³⁹ Kreimer, A., Munasinghe, M., Preece, M. (1992), « Reducing Environmental Vulnerability and Managing Disasters in Urban Areas », p 29, in Kreimer and Munasinghe, op. cit. pp 21-50.

p 29...

⁴⁰ Parker, R.S. « Vulnerability and Resiliency : Environmental Degradation in Major Metropolitan Areas of Developing Countries », p 115, in Kreimer and Munasinghe, op. cit., pp 107-152.

coastal water-related hazards, contributing both to increased exposure and more frequent and intense hazards.

d. Global ecological changes: climate change and sea-level rise

Finally, another ecological loop can be underlined. Cities are the biggest contributors to global ecological perturbations by releasing polluting substances in the atmosphere. But they are also negatively affected by its outcomes : as climate change will accelerate, more water-related hazards will affect cities, and sea-level rise will become threatening for many of them. Some are even more pessimistic :

“The destruction of many ports and harbors will be difficult to prevent⁴¹.”

Therefore, human-induced global ecological perturbations, mostly urban-generated, contribute to urban vulnerability to natural hazards.

Urban vulnerability to hazards also comprises a more « internal » part, i.e. incapacities to prevent, prepare for, face and cope with hazards and disasters.

3. Physical weakness

Vulnerability is also a component of the non-resistance of the stakes, i.e. the physical incapacity to withstand the shocks induced by hazards impact. People with important physical (such as HIV, malaria, etc.) or mental illnesses, babies and elderly people, malnourished or undernourished people, etc. are less likely to resist to injuries and eventually escape from the impact. The same vulnerability applies to physical structures, such as buildings or houses: degraded or weak structures won't resist to hazards nor protect much from water infiltrations or flooding. In the case of material stakes, the physical weakness is also related to the technical vulnerability.

4. Juridico-legal vulnerability

This vulnerability is generally underestimated or neglected. That is, when legislative and judiciary disposals are not contributing or even impeding all the disaster phases: prevention, mitigation, preparation, and disaster management.

For example, urban protection obligations and codes might exist without any legal disposal for compliance, or they may be inadapted to reality, being too remote from the practices to be applied.

Some legal obligations also may increase vulnerability, especially those regulating land-use practices and prices, encouraging housing speculation:

⁴¹ Parker, op. cit., p 115.

“ If the structure of urban landownership and rent means that the closest they can get to economic opportunities is a hillside slum, people will locate there regardless of the landslide risk⁴²”

This is of course closely linked to political vulnerability.

Another example of a legal measure contributing to urban vulnerability is brought by Saleemul Huq for Dhaka, Bangladesh :

“Many poor residents moved out of Dhaka to settle on adjacent flood-prone territories because the municipal authorities raised city taxes⁴³.”

5. Organizational vulnerability

Organizational vulnerability is the lack or inability of the exposed society to create organizational conditions to manage risks and disasters.

a. Urban pressure too strong to allow planification and organization

The size and rapid growth of the cities constitute pressuring factors that contribute to organizational vulnerability.

Firstly, 37% of the urban population in “developing countries” is employed in the informal sector⁴⁴. Not only is this sector highly vulnerable to the impacts of hazards, being fragile, uncertain and uninsured; but also it is extremely difficult to plan for it and elaborate adequate policies, for lack of knowledge, permanent change and difficulty to apply legal measures to illegal sectors.

Second, Hegel’s law of transformation of quantity into quality is applicable to cities, as complexity appears with size. As Anderson states:

« it may be impossible to develop management systems which are adequate for the scale of the mega-metropolises of tomorrow. There may, quite simply, be an upper limit to human organizational capacities where diseconomies of scale (congestion, density) (...) overwhelm planning and coordination mechanisms⁴⁵. »

But the author remarks quite intelligently, that the same pressures towards concentration, increase and size can first induce positive evolutions and decrease vulnerability, and after a certain point of gigantism raise vulnerability :

“some of the same factors which increase metropolitan vulnerabilities can also reduce risks and mitigate disaster impacts. (...) The difference between being more vulnerable or less vulnerable in metropolitan areas seems to hinge on some kinds of tip-over points where “a lot” becomes “too much”, where the provision of basic services results in over-use and despoiling, where systems developed to support life go out of control and become unmanageable⁴⁶.”

b. Lack or inadequacy of organizations

⁴² Blaikie and al, op. cit., p 10 (quoted from Hardoy and Satterthwaite, 1989)

⁴³ Huq S. (1999), “Environmental Hazards in Dhaka”, p 132, in *Crucibles of Hazards*, op. cit.

⁴⁴ Source: UN HABITAT, 2001 Report.

⁴⁵ Anderson (1992), op. cit., p 82.

⁴⁶ Ibid., p 85.

The gigantism and complexity of the city provokes disorganization, whereas risks and disasters necessitate to be handled, in order to be avoided or reduced. If no specific municipal organization exist, capable of having a holistic view of the city and its surroundings, plan its development and execute related decisions, it is likely that urban growth will be unsustainable and even disastrous.

In Buenos Aires, management is unsustainable in front of the urban socio-natural system:

there is a « decisional lack, given that the hydrological and climatic behavior, as well as the social variables, make that the metropolitan area functions as a whole. (...) What occurs with water behavior in the capital is intimately bound to what occurs in the province and vice-versa⁴⁷. »

c. Lack of cooperation

Even when there are specific organizations, lack of cooperation impedes risk management and adds to urban vulnerability.

- Lack of horizontal cooperation

At the community or household level, there might be a lack of « social capital » or « bridging capital » to lessen vulnerability and prepare for disasters. As Mark Pelling remarks, in the countryside there is often a « moral economy » consisting in mutually supportive relationships of help, services, and exchanges between individuals. It has been shown that such a type of horizontal organization is a great factor of resilience and lessens vulnerability. In cities, this type of interactions are less present, and people tend to be more isolated.

Taking into account this important factor, sociologists have used the notion of « social capital » to describe the amount and quality of relations and interactions an individual disposes and is able to mobilize. The more social capital one has, the less isolated one is. This allows to develop the « adaptative potential » :

« The concept of adaptative potential is used too describe actions that utilize social and political assets to enhance local resilience⁴⁸. »

Horizontal cooperation is also needed between risk management organizations or even within elements of an organization to lessen this type of vulnerability.

- lack of vertical cooperation

As Pelling remarks,

« lack of vertical cooperation between city and national government has been identified as contributing to high losses from flooding⁴⁹. »

Organizational vulnerability to hazards is thus also a function of non-existent or inadequate cooperation between the organizations in charge of risk management, creating overlaps, communication problems, poor disaster management, and the like.

⁴⁷ Federovski, op. cit., p 40. Our translation from Spanish

⁴⁸ Pelling, op. cit., p 67.

⁴⁹ Ibid., p 64

In cities of the Third world, different layers of organizations quite often add and superpose to develop small projects which are totally isolated the ones from the other. As a result, a risk in one place or domain might just be transferred to another place or domain.

6. Technical vulnerability

Technical vulnerability is the use of inappropriate technologies to manage risks and disasters, like housing construction materials and methods, agricultural techniques and materials, etc. Adobe houses, for instance, represent a big proportion of Latin American urban houses, which not only are not resistant to earthquakes, floods or debris slides, but also contribute to destabilizing the slopes, as the material for these autoconstructions is extracted on site, provoking frequent land and mudslides.

For very long, the dominant paradigm in risk management was that engineering techniques, modern materials, and technical development alone were necessary and sufficient to protect against hazards. And indeed, technique sometimes provides amazing results, such as water drainage systems, shelters against storms, GIS, satellite imaging and monitoring, meteorological models and early warning systems, etc. That is the reason why « technology transfer » in vernacular societies is often advocated as the ideal risk management solution.

However, this view is misleading for two main reasons. First, technology is highly social in essence, and cannot be separated from a cultural context and even vision⁵⁰. Technology transfer is often the imposition of a specific cultural arbitrary provoking social change, domination and dependence, which explains the failure of many development projects. This is exemplified by social and technical changes brought by colonization, as in this example for the city of Cuzco, Peru:

« The current weakness of Cusco can be explained, partly, by a socio-cultural, political and technological havoc that accompanied the Spanish conquest. This has translated into the abandon, destruction or burying of Inca constructions, the concentration of the population in the city center (...), agricultural under-exploitation, changes in the landownership regime, due to the appearance of private property and new limits, which have shaken territorial organization. At the technological level, the general introduction of adobe and heavy tile roofing would have played a decisive role in future city vulnerability⁵¹»

Second, modern technology, especially in water management, is often inadequate and catastrophic in essence. We know the ecological and human tragedy that big dam construction projects have induced. It is also recognized today, that dikes, river diversion and embankments, and the like perturbate the natural water cycle and create less frequent but more intense floods, and often a false sentiment of security.

Technology transfer is sometimes also just a risk transfer from a social group to another:

⁵⁰ Many researchers have demonstrated it. Alain Gras, for example, have shown that a « technological trajectory » is a cultural choice. The Aztecs had the knowledge of the wheel but did not want to use it for utilitarian purposes. Gras, A. (2003), *Fragilité de la puissance. Se libérer de l'emprise technologique*, Paris, Fayard.

⁵¹ Carreño, R.C. (1994), « Risques naturels et développement urbain dans la ville andine de cusco, Pérou », p 38, in *Revue de Géographie Alpine*, op. cit., pp 27 - 43. Our free translation.

“The introduction of technology can modify and shift patterns of vulnerability to hazards. For some, the Green Revolution varieties of grain have shifted the risk of drought and flood from an emergent class of ‘modern’ farmers to the increasing number of landless and land-poor peasants⁵².”

Indeed, traditional practices and materials are often well-adapted to hazards. Traditional crops and agricultural practices, as well as housing, are often hazard-resistant.

In fact, engineering responses are also political decisions:

« They provide a source of income for vested interests in the construction business, in some cases including political leaders, and in this way contribute to the strengthening of existing power disparities in the city and nationally. India is an example of such collusion, where enormous amounts of money have been spent on river embankments despite their continued failure to prevent flooding⁵³. »

This leads us to another type of vulnerability, the political one.

7. Political vulnerability

Political vulnerability accounts for the inadequacy of the control schemes, policies, or broad political conditions that impede risk management and contribute to raise the vulnerability to hazards for the majority of the urban dwellers. We shall divide it in three main aspects: policies contributing to vulnerability, interest conflicts and political weakness of the most exposed.

a. Policies contributing to vulnerability

At the city level, the market of landownership directly and indirectly determine the area of settlement, the housing opportunities and thus exposure to hazards. Housing policies directed towards private property instead of collective well-being⁵⁴ induce speculation, a raise in the prices of urban land and houses and a segregation by wealth.

Inadequate municipal public policies that raise the probability of urban disasters also comprise those which increase the other types of vulnerabilities, such as the socio-economical one : marginality, misery and disparities, non or bad representation of citizen, social differentiation of status, wealth, power, etc. These are clearly linked with broader political and economical conditions in which the city is embedded, such as the debt and financial crisis and related responses:

« The debt crisis of the 1980s forced governments throughout Latin America, Asia and Africa to slash subsidies on food, light and transportation just when fiscal reform and restructuring of the public sector meant that urban unemployment and inflation were on the increase. These policies were disproportionately felt by the urban poor and middle-classes, whose livelihoods were put at risk⁵⁵ »

⁵² Blaikie et al., op. cit., p 17.

⁵³ Pelling, op. cit., p 49.

⁵⁴ The opposition between the logics of property and the logics of possession is essential to understand the social and ecological world. See “La petite différence et ses grandes conséquences : possession et propriété - Entretien avec Rolf Steppacher », in Nouveaux Cahiers de l’IUED, Genève, 2003 : « Brouillons pour l’avenir : contributions au débat sur les alternatives ».

⁵⁵ Pelling, op. cit., p 30.

This financial pressure translated into political pressure by donors and international monetary organs towards structural adjustments, which led to a social catastrophe, non-planification and *laissez-faire* policies in social fields, increasing vulnerability to hazards:

« Decentralization and privatization decrease opportunities for coherent collective action and often reinforce the uneven distribution of power over resources...The impacts of future climate change on Vietnam, for example, will be experienced by a more atomized social structure that will only exacerbate collective social vulnerability⁵⁶»

In Santiago (Chile), these political and ideological pressures have clearly pushed towards non-action, deregulation and organizational vulnerability :

“For almost ten years, no protective public works were realized, norms and controls were eliminated, and the capacity of intervention of the public sector was eliminated⁵⁷.”

Neoliberal policies are thus highly contributing to the overall vulnerability to hazards in cities.

b. Interest conflicts, especially between rich (economic) and poor (social)

Political vulnerability also consists in hard interest conflicts between groups, especially between the economical and social spheres, (e.g. between rich and poor people and groups) or between economic development and planning groups:

“tension between economic development interest groups and planning interest groups. Both groups are supported by considerable bodies of legislation and policy. (...) Implementation of sound hazard and environmental policies is often subject to strong resistance from elements of the commercial and political worlds⁵⁸.”

Broadly, public policies are the result of the struggle between economical interests, environmental protection and social justice⁵⁹. The main actors in cities of the Third world are “real estate agents and urban developers; the state; and the poor and informal sector⁶⁰.” As the economic sector is currently dominating the cities’ policies, these are now first and foremost made to reproduce private capital and social order, and not disaster mitigation, social welfare, and the like. As a consequence, the most exposed are the weakest politically and least serviced.

c. Political weakness of the most exposed

Misery, marginalization, deprivation of basic public and private services are political issues, rendered possible because of the maintenance of an inequal and highly stratified society, with strong domination patterns, and a political system at the service of the minority of dominants. Political weakness of the most vulnerable people is both a cause of their vulnerability and a consequence : the most dominated are also excluded from the political system. This leads to an extreme political vulnerability of those who are most exposed to hazards (e.g. miserable people

⁵⁶ Pelling, op. cit., p 63. Quoted from Adger (2000), p 756.

⁵⁷ Rodriguez, A. (1990), "Desastres urbanos, fenómenos no-naturales", p 19, in IIED, op. cit, pp 11 – 20. Our free translation from Spanish.

⁵⁸ Handmer, J. (1999), “Natural and anthropological hazards in the Sydney sprawl: Is the city sustainable?”, chapter 6, in *Crucibles of Hazards*, op. cit., p 163.

⁵⁹ Mitchell, “Conclusion”, op. cit., p 499.

⁶⁰ Puentes (1999), op. cit., p 317.

living in slums exposed to floods and mudslides) which adds to their other vulnerabilities and contributes to non-resilience.

This leads to the socio-economical vulnerability.

8. Socio-economical vulnerability

a. Socio-spatial segregation, stratification and polarization within cities

Cities are usually extremely polarized and reproducing social stratification in space. North American Ghettos and southern slums exemplify this pattern, showing extreme disparities in lifestyles. Cities are often functionally organized between rich and overequipped neighborhoods of consumers, and poor underequipped neighborhoods of producers. This dichotomy also often corresponds to other oppositions⁶¹: central/periphery, vertical urbanization (buildings) / horizontal (pavilions). Of course, the wealthiest, most equipped and serviced neighborhoods are generally also those less at risk, and vice versa.

These local socio-spatial patterns of social stratification and segregation are clearly linked with national economical and political trends:

“Vulnerability to hazards in Lima, like poverty, is stratified by race, ethnicity, age gender, and income. Moreover, the pattern of vulnerability in Lima is closely tied to the structure of the nation’s political economy and the role of the city in that structure⁶².”

But why is urban great poverty and misery a problem related to hazards ?

b. Misery, social risks

Because « urban life is more *commodified* than rural life⁶³ ». The vast majority of what is basically necessary for life in urban contexts is acquirable only with money through the market economy, as opposed to the « moral economy » mentioned above. In simple words, one needs money to live in cities, and without money one is condemned to survival strategies that threaten one’s own security and constitute a strong vulnerability to hazards. For the urban miserable,

« the ‘best’ land is not the least expensive, but the one that does not cost anything. Moreover, for [these persons] natural risk is only a very relative notion, given the concurrence of other social risks, much more obsessing⁶⁴. »

At this point, the livelihoods access theories are useful to understand vulnerability and coping strategies of the urban miserable. It seems evident, that people would first seek to ensure the stability of their lives⁶⁵ before being preoccupied by a remote possible natural disaster. And this stability would only be achieved by a permanent source of livelihood. Therefore, non access or

⁶¹ After “Editor’s Overview”, op. cit.

⁶² Oliver-Smith, A. (1999), « Lima, Peru: underdevelopment and vulnerability to hazards in the city of the kings”, p 269 , in Mitchell,J.K., *Crucibles of hazards: mega-cities and disasters in transition*, UNU Press.

⁶³ Pelling, op. cit., p 56.

⁶⁴ D’Ercole, R. (1996), « La catastrophe et son impact à moyen terme : l’exemple de Popayan (Colombie), dix ans après le séisme du 31 mars 1983 », in *Cahiers des sciences humaines*, vol 32, n°2, pp 445-470.

⁶⁵ This is the essence of the « human security » concept. See Alkire (2002), *Conceptual framework for Human Security*, Human Security Commission, 16 February 2002.

difficult access to livelihoods⁶⁶ induced by misery and social risks (unemployment, insecurity, isolation...) is a very important factor of vulnerability.

It is also linked with psychological and cultural vulnerability.

9. Psychological and cultural vulnerability

a. Risk perception of the exposed people is bound to coping strategies

Risk perception is also an important factor of vulnerability or capacity. Historical and cultural factors, risk culture and memory⁶⁷ (which fades with time), attitudes towards death, techniques, prioritization of risks, and the like orient risk perceptions and practices and determine coping strategies:

“While outsiders might label two households as equally vulnerable - because they live in apparent similar conditions - the two households might still perceive risk differently and, as a consequence, prefer different risk reduction measures.⁶⁸”

Risk perception is difficult to explain, but we shall make the hypothesis for the individual level: it depends on psychological factors induced by socio-professional position and trajectory, expectations (adapted to objective possibilities), cultural belonging, gender⁶⁹, and past experience, among other confrontation to disasters.

Acceptable and unacceptable risk is part of this perception and dependant on many variables, among other cultural tolerance towards death and pain⁷⁰. The difference between “developing” and “developed” countries and cities is striking: in the former, the threshold is very high, whereas in the latter, it is almost non existent, inducing securitarian policies towards “zero risk”.

Cultural change thus can induce higher or lower vulnerability.

b. Cultural change inducing higher vulnerability

We have seen that technical vulnerability is sometimes induced by cultural change brought by development. In vernacular societies human settlements were often well-adapted to their environment, whereas colonization destroyed the prevailing risk culture, inducing high urban vulnerability. As an example, pre-Colombian disaster prevention and mitigation (selection of settlement, urban design, building materials) was well adapted in Peru. But

⁶⁶ See note 21.

⁶⁷ Cf. Favier, R. et Granet-Abisset, A-M. (dir) (2000), *Histoire et mémoire des catastrophes naturelles*, Grenoble, MSH-Alpes, déc. 2000, 281 p.

⁶⁸ Heijmans, a. (2001), *vulnerability : a matter of perception*, Benfield Greig Hazard Research Centre, University college of London, working paper, november 2001, p 1. www.benfieldhrc.org

⁶⁹ In Popayan, D'Ercole found out that women are more worried than men, and take more precautions.

⁷⁰ See Nathan, F. (2002), *Les catastrophes naturelles : introduction panoramique a leur étude sociologique*, mémoire de D.E.A. sous la direction du Pr. de Montlibert, *Nouvelles Littératures Editions*, Strasbourg 2002, www.nouvelleslitteratures.com

“these features of Peruvian life were altered significantly by the Spanish conquest⁷¹.”

But cultural vulnerability is not only a matter of the past. Today, inappropriate ideas or ideologies still shape urban vulnerability to hazards.

c. Inappropriate ideas/ideology

We have seen the ravages of structural adjustment to urban resilience. These are part of a broader prevailing ideology, (neo)liberalism, which affects every aspects of life, including risk management. Dennis Parker has shown that “contrasting values affecting hazard management in London” are at stake in the management of floods. One paradigm is market-based (liberalism), advocating for individual responsibility, commercial interests, market mechanisms, deregulation, the main role of private sector, and the reject of public sector and municipal government. The other is planning-based, advocating for the role of the public authorities, the public sector, a regulatory approach, with public controls and restrictions. One can easily imagine which one will most contribute to future disasters, given our previous developments.

⁷¹ Oliver-Smith, A. (1999), « Lima, Peru: underdevelopment and vulnerability to hazards in the city of the kings”, p 256, in Mitchell, J.K., *Crucibles of hazards: mega-cities and disasters in transition*, UNU Press.

Conclusion

The paper aimed at showing, that urban water-related risks pose an increasing problem in term of sustainability and security, and help to explain this trend and guide the analysis. To comprehend all their aspects is not an easy task, given the potential, complex, moving and blurred character of risks and vulnerability. The paper attempted to define vulnerability and its dimensions, and apply it theoretically to water-related urban risks. It now needs to be applied practically in field studies. However, this framework is not a complete model of analysis: it slices reality analytically to be able to seize it. All these aspects ought to be present in comprehensive studies, but must be related the ones with each other. For that purpose, sociological models such as the Pressure and Release, and the access models, may be used in a complementary way. The aim of this contribution was to give lust and provide some useful elements to undertake such studies.

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