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**Cities Confronted with Climate Change : How to  
Break the Infernal Loop of their Coevolution to  
Avoid Future Disasters ?**

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**Abstract.** The development of strategies to reduce vulnerability and increase adaptation to global changes has become a major challenge for sustainable urban development, but urban vulnerability and adaptation are not easy concepts to understand. The objective of this study is to review the dialectic relations between vulnerability and adaptation and to show how integrating vulnerability perception into local urban management induces a chain of complex processes. There will be unwanted backwards loops appearing within this chain. This may explain that the willingness of cities to adapt to climate change can, far from the objective pursued to reduce their vulnerability, create on the contrary the conditions of future catastrophic events.

**Keywords:** vulnerability, resilience, adaptation, urban system, systemic approach.

## 1 Introduction

In many areas of the world, climate change (CC) has potentially catastrophic effects on urban systems (Adger, 2001). On one hand, increasing urbanization makes cities more vulnerable to CC: more people may be potentially exposed to the same risk (UN-Habitat, 2008; 2011). And on the other hand, increasing urbanization, as a result of population boom and spatial extension of towns, is contributing to increase the responsibilities of cities in the emissions of greenhouse gases (GHGs). Indeed, if all production and consumption-based emissions that result from lifestyle and purchasing habits are included, urban residents and their associated affluence likely account for more than 80 per cent of the world's GHGs emissions (Satterthwaite, 2008; Hoornweg et al., 2011). Thus, cities themselves are referred to as the main guilty « victims » of the adverse effects of CC (Dodman, 2009; Gill et al., 2007; Grimm et al., 2008). Among these, we find the intensification of climatic hazards like extreme weather events such as heat waves, cold snaps, floods, etc. (Wilson, 2006).

Since the two worldwide phenomena's of CC and urbanization are co-evolving within the global ecosystem, they represent a dual challenge for sustainable development. Each emphasises the global threats that weigh on ecological stability, economic development and social equity. Urban vulnerabilities themselves being highly dependent on the responsiveness of the complex socio-ecological systems to these new threats, cities are therefore expected to be key players in the fight against CC and its impacts through their mitigation and adaptation policies (Sánchez-Rodríguez et al., 2005).

In this context, this paper, which is essentially *theoretical* and *conceptual* in scope, helps identifying the factors that lead to urban vulnerability and those that determine the capacity of cities to respond to climate change. The challenge is to identify a way to curb down the ground trend towards increased coupled urban and climatic problems hoping to avoid the occurrence of future disasters. This challenge calls for an interdisciplinary and systemic approach linking the two concepts of vulnerability and adaptation. It will need to understand the crisis situations climate hazards will be likely to contribute to, while taking into account urban vulnerabilities, urban management and planning. The dual traditional interpretation of the couple vulnerability/adaptation to CC cannot meet this need. As shown in section 2, it is based on mono-disciplinary and linear causality. This traditional approach mainly refers to two contrasting conceptions of urban vulnerability conceived as a “post-adaptation” state or “pre-adaptation” state. This is why we propose to turn to an interdisciplinary and systemic approach in section 3. This alternative representation of the couple vulnerability/adaptation shows that urban vulnerability to climate change, far from being a static state, represents a complex and dynamic process constrained by co-evolution and uncertainty.

## 2 Vulnerability and adaptation to climate change

The responsibilities regarding CC, quantified in terms of use of energy and GHGs emissions raise the problem of the sustainability of urban areas facing the increasing use and potential scarcity of fossil energy sources (Droege, 2002). These responsibilities raise also the issue of mitigation intended to address the human-induced causes of CC in order to reduce the hazards (Sherbinin et al., 2007; Revi, 2008).

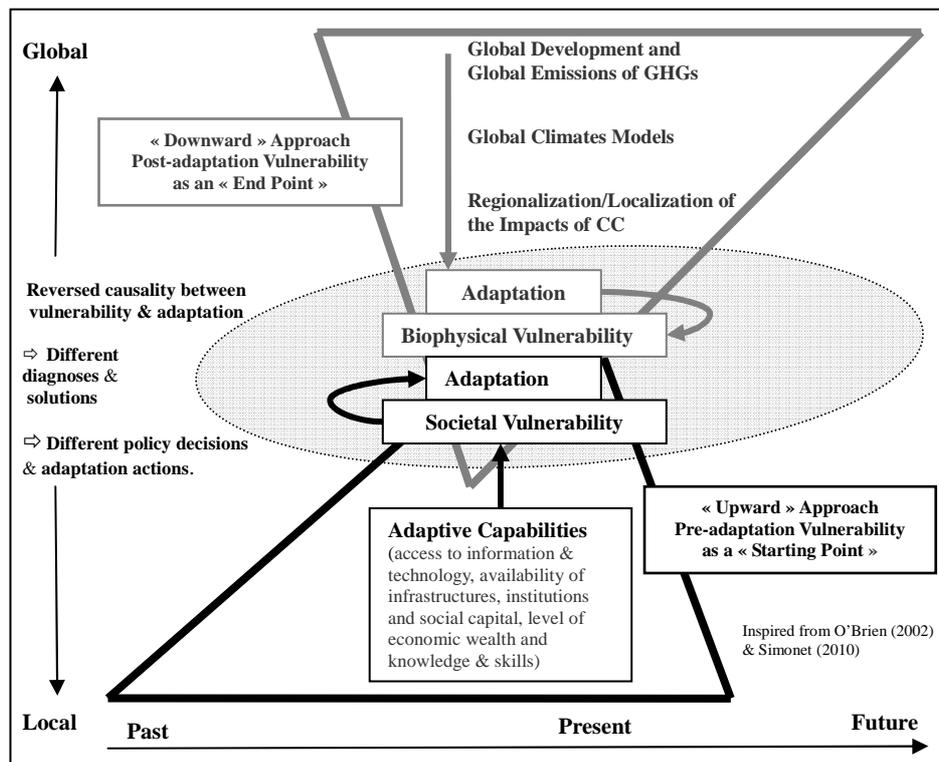
Due to their multidimensional nature, it is difficult to estimate the vulnerabilities (Adger, 2006) of urban systems. Vulnerabilities call into question the sustainability of urban areas facing the occurrences of multiple failures implying social interaction (Beckhoven and Kempen, 2003), economic and environmental inequality (Beckerman, 1992), pressure on resources and environments (Shen et al., 2005). Others urban dynamics are also at stake such as the urban or spatial mix between risk activities and habitat (Schreider et al., 2000; Mcgranahan, 2007; Douglas et al., 2008), the exposure of urban areas either to climatic and potentially dangerous hazards (Nelson et al., 2002) or to urban heat islands (Oke, 1982) and heat waves, etc. These urban features may hinder the improvement of living conditions of the whole population or of the most vulnerable parts of it (Chaline and Dubois-Maury, 1994). These vulnerabilities, which depend as much on the intrinsic characteristics of urban territories as on the multiple dynamics increasing risks, raise the issue of the adaptation. It is intended to act on the consequences of CC by reducing vulnerabilities.

Without neglecting the first couple "responsibility/mitigation" it is the second pair "vulnerability/adaptation" which is our main object of study. The challenge here is how to integrate the dual interpretation of the couple vulnerability/adaptation that coexists within the scientific community (or even inspires politics based on it). Depending on which of the two components of risk the focus is put on (Scarwell et Laganier, 2004; Quenault et al., 2011), namely the hazard or the vulnerability (Adger, 2006), two types of approaches can be distinguished: the first one (focused on hazards) is based on an underlying causal relationship where adaptation determines vulnerability whereas the second one (focused on vulnerability) is based on a reversed linear causality between vulnerability and adaptation (O'Brien, 2002; Simonet, 2010) to CC. These can be schematically represented by inverted pyramids (Quenault et al., 2011) as is shown in figure 1.

### 2.1 The "top-down" vs "bottom-up" interpretation of vulnerability / adaptation couple or vulnerability seen as "starting vs end" point

On the one hand, is the "top-down" interpretation which considers vulnerability as the "*end point*" of a linear relationship, where adaptation

actions implemented in response to the potential climatic hazards and their expected impacts determine the vulnerability of the studied system (grey pyramid, Fig. 1). It reflects traditional "hazard-centered" approaches of climate risk developed in particular by the "climate sciences", which are based on a model starting with the economic and global climate system to go "down" towards a regionalisation/localisation of the effects (when following the vertical axis of the diagram, from global to local scale). Within this first interpretation, (biophysical) vulnerability is conceived as the result of the impacts of CC once the adaptation measures have been implemented. Vulnerability thus reflects the cost of inaction facing the projected proliferation and intensification of meteorological hazards (IPCC, 2007). In this first view, adaptation actions undertaken today determine the extent of future vulnerability mainly addressed in its biophysical dimension (Quenault et al., 2011).



**Fig. 1.** The inverted pyramids or dual interpretation of the couple of vulnerability/adaptation to climate change. Source: Quenault et al. (2011).

On the other hand, there is the ascending - "bottom-up" - approach that considers vulnerability as the "*starting point*" of another underlying linear

causality where vulnerability is the driver of adaptation actions undertaken by the studied system (see black pyramid, fig. 1). This vision reflects the more 'societal' analyses of climate risk, mainly representative of Humanities and Social Sciences (HSS), starting from the local scale and focused on the vulnerabilities of the systems studied (cities, territories, communities, etc.) rather than on climatic hazards. This second interpretation conceives vulnerability as a general, inherent characteristic of a system, created or strengthened by many factors and underlying processes (geographical, socio-economic, political, institutional, cultural ...), which determine the adaptive capabilities of its territory against various threats. In this second view, this vulnerability, seen mainly in its societal dimension, comes from a lack of adaptive capabilities inherited from the past and represents a predisposition of the (urban) system to be affected or damaged by the potential impacts of CC (Kelly and Adger, 2000).

Vulnerability, as a prevailing condition pre-existing the hazard manifestation, therefore determines the adaptation actions to be taken to avoid future disasters (Quenault et al., 2011). A major difference between these two approaches therefore lies in the reverse causation that links vulnerability to adaptation. This reverse causation is reflected not only in problem assessments but also and especially by different types of solutions. In turn, they impact how policy makers consider meeting the climate challenge, given that each of these views neither deals with quite the same vulnerability nor the same adaptation (Quenault and Bertrand, 2010).

In the '*end-point*' interpretation, CC being considered the main problem, the solutions proposed are highly hazard-centered. Therefore, the responses planned depend above all on CC mitigation through GHGs emissions reductions. When "adaptation" actions are also envisaged they have a rather technical or engineer character highly shaped by the specific hazards addressed. In turn they challenge specific sectors or subsystems particularly exposed or sensitive to their impacts.

With regard to the '*starting-point*' interpretation, CC is just a "background factor" (Bertrand, 2010) contributing to the exacerbation of many other problems that threaten the livelihoods and reproduction of urban areas. This type of approach is based on the dual assumption that responding to current vulnerability will allow us to adapt to future climate conditions (Burton et al., 2002) and that the lack of adaptive capabilities is critical to the degree of vulnerability of the system. Therefore, the proposed adaptation solutions focus primarily on reducing vulnerability in its societal dimension (which is more hazard independent than its biophysical dimension in relation to impacts). In order to cope with the multidimensional urban vulnerability, the inherent processes of fragility and segmentation of territories, sources of growing inequalities and marginalization for part of their population, are to be identified and overcome. The purpose is to initiate multi-factorial adaptation

actions aimed at enhancing vulnerable urban systems adaptive capabilities. This improvement should contribute reducing the sensitivity of the effected system, changing its exposure and increasing its resilience (Adger et al., 2005).

## **2.2 The “inverted pyramids” figure learning’s: towards an interdisciplinary and systemic re-reading of the vulnerability / adaptation couple in relation to climate change**

Figure 1 displays at least three benefits attached to the “inverted pyramids” schema whose “heart” is the “ellipse” surrounding the “overlapping area” at the intersection of the two grey and black pyramids.

First, the “ellipse” allows to “visualising” the vulnerability/adaptation couple to climate change, this “poorly investigated” area of academic researches which is as well little operationalized in the field of both urban risk management and urban planning. Therefore, the ellipse represents the “system” which is the central object of this study. Subsequently, the “ellipse” illustrates the need to think about and develop local climate policies, articulating these two complementary approaches, e.g. the “top down” and the “bottom up” interpretations of the vulnerability/adaptation couple. In other words, climate policies of urban systems should be aimed both at attenuating the CC phenomenon itself and at adapting to its impacts by alleviating vulnerabilities. It induces to analyse the cities as socio-ecological systems coevolving with CC. It advocates for a real interdisciplinary perspective crisscrossing the natural and physical sciences as well as the HSS in order to comprehend the vulnerability/adaptation couple as a whole. This co-evolution perspective also invites us to favour a systemic approach of both the vulnerability/adaptation couple and the functioning of the urban system itself. Both are marked by feedback loops. Systemic allows analysing complex and dynamic interrelationships of the various components of urban systems that have strong potential to be drivers of their vulnerabilities to CC.

In addition, the “ellipse” is also “significant” with regard to the delicate question of articulating spatial scales, a recurrent problem of analyses in terms of sustainable development and a key issue for the effectiveness of policies that combat CC. By locating the couple vulnerability/adaptation on the “spatial” vertical axis in the midway between the two extremes, the “ellipse” reminds us that CC is not only a global problem, but also a local one. This phenomenon, rooted territorially from the point of view of its impacts as well as the responses to it, is centred on urban areas by their complex relationships with it. Taking into account the spatial dimension raises questions not only about the “appropriate level” of action, and thus the “relevant territory” for tackling and resolving problems linked to CC, resumed by the term ‘subsidiarity in policy’. The scale issue raised by sustainable development

implementation through CC fighting also calls into question the objectives to be pursued locally. Similarly, positioning the "ellipse" on the intermediate scale levels, insufficiently investigated so far, highlights their importance for the analysis of vulnerabilities of urban systems and local climate policies. Metropolitan areas, which fit the concepts of intermediate scales and urban system as they are apprehended here, are highly dependent for their "proper functioning" on other territories, located in more or less remote areas. In the case of a hazardous event, these urban systems can therefore be the scene of vulnerabilities and dependencies (Guézo et Verrhiest, 2006), systemic in nature, which reach far beyond the borders of the agglomeration and can provoke major disruptions within and outside the urban system itself.

Finally, the "ellipse" is also "illustrative" of the delicate crushing question of structuring temporal scales, equally a recurrent problem of analysis in terms of sustainable development and particularly significant in regard to the climate issue. On the horizontal temporal axis, the "ellipse" covers a broad spectrum (from past to future) to emphasise the need to take into account the long-time which complicates the understanding of problems and decision-making relating to adaptation. This question poses a problem both for the acceptability of political decisions (given the phenomena of uncertainty surrounding the co-evolution of urban systems with CC) and the irresponsibility that the choice of inaction (instead of an early action implied by the precautionary approach) would represent due to phenomena of inertia, irreversibility, and generational interdependence at the heart of urban as well as climatic dynamics.

### **3 Necessity to break off the vicious circle linked to the climate and urban co-evolution to avoid future disasters**

The future climate (change) risks will threaten cities through their effects on both urban vulnerabilities and resilience. However, these two urban features are not only hazard-dependent, they also highly depend on the evolution of the local context itself and on the response measures envisaged to address the climate risks (as far as these risks are seen and interpreted as priorities for action). The adoption of an interdisciplinary and systemic approach appears to be an appropriate way to apprehend this co-evolution process for at least two reasons. First, this type of approach deals well with complexity and uncertainty that are both surrounding our object of study. Together, complexity and uncertainty represent a huge challenge for local politic decisions (and their acceptance) to fight climate change and its impacts. Given this context, what is at stake for local decision-makers is to be able to put into place "no regret" strategies (that is to say responses that target reducing future damages in relation with CC and other issues in order to increase the

acceptance level of these policies). Secondly, this type of approach, centered on interdependencies and feedback loops, also appears highly capable of improving urban resilience in the right way. This implies a better articulation of local adaptation and mitigation strategies and, more importantly, their integration within sustainable urban development policies. As a matter of fact, to break off the trend towards increased co-evolutions between urbanization and climate that prepares tomorrow's disasters, the challenge for local decision-makers is, within the framework of sustainable urban development policies, to increase certain aspects of the urban resilience. It would need improving its adaptive capabilities (Kelly et Adger, 2000).

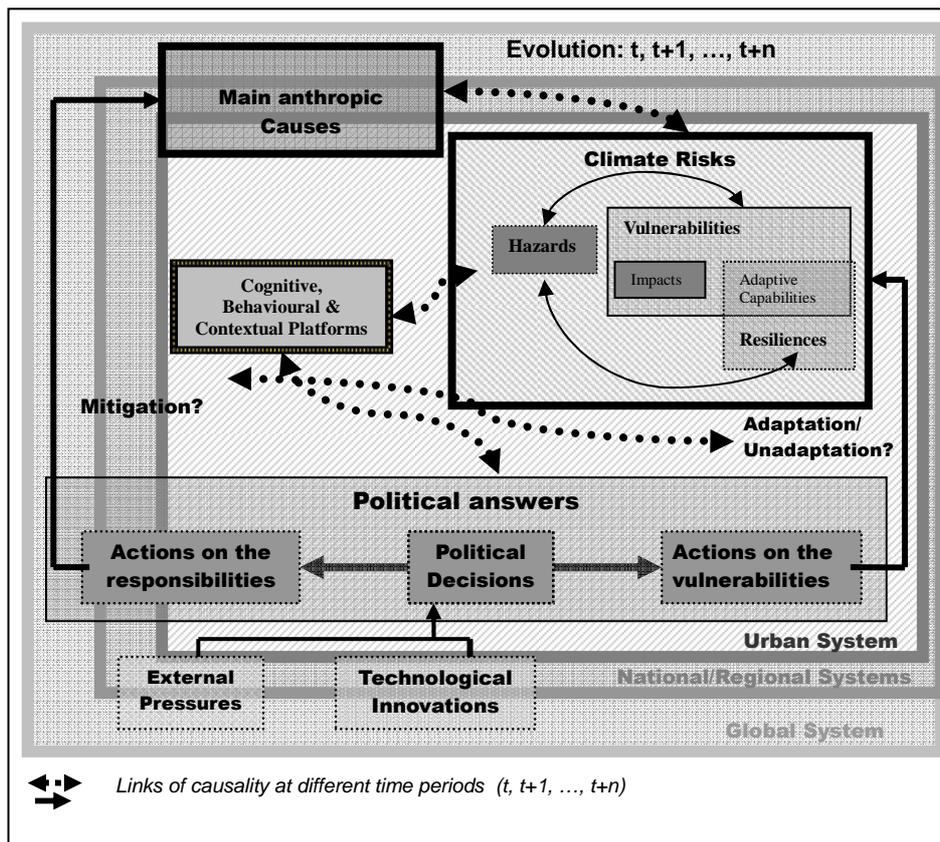
### **3.1 The coevolution of the urban system with climate risks**

Analyzing the urban system as confronted with climate risks, is less about looking at each of its parts individually and more about carefully examining how these parts interact, in dynamic and complex ways. These dynamic and complex interactions relate directly to our main question that is to appreciate if the urban system, through its evolution and decision processes, is prone to adapt (or not) facing this new climate risk. It is by focusing on complementary or competitive relationships between the various components that we can apprehend the capability of a city to "absorb" or prepare for a perturbation (here due to either climate variability or CC). It refers respectively to its reactive and proactive resilience.

One advantage of using the concept of "urban system" to analyze the vulnerability or the resilience of a city to CC is that it allows us to enlarge the view on spatial as well as temporal levels. As regard the spatial scale, the concept of system supposes to consider the cities not only as a systems as a whole composed of various interrelated sub-systems, but also as a part or subsystem of higher systems where they are included and whose they are linked to by many interdependencies (Gunderson et Holling, 2002). As regard the temporal scale, the concept of system implies to consider longer time horizon to grasp dynamic processes linking urban system with CC. Another advantage of the systemic approach, which implies the existence of interactions between several parameters, is to identify underlying trends, co-evolutions and feedback loops, which are generators of uncertainty (Pigeon, 2010). And it is only through analyzing the above that we will be able to better understand the issue, which currently is surrounded by great uncertainty, given that both cities and CC are constantly evolving, on local and global scales (Quenault et al., 2011).

Spatially, at first, the urban system is considered as caught in an array of interdependencies beyond its borders which leads to "exiting from" the area subject to the hazard in the narrow sense. As a matter of fact, some elements are likely to affect urban vulnerability and local responses impact larger scales

such as the territories and networks cities belong to. The principles of a systemic analysis should thus be applied here on spatial and temporal scales not only regarding the functioning of cities themselves, but on all the territorial, economic, political and social networks contexts in which urban systems are involved and have to fit with. That is why we have represented the urban system as being embedded in larger systems that encompass it and with which it interacts and even coevolves (fig. 2). These larger systems are national, regional and local urban systems in which climate risks occur. However, whilst being affected by CC, they also contribute in generating climate risks, (particularly at a local level) through their own characteristics and operations. These larger systems can also generate certain external pressures and innovations (technological, organizational, institutional, etc.) that will influence, or even compel, local political decisions against CC. That is why the box "policy responses" of the urban system spills outside its borders.



**Fig.2.** From anthropic main causes of climate risks towards local political answers linked with identified responsibilities and vulnerabilities. Source: Quenault et al., 2011).

Temporally, subsequently, it would also be appropriate to broaden the scope in order to take the long term into account and consider the fact that relationships characterizing an urban system and its interactions with the climatic system include a number of different temporal cycles. The various elements represented in the urban system (fig. 2) and the arrows that connect them display causation links existing at different periods of time (T, T+1,... T+n) between the multiple components of the diagram/scheme. It allows highlighting the feedback loops characteristic of their co-evolution. The main anthropogenic causes, factors that accentuate present and future climate risks (seen as a combination of hazards and vulnerabilities in co-evolution), having passed through cognitive, behavioral and contextual filters, call for political responses (actions of mitigation and adaptation). In turn the co-evolution of the urban system with its environment is being transformed (Quenault et al., 2011).

This representation of the urban system, illustrative of climate risks and policy responses which developed feedback loops in turn, allows us to reconsider a paradox. It helps understanding how it is possible that we have witnessed for a long time the implementation of devices intended to reduce risk. Yet, they often helped to create or strengthen them (Revet, 2009; Pigeon, 2005). For example, whereas more structural measures against flooding are developed, such as dikes, more the potential for damage increases given the consequences of this increased protection of urban dynamics (building on floodplains). This increased vulnerability then justifies in turn still more structural measures at an official level (Sauri-Pujol et al., 2001).

How to explain this apparent paradox Weichselgartner (2004) put forward, whereby more and more preventive risk management is, however, accompanied by more and more disasters? The paradox is apparently linked to the discrepancy between the official claim of increased protection to hazards and the increase in damage that this promotes; but, indeed, it enables us to understand that policies managing the risks are inevitably imperfect, in that they will necessarily produce unwanted, unexpected effects. The paradox disappears as soon as the recognition occurs that climate risk management and urbanization are co-evolving: preventive management of disasters promotes urbanization which continues to recompose while intensifying, precisely because it is never truly able to eliminate risks given the inherent limitations of the policies supposed to manage them (Pigeon, 2010).

These arguments highlight the trend towards the intensification of partial interactions between several groups of parameters (systems), and on several scales, which may indicate the complexity. A co-evolution can therefore be

identified between the institutional recognition of disasters increased in absolute terms, the intensification of political actions justified by it and the simultaneous intensification of human settlements (the growing urbanization). Furthermore, we can highlight an underlying trend towards positive co-evolution between urbanization and risk management. Urban systems are evolving, while helping to prepare for future disasters that are partially predictable. The intensification of this type of co-evolution, that is the positive trend in the systemic sense, has moreover been demonstrated and formalized at a local level (Pigeon, 2005).

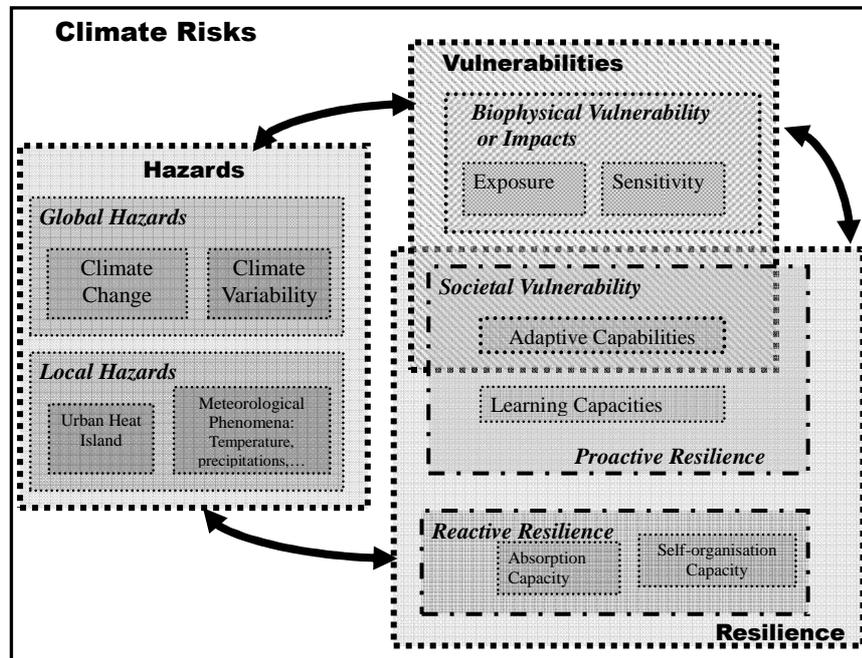
### **3.2 Vulnerability/adaptation couple between circular causality and feedback loops**

The concentration of people in urban centers, under demographic pressure, modifies the land use (soil anthropization) while increasing human impacts related to morphological urban expansion. Worldwide, the urbanization process includes urban sprawl, peri-urbanization, suburbanization, increasing mineralization related to the expansion of hard surfaces, pressures on vegetation and the reduction of green spaces. The use of energy is growing (through transport, heating, air conditioning, lighting, etc.) that contributes to higher global GHGs emissions (Dodman, 2009) and favors an increase of local temperature named urban heat island (Oke, 1987). The study conducted on the Los Angeles Basin by Akbari et al. (2001) shows that every degree increase in temperature adds about 500 megawatts to the air conditioning load. These urban developments, in addition to the social pressures they induce, have resulted in an increase in climate risks (Han et Yan, 1999; McGranahan, 2007). Combination of planetary (CC and climate variability) and local hazards (urban heat island and other weather hazards) favors them. But vulnerabilities and disaster risk reduction policies co-evolve with the hazards (fig. 3).

Urban vulnerability refers not only to the fact that the city can be more or less exposed to climatic hazards, but also to the fact that it can generate and amplify them or give them special characteristics. This is due to its own developments that interact with CC to exacerbate risks and enhance current and future urban vulnerabilities. The idea of vulnerability suggests upsurges of crises or disturbances linked to climatic impacts, the existence of practices, policies and/or inappropriate decisions. As a result, they intensify or even create the problem (Bertrand et Rocher, 2007) by increasing either the exposure or sensitivity to it or both that point out the problem of maladaptation (Quenault et al., 2011). Vulnerability also depends on the adaptive capabilities conceived as the potential capacity of the urban system to adapt to hazard before and after its occurrence. That means that adaptive capabilities refers to the ability of the urban system to anticipate and to manage the crisis

and then to resume a normal functioning (Vale et Campanella, 2005). In other words, adaptive capabilities relates to the resilience of the urban system. In principle, vulnerability increases with both exposure to climatic hazards and the sensitivity of the system to their impacts while it decreases as the adaptive capabilities increases. When they occur, hazardous events reveal pre-existing vulnerabilities just as they can create future vulnerabilities by reinforcing the sensitivity of the urban system to adverse effects of future hazards or by overcoming its adaptive capabilities. However, the reality is more complex than this simple linear causality - vulnerability lies at the heart of several feedback loops.

Resilience to future events, recognized here as a partial component of vulnerability (via adaptive capabilities) (fig. 3) can be improved by the impact of the hazard. But in turn, the reduction in vulnerability that may result from this increased resilience may also increase vulnerabilities in other areas with respect to other hazards (Provitolo, 2009). Given its dual nature (proactive *versus* reactive) and the fact that it has little meaning in absolute terms regardless of the type of hazard, resilience does not necessarily increase the effectiveness of policy actions seeking to prevent disasters. Far from a simple linear causality, resilience maintains complex relationships with vulnerability that it does not necessarily reduce (Gunderson et Holling, 2002). It may even contribute to the preparation of future disasters.



**Fig.3.** The three components of climate risks and their complex interactions. Source: (Quenault *et al.*, 2011).

Urban systems themselves contribute to generate or to reinforce climate risk, and this calls for a response from local decision-makers (and even from others stakeholders such as the inhabitants or firms). The elaboration of a local response implies however that these risks have been perceived as such and interpreted as priorities for action through the "filter" of cognitive, behavioral and contextual platforms. Because, prior to taking the decision and action intended to fight against CC and its impacts, cities must have proceeded to identify their vulnerabilities and the characterization of potential effects of CC at their level to elaborate an appropriate cognitive base and eventually adjust their behavior in return, or simply said to adapt to these risks. These aspects relate to both production and circulation of knowledge and the acceptance of expert knowledge. More generally it questions the links between knowledge, attitudes and actions. Indeed, strategies to reduce risks and hazards such as adaptation strategies are iterative processes that include the development and control of information, increased awareness, planning, design and the implementation of learning effects and feedback from past experience. In this regard, real-life experiences may play a role in risk perception, both on individual and institutional levels, and it concerns proactive adaptation (Grothmann *et Patt*, 2005). But these do not necessarily lead to learning in response to risks that may be the object of denial. In addition, learning related to feedback experience shows in itself more limits than one could think. In France, what does exactly mean the feedback from experience if local officials fail to implement the plans for prevention from flood risk and do not prevent constructions in flood zone? In this case, the learning process, far from reducing vulnerability by strengthening local capacity to adapt, emphasizes the preparation for the future disaster (Pigeon, 2009). It also underscores the limits of local management as well as urban planning and raises the question of risk culture.

Once the "filter" of cognitive, behavioral and contextual platforms has been passed through, the steps to be taken by territories to reduce climate risks vary significantly depending on the variables on which they act, the spatial and temporal scales of apprehension of the problem and the levels of the political-administrative system issuing regulations (Rocher *et Bertrand*, 2007). At the city level, the factors that lead to early action for adaptation to CC differ quite significantly since local representations can vary widely including in the face of equivalent climate changes. This is because the local construction of knowledge about CC and its consequences can develop in very different ways and its sharing by all stakeholders is not always automatic. The pertinence of local responses in terms of adaptation will depend mainly on the values associated with the effects and potential impacts of CC. Locally, this

phenomenon can play the role of a factor activating debates and controversies about the future of the territory. There is thus a strong heterogeneity in the reactions and responses in terms of the adaptation policies of the territories in the face of similar climate challenges (Quenault et Bertrand, 2010).

Adaptation to CC refers to the flexibility of the system that allows it to develop its structures and modes of operation as well as its development strategies based on the disturbances that occur. Adaptation to CC challenges the ability of urban systems to integrate new more distant spatial-temporal horizons in the decision making. The challenge is to conceive risk management and urban planning in an integrated manner over long term period and for a large territory. What is also at stake for local decision-makers is their ability to deal with uncertainty and anticipation of new risks in urban planning and management while being able to meet short term needs or to repair damages in a hurry, despite limited resources (Quenault, 2012). Adaptation to CC requires not only developing *preventive policies* against the regular and irreversible transformations of urban living spaces and their climates but also the implementation of *emergency measures* (alert systems and information / communication with the public, plans for disaster relief and emergency evacuation, etc.) against extreme events that may be more frequent and intense. Adaptation policies are even more complex, given the increasing interdependence and systemic character of risks; they cannot be confined to the treatment of a specific event as a crisis can affect the system on a global and multi-faceted scale (Laganier, 2011). Proactive adaptation strategies involve a new "governance by consequences" (Rumpala, 2010). It is linked to the recognition of the political impossibility of eliminating the risks (related to feedback effects of decisions) while aiming to limit the damage at the greatest possible extent in case of disruption in human settlements systems (fig. 3).

Recognizing that using adaptation measures to manage risk management will necessarily cause unwanted effects and that the post-disaster experiences in return show the limits of remedial work such as the use of international emergency aid, must lead to the desire to increase the resilience of local populations in case of a potentially catastrophic event. Reinforcing local management of civil security, developing the risk culture and/or encouraging a more detailed examination of the risks already identified in land development or building structures are the factors that participate in this search for urban resilience (Pigeon, 2010). Preventive management of climate risks, besides introducing technological adaptations, which are certainly necessary, particularly includes a better management of social vulnerability (Barles, 2010). Instead of resisting the events (which refers to reactive resilience), the urban system must accompany and adapt to them not only by physical facilities but also by behavioral adaptations using devices for information, preparation, training and pre-organization of residents and stakeholders in (pro)active social networks. Whereas the potential

catastrophes looming with CC are mainly socioeconomic and socio-political events by nature (as far as they involve societal vulnerability and resilience of urban systems), they can't be avoided and solved through purely technical solutions (Quenault et al., 2011). It is a mistake to focus solely on reducing a hazard or its impact without enhancing the adaptive capabilities of the system; this is a strategy doomed to failure. Consequently, the imposition or implementation of solutions relating to adaptation "from above" can be deemed largely inappropriate. Adaptation can't be shaped in a generic way and simply transposed locally such as mitigation measures. Mitigation, which may be reduced to a huge energy challenge (reduction of energy consumption, improvement of energy efficiency, and development of renewable energies), can mostly rely on technical solutions (construction of energy friendly buildings or development of eco-mobility - what means that behaviors are important too -...) in large part reproducible and replicable (Quenault et Bertrand, 2010).

Adaptation to CC fundamentally questions territorial dynamics, spatial planning and practices of space and resource consumption. Human societies cannot continue without deflecting or reconsidering the urban development patterns facing current and future threats that weigh on urban systems. If the links between land uses, increasing interdependencies, unsustainable urban development trajectories and the evolving vulnerabilities to systemic risks seem increasingly obvious and confirmed by experience, consequences are insufficiently drawn from it. This is due to the fact that despite the political display of the interlinked challenges of sustainable development and the fight against CC, programs for CC adaptation struggle to operate within the definition of territorial development policies and urban planning.

## 4 Conclusion

The experiences of recent disasters (Gaurav et al., 2011) invite a shift in the trajectory that links human societies, especially urban, to the Biosphere. Sustainable development requirements and prospects for CC reinforce the need to take steps to adapt, in order to rethink the organization and management of the cities of tomorrow. All around the world, cities, every day more numerous, have begun to initiate adaptation measures. These "proactive", early experiences, often implemented without regard to national frameworks (Heinrichs et al., 2009), are often implemented in accordance with international networks of cities<sup>1</sup>. Several European cities that are members of these networks (London, Amsterdam, Copenhagen ...) are

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<sup>1</sup> [www.c40cities.org](http://www.c40cities.org); [www.aimf.asso.fr](http://www.aimf.asso.fr); [www.energie-cites.eu](http://www.energie-cites.eu); [www.metropolis.org](http://www.metropolis.org); [www.eurocities.org](http://www.eurocities.org); [www.cities-localgovernments.org](http://www.cities-localgovernments.org); [www.citynet-ap.org](http://www.citynet-ap.org).

piloting adaptation measures, in addition to their involvement in terms of sustainable urban development and CC mitigation programs. Among them, the French cities (i.e. the “Grand Paris” and the ‘Grand Lyon”) are getting further involved in adaptation especially during the review or development of their Territorial Climate and Energy Plans, which until now have been essentially conceived as territorial sustainable development projects based on energy management and reduction of GHGs emissions (Criqui et Lefèvre, 2010). But generally the component "adaptation" is totally absent, and even when it exists it remains embryonic. A kind of "taboo" of adaptation (Pielke et al., 2007) persists linked to a problem of acceptability of the policies that demand it. These policies are all the more difficult to implement since uncertainties are particularly strong and deferred temporality is neither daily palpable. Moreover, CC is not the only nor the major issue that local elected officials, facing multiple problems and limited resources, have to manage (Quenault et al., 2011). In addition, adaptive responses to climate are complex to develop and a lack of collective know-how can exist regarding them. Finally, knowledge of feedback effects between climatic factors and urban Socio-ecological systems is inadequate and fragmented, and public policies often tend to stick to the level of discourse. Such considerations help clarify in part the fact that the motto of CC adaptation is increasingly integrated into the discourse of communities, yet poorly implemented. However, it is hoped that soon every important city without a major adaptation strategy will be perceived as behind the times or being negligent in its responsibilities to protect its citizens, its economy and its quality of life (Penney et Wieditz, 2007). Given the high inertia of urban morphologies, the sustainable city can only be built in the long term by successive, adaptive shifts of its development trajectory making an early commitment in favor of CC adaptation even more necessary and urgent.

This is why contributing to make the models evolve from linear to systemic could contribute to explain why disaster risk reduction policies meet such implementation limitations. And why they are useful in spite of their necessary limitations.

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