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The concept of adaptation : interdisciplinary scope and involvement in climate change

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The concept of adaptation: interdisciplinary scope and involvement in climate change

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Abstract *Adaptation refers to both a process and its outcome, leading to many interpretations and much debate. The origin of this semantic duality is related to the epistemological rupture that occurred during the 19th century when it collided with the emerging Theory of Evolution and established Creationism. The temporal scale of Evolution is an abstract concept that is outside the realm of immediate human perception, which makes the adaptation debate all the more complex. However, adaptation became a central concept in several major social disciplines, such as psychology, anthropology and geography, as well as in many fields of biology. In each discipline, the environment is strongly linked to the concept of adaptation. Environmental sciences are at the intersection of natural and social sciences and have strong interdisciplinary features as does adaptation. Because of the acceleration of global environmental and socio-economic change, there is a growing interest in adaptation in environmental science. Climate change has become one of the major topics concerned by adaptation since this subject became a priority in research and on the political agenda. However, implementation of adaptation to climate change faces barriers, because of its unclear definition, in particular. The objective of this paper is to contribute to a greater understanding of the interdisciplinary nature of the concept of adaptation in climate change through a comprehensive and interdisciplinary review of the literature.*

Keywords: Adaptation, environment, interdisciplinary, concept, climate change.

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1. INTRODUCTION

Confronted with the acceleration and intensification of global environmental and socio-economic changes, which are the source of this problem, research into the adaptation of systems continues to grow (Moran 2000). Adaptation to climate change, an emerging scientific field of study, is the best example of this. Yet, despite efforts to be precise, its expression remains confused and is condemned to be so due to the lack of clarity of its definition, which is still evolving, (Burton, 2002). Participating in the movement for better clarification of adaptation to climate change, this paper proposes a semantic and historical study of the concept of adaptation in the strict sense by a non-exhaustive review of those fields in which it remains the focal point, such as biology, psychology, geography, anthropology and sociology.

1.1 ETYMOLOGY OF ADAPTATION

To adapt comes from the Latin *apere* (to bind, to attach). Its past form, *aptus* (apte), when added to the locution *ad* (to, towards) created the verb *adaptare* (to adjust to, in prevision of) (Rey, 2006). Borrowed from the Latin in the 13th century, *to adapt* appeared in a tangible sense (to apply), then in an abstract sense (to put in accordance with something). Some uses of the verb have disappeared (to adapt against someone). The present use of *to adapt* emerged in the 16th century, along with a few other derived meanings (aptitude, to appropriate or to adhere) (Rey-Debove and Rey, 2007). "Adaptation" derives from the Medieval Latin word *adaptatio*, testified in the 13th century, but generalized in French and then in English in the 16th century to designate the action of adapting, the sense of adjusting. Rhetorically, the term expresses the suitability to a situation (1578), a meaning that was revived in the 19th century to indicate the transformation of a work into a new form. In 1789, "the adjustment between two things" is the only definition that was mentioned (Cormon, 1789). In the 19th century, due to the expansion of biology, adaptation included the idea of modification and finally gained its full semantic dimension through trans-disciplinary appropriation, notably by psychology, and its transposition to sociology (Taché, 2003). The antonym *inadaptation*, which appeared in 1931, also comes from the Latin *inaptus*, giving *inapt* or *inappropriate*. It remains used in psychology, only as *disadaptation* (1894), (loss of adaptation) and *readaptation* (1904).

1.2 CONCEPTUAL HISTORY OF ADAPTATION: FROM THE THEORY OF EVOLUTION TO A TRANSDISCIPLINARY USE

Adaptation takes its conceptual glory from the theory of evolution, a subject that for a long time has been skimmed over and that poses the question "What is life?" (Smit and Wandel, 2006; Lambert and Rezsöhazy, 2004). One of the first writings to suggest the notion of the evolution of life by adaptation to the milieu is attributed to Anaximander (Obenga, 2005). There were a few other references in Empedocles and Democritus. Then, Aristotle dealt with "The influence of climate on animals" and "The influence of the milieu on

the behavior of animals" and defended a teleological vision in which all biological development takes place within a final, pre-established perspective: "The very form that nature imagined for the hand is adapted to the function of seizing and holding" (Labarrière, 2005; Aristotle quoted in Piveteau, 1991). In the early middle-ages, Aristotelian philosophy, rediscovered and translated, was mixed with the precepts of the Catholic Church by Thomas Aquinas. His fixist influence prevented any debate regarding the sciences of life to emerge until the scientific renewal in the 17th century. The bonds between natural and living circles were limited to observing the appearances of illnesses under certain environmental conditions (Moran, 2000). The arrival of the first evolution theories during the 19th century clashed with the established concept of a life that was descended from a divine creation. This generated an epistemological fracture and, from this, adaptation was born. The idea of an evolutionary adaptation comes from the notion of adaptation to the natural environment, the back bone of Lamarck's theories (1809) and influenced by Buffon and Maupertuis. Lamarck saw in living beings the capacity to stick to "influential circumstances" (the set of the external actions that are implemented today in the notion of environment) in developing certain organic functions, according to need. This transformist adaptation was perceived as a continuous effort of the living to benefit from the milieu in which it evolves. Once acquired, adaptation was hereditary. The ideas of resistance and survival preponderated. The environment, devoted to itself and subjected to its own laws, ignores the living (Canguilhem, 1952). The Darwinian explanation of a natural selection as an evolving, driving force eclipsed the Lamarckian adaptation, which was then perceived as a simple result of evolvments and not a process, before the former also came to a dead end when faced with the rediscovery of work in genetics and the notion of organization. Rabaud's work on biological adaptation (1922) and, subsequently, Cuénot's (1925) marked the beginning of a prosperous era for the enrichment of the notion of adaptation. In the second half of the 20th century, contributions were made by new sciences, such as cybernetics, and the advancements in information theories, as well as thermodynamics of open systems. First defined on an individual level, the concept was then studied on a collective human scale (Orlove, 2005). The research in the 1990s on auto-organization, complexity and systemics contributed to the refinement of adaptation thus creating a concept. Despite all of these achievements, adaptation remains a prisoner of its etymology. This refers simultaneously to an action (process) and finality (state) as a result, the terminological duality resumed by "the adaptation state" and the "adaptation process" discussed by Piaget (1967). The difficulty of interpretation resides in the human perception of time. The observed adaptations seem to be relatively stable when they are the results of constant evolution (Bocquet, 2002). This ambivalence originates from both semantic wealth and a level of advanced reflection, as witnessed in its transdisciplinary usage.

2. THE POSITION OF THE CONCEPT OF ADAPTATION IN BIOLOGY, FIELD OF ORIGIN

Originating mainly in studies of the living, the concept of adaptation remains the centre of focus in biology, borrowing



diverse terminologies (biological, physiological and evolutionist adaptations) (Bock, 1980). However, despite the construction of the theory of adaptation, the semantic duality of the term renders the definition and comprehension of the concept difficult to grasp. Hence, it remains elusive and non-consensual, despite its many different contributions (Huneman, 2005). To globally summarize, biological adaptation can be defined as “is adapted a living being.” This short cut that was inspired by Laborit (1976) introduced the idea that, if a being lives and reproduces, it is because it has adjusted its biological functions to its external conditions. Morin adheres to this general idea by affirming that adaptation is the prime and general condition of all existence (Morin, 1985). In greater detail, biological adaptation designates above all a process that can be transposed at an individual level, resulting from genetic organization at a cellular level. Thus, the immune system is capable of perception and acquisition on a physiological level. This process is then qualified as “acclimatization” or “apprenticeship” (Prochiantz, 1997; Stewart, 1994). At a species level, the concept of adaptation is the result of a long term evolution produced by natural selection. The spatial scale can reach that of a population, an ecosystem or even Earth, as maintained by the Gaia hypothesis in its definition of the Earth as “a dynamic, physiological system that includes the biosphere and maintains our planet in harmony with life” (Lovelock, 1969, p.30). However, biological adaptation also describes the product (state, character) of the evolving processes. Gould and Vrba, in particular, see a character as an adaptation if it fulfils a role for an individual in the present whereas Bock (1980) defines a character as an adaptation if it contributes to the reproductive success of the individual. These subtleties guide Reeve and Sherman (1993) to emphasize the importance of defining adaptation in an appropriate way in relation to the problem addressed.

The interactions between the organisms and their environment and the mechanisms of adaptation are now better understood. The LEGO bricks analogy is often used to explain how each essential, elementary functions are insured by distinct biological modules which are exquisitely adapted to their particular role (see for instance Csete et Doyle, 2002). This modular organisation is robust and at the same time flexible: when a new trait emerges, natural selection does not start from scratch, but from the available modules: existing organs, tissues and cells, existing genes and gene networks. By combining modules—the LEGO bricks—within an organism it is possible to make something new. A common theme that has emerged from analyses in evolutionary biology is thus that organisms are robust and flexible systems. If the surroundings of an organism change, its developmental systems provide the ability to adapt to achieve and maintain some function (Breuker, 2006). Robustness and flexibility are thus two antinomic properties that result from modularity. This “property of the systems that are susceptible to deforming themselves in a coherent and autonomous manner in order to respond to internal and external stress,” (Lambert and Rezsöhazy, 2004, p.304) is called plasticity and is seen as the real “adaptive capacity” of life.

Research into the temporal dimension of evolving adaptation has been more theoretical. Its difficulty of conception lies in the difference between the time scale of the human observations and that of the history of life. The adaptive landscapes developed by Wright (1932), and then Kauffman (1993), enable a representation of the adaptive mechanisms of evolution through time. Symbolized by a series of three-dimensional pikes, on which altitude represents the level of adaptability, it emphasizes the idea of plasticity and multistationarity, characteristics of life’s processes. In regard to the speed of evolutionary adaptation, Eldredge and Gould’s theory of punctuated equilibrium (1972) brought forth the idea of an alternation between periods of balance and of intensive changes. It differs itself from the constant temporal gradualism that has been associated with evolution since Darwin. In the Red Queen theory proposed by Van Valen (1973), organisms maintain a continuous effort of co-evolution with the objective of survival based upon the premise of a constancy of change of environmental conditions. Finally, as to knowing if need creates adaptation or the reverse, Cuénot (1925) envisaged *preadaptation*, in which an organism acquires a useful characteristic before needing it, a limited concept due to its finalist vision. Gould and Vrba (1982) proposed the concept of “exadaptation,” which evokes the characteristics of an organism that is initially developed for a function other than its current function. Exadaptation corresponds to Jacob’s idea: “*the real is but one amongst countless possible others*” (see Barrette, 2000 for a discussion of this idea). Exadaptation enlarges the explanations of the appearance of organs or behaviors by creating a large possibility off chance and the individual within a non-teleological dimension (finality study). Therefore, need is no longer seen as the sole creator of functions: “the question of whether the need create the organ or vice versa is thus a non-problem (...) that exists only when creation or apparition is conceived (...) the answer is: neither the first nor the second, but a combination of the two” (Barrette, 2000).

3. THE USAGE OF THE ADAPTATION CONCEPT IN PSYCHOLOGY

Influenced by biology, the concept of adaptation has been at the heart of psychological modelling since its origin in psychological adaptation. It is defined as the process of unceasing interaction between Man and the ever-changing world within which he evolves. It is like a complex dynamic that articulates the different actions of the subject, as well as the different processes that enable the emergence of transformation perspectives (Jakubowicz, 2002). These are updated by the process of information processing and decision making, to act recursively on the internal organization of the subject, giving it the possibility (ability? opportunity?) to adapt to new situations (Taché, 2003). The subject is never isolated from the collectives in which he participates and the other (actor, situation, organization) is a stakeholder in adaptation scenarios. This field also distinguishes the faculty of adaptation, the aptitude of an individual to modify his structure or behavior in order to respond to new situations. Clinical psychology has unravelled an idea of the complex

adaptation as a result of the discovery of the unconscious via psycho-analysis and its implications in the process of one's identity. Social psychology, as well, developed a definition of adaptation using a reflexive dynamic from "trans-construction" in which the subjects' values and those of the environment or organizations are adjusted. Genetic psychology developed the concept of adaptation by positioning it in a constructivist modelling (theory of acquisition). This inspired Piaget to conclude (1967) that the subject's adaptation comes from the ongoing search for a balance (equilibrium) between the processes of assimilation and accommodation, and remains inseparable from knowledge and the act of organizing. Thus Piaget distinguishes between the adaptation state (associated with the closure, reconstitution and organization of the system) and the adaptation process (associated with the opening and exchanges of this same system). Psychological adaptation also hinges on maladaptation. These two antonyms form a frontier on which the human subject is constantly evolving. Maladaptation is associated with the sentiment of discrepancy between oneself and others and can be the source of inspiration, withdrawal or psychic dysfunctions. It is treated by social exclusion since the capacity to adapt is considered to be the best indicator of mental healthiness (Rouillon, 1996). Generally speaking, mankind is evolutionally maladapted, despite its immense adaptation potential, as witnessed by its long post-natal dependence, even though it originated in collective construction due to its obligation to cooperation (Taché, 2003). In paradox, the city, which is a project of collective dimension, concentrates the factors of maladaptation and the sources of stress, particularly those that are related to the material environment and the rhythm of life. These are urbanization, journeys and the importance of the mass media (Scotto, 1996). In addition, stress represents the reaction of adaptation to the constraints of the environment and is an essential reaction for survival. To be more precise, stress is the process of transaction between the individual and the milieu at the origin of behavioral and psychological adjustments that the individual must undertake to re-establish his internal balance when faced with events and their interpretation that threatens his integrity or well-being (Trudel *et al*, 2001). When the constraints continue, the adaptation system becomes exhausted and "adaptation" illnesses appear (asthma, ulcers, hypertension or psychosomatic diseases) (Plancherel, 2001). By emphasizing the importance of perception and interpretation in a situation that is perceived to be stressful, Lazarus and Folkman (1984) define "coping" or adaptive strategies as cognitive and behavioral efforts to manage stress and to know how to dispose of the necessary resources available to enable this. At the frontier between psychology and progressive biology, the evolutionist psychology that was proclaimed to be Darwinian appeared in the 1980s and 1990s. It is sometimes considered to be a reorientation of socio-biology, a theory exposed by Wilson (1975) that sees, in social behavior, adaptations of reproductive behaviors, thus seeking an optimal propagation of genes. This field became controversial when applied to Man because of the setting aside of psychological and social aspects that are peculiar to the species (Sperber and Hirshfield, 1999). Evolutionistic psychologists are interesting

themselves in the evolution of the human brain, which they consider to be the link between genes and behaviors and acting as a centre of information processing that is cast by natural selection to resolve, in an adaptive way, the problems encountered by our hunter-gathering ancestors (Cosmides and Tooby, 1997).

4. USE OF THE ADAPTATION CONCEPT BY ANTHROPOLOGISTS

Anthropology studies the evolution of human cultures and the cultural and biological changes that have unfolded on the planetary scale. It looks at the manner in which individuals and groups adapt to their environment by measuring the costs/benefits and successes/failures of these changes. The term adaptation is largely missing from the dictionaries and glossaries of French anthropology, whereas we find the terms *adaptation* and/or *adjustment* in English (Bonte and Izard, 2007). However, the concept of adaptation remains an important concept in anthropology, notably within the American school (Robson, 1978). It is defined as the process through which organisms or populations of organisms make biological or behavioral adjustments that will facilitate or assure their reproductive success, and therefore survival, in their environment. The success or failure of adaptive responses can only be measured on a long term basis and the consequences of the observed behaviors on evolution are not predictable (Bates, 2005). From the time of its scientific advent, (19th century) anthropology adopted an evolutionist approach that was influenced by Darwin's work directly. The application of Darwinian theories to the evolution of cultures and societies assumed a unique sequence of development in the evolution of societies. However, adaptation did not play a central role in these evolutionist theories within which determinism prevailed. The anthropology of the 20th century developed around the criticism of these evolutionist theories, moving the analysis toward the study of structural and functional configurations peculiar to any given society (Bonte, 2007). It is within North American anthropology that the concept of adaptation took shape in the late 1950s. This was a period during which Steward elaborated his multi-linear evolution theory within which cultures evolve in a distinct manner according to their own environments. In this way, the cultures that existed in comparable environments had a tendency to formulate similar responses when faced with environmental challenges (McGee and Warms, 2004). The developed methodology implicated cultural ecology, which examines cultural adaptations of human beings to surpass the barriers set by their environment (Guille-Escuret, 2007). Today, we find the concept of cultural adaptation in social anthropology, which includes all behaviors and acquired responses (socially or by learning) that affect human survival (reproduction, provisioning and habitat), such as oral communication. This is a type of cultural and biological adaptation that is responsible for the development of human culture, which co-evolved with the human brain, each stimulating and strengthening the other. One of the keys to the process of adaptation is biological or behavioral variation, thereby implicating the notion of selection and the processes of decision making (Bates, 2005).



5. THE FACETS OF ADAPTATION IN SOCIOLOGY

Despite intertwined roots with biology, sociology seldom uses the concept of adaptation, preferring the terms “acculturation,” “deviance” or “socialization” (Étienne *et al*, 2005). Nevertheless, the concept of adaptation exists in sociology by social adaptation. It is found in changes in the individual at the beginning of the development of aptitudes to integrate and acquire the feeling of belonging to a group (Boudon, 2002). Social and cultural adaptations have several aspects in common through inadaptation and psychological adaptation and conform to the concepts of social integration and socialization. Socialization requires an individual to have interiorized and integrated the models, values and symbols of the milieu to the structure of his personality in order to communicate and evolve with ease. Social adaptation, however, does not signify “conformity” as the adaptation to a milieu can introduce the notion of innovation or modification (Rocher, 1992). Furthermore, the sociological theories of adaptation and the sociological analysis of integration are complementary and participate in the enrichment of adaptation in a more general sense. The sociology of the 19th century, influenced by biology, saw the appearance of evolutionism, which searched for laws at the source of social transformations in time. At the beginning of the 20th century, evolutionist sociology was criticized by functionalism, sociology of conflict and individualism. This influenced new waves through the concept of change. In turn, this enabled the concept of adaptation to be re-born (Taché, 2003). The contribution of new sciences created epistemological ruptures. From this emerged the concept of interdependence, the premise of the complex and systemic sociology that was instigated by Morin and in which adaptation draws the essential from its conceptualization. Morin’s work, sometimes closer to epistemology than to sociology, connects social anthropology to the sciences of nature using the concepts of systems and organization, thus redefined (Durand and Weil, 2006). Adaptation is therefore conceived as the process central to change by which a complex system can raise its complexity by lowering its constraints. Morin (1985) emphasizes that the concept is wired to a conceptual loop mixing auto-organization that integrates an eco-organization, thus participating in Evolution. The notion of adaptation is itself subject to change and transformation. Thus, Taché (2003) proposes a generic definition of the adaptation of the complex systems that integrates a wide range of notions. He ends his work on the sociologic implication within the complex process adaptation on a theoretical level, as well as a level of intervention, notably within the existing global context that is characterized by numerous changes and uncertainties. In the 1950s, using his general theory of action, Parsons developed the function of adaptation in the context of the action system represented by social actors and defined by the interdependence of the under systems (cultural, social, psychic, biological) and the system of action with its environment. Therefore, the function of adaptation is a principal of organization that enables one to understand the relation between parts of the system, as well as the system as a whole. It deals with all the means that the system and its members must

use in the pursuit of goals. In this way, adaptation becomes an endogen process that enables the system to either assimilate the innovation, or to modify its internal structure in order to assimilate this innovation. The subject of adaptation is also treated in the sociology of organizations, Faced with change (social, economic, technological), there exist organizations that are resistant to adaptation, but which must transform to avoid disappearance by accepting a gradual and permanent change, rather than an endured and brutal change. Henceforth, the collective apprenticeship notion of the actors of new ways of being and doing constitutes social adjustments that represent the system that is changing with time. In this vein, the study of the relations of power by the strategic and systematic analysis developed by Crozier and Friedberg (1977) enabled them to show that the actor is free to take a step back from expectations in choosing a group of possibilities, rather than passively adapting to his structure.

6. ADAPTATION TO THE DEVELOPED MILIEU IN GEOGRAPHY

The concept of adaptation as used in geography comes close to the notion of natural milieu, which implicates the integration of the physical to the social and of the natural to the cultural. This notion first developed in a determinist sense in its relation with living beings before integrating a complex vision, interdisciplinary and systemic (Blanc-Pamard, 2007). The contributions on geographical distribution and the influence of the milieu on the populations appeared in the 18th century in the wake of maritime exploration. The explanatory argument was of divine intent, which has “always welcomed environmental theories because both systems rest on the concept of adaptation” of the living to its environment (Glacken, 2005). The idea of a humanity that modifies its milieu (by collective action, according to A. Comte) appeared in the 19th century, creating the notions of natural or transformed landscape. Just as in biology, the concept of adaptation in geography was debated during an epistemological analysis that was guided by reflections on the importance to be given to mankind in nature. Several authors focused on the influence of the milieu on mankind, his culture or his character traits. The behaviorism marked the extreme: the milieu, endowed with a powerful influence, dominates the heredity and the genetics of the individual; behaviors are neurobiological responses or adaptations to stimuli of the milieu. The limits that the environment imposes on life are also evoked (Malthus, Boas). The acceleration of technical progress on the extraction of resources, knowledge on the transformations of nature, and then on evolution, precipitated the emergence of a multi-disciplinary study of the relation of man/nature (Moran, 2000). A geography that integrates human beings emerged to counterbalance the physical geography that prevailed (Reghezza, 2007). In the United States, links wove between ecology and geography touched the different schools of thought of the 20th century. The 1920s saw an urban sociology that was formed to study the relation between man and his urban environment that had become man’s natural environment in society (Philifert, 2007). The Chicago school of

Field	Definition	Associated concepts
Biology	"By saying Biological adaptation, we mean all internal and external correlations (organism-milieu relations) that allow an organism to live in a certain manner in a given habitat, and to contribute to the perpetuation of the species to which it belongs" (Boquet, 2002).	Evolution Interaction Acclimatization
Psychology	"The process that surrounds the unceasing interaction between Man and the dynamic world in which he evolves and interacts" (Jakubowicz, 2002).	Equilibration Habituation
Anthropology	The process through which organisms or populations of organisms make biological or behavioral adjustments that will facilitate or assure their reproductive success and therefore survival in their environment. The success or failure of adaptive responses can only be measured on a long-term basis and the consequences of the observed behaviors on evolution are not predictable (Bates, 2005).	Adjustment Behavior
Sociology	Despite intertwined roots with biology, sociology seldom uses the concept of adaptation, preferring the terms acculturation, deviance or even socialization. Nevertheless, the concept of adaptation exists by social adaptation, which dwells on changes in the individual at the origin of the development of aptitudes, to integrate and acquire the feeling of belonging to a group". (Boudon, 2002).	Integration Socialization Acculturation
Geography	The Chicago School of Geography borrowed the concept of adaptation from ecology to define it as the fruit of deliberate choice, so as to escape the constraints of the milieu, thus distancing itself from biological determinism descended from natural selection and leaning more on the notion of adjustment: "the object of geography is the adjustment of Man to the environment and not to the influence of this environment" (Barrows, 1923).	Adjustment

Table 1. Summary of various definitions of adaptation and associated concepts according to several fields.

The environment	Taken from English, environment means here at the same time a milieu and a system of relations because of the systems' actions and reciprocal reactions between the natural milieu and the systems (George, 1971). Whatever the field, the concept of adaptation is to be considered when the concept of adaptation is evoked, as it is always referenced to the environment of the studied system (Brandon and Antonovics, 1996).
Change and evolution	In the hypothesis of complex dynamic systems, change is permanent, emphasizing the fact that a process of adaptation to it is continuous. In this way, evolution, change and adaptation are interlinked and therefore it is inconceivable to imagine the possibility of one without the others (Taché, 2003).
Semantic duality	Terminological ambiguity is to be considered in the usage of the concept. The human is trapped between his immediate perception and that of one more theoretical progressive future. As Piaget said, "the adaptation-process includes a succession of temporary state-adaptations, which are to be clearly distinguished."
Influence, modification, interaction, organization	Adaptation implicates two interacting entities: it is the adaptation of something (an object, an entity, a system) to its environment (external or internal). The interaction, influence and reciprocity between these two systems are part of the adaptation process. The result being an (re- or auto-) organization of the system to re-adjust to its environment.
Survival and balance	Since life resembles and reflects a successful adaptation, the sole objective of the adaptation of a system resides in its survival. Adaptation is the perpetual movement of a system undertaking a continuous search for a balance with the environment in which it evolves.
Innovation and apprenticeship	Adaptation implies the appearance of new things and, for this, creativity is needed. Change brings forth innovation, which is different from conformity. The process of adaptation facilitates the absorption of this novelty. The notion of apprenticeship is equally essential to the success of the adaptation.
Speed	The speed of adaptation depends on that of change, as it implies survival. When the scale or the speed of change is superior to that of adaptation, there is a risk of failure: the system cannot adapt and, therefore, it disintegrates.
Plasticity	The implementation for adaptation belongs to the system. However, the wider the range of possible responses, the greater the chance that the adaptive strategies that have been put in place have of guaranteeing the survival of the system.
The spatial scale	Adaptation can be symbolized by a succession of systems that adapt to their respective milieu along the spatial scale, the limits of which are unknown.
Perception, information and decision making	To perceive the changes of its environment, the system calls upon tools of perception and data processing, which are vital in the adaptation process of the system. The selection from the possible choices constitutes the following stage, which is essential to the success of the adaptive mechanism.

Table 2. Summary of common notions, resulting from several interdisciplinary definitions of the adaptation concept that can be relevant for adaptation to climate change.

geography borrowed the concept of adaptation to geography to define it as the fruit of deliberate choice, so as to escape the constraints of the milieu, thus distancing itself from biological determinism descended from natural selection and leaning more on the notion of adjustment: the object of geography is the adjustment of man to the environment and not to the influence of this environment (Barrows, in Reghezza, 2007). Henceforth, this notion of adjustment, an occasional response to a punctual event, strayed from the concept of adaptation, a long drawn out process, the capacity of which allows the reduction of the vulnerability of social systems faced with any crisis (Burton *et al.*, 1993). In the

1960s, research into natural disasters questioned the interactions between the social system and environment, as well as the social response, when faced with a risk. The interdisciplinary works were orientated towards the analysis of adaptation of populations to the natural risks by the capacity to face and respond to them, the study of the choices of engineers in public politics, and the analysis of the influence of perceptive and cognitive factors, as well as the elaboration of the concept of vulnerability. Recently, a geography of adaptation was mentioned by Mainguet (2003) during his studies on the importance of man in dry environments, whereas Pumain (2007) defined cities as



many complex and evolving objects that are endowed with a remarkable capacity for adaption and transformation.

7. FROM THE ADAPTATION TO CLIMATE TO THE ADAPTATION TO CLIMATE CHANGE

The biological evolution of living beings and climate evolution are closely related. The idea of inconstancy of past climate goes back to the scientific discoveries of the 18th century. Beyond climate determinism that aims to explain human diversity (cultural, social, intellectual and artistic) through climate causality, climate variations have played a role in human history (Acot, 2003). The hypothesis of the origin of bipedism suggests a physiological adaptation of hominids after an important drought. The hand development, the cognitive and social elements that favored the production of food and also the evolution of culture and language can be linked in one way or another to climate fluctuations (Orlove, 2005). Certain periods of mild climate conditions aided the expansion of farmable areas or resources, enabling the development of social structures (Diamond, 2005). Therefore, since individuals have always adapted to climate, there is a strong chance that they will continue to do so. However, despite an influence on an old regional scale, the appearance of climatic changes induced by man on the planetary scale is unprecedented (Füssel, 2007). The particularity of this phenomenon resides in the speed of its evolution, the uncertainty of its extent and human responsibility, as well as the implication of multiple, interrelated causes (IPCC, 2007). Consequently, climate change is at the forefront of humanity's limits of experience, or is even totally new, as was the Chernobyl tragedy (Alexievitch, 2004). For this reason, the need to learn from past and present adaptations, to understand their processes and to grasp the mechanisms of the agents of change (states, markets and civil society) becomes pressing (Adger *et al*, 2003).

8. CONCLUSION: INTERDISCIPLINARY RANGE OF THE CONCEPT IN ENVIRONMENTAL SCIENCES

Throughout its transdisciplinary polysemy, the concept of adaptation consists of pertinent viewpoints for clarifying adaptation to climate change or even for the environment sciences in general as environment, interdisciplinarity and adaptation can be easily linked (see table 1 and 2). Indeed, today the notion of adaptation capacity includes numerous interdisciplinary aspects of the theme of the environment. It is because of this interdisciplinarity that the concept of adaptation becomes a means for reflecting upon the link between the environment and society in a systemic perspective of reciprocal actions (Reghezza, 2007). There is, therefore, a growing interest in the study and research of solutions to the problem of multifactorial origins descended from actual acceleration of global environmental and socio-economic changes. Henceforth, the entire challenge lies in the implementation of the theoretical aspects of the concept of adaptation. This is a delicate stage, in light of adaptation's complex dual etymological history that

entwines it with other concepts. Following his study in biology, Cuénot qualified adaptation as "a frightening question" because of the philosophical and metaphysical considerations that it presupposes (Cuénot, 1925).

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