Introduction

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In the first decade of the 21st century, adaptation of humans to climate change has suddenly become a question for public debate and has been regarded as a focus for scientific research, an issue in technical/political planning at local, national and international levels and a topic for promoting public awareness (IPCC, 2007; SMIT *et al.*, 2009). In its 4th Synthesis Report, the Intergovernmental Panel on Climate Change (IPCC) explained this interest by showing that the reduction in greenhouse gas (GHG) emissions would not stop all climate change impacts, some of which are already being felt (PARRY *et al.*, 2007). Past and current emissions will have inescapable consequences tomorrow due to their very long atmospheric lifetime. Adaptation measures are therefore urgent and necessary in addition to efforts for reducing GHG emissions.

Generally, adaptation aims at reducing vulnerabilities of natural and socio-economic systems to face climate changes at least cost. According to the IPCC's usual definition, 'adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities' (IPCC, 2007: 27). Thus, the notion of adaptation is opposed to that of mitigation as adaptation operates primarily at the local level and its benefits in terms of vulnerability reduction are obtained on a shorter term basis. In contrast, it is more difficult to estimate the impacts of adaptation actions on the vulnerability of people, societies and territories, as there is no measurement akin to carbon footprint (ton CO_2 equivalent) to quantify GHG reductions. Finally, the IPCC's understanding of adaptation is very specific with no reference to its complexity, although this concept was shaped for other paradigms on the basis of extensive interdisciplinary research.

Adaptation is thus considered through climate change alone and adaptation responses only aimed at mitigating the impacts of a climate shock or using the benefits of a climate opportunity. But we know that the overall processes leading to changes in societies and enhancement of people's quality of life can also contribute—directly or indirectly—in reducing the vulnerability of social systems to climate change, without necessarily causing major adverse effects on the natural environment and the climate (Adger *et al.*, 2009; Moser and Ekstrom, 2010).

There is nothing new about individual or societal adaptation in the history of humanity either as an empirical experience or even as a theoretical construct. Humans have faced precarious resources and living conditions resulting from climate change for a very long time, in particular by developing technical innovations (irrigation, breeding resistant crop plants, weather forecasting, etc.) and socioeconomic aspects (including insurance covering natural catastrophes). Many authors, however, have argued that it is not so much a question whether human societies can adapt—in absolute terms, they demonstrate this every day—but that of proving that past adaptations can foreshadow capacities that will be useful to future generations in adapting to tomorrow's global changes. Indeed, adaptations made in the past cannot be compared with those that will have to be provided in the future to the impacts of climate change whose scale, intensity, speed and variability are totally unprecedented (Adger and Barnett, 2009; Adger *et al.*, 2009; Berrang-Ford *et al.*, 2011). The adaptation of human societies to climate change thus involves the quasi-consubstantial question of the limits to adaptation.

Scientists often resort to the concepts of limits or barriers and also constraints or stress almost interchangeably, although their meanings differ considerably. While barriers generally suggest constraints or stress factors that can be surmounted, the limits—in line with the IPCC's understanding (IPCC, 2007)—refer to insuperable obstacles, thresholds beyond which human activities, land use, ecosystems and species cannot be maintained, even in a modified form. Ecological and physical constraints thus jointly set the limits of adaptation. The latter can take various forms, ranging from ecosystem thresholds (habitat, biodiversity, functioning), beyond which adaptation (resilience) is no longer possible to limits of biomes and to the exhaustion of resources (Parmesan and Yohe, 2003; Fischlin *et al.*, 2007; USGS, 2009). Thus, the limits of adaptation are defined as exogenous to the social system, like physical and ecological constraints.

The other factors that oppose adaptation, but without ruling it out entirely, are usually barriers that come from society and its interactions with nature. Adaptation is not solely a necessity fully assessed by international experts and required by external natural conditions but is also a choice made by individuals and communities and based on: i) scientific knowledge and collective experiences of danger; ii) individual and collective norms and values that shape ways of thinking and acting; iii) economic, sociocultural and symbolic costs of adaptation; iv) and the purpose of adaptation (a return to previous equilibrium or a stage towards new technical-economic progress). These subjective barriers that change strongly according to context and history partly overlap the factors generally raised by 'adaptation capacity' and 'vulnerability'. For both individuals and communities, the low level of economic

resources, the limited access to technology and the lack of skills are clearly factors that hinder adaptation. Many researchers even consider that they account for ongoing lack of adaptation in low-income countries, particularly in Africa (Adger *et al.*, 2005a and b; Smit and Wandel, 2006; Hulme *et al.*, 2007; Moser and Ekstrom, 2010; Dow *et al.*, 2013).

As a rule of thumb, adaptation strategies should include three levels of uncertainty with regard to: i) the future climate; ii) climate change impacts on natural and socio-economic systems (Meehl *et al.*, 2007); and iii) future benefits of an adaptation process undertaken today (Magnan, 2013). Each of these uncertainties can become a barrier in the adaptation process (problem identification phase and action planning stage) (Moser and Ekstrom, 2010). These uncertainties are all the more high and determining for action that adaptation is a local phenomenon by definition, and projections of the climate and its impacts are provided at continental or regional levels. Furthermore, uncertainly related to long-term forecasts is more important in Africa than anywhere else in the world due to the lack of reliable and sufficient meteorological data. Admittedly, uncertainty justifies focusing on reactive rather than on proactive adaptation all around the world. Several authors have shown that the economic, social and environmental costs of climate change impacts will necessarily be higher if adaptation measures are not anticipated (Stern, 2006; Parry *et al.*, 2009). However, reactive adaptation is by far the most common category in both poor and rich countries (Adger *et al.*, 2003; Amundsen *et al.*, 2010). It is implemented after an extreme event has occurred and therefore does not involve a proactive response. Likewise, the benefits of reactive adaptation are often immediate or short term—another feature that limits potential maladaptation (when adaptation increases the climate change vulnerability of populations and territories) or avoids adaptation with regret (when the environmental risk that the adaptation is designed to counter does not take place).

Several recent studies on adaptation practices and their processes have shown that the capacity of a system to respond effectively to climate change and variations does not depend solely on knowledge that reduces uncertainty and increases awareness, or entirely on economic and technological development. It is also determined by social norms and cultural values and rules (Brooks et *al.*, 2005; Naess *et al.*, 2005; Ford *et al.*, 2006; Coulthard, 2008; Adger *et al.*, 2009). Adaptation is a local process and depends on the social and cultural context in which it is constructed. Therefore it varies between individuals, within communities and between communities, territories and countries (O'Brien *et al.*, 2006; IPCC, 2007).

Social institutions and customary law often govern access to and control of resources at community scale. According to E. Ostrom (2005), an institution is the 'rules' that govern systems of beliefs, organisational structures and the practices of a community. These rules generally include land rights, rules for the management of common fallows, closure to grazing animals, access and management rules for common resources, etc. Likewise, caste, ethnic group and gender in certain societies are institutions that generate norms, values and rules that may affect the behaviour of individuals when they are faced with stress or shocks. When they are well established and recognised by all, these institutions allow communities to make better responses

to social and environmental changes. But when the rules, whose legitimacy is often based on tradition, can no longer handle the changes in ecological and social systems, they may become norms that are real barriers to adaptation. This applies to adaptive responses used repetitively and in conformity with culture and tradition but that may prove to be inappropriate in the face of future environmental changes (maladaptation) and unsustainable (JONES *et al.*, 2010; JONES and BOYD, 2011; NIELSEN and REENBERG, 2010). In other words, institutional rigidity may sometimes limit the innovation capacity of sociosystems faced with climatic and environmental shocks.

In West Africa, as elsewhere in the world, the adaptation of agriculture to climate change is not a new idea. Small farming in Africa is mainly rainfed and strongly subject to climate change and variability, making it necessary for farmers and their families to implement adaptation strategies to maintain their standard of living and production (of foodstuffs, forage, firewood, construction materials, etc.) Even without economic and technical resources, African farming populations are thus neither necessarily nor completely vulnerable when faced with threatening, harmful events. But their responses must also fit in with all the constraints, uncertainties, barriers and limits that have been listed and that reduce their scope for action. This results in minimal 'survival' adaptations that are not always effective and are rarely sustainable.

The last part of the book is focused on farming adaptations and we have considered four different agricultural pathways in three West African geoclimatic contexts (Benin, Niger and Senegal). As is seen in Chapter 4, climate change takes various forms in the three study areas: the warming trend can be seen everywhere but rainfall displays singular patterns. In northern Benin, precipitation has been stable at around 1,200 mm per year since the early 1990s. In central Senegal, rainfall increased rapidly at the end of the 1990s, reaching an average of more than 600 mm per year in the last decade. Finally, although rainfall recovered in southern Niger after the great drought, the cumulated totals have decreased significantly over the last ten years. Adaptation by farmers is clearly at a local scale, responding to the meteorological conditions of the moment while taking into account the constraints and opportunities of the environment. Senegalese farmers thus profit from more abundant, longer rainy seasons by growing long-cycle cereal varieties (Chapter 18) while those in Niger make up for the shortage of rainfall and the small yields of rainfed crops by growing counter-season crops and using underground water (Chapter 20). But the adaptations described in this part of the book are not all a response to climate logic alone. Farming innovations such as potatoes in Niger (Chapter 20), cashew nuts and soya in Benin (Chapter 17) and cattle fattening in Senegal (Chapter 19) tend rather to draw a benefit from the sales opportunities created by the development of the urban market. But all these adaptations—related to climate change or not—reduce the vulnerability of families, especially as regards the climate. It is reminded here that counter-season activities such as fattening livestock and growing potatoes tend to settle farmers in their area and reduce seasonal migration of labour whereas the drought years could trigger rural exodus.

All the examples of adaptation examined 'confirm the rule' in a way: the adaptation of small farmers in Africa is generally spontaneous (with no substantial dialogue

and coordination between the stakeholders), reactive and involves little risk. The return of more abundant rainfall in Senegal has enabled farmers to return to an old (pre-drought) agrarian system, that is to say traditional practices that are less risky practices because they are culturally acceptable and economically viable. They thus reintroduced long-cycle millet that had practically completely disappeared between 1970 and 2000 (Chapter 18). Likewise, the virtuous combining of crops and livestock that had been very difficult during the drought period reappeared with the development of cattle fattening. This not only allowed a return to the old method of transfer of fertility but also has been found to be a richer and better source of organic matter than traditional extensive cattle farming (Chapter 19). In other words, adaptation did not hinder the potential for changing the agrosystem. While conserving the guiding principles that ensure its sustainability (the combination of crops and livestock), an innovation has been incorporated in the farming system that improves its performance with regard to the conservation of soil fertility.

It can be said more generally that all these adaptations show how farming societies in Africa manage to adapt to global changes but without becoming too resistant to disturbances—that is to say incapable of change—in the face of shocks that are as random and creative as destructive. When so required by ecological, social and political constraints, this means in-depth changes to the system, in the same way as what could happen at the global scale with a transition to low carbon economies.

Adaptation thus requires resilience and the ability to change, that is to say a dynamic capacity of the system to rebuild itself differently within a new area of balance.

References

Adger W. N., Huq S., Brown K., Conway D., Hulme M., 2003
Adaptation to climate change in the developing world. *Progress in development studies,* 3 (3) : 179-195.

Adger W. N., Hughes T. P., Folke C., Carpenter S. R., Rockström J., 2005a
Social-ecological resilience to coastal disasters. *Science,* 309 (5737) : 1036-1039.

Adger W. N., Arnell N. W., Tompkins E. L., 2005b
Successful adaptation to climate change across scales. *Global environmental change,* 15 (2) : 77-86.

Adger W., Agrawala S., Mirza M., Conde C., O'Brien K., Pulhin J., Pulwary R. S., Smit B., Takahashi K., 2007
« Working group II: impacts, adaptation and vulnerability ». *In* : *Fourth assessment report of the intergovernmental panel on climate change,* Cambridge, UK, Cambridge University Press : 717-743.

Adger W. N., Dessai S., Goulden M., Hulme M., Lorenzoni I., Nelson D. R., Næss L. O., Wolf J., Wreford A., 2009
Are there social limits to adaptation? *Clim. Change,* 93 : 335-354.

Adger W. N., Barnett J., 2009
Four reasons for concern about adaptation to climate change.
Environment and Planning A, 41 (12) : 2800-2805.

Amundsen H., Berglund F., Westskogô H., 2010
Overcoming barriers to climate change adaptation: a question of multilevel governance?
Environment and Planning C: *Government and Policy*, 28 : 276-289.

Berrang-Ford L., Ford J. D., Paterson J., 2011
Are we adapting to climate change?
Global environmental change, 21 (1) : 25-33.

Brooks N., Adger W. N., Kelly P. M., 2005
The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation.
Global environmental change, 15 (2) : 151-163.

Coulthard S., 2008
Adapting to environmental change in artisanal fisheries - insights from a South Indian Lagoon.
Global Environmental Change, 18 (3) : 479-489.

Dow K., Berkhout F., Preston B. L., Klein, R. J., Midgley G., Shaw M. R., 2013
Limits to adaptation.
Nature Climate Change, *3* (4) : 305-307.

Fischlin A., Midgley G. F., Price J. T., Leemans R., Gopal B., Turley C., Rounsevell M. D. A., Dube O. P., Tarazona J., Velichko A. A., 2007
« Ecosystems, their properties, goods, and services. Climate Change 2007: Impacts, Adaptation and Vulnerability ».
In Parry M. L., Canziani O. F., Palutikof J. P.,. van der Linden P. J., Hanson C. E., eds : *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, Cambridge University Press : 211-272.

Ford J. D., Smit B., Wandel J., 2006
Vulnerability to climate change in the Arctic: a case study from Arctic Bay, Canada.
Global Environmental Change, 16 (2) : 145-160.

Hulme M., Adger W. N., Dessai S., Goulden M., Lorenzoni I., Nelson D., Næss L. O., Wolf J., Wreford A., 2007
Limits and barriers to adaptation: four propositions.
Tyndall Center for Climate Change Research.

Jones L., Ludi E., Levine S., 2010
Towards a characterisation of adaptive capacity: a framework for analysing adaptive capacity at the local level.
Overseas Development Institute.

Jones L., Boyd E., 2011
Exploring social barriers to adaptation: insights from Western Nepal.
Global Environmental Change, 21 (4) : 1262-1274.

Magnan A., 2013
Éviter la maladaptation au changement climatique.
Policy briefs, 8, 2013.

Meehl G. A., Stocker T.F., Collins W.D., Friedlingstein P., Gaye A.T., Gregory J.M., Kitoh A., Knutti R., Murphy J.M., Noda A., Raper S.C.B., Watterson I.G., Weaver A.J., Zhao Z.-C., 2007
« 2007: Global Climate Projections ».
In Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt K. B., Tignor M., Miller H. L., eds : *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, Cambridge University Press, United Kingdom and New York, USA : 747-845.

Moser S. C., Ekstrom J. A., 2010
A framework to diagnose barriers to climate change adaptation.
Proceedings of the National Academy of Sciences, 107 (51) : 22026-22031.

Næss L. O., Bang G., Eriksen S., Vevatne J., 2005
Institutional adaptation to climate change: flood responses at the municipal level in Norway.
Global Environmental Change, 15 (2) : 125-138.

O'Brien K., Eriksen S., Sygna L., Naess L. O., 2006
Questioning complacency: climate change impacts, vulnerability, and adaptation in Norway.
AMBIO: a journal of the human environment, 35 (2) : 50-56.

Ostrom E., 2005
Understanding Institutional Diversity.
Princeton University Press.

Parmesan C., Yohe G., 2003
A globally coherent fingerprint of climate change impacts across natural systems.
Nature, 421 (6918) : 37-42.

Parry M. L., Canziani O. F., Palutikof J. P., van der Linden P. J., Hanson C. E., 2007
« Working Group II Report. Impacts, Adaptation and Vulnerability ».
Contribution of Working Group II to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.

Parry M., Arnell N., Berry P., Dodman D., Fankhauser S., Hope C., Kovats S., Nicholls R., Satterthwaite D., Tiffin R., Wheeler T. 2009
Assessing the costs of adaptation to climate change: A review of the UNFCCC and other recent estimates.
London, International Institute for Environment and Development & Grantham Institute for Climate Change.

Nielsen J. Ø., Reenberg A., 2010
Cultural barriers to climate change adaptation: A case study from Northern Burkina Faso.
Global Environmental Change, 20 (1) : 142-152.

Smit B., Wandel J., 2006
Adaptation, adaptive capacity and vulnerability. *Global environmental change*, 16 (3) : 282-292.

Smith J. B., Vogel J. M., Cromwell J. E. III., 2009
An architecture for government action on adaptation to climate change. An editorial comment.
Clim. Change, 95 : 53-61.

Stern N. H., 2006
Stern Review: The economics of climate change (Vol. 30).
London, HM treasury.

USGS, 2009
Tresholds of Climate Change in Ecosystems: Final Report, Synthesis and Assessment Product 4.2. University of Nebraska, US Geological Society.

Lalou Richard.

Part IV : Adaptation of farming systems, innovations : introduction.

In : Sultan Benjamin (ed.), Lalou Richard (ed.), Amadou Sanni M. (ed.), Oumarou A. (ed.), Soumaré M.A. (ed.).

Rural societies in the face of climatic and environmental changes in West Africa.

Marseille : IRD, 2017, p. 327-333. (Synthèses). ISBN 978-2-7099-2424-5